

PROJECT MANUAL

ASHLAND PUBLIC SAFETY BUILDING

12 UNION STREET
ASHLAND, MA

CONSTRUCTION DOCUMENTS
OCTOBER 23, 2020

VOLUME 2

HKT Architects
24 Roland Street, Suite 301
Charlestown, MA 02129
617-776-6545
www.hktarchitects.com

PROJECT MANUAL

DOCUMENT 000110

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SECTION 210000

FIRE PROTECTION
(Filed Sub-Bid Required)

PART 1 - GENERAL

1.1 ~~FILING SUB-BIDS~~

- ~~A. Sub-bids for Work under this Section shall be for the complete Work required hereunder and shall be filed in a sealed envelope with the Awarding Authority before the time and date and at the location indicated in the Instructions to Bidders and at that time will be publicly opened and read aloud.~~
- ~~B. Procedure for filing Sub-Bids shall be as set forth in the Instructions to Bidders contained in this Project Manual and shall conform to all requirements of the Commonwealth of Massachusetts General Laws, Chapter 149, as amended to date.~~
- ~~C. Every Sub-Bid submitted for Work under this Section shall be on a form furnished by the Awarding Authority as required by Section 44G of Chapter 149, as amended, which form is required to be completely filled in. A sample bid form for Subcontractors is contained in this Project Manual and the bid form to be used in filing a Sub-Bid is available at the office of the Architect.~~
- ~~D. Every Sub-Bid filed with the Awarding Authority shall be accompanied by bid security in the form and amount stipulated in the Instructions to Bidders.~~
- ~~E. No sub-sub bids are required for this Section.~~

1.2 GENERAL PROVISIONS

- ~~A. All the Contract Documents and General Provisions of the Contract including, but not limited to, General and Supplementary Conditions, and Division 1 Specification Sections apply to this Section.~~
- ~~B. The work of this Section provides and contains general information which is inherently made a part of each Section and applies to all work performed under this Contract.~~
- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.**

Time, Manner and Requirements for Submitting Sub-Bids:

- 1. Sub-bids for work under this Section shall be for the complete work and shall be filed electronically, as noted in "INSTRUCTIONS TO BIDDERS".**

The following should be included in the submission:

NAME OF SUB-BIDDER: (Insert name of sub-bidder)
MASS. STATE PROJECT: ((Insert project number from top of page))
SUB-BID FOR SECTION: 210000 – FIRE PROTECTION

- B. Sub Sub-Bid Requirements: (None required under this Section.)**

C. **Reference Drawings: The Work of this Filed Sub-Bid is shown on the following Contract Drawings:**

FP-001	FIRE PROTECTION – LEGEND, DETAILS AND NOTES
FP-002	FIRE PROTECTION – SITE PLAN
FP-100	FIRE PROTECTION – FIRST FLOOR RCP
FP-101	FIRE PROTECTION – SECOND FLOOR RCP
FP-102	FIRE PROTECTION – THIRD FLOOR RCP
VS-1	VIBRATION & SEISMIC DETAILS

1.3 DESCRIPTION OF WORK

- A. Provide all labor, materials, equipment, services and accessories necessary to Design, Furnish and Install the work of this Section, complete and functional, as indicated in the Contract Documents and as specified herein. The Design shall conform to the documents and shall be subject to approval by the Architect.
- B. Without limiting the generality thereof, the work to be performed under this Section includes:
1. Fire Service connecting to Municipal water main in Union Street.
 2. A hydraulically designed combination automatic sprinkler system to provide 100% protection for the building as noted on the Drawings. Refer to Fire Protection Criteria on the Drawings. Prepare Working Drawings for approval of the Architect, the local authority having jurisdiction, and the owner's insurance company under stamp of an independent Massachusetts Registered Professional Fire Protection Engineer.
 3. Hydrant flow test
 4. Backflow Control Device
 5. Fire Department Connections.
 6. Pipe and Fittings
 7. Fire Hydrants
 8. Valves
 9. Hangers
 10. Sprinkler Heads
 11. Pre-action system
 12. Furnishing and installation of Supervisory Switches and Controls
 13. Systems Identification
 14. Flushing and Testing of the interior and exterior system as provided herein.
 15. Drilling, Coring, Cutting & Patching of holes and openings (where the largest dimension thereof does not exceed 12 inches), for Fire Protection Piping and Equipment. All such holes require sleeves.
 16. Scaffolding, Rigging, and Staging required for all Fire Protection Work. Comply with Division 1 requirements.
 17. Provide Seismic Restraints for all Fire Protection Systems conforming to the requirements of Section 230548 which Section is herein incorporated by reference as work of the Fire Protection Sub Contractor. Building is located in Seismic Design Category C; Seismic Restraints are required throughout the building.
 18. Furnishing of Access Panels
 19. Smoke and Firestopping Seals and sealing of all wall penetrations as detailed on the drawings. Refer to Section 078400 which defines the firestopping materials and methods.
 20. When open-flame or spark producing tools such as blower torches, welding equipment, and the like are required in the process of executing the work, the General Contractor shall be notified not less than twenty four hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant non-working fire watch through the Local Fire Department where work is being performed and until it is completed.

21. It is the responsibility of this fire protection contractor to provide skilled and properly licensed Sprinklerfitter Foreman, Journeyman, and Apprentices for each project. At any time when an unlicensed labor is found to be on the job, it is the sole responsibility of this fire protection contractor to replace these workers with properly licensed personnel immediately. Any and all work found to be incorrect, defective, installed in contrary to state, local or NFPA standards, regulations or good engineering practices, shall be expeditiously corrected without delay to the project schedule and at no additional cost to the Owner or General Contractor.
22. It shall be the responsibility of this division 210000 to provide all personnel as required to fully coordinate with the commissioning agent. The hours of training and instruction outlined in this division 210000 and the Testing requirements shall be in addition to those tests and requirements outlined in section 018100 and required to fulfill section 018100 commissioning obligations.

1.4 RELATED WORK

- A. The following items of work related to the Fire Protection Work are included under other Sections of the Specifications:
 1. Cutting & Patching beyond 1.3B.15 above: SECTION 017329 - CUTTING AND PATCHING.
 2. Installation of Access Panels: Respective finish section.
 3. Excavation and Backfill: DIVISION 31
 4. Finish Painting: SECTION 099000: PAINTING
 5. Wiring for Supervisory Switches, Electrical Alarm, and Flow Switches, and Power Wiring: SECTION 260000 - ELECTRICAL
 6. Temporary Facilities: SECTION 015000 - TEMPORARY FACILITIES
 7. Installation of Hood Suppression System – SECTION 114000 FOOD SERVICE EQUIPMENT

1.5 CODES, ORDINANCES, AND PERMITS

- A. Perform all work in accordance with the following Codes:
 1. 780 CMR: The State Building Code.
 2. 527 CMR: The Fire Prevention Regulations.
 3. NFPA-13-2013, NFPA-24-2010, NFPA-241-2013, and Owner's insurance company requirements.
 4. All applicable Local, State, and Federal Codes, Statutes, or Regulations.
 5. Town of Ashland Fire Department.
 6. Town of Ashland Building Department.
- B. Obtain all permits, inspections, and approvals, from the governing authorities and pay all fees and include cost in the bid, including approvals for the cross connection control device. Provide the Owner with the cross connection permit for the device in the Owner's name.

1.6 DISCREPANCIES IN DOCUMENTS

- A. Where Drawings or Specifications conflict or are unclear, advise Designer in writing before Award of Contract. Otherwise, Designer's interpretation of Contract Documents shall be final, and no additional compensation shall be permitted due to discrepancies or unclarities thus resolved.
- B. Where Drawings or Specifications do not coincide with manufacturers' recommendations, or with applicable codes and standards, alert Designer in writing before installation. Otherwise,

make changes in installed work as Designer requires within Contract Price.

- C. If the required material, installation, or work can be interpreted differently from drawing to drawing, or between drawings and specs, this contractor shall provide that material, installation, or work which is of the higher standard.
- D. It is the intent of these contract documents to have the contractor provide systems and components that are fully complete and operational and fully suitable for the intended use. There may be situations in the documents where insufficient information exists to precisely describe a certain component or subsystem, or the routing of a component. In cases such as this, where the contractor has failed to notify the Designer of the situation in accordance with the paragraph above, the contractor shall provide the specific component or subsystem with all parts necessary for the intended use, fully complete and operational, and installed in workmanlike manner either concealed or exposed per the design intent.
- E. In cases covered by the paragraph above, where the contractor believes he needs engineering guidance, he shall submit a sketch identifying his proposed solution and the Designer shall review, note if necessary, and approve the sketch.

1.7 MODIFICATIONS IN LAYOUT

- A. HVAC, Plumbing, Fire Protection, and Electrical Drawings are diagrammatic. They indicate general arrangements of mechanical and electrical systems and other work. They do not show all offsets required for coordination nor do they show the exact routings and locations needed to coordinate with structure and other trades and to meet architectural requirements.
- B. In all spaces, prior to installation of visible material and equipment, including access panels, review Architectural Drawings for exact locations and where not definitely indicated, request information from Designer.
- C. Check Contract Drawings as well as Shop Drawings of all subcontractors to verify and coordinate spaces in which work of this Section will be installed.
- D. Maintain maximum headroom at all locations. All piping and associated components to be as tight to underside of structure as possible.
- E. Make reasonable modifications in layout and components needed to prevent conflict with work of other trades and to coordinate according to Paragraphs A, B, C, D above. Systems shall be run in a rectilinear fashion.
- F. Where conflicts or potential conflicts exist and engineering guidance is desired, submit sketch of proposed resolution to Designer for review and approval.

1.8 RECORD DRAWINGS

- A. General: Refer to DIVISION 01 - GENERAL REQUIREMENTS for general requirements for maintaining as-built drawings and submitting final reproducible record documents.
- B. The General Contractor will provide two sets of black or blue line on white Drawings to the Fire Protection Subcontractor, one set of which shall be maintained at the site and which shall, at all times, be accurate, clear, and complete, showing the actual locations of all equipment and piping as it is being installed. The Record Drawings shall be available to the Architect/Engineer's field representative at all times.

- C. Provide electronic AutoCAD drawings to indicate revisions to piping size and location both exterior and interior; including locations of valves and other equipment requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; concealed equipment, dimensioned to column line; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located.
- D. Include in the Record Drawings any addenda, sketches, and supplementary Drawings issued during the course of construction.
- E. Non-availability of Record Drawings or inaccuracies therein will postpone the final inspection until they are available.
- F. All valves shown on these Drawings shall be numbered with numbers corresponding to those on the valve charts.
- G. All costs related to the foregoing requirements shall be paid by the Fire Protection Subcontractor.

1.9 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

- A. Provide operating instructions to the owner's designated representative with respect to operation functions and maintenance procedures for all equipment and systems installed. At the completion of the project, turn over to the Architect four (4) complete manuals in three-ring, loose-leaf binders, containing the following:
 - 1. Complete Shop Drawings of all equipment.
 - 2. Operation description of all systems.
 - 3. Names, addresses, and telephone numbers of all suppliers of the system.
 - 4. Preventive maintenance instructions for all systems.
 - 5. Spare parts list of all system components.
 - 6. Valve tag chart noting location of any and all valves controlling the fire protection systems including main control, main drain, auxiliary drain, drum drip, inspectors test connections and any low point drains connected to these systems.
 - 7. Copy of NFPA 25, latest edition.
- B. Provide DVD recording of operation and maintenance training sessions and include as part of O & M Manual submittal. Training session video recording and DVDs shall be performed by a professional videographer. Provide indexed table of contents for DVD recording.

1.10 SHOP DRAWINGS AND MATERIAL SCHEDULES

- A. Refer to SECTION 013300 - SUBMITTALS for substitution of equipment and submittal of Shop Drawings. If apparatus or materials are substituted for those specified, and such substitution necessitates changes in or additional connections, piping, supports or construction, same shall be provided as the responsibility, and at the expense, of the Fire Protection Subcontractor.
- B. Fabrication of any material or performing of any work prior to the final approval of the Submittals will be entirely at the risk of the Subcontractor. The Subcontractor is responsible for furnishing and installing materials called for in the Contract Documents, even though these materials may have been omitted from approved Submittals.

C. Submit Shop Drawings for the following materials and equipment.

1. Coordinated Working Drawings and hydraulic calculations including size, type, length, temperature rating of sprinkler heads, piping and the like. Indicate flow test results, design criteria, hydraulic reference points, diffuser and light locations.
2. Access Panels and Covers
3. Sprinkler Heads
4. Hangers and Seismic Restraints
5. Pipe, Fittings, and Appurtenances
6. Systems Identification
7. Valves
8. Fire Department Connection
9. Cross Connection Devices
10. Fire Hydrants

1.11 COORDINATION DRAWINGS

- A. Before materials are purchased or Work is begun, prepare and submit to the Architect, Coordination Drawings showing the size and location of all equipment and piping lines relevant to the complete system. Ensure that these Drawings are compatible and correctly annotated and cross-referenced at their interfaces.
- B. Coordination Drawings are for the Contractor's and the Architect's use during Construction and shall not be construed as replacing any Shop or Record Drawings required elsewhere in these Contract Documents.
- C. Detailed procedures for Coordination Drawings are contained in DIVISION 01 of these Contract Documents.

1.12 GUARANTEE

- A. Guarantee all work under this Section free from defects in workmanship or materials for a period of one (1) year from the date of final acceptance of the building, as set forth in the Contract.
- B. Replace any such defective work developing during this period, unless such defects are clearly the result of bad usage of equipment by others. Where such defective work results in damage to work of other Sections of the Specifications, restore such work to its original condition by mechanics skilled in the affected trade.

1.13 DRAWINGS

- A. All work shown on the Drawings is intended to be approximately correct to scale but shall be taken in a sense as diagrammatic. Sizes of pipes and general method of running them are shown, but it is not intended to show every offset and fitting. To carry out the true intent and purpose of the plans, furnish all necessary parts to make a complete working system ready for use.
- B. The Drawings and Specifications are intended to supplement each other so that any details shown on the Drawings and not mentioned in the Specifications, or vice-versa, shall be executed the same as if mentioned in the Specifications and shown on the Drawings.

- C. Refer to the Architectural, Structural, and Other Mechanical and Electrical Drawings which indicate the construction in which this work shall be installed. Locations shown on the plans shall be checked against the general and detailed drawings of the construction proper. All measurements must be taken at the building.

1.14 SYSTEM DESCRIPTION

- A. The building shall be 100% sprinklered with an automatic sprinkler system. The system shall be designed in accordance with NFPA-13-2013.
- B. Building is to be 100% sprinklered including all closets and Electric room. The Emergency Electrical Room is constructed to meet the exceptions of NFPA 13, 8.15.11, and is not sprinklered. The elevator shaft and elevator machine room are not sprinklered. The Server Room 135 shall be protected with a dry pre-action system.
- C. Refer to Fire Protection Criteria on the Drawings. Conform to the zoning shown on the plans.
- D. Locations of sprinkler heads are shown in some of the areas to be sprinklered only to establish the patterns and design intent. Major equipment and runs of piping may also be shown. Refer to reflected ceiling plan for location of all sprinkler heads. All sprinkler heads are to be installed dead center of tile.
- E. The documents require that the building be covered 100%. This includes all closets, combustible concealed spaces, and other areas as required under NFPA-13-2013. These areas are to be included in the Sub-contractor's bid whether or not the heads are shown on the sprinkler plans.

1.15 ALARM FACILITIES

- A. Furnish and install all Supervisory Switches, Flow Switches, Pressure Switches, and other Alarm Devices. Install all such devices on the piping and coordinate with the Electrical Subcontractor who shall wire all such devices to the Fire Alarm System. Every shutoff valve installed on this project shall have a supervisory trouble switch wired to the Fire Alarm Panel.

1.16 PIPE MARKER IDENTIFICATION SYSTEM

- A. Mark all piping installed under this Section with a marking system in basic colors conforming to those specified in ANSI/ASME A-13.1. Markings shall indicate pipe content and direction of flow. Apply markers every 20 feet on center on piping which is exposed in mechanical or storage areas and above suspended accessible ceilings. Also, apply at all access panels, valves, tee joints, alarms, and/or controls.
- B. Adhesive system may be used throughout except at the mechanical rooms in which case markings shall be painted on.

1.17 VALVE TAGS

- A. All valves installed in the Fire Protection Contract shall be tagged. Tags shall be secured to valves with chain link and shall be marked with 3/4 inch high letters as to function. All valve tags shall indicate the Fire Zone.

- B. A corresponding framed Valve Tag Chart shall be installed within each Sprinkler Riser or Control Valve Room indicating location of each valve and the section it serves. This chart shall also be included within the Owner's O&M Manual with valve tag locations noted on the As-Built Sprinkler drawings.

1.18 IDENTIFICATION SIGNS

- A. All equipment and systems shall be identified with signs furnished and attached in accordance with NFPA 13.

1.19 PAINTING

- A. All interior exposed piping is to be painted and all painting, except as noted, will be done by the Painting Subcontractor. All uncovered piping and hangers shall be thoroughly cleaned of rust, oil, and other containments by the Fire Protection Subcontractor and left ready to receive primer coat.
- B. Painting for pipe markings shall be done under this Section.

1.20 WATER SUPPLY TEST DATA

~~A. The following water supply data is included as information available to bidders.~~

~~B. A hydrant flow test was performed on _____, by _____ at _____.~~

~~C. Flow Test Results:~~

~~1. Static Pressure = _____ PSI~~

~~2. Residual Pressure = _____ PSI~~

~~3. Flow = _____ GPM~~

~~4. Estimated Flow at 20 PSI = _____ GPM~~

A. **The following water supply data is included as information available to bidders.**

B. **A hydrant flow test was performed on October 29, 2020 by Fire Protection Services. Flow Hydrant is located on Waverly Street north of the site. Gauge hydrant is located on Union Street adjacent to the proposed Public Safety Building.**

C. **Flow Test Results:**

Static Pressure = 111 PSI

Residual Pressure = 92 PSI

Flow = 1,324 GPM

Estimated Flow at 20 PSI = 3,085 GPM

1.21 HOISTING EQUIPMENT AND MACHINERY

- A. Unless otherwise specified, all hoisting and rigging equipment and machinery required for the proper and expeditious prosecution and progress of the Work of this Section shall be furnished, installed, operated and maintained in safe condition by each sub-contractor, as specified under Section 015000, TEMPORARY FACILITIES AND CONTROLS.

1.22 STAGING AND SCAFFOLDING

- A. Unless otherwise specified, each sub-contractor shall provide all lifts and man-lifts, and furnish, erect and maintain in safe condition, all staging and scaffolding as specified under Section 015000 Temporary Facilities and Controls, as needed for proper execution of the work of this Section. Staging and scaffolding shall be of adequate design, erected and removed by experienced stage builders having all accident prevention devices required by Federal, state and local laws.

1.23 COMMISSIONING

- A. Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 018100 – General Commissioning Requirements.
- B. Complete installation and startup checks and functional tests according to Section 018100 – General Commissioning Requirements and manufacturers written instructions.
- C. Operational Test: After plumbing systems have been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the startup procedure.
- D. Verify that equipment is installed and commissioned as per requirements of Section 018100 and manufacturers written instructions/requirements.

1.24 BREAKDOWN

- A. Submit a breakdown of the contract price to aid the Architect in determining the value of the work installed as the job progresses.
- B. No requisition will be approved until the breakdown is delivered to the Architect.

1.25 VISIT TO SITE

- A. Prior to submitting a bid, visit the site of work and become familiar with existing conditions at the site of the work. Any assumptions made are at this Subcontractor's expense.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All materials and equipment furnished under this Section shall be new, unused, first quality of a manufacturer of established reputation and shall be U.L./F.M. approved. Each valve, fitting, section of pipe, and piece of equipment shall have cast or indelibly stamped thereon the manufacturer's name and pressure rating where applicable. All threads for fire department connection shall conform to the standards of the Local Fire Department.

2.2 PIPE AND FITTINGS

- A. Pipe and fittings shall conform to the latest A.S.A., A.S.T.M., C.A., and F.S. Standards. All grooved products shall be of one manufacturer to conform to NFPA Standards.

- B. All piping installed under this Section shall be in accordance with the following:

<u>Service</u>	<u>Materials</u>
Trim piping around alarm valves, sprinkler piping 1-1/2 inch and smaller	ASTM A-53, Schedule 40 black steel pipe
Sprinkler and standpipe piping 2 inch and larger	Schedule 10, ASTM A-135 U.L./F.M. black steel pipe
Dry/Pre-action sprinkler system, regardless of size	ASTM A-53, Schedule 40 galvanized steel pipe
Underground service	CL 52 ductile iron pipe

- C. Fittings on fire line piping, 2 inch and larger, shall be Victaulic Fire Lock Ductile Iron Fittings conforming to ASTM A-536 with integral grooved shoulder and back stop lugs and grooved ends for use with Style 009-EZ or Style 005 couplings.
- D. Fittings for standpipes and risers, 2-1/2 inch and larger, and where ever required to conform to Seismic Requirements shall be Victaulic Vic-Flex Style 75 or 77 with Fire Lock Gasket.
- E. Branch line fittings shall be welded or shall be Victaulic 920/920N Mechanical Tees.
- F. Schedule 10 pipe shall be roll grooved. Schedule 40 pipe where used with mechanical couplings shall be rolled groove and shall be threaded where used with screwed fittings.
- G. Fittings for threaded piping shall be malleable iron screwed sprinkler fittings.
- H. All pipe and fittings shall be U.L./F.M. approved for sprinkler and standpipe service. All pipe and fittings shall be galvanized for dry or pre-action system and black for wet system.
- I. Fittings on underground fire service piping shall be 250 psi gray iron fittings with mechanical joint ends. Coordinate with site contractor to assure all joints are properly thrust blocked.
- J. Grooved fittings shall be manufactured by Victaulic, Grinnell, Anvil, or equal.

2.3 JOINTS

- A. Threaded pipe joints shall have an approved thread compound applied on male threads only. Teflon tape shall be used for threads on sprinkler heads.
- B. Joints on piping, 2 inch and larger, shall be made up with Victaulic, or equal, Fire Lock Style 005, rigid coupling of ductile iron and pressure responsive gasket system for wet or dry sprinkler system as recommended by manufacturer. Couplings on dry systems shall be galvanized. Cutting, roll grooving, lubrication, and assembly of all joints shall be made strictly in accordance with manufacturer's recommendations. Exercise particular caution in the use of lubricant to avoid "squeeze out" of lubricant when system is in service.
- C. Grooved joints and fittings shall be manufactured by Victaulic, Grinnell, Anvil, or equal.
- D. Furnish and install where piping crosses building expansion joints a listed expansion joint. Expansion joints shall be Metraflex "Fireloop", or manufactured by Flexonic Company or Hyspan, or equal. Expansion joints shall be UL approved for use for fire sprinkler systems.

- E. All joints on Fire Service under slab shall be restrained up to the service stub flange connection above slab.

2.4 VALVES

- A. All shutoff and control valves shall be U.L./F.M. approved, indicating type valves equipped with a supervised trouble switch wired to the fire alarm system. Shutoffs and zone valves may be either OS&Y indicating gates or butterfly valves.
- B. Gate valves shall be outside screw and yoke indicating type, 175 psi W.P. and U.L./F.M. listed, Jenkins or equal. All such valves shall have supervised trouble switch.
- C. Butterfly valves shall be Victaulic Series 705-W for 2-1/2 inch and larger, and Milwaukee indicating type U.L./F.M. butterfly for threaded service. Coordinate with Electrical Sub-contractor to have factory installed monitor switches compatible with the remainder of the Fire Alarm System.
- D. Check valves shall be iron body bronze mounted U.L./F.M., 175# W.P. or U.L./F.M. wafer checks. Grooved end valves shall be Victaulic Style 717 Fire Lock Check Valve.
- E. Pressure relief valves shall be located on wet systems pressure regulating valves and downstream of check valves per NFPA-13-2013. Pressure relieve valves shall be listed and not less than 1/2 in. in size and shall be by AGF, Watts, Cla-Val or equal.
- F. Ball drips shall be Potter Roemer #5682, 3/4 inch straight design ball drip valve, or by Victaulic, Viking, or equal.
- G. Drains shall be provided in the systems as may be required by field conditions. Provide drains at all low points and wherever necessary to insure that all portions of the sprinkler piping may be completely drained. Test connections shall be provided as required to test all portions of the system. Pipe low point drains and test connections to suitable receptor as determined in field or shown on Drawings.
- H. Install an inspector's test connection at the furthest point of each sprinkler zone. Run discharge back to a suitable receptor. Exterior wall penetration is permitted with test drain but only as approved by the Architect.
- I. Valves shall be manufactured by Victaulic, Nibco, Viking, or equal. Inspector's test stations shall be manufactured by AFG, Tyco, Victaulic, or equal.

2.5 SPRINKLERS

- A. All sprinklers to be used on this project shall be Quick Response type and shall be stamped with date of manufacture and temperature rating. Temperature ratings shall be determined by the location of the heads per NFPA 13-2013, section 8.3.2.5, and shall be minimum 155 degrees F. throughout except in special areas around heat producing equipment, skylights, and attics in which case use temperature rating to conform with hazard as specified in NFPA 13-2013. Orifice diameter and K factor shall be appropriate to meet the hydraulic design criteria, the available water supply, and NFPA Standards.
- B. Furnish spare heads of each type installed located in a cabinet along with special sprinkler wrenches. The number of spares and location of cabinet shall be in complete accord with NFPA 13-2013.
- C. Sprinklers shall be manufactured by Tyco, Victaulic, Viking, or equal.

- D. Upright sprinkler heads in areas with no ceilings shall be Tyco Model "TY-FRB" Quick Response, upright natural brass finish heads. Include heavy duty sprinkler guards on all upright sprinkler heads.
- E. Sidewall heads shall be Tyco Model "TY-FRB" Quick Response with white polyester head and escutcheon.
- F. Pendent wet sprinkler heads shall be Tyco Model "TY-FRB" Quick Response recessed adjustable escutcheon, white polyester finish.
- G. Concealed heads shall be Tyco Model "RFII" Quick Response concealed type, 1-1/2 inch adjustment white cover plate. In special areas, as may be noted on the Drawings, provide alternate cover plate finishes.
- H. Pendent dry sprinkler heads shall be Tyco Model "DS-1" Quick Response dry type, white polyester finish and escutcheon.
- I. Dry sidewall heads shall be Tyco Model "DS-1" dry horizontal sidewall heads, white polyester finish.
- J. Sprinkler heads located in the detention portion of the project (Shown on plans as Institutional Heads) shall be Tyco Model "Raven" Quick Response Institutional Automatic Sprinkler Heads furnished in bright chrome plated finish, tamper proof mounting, and anti-suicide heat sensors. Heads shall be either pendant or sidewall as indicated on the drawings.
- K. Use of flexible stainless steel hose with fittings for fire protection service that connect sprinklers to branch lines in suspended ceilings is acceptable. Flexible hoses shall be UL/FM approved and shall comply with NFPA 13 standards. Hose assemblies shall be type 304 stainless steel with minimum 1-inch true-bore internal hose diameter. Ceiling bracket shall be galvanized steel and include multi-port style self-securing integrated snap-on clip ends that attach directly to the ceiling with tamper resistant screws.

2.6 FIRE DEPARTMENT CONNECTION

- A. Fire Department Inlet Connection shall be Croker #6350 Series; 4 inch Storz inlet x 4 inch outlet, 30 degree elbow, brass plate, and stamped "Sprinkler-Standpipe". Install 1/2" ball drip valve and chrome plated trim wall fitting on bottom of inlet fitting body. Provide access panel for servicing the ball drip.
- B. Fire Department Connection shall be manufactured by Croker, Potter Roemer, Elkhart, or equal.

2.7 FIRE STANDPIPE EQUIPMENT

- A. Fire Department Valves shall be Croker Series 5015 Fire Department Valves fitted with 2-1/2 inch x 1-1/2 inch reducer, caps and chains all conforming to Local Fire Department thread standard. Valves shall be polished chrome plated and shall be mounted in a recessed cabinet as indicated on Drawings.
- B. Cabinets for the Fire Department Valves shall be Croker model 1710 - 18 inch x 18 inch x 10 inch deep. cabinet, fully recessed, solid door, prime painted steel. Include graphic and door catch.
- C. Provide 32 inch x 32 inch access panels at floor control locations or recessed cabinets as appropriate to the wall construction. Provide graphic.

- D. Cabinets and access panels provided at fire standpipe equipment shall be fitted with pull handles. Cylinder locks are not allowed.
- E. Valves shall be manufactured by Croker, Potter Roemer, Elkhart, or equal.

2.8 SUPPLEMENTARY STEEL, CHANNEL, AND SUPPORTS

- A. Furnish and install All Supplementary Steel, Channels, and Supports required for the proper installation, mounting, and support of all equipment.
- B. Supplementary Steel and Channels shall be firmly connected to building construction in a manner approved by the Architect.
- C. The type and size of the Supporting Channels and Supplementary Steel shall be determined by the Fire Protection Subcontractor and shall be sufficient strength and size to allow only a minimum deflection in conformance with the manufacturer's requirements for loading.
- D. All Supplementary Steel and Channel shall be installed in a neat and workmanlike manner parallel to the walls, floor, and ceiling construction. All turns shall be made with 90 degree fittings, as required to suit the construction and installation conditions.

2.9 HANGERS AND SEISMIC RESTRAINTS

- A. Hangers shall be furnished, installed, and supported from the building structure in accordance with NFPA - 13, Section 230548 and Drawing VS-1.
- B. All piping shall be seismic restrained.

2.10 ALARM DEVICES

- A. Flow switches shall be vane type water flow detectors with 0-90 Sec. Adjustable non-accumulative retard device and (2) single pole double throw contacts, Notifier Series WFD Potter, VSR.F or equal. At base of standpipe risers, flow switch shall be a non-water discharge, auto-test vane type water flow detector with 0-90 second adjustable non-accumulative retard device and (2) single pole double throw contacts, Potter VSR.AT or equal. The flow switch shall be paired with either a single gang box test switch, Potter ATC-1 for testing a single device or ATC-4 for testing up to four devices."
- B. Pressure switches shall be adjustable Potter Model PS10A or equal.
- C. High/Low pressure switches shall be adjustable Potter Model PS40A or equal.
- D. Supervisory switches on all O.S. & Y. gate valves shall be Notifier NGV complete with mounting bracket.
- E. The wet system alarm device shall be Reliable Model 'E' alarm valve with "E1" trimmings. Package to include electric bell.
- F. Refer to Drawings for additional devices. Co-ordinate, prior to ordering devices, with the Electrical Sub-Contractor to assure device compatibility with the Fire Alarm System.
- G. Alarm valves shall be as manufactured by Reliable, Victaulic, Tyco, or equal. Flow, pressure and supervisory switches shall be manufactured by Potter, Notifier, System Sensor, or equal.

2.11 PRE-ACTION SYSTEMS

- A. Furnish and install a Pre-Action System for the indicated areas shown on the drawings. System shall be an Electric Activation Double Interlock Pre-Action System as manufactured by Reliable PrePak., Victaulic Fire-Pac, Tyco DV-5, or equal.
- B. The system shall be a pressurized Dry Pipe Pre-Action System utilizing 10 PSI Supervisory Air in the piping network. Water flow shall not occur unless there is a fusing of a sprinkler head plus the activation of electrical detection system. The detection and electrical system shall be furnished and wired by the Sprinkler Subcontractor. The Electrical Subcontractor shall wire to the Pre-Action Control Panel with a dry contact closure. The Fire Protection Subcontractor is responsible to do all control wiring within the pre-action panel and to all of the devices included in the Pre-Action System including final testing of all components. The Electrical Subcontractor shall furnish and install into the control panel and air maintenance device 120V AC power source and shall furnish and install wiring to dry contacts at the local alarm and trouble annunciator as well as the Electric Alarm Pressure Switch.
- C. Furnish and install the system including all trim and accessories within the control panel. System shall be Reliable PrePak or equal.
- D. Division 21 shall furnish and install all smoke detectors and devices in each room and wire to pre-action system panel. Division 21 shall install all conduit and wiring from detectors and devices to the pre-action control panel in accordance with the requirements set forth in Division 26.

2.12 DOUBLE CHECK VALVE ASSEMBLY

- A. Double check valve assembly shall be State approved, U.L./F.M. approved, with iron body bronze mounted construction complete with supervised OS & Y gate valves and test cocks. Furnish two spare sets of gaskets and repair kits.
- B. Double check valve assembly shall be of one of the following:
 - 1. Watts Series 757-OSY
 - 2. Wilkins 350A-OSY
 - 3. Conbraco Series 4S-100
 - 4. Or equal.
- C. In the name of the owner pay for, file for, and obtain required permits from D.E.P. and/or local authority whichever has jurisdiction prior to installation.

2.13 ACCESS DOORS

- A. Furnish Access Doors for access to all concealed control valves, drains, inspector's tests, supervisory devices, and to all other concealed parts of the system that require accessibility for the proper operation and maintenance of the system. These doors shall be installed under the appropriate Section of the Specifications for the surface upon which the panels are mounted.
- B. All Access Doors shall be located in a workmanlike manner in closets, storage rooms, and/or non-public areas, positioned so that the valve or part can be easily reached, and the size shall be sufficient for this purpose (minimum size 12 inch x 16 inch). When access doors are required in corridors, lobbies, or other habitable areas, they shall be located as directed by the Architect.

- C. Refer to Section 083100 - Access Doors and Frames, for all product requirements for furnishing access panels.
- D. Coordinate locations and schedule with the work of trades involved with construction in which access panels will be installed.
- E. Access Door Shop Drawings shall be submitted to the Architect for approval.
- F. All access panels shall be keyed alike. Coordinate keying with other trades.

2.14 POST INDICATOR VALVE

- A. Post indicator valves (PIV) shall be Mueller co. UL/FM model A-20806 adjustable type indicator post with supervisory control valve switch model #PCVS-2. Post indicator valve shall be left hand open.
- B. Post Indicator Valve shall be manufactured by Mueller, Clow, American Flow Control, or equal.

2.15 DUCTILE IRON PIPE

- A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated, 350 psi.
 - 1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - 2. Glands, Gaskets, and Bolts: AWWA C111, ductile or gray iron glands, rubber gaskets, and steel bolts.
- B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated, 350 psi.
 - 1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - 2. Gaskets: AWWA C111, rubber.
- C. Grooved-Joint, Ductile-Iron Pipe: AWWA C151, with cut, round-grooved ends.
 - 1. Grooved-End, Ductile-Iron Pipe Appurtenances: ASTM A47, malleable-iron castings or ASTM A536, ductile-iron castings with dimensions matching pipe, 350 psi.
 - 2. Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions, Include ferrous housing sections, gasket suitable for water, and bolts and nuts. Joints shall be Tyton.
 - 3. Gaskets: AWWA C111.
- D. Flanged Ductile Iron Pipe: AWWA C115/A21.11, with factory applied screwed long hub flanges.
 - 1. Flanges: ASME B16.1 250 psi pressure ratings, as necessary.
 - 2. Wall Sleeve Castings, size and types shown on the drawings, shall be hot dipped galvanized per ASTM A123.
- E. Cement Mortar Internal Lining: Cement mortar lining and bituminous seal coat as per AWWA C104.
- F. Exterior Pipe Coating: The exterior of pipe shall have the standard asphaltic coating.

2.16 EXTERIOR GATE VALVES

- A. All gate valves shall conform in design and manufacturing to the latest issue of AWWA Standard C500 "Resilient-Seated Gate Valves for Water Supply", rated at 150 psi working pressure with a minimum 300 psi pressure test
- B. All valves shall have a 2 inch operating nut, mechanical joint hubs (except for wet tapping sleeves).
- C. Coordinate direction of valves opening with the local Water Department.

2.17 TAPPING SLEEVES

- A. Tapping sleeves shall be iron bodied and have a maximum working pressure of 250 psig and certified to ANSI/NSF 61. Outlet flange dimensions and drilling shall comply with ANSI B16.1, class 125 and MSS SP-60.
- B. Couplings to be used in connecting two plain ends of cast, ductile iron, or PVC pipe shall be of cast or ductile iron with bolts and nuts complying with AWWA C111. Couplings shall be Dresser Style 38, Smith-Blair Style 441, Clow Type F12308, or approved equal.

2.18 FIRE HYDRANTS

- A. Hydrants shall conform to the requirements of local Water and Fire Departments, AWWA C502, and be designed for 150 psi working pressure tested to 300 psi hydrostatic. Hydrants shall be 6-inch mechanical joint, 4-1/4 inch valve opening, with 2-1/2 inch hose nozzles and 4-1/2 inch pumper connection, Coordinate threads and open "left or right" with location water department. Bury length shall be 5'-0" minimum.
- B. Hydrant shall be able to be rotated 360 degrees. They shall have a positive closing, self-cleaning drain valve and drainage area shall be completely bronze or brass lined.

2.19 DETECTABLE UNDERGROUND WARNING TAPE

- A. Detectable warning tape shall be installed 12" directly above all buried utilities. Detectable warning tape shall consist of a nominal 4.5 mil (0.0045") overall thickness and 6" wide, with a solid aluminum foil core. The imprinted warning message is "Buried, or Encased" to prevent rub-off, and is impervious to acids, alkalis and other destructive elements found in soil. The imprint is as such that it allows for total reflectivity. A tape must be visibly seen before it can be read. The tape shall meet the testing requirements of ASTM D-882, Method A.
- B. Legend/Color & Imprint:
 - 1. Tape shall read "CAUTION BURIED WATER LINE BELOW".
 - 2. Tape color coding shall be Blue.

2.20 FIRESTOP SYSTEMS

- A. General: Provide firestopping at all new fire-rated construction where penetrated by the Work of this Section.
- B. Refer to Section 078400 - Firestopping, for all product requirements for maintaining integrity of fire-rated construction at penetrations.

2.21 SCAFFOLDS AND STAGING

- A. General: Trade Contractors shall obtain required permits for, and provide scaffolds, staging, and other similar raised platforms, required to access their Work as specified in Section 01 50 00 - Temporary Facilities and Controls and herein.
 - 1. Scaffolding and staging required for use by this Trade Contractor pursuant to requirements of Section 01 50 00 - Temporary Facilities and Controls shall be furnished, erected, maintained in a safe condition, and dismantled when no longer required, by this Trade Contractor requiring such scaffolding.
 - 2. Each Trade Contractor is responsible to provide, maintain and remove at dismantling, all tarpaulins and similar protective measures necessary to cover scaffolding for inclement weather conditions other than those required to be provided, maintained and removed by the General Contractor pursuant to MGL (Refer to Section 01 50 00 - Temporary Facilities and Controls and as additionally required for dust control).
 - 3. General Contractor is responsible to provide enclosures required for temporary heat; refer to Section 01 50 00 - Temporary Facilities and Controls.
 - a. Furnishing portable ladders and mobile platforms of all required heights, which may be necessary to perform the work of this trade, are the responsibility of this Trade Contractor.

2.22 HOISTING MACHINERY AND EQUIPMENT

- A. All hoisting equipment, rigging equipment, crane services and lift machinery required for the work by this Trade Contractor shall be furnished, installed, operated and maintained in safe conditions by this Trade Contractor, as referenced under Section 01 50 00 - Temporary Facilities and Controls.

PART 3 - EXECUTION

3.1 WORKMANSHIP AND INSTALLATION METHODS

- A. All work shall be installed in a first-class manner consistent with the best current trade practices. All materials shall be securely installed plumb and/or level, and all flush mounted equipment shall have front edge flush with finished wall surface.
- B. Protect all concealed heads. Coordinate and advise finishing trades so as to prevent painting of sprinkler heads or inadvertent filling with paint or jointing compound of required air spaces in the case of the concealed type sprinkler heads.
- C. Training:
 - 1. Train the Owner's maintenance personnel on troubleshooting procedures, and servicing and preventative maintenance schedules and procedures.
 - 2. Schedule training with Owner through the Architect with at least 7 days prior notice.

3.2 WORK COORDINATION AND JOB OPERATIONS

- A. The equipment shall not be installed in congested and possible problem areas without first coordinating the installation of same.

- B. Before materials are purchased or work is begun, prepare and submit to the Architect, Coordination Drawings showing the size and location of all equipment and piping lines relevant to the complete system. Ensure that these Drawings are compatible and correctly annotated and cross-referenced at their interfaces.
- C. Coordination Drawings are for the Contractor's and the Architect's use during construction and shall not be construed as replacing any Shop or Record Drawings required elsewhere in these Contract Documents.
- D. Detailed procedures for Coordination Drawings are contained in DIVISION 01 - GENERAL REQUIREMENTS of these Contract Documents.
- E. Particular attention shall be directed to the coordination of piping and other equipment installed in the ceiling areas. Coordinate the elevations of all piping in hung ceiling areas to insure adequate space for the installation of recessed lighting fixtures before other mechanical equipment is installed.
- F. Furnish to the General Contractor, and all other Subcontractors, all information relative to the portion of the Fire Protection installation that will affect them, sufficiently in advance so that they may plan their work and installation accordingly.
- G. In case of failure to give proper information as indicated above, sufficiently in advance, pay for all back-charges for the modification, renovation, and relocation of any portion of the work already performed.
- H. Obtain from the other trades, all information relative to the Fire Protection Work to be executed in conjunction with the installation of their respective equipment.

3.3 CUTTING AND CORE DRILLING

- A. Perform all cutting and core drilling operations that are outlined in Part 1 of this SECTION. Throughout the performance of the cutting and coring work, ensure that the structural integrity of the walls, floors, overhead structure, and other structural components is maintained until permanent work is installed. Prior to any coring or cutting, verify all locations of same with the General Contractor. All cutting and coring is to be performed in accordance with approved Coordination Drawings.
- B. Cut all masonry and concrete with an approved diamond blade concrete saw in a neat straight direction, perpendicular to the plane of the wall or floor.
- C. Use a core drilling process which produces clean, sharp edges and the minimum hole size which will accommodate the size of pipe sleeve specified.
- D. Patch all holes up to the sizes indicated in this Section with material and methods as are specified in the Section of the Specifications for the finish trade involved. Holes which are improperly done due to poor materials or method, shall be patched to the satisfaction of the Architect by the finish trade and back-charged to this Subcontractor.

3.4 CLEANING AND PROTECTION

- A. Protect all materials and equipment during shipment and installation and properly handle and store at the job site so as to prevent damage. Assume full responsibility for protection of work until its completion and final acceptance.

- B. Keep the premises reasonable clean at all times and remove rubbish caused by the Fire Protection work as directed by the Architect.
- C. Upon completion of this work, clean all sprinklers, and equipment and replace damaged parts. Failure to fulfill this obligation will result in back-charges for correction of the defective work by others.

3.5 SLEEVES, INSERTS, AND ESCUTCHEONS

- A. All piping passing through slabs, floors, walls, and partitions shall be sleeved and all such sleeves shall be furnished and installed by the Fire Protection Subcontractor as detailed on the Drawings and herein specified. Fire Protection Contractor, shall do his core drilling as approved by the Architect and the cored opening shall have a sleeve caulked and leaded in place. Set sleeves in concrete floors and walls as soon as forms set and before concrete is poured.
- B. All pipes passing through floor, whether slab-on grade or above grade levels shall be sleeved with sleeve extending 1 inch above floor. This includes all piping in toilet room pipe space, stairwells, closets, and partitions. In mechanical penthouses, pipe sleeves shall extend 4 inches above floor.
- C. All sleeves shall be Schedule 40 galvanized steel pipe and shall be reamed. There shall be annular space between the sleeve and pipe per NFPA requirements. Sleeves on drywall, masonry, or concrete walls and partitions shall be flush with wall on both sides.
- D. The space between sleeve and pipe, in all cases, shall be filled with U.L./F.M. approved caulking compound. This includes pipes concealed in chases and/or partitions.
- E. Inserts, where required, shall be furnished and set by the Fire Protection Subcontractor and, where necessary, may be drilled or power driven and shall be sized such that the insert will not exceed a depth of penetration of 1 inch into concrete.
- F. Escutcheons: All exposed pipe, uncovered, passing through walls, or floors, or ceilings, shall be fitted with C.P. brass spun or split type escutcheons with approved clamping device for holding in position. Floor escutcheons shall be deep enough to fit over sleeves, fastened to pipe, and extend down to floor.

3.6 TESTING

- A. Flush the system and test all work in the presence of the Architect and/or Engineer and as required by NFPA and the Insurance Company. The flushing and testing procedures to be followed are specified herein. At the completion of the testing, submit fully executed copies of Contractor's Material and Test Certificate for both above ground and underground piping as contained in NFPA-13.
 - 1. Water Supply:
 - a. Flushing: Underground/exterior service entrance shall be flushed at a minimum velocity of 10 fps in accordance with NFPA Standards 13, 14, and 24. The Fire Protection sub-contractor shall coordinate with Division 33 and shall notify the Water and Fire Departments prior to testing of the entire exterior system.
 - 2. Sprinkler System:
 - a. Hydrostatic Testing: The interior system shall be hydrostatically tested at 200 psi for 2 hours in accordance with NFPA 13 paragraph 25.2.1.

- b. Operational Testing: Water flow switches and associated alarm systems shall be tested by water flow through the inspectors test assemblies in accordance with NFPA 13, 25.2.3.
 - c. Main Drain Test: A flow test shall be performed on the main drain valve and recorded on the Contractor's test certificate in conformance with NFPA 13, 25.2.3.4.
 - d. Backflow Preventor Flow Test: The double check valve assembly shall be flow tested in conformance with NFPA 13, 25.2.5. Provide piping and or valving arrangement to preform full flow testing of backflow device.
 - e. Underground Piping: Underground piping and fire sprinkler lead in connections to each building shall be hydrostatically tested, flushed and chlorinated in accordance with NFPA 24, the Local DPW, and any other pertinent laws or governing standards. Flushing, Testing and chlorination reports shall be given to the owner for review and included in the O&M Manuals for the fire protection systems.
3. Standpipe:
- a. Flushing: The fire department connection piping shall be flushed at a minimum velocity of 10 fps in conformance with NFPA 13, and NFPA 14.
 - b. Hydrostatic Testing: All piping shall be pressure tested at 200 psi for 2 hours in conformance with NFPA 14.
 - c. Flow Tests: The system shall be flow tested at the hydraulically most remote hose connection in conformance with NFPA 14.
 - d. Valve and Supervisory Switch Test: All valves and tamper switches will be tested by opening and closing valves in conformance with NFPA 14.

3.7 FIRESTOP SYSTEMS

- A. General: Install firestop systems at all new fire-rated construction where penetrated by the Work of this Section.
- B. Refer to Section 078400 - Firestopping, for all installation requirements for maintaining integrity of fire-rated construction at penetrations.

3.8 SEISMIC RESTRAINTS

- A. The independent engineer responsible for design of seismic restraints shall visit the project upon completion of the work to certify the installation is consistent with the approved shop drawings. The certification shall be submitted to the Architect and must precede the closing in of ceilings.

3.9 SYSTEM SHUTDOWNS

- A. Coordinate shutdowns of existing systems with the Owner and submit a written request at least ten working days in advance. Minimize system shut downs as much as possible. Submit a list of all affected areas, the proposed work to be performed, and the expected length of the shut-down including time for retesting.
- B. Provide temporary services to maintain active system during extended shut-downs as required for demolition and construction phasing.

END OF SECTION

SECTION 220000

PLUMBING
(Filed Sub-Bid Required)

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END OF INDEX

SECTION 220000

PLUMBING
(Filed Sub-Bid Required)

PART 1 - GENERAL

1.1 ~~FILING SUB-BIDS~~

- ~~A. Sub-bids for Work under this Section shall be for the complete Work required hereunder and shall be filed in a sealed envelope with the Awarding Authority before the time and date and at the location indicated in the Instructions to Bidders and at that time will be publicly opened and read aloud.~~
- ~~B. Procedure for filing Sub-Bids shall be as set forth in the Instructions to Bidders contained in this Project Manual and shall conform to all requirements of the Commonwealth of Massachusetts General Laws, Chapter 149, as amended to date.~~
- ~~C. Every Sub-Bid submitted for Work under this Section shall be on a form furnished by the Awarding Authority as required by Section 44G of Chapter 149, as amended, which form is required to be completely filled in. A sample bid form for Subcontractors is contained in this Project Manual and the bid form to be used in filing a Sub-Bid is available at the office of the Architect.~~
- ~~D. Every Sub-Bid filed with the Awarding Authority shall be accompanied by bid security in the form and amount stipulated in the Instructions to Bidders.~~
- ~~E. The Filed Sub-Bidder for the work of this SECTION 220000 shall list, in Paragraph E, of the FORM FOR SUB-BID, the name of each person, firm, or corporation, whom he proposes to use to perform the following classes of work or part thereof, at the bid price therefore:~~

~~CLASS OF WORK~~ _____ ~~PARAGRAPH NUMBERS~~

~~Insulation~~ _____ ~~2.5~~

1.2 GENERAL PROVISIONS

- ~~A. All the Contract Documents and General Provisions of the Contract including, but not limited to, General and Supplementary Conditions, and Division 1 Specification Sections apply to this Section.~~
- ~~B. The work of this Section provides and contains general information which is inherently made a part of each Section and applies to all work performed under this Contract.~~
- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.**

Time, Manner and Requirements for Submitting Sub-Bids:

- 1. Sub-bids for work under this Section shall be for the complete work and shall be filed electronically, as noted in "INSTRUCTIONS TO BIDDERS".**

The following should be included in the submission:

NAME OF SUB-BIDDER: (Insert name of sub-bidder)
MASS. STATE PROJECT: ((Insert project number from top of page))
SUB-BID FOR SECTION: 220000 – PLUMBING

- B. Sub Sub-Bid Requirements: Insulation, paragraph 2.5**
- C. Reference Drawings: The Work of this Filed Sub-Bid is shown on the following Contract Drawings:**

P-001	PLUMBING – LEGEND, NOTES, AND DETAILS
P-002	PLUMBING DETAILS
P-003	GAS RISER DIAGRAM
P-100	PLUMBING – UNDERGROUND PLAN
P-101	PLUMBING – FIRST FLOOR PLAN
P-102	PLUMBING – SECOND FLOOR PLAN
P-103	PLUMBING – THIRD FLOOR PLAN
P-104	PLUMBING – ROOF PLAN
VS-1	VIBRATION & SEISMIC DETAILS

1.3 DESCRIPTION OF WORK

- A. Provide all labor, materials, equipment, services and accessories necessary to furnish and install the work of this Section, complete and functional, as indicated in the Contract Documents and as specified herein.
- B. The work covered by this Section of the Specifications includes the furnishing of all labor and materials and in performing all operations in connection with the installation of the Plumbing Work.
- C. Without limiting the generality thereof, the work to be performed under this Section includes:
1. Domestic water service to 10 ft. outside building and/or as shown on the Drawings.
 2. Complete Sanitary, Waste & Vent System to 10 ft. outside building and/or as shown on the drawings.
 3. Storm drainage to 10 ft. outside foundation wall.
 4. Garage waste and vent system including precast concrete oil/gas separator structure and access manhole.
 5. Potable Cold, Hot, and Hot Water Re-circulation System.
 6. Non-Potable Cold Water System.
 7. Natural Gas System.
 8. Shop compressed Air System
 9. Furnish and install domestic water heater air intake and exhaust breeching.
 10. Furnish and install boiler air intake and exhaust breeching.
 11. Insulation.
 12. Potable Water Heating Equipment.
 13. Kitchen Gas Solenoid Valve
 14. Fixtures and Equipment
 15. Connection to Equipment Furnished by Others
 16. Flushing, Sterilization, and Tests
 17. Furnishing of Access Panels
 18. Drilling, Coring and Cutting & Patching of holes and openings where the largest dimension thereof does not exceed 12 inches for Plumbing Piping and Equipment.

19. Scaffolding, Rigging, and Staging required for all Plumbing Work. Comply with Division 1 requirements.
20. Provide Seismic Restraints for all Plumbing Systems conforming to the requirements of Section 230548 which Section is herein incorporated by reference. Seismic restraints are required on all new systems whether in new or existing building.
21. Preparation of Co-ordination Drawings.
22. Smoke and Firestopping Seals and sealing of all wall and floor penetrations as detailed on the drawings. Refer to Section 078410 which defines the firestopping materials and methods.
23. At Project close out the Plumbing Sub-Contractor shall provide the services of an outside firm who shall run an underground video camera, locating all drainage system lines including depth, preparing a video and identifying & correcting any problem areas. The Plumbing Sub-Contractor shall rod-out and power wash all underground drainage systems. Turn over 4 copies of the video and written report to the owner. Videos are required for the underground sanitary, garage waste, and special waste systems, main lines. Branches are not required.
- ~~24. It shall be the responsibility of this division 220000 to provide all personnel as required to fully coordinate with the commissioning agent. The hours of training and instruction outlined in this division 220000 and the Testing requirements shall be in addition to those tests and requirements outlined in section 018100 and required to fulfill section 018100 commissioning obligations. It shall be the responsibility of this division 220000 to provide all personnel, including third party commissioning agent, to commission the plumbing systems.~~
25. When open-flame or spark producing tools such as blower torches, welding equipment, and the like are required in the process of executing the work, the General Contractor shall be notified not less than twenty four hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant non-working fire watch, paying all fees, where work is being performed and until it is completed. Fee for fire watch shall be included in the bid.

1.4 RELATED WORK

A. The following Related Work will be performed under the designated Sections:

1. Domestic Water Service to 10 ft. outside – DIVISION 33 – UTILITIES
2. Cutting and Patching beyond 1.3C.18 above: SECTION 017329 - CUTTING AND PATCHING
3. Installation Of Roof Drains, Flashing for vents through roof: SECTION 076200 – SHEET METAL FLASHING AND TRIM
4. Electric Power Wiring: SECTION 260000 - ELECTRICAL
5. HVAC Equipment: SECTION 230000 - HVAC
6. Excavation and Backfill: DIVISION 31 - EARTHWORK
7. Sanitary Sewer and storm drains to 10 feet outside the foundation wall: DIVISION 33 - UTILITIES
8. Finish Painting: SECTION 099000 – PAINTING AND COATING
9. Installation of Access Panels: SECTION describing material in which panel is installed.
10. Toilet Room Accessories: SECTION 102800 - TOILET ACCESSORIES
11. Temporary Facilities: SECTION 015000 - TEMPORARY FACILITIES AND CONTROLS

1.5 CODES, ORDINANCES, AND PERMITS

- A. Perform all work in accordance with the requirements of the Town of Ashland Building Department, Massachusetts State Plumbing and Fuel Gas Codes, D.E.P., A.D.A., NFPA, The Architectural Barrier Code, and applicable State and Federal Laws. Give all requisite notices, file all requisite plans, and obtain all permits required to perform all Plumbing Work. Where the Contract Documents indicate more stringent requirements than the above Codes and Ordinances, the Contract Documents shall take precedence.
- B. Obtain all permits, inspections, and approvals, from the governing authorities and pay all fees and include cost in the bid, including approvals for the cross connection control device. Provide the Owner with the cross connection permit for the device in the Owner's name.
- C. Owner will pay all related Gas Utility Company back charges.

1.6 DISCREPANCIES IN DOCUMENTS

- A. Where Drawings or Specifications conflict or are unclear, advise Designer in writing before Award of Contract. Otherwise, Designer's interpretation of Contract Documents shall be final, and no additional compensation shall be permitted due to discrepancies or unclarities thus resolved.
- B. Where Drawings or Specifications do not coincide with manufacturers' recommendations, or with applicable codes and standards, alert Designer in writing before installation. Otherwise, make changes in installed work as Designer requires within Contract Price.
- C. If the required material, installation, or work can be interpreted differently from drawing to drawing, or between drawings and specs, this contractor shall provide that material, installation, or work which is of the higher standard.
- D. It is the intent of these contract documents to have the contractor provide systems and components that are fully complete and operational and fully suitable for the intended use. There may be situations in the documents where insufficient information exists to precisely describe a certain component or subsystem, or the routing of a component. In cases such as this, where the contractor has failed to notify the Designer of the situation in accordance with the paragraph above, the contractor shall provide the specific component or subsystem with all parts necessary for the intended use, fully complete and operational, and installed in workmanlike manner either concealed or exposed per the design intent.
- E. In cases covered by the paragraph above, where the contractor believes he needs engineering guidance, he shall submit a sketch identifying his proposed solution and the Designer shall review, note if necessary, and approve the sketch.

1.7 MODIFICATIONS IN LAYOUT

- A. HVAC, Plumbing, Fire Protection, and Electrical Drawings are diagrammatic. They indicate general arrangements of mechanical and electrical systems and other work. They do not show all offsets required for coordination nor do they show the exact routings and locations needed to coordinate with structure and other trades and to meet architectural requirements.
- B. In all spaces, prior to installation of visible material and equipment, including access panels, review Architectural Drawings for exact locations and where not definitely indicated, request information from Designer.

- C. Check Contract Drawings as well as Shop Drawings of all subcontractors to verify and coordinate spaces in which work of this Section will be installed.
- D. Maintain maximum headroom at all locations. All piping and associated components to be as tight to underside of structure as possible.
- E. Make reasonable modifications in layout and components needed to prevent conflict with work of other trades and to coordinate according to Paragraphs A, B, C, D above. Systems shall be run in a rectilinear fashion.
- F. Where conflicts or potential conflicts exist and engineering guidance is desired, submit sketch of proposed resolution to Designer for review and approval.

1.8 SHOP DRAWING AND MATERIAL SCHEDULES

- A. Refer to SECTION 013300 – SUBMITTAL PROCEDURES for submittal of Shop Drawings. If apparatus or materials are substituted for those specified, and such substitution necessitates changes in or additional connections, piping, supports or construction, same shall be provided as the responsibility, and at the expense, of the Plumbing Subcontractor.
- B. Fabrication of any material or performing of any work prior to the final approval of the Submittals will be entirely at the risk of the Subcontractor. The Subcontractor is responsible for furnishing and installing materials called for in the Contract Documents, even though these materials may have been omitted from approved Submittals.
- C. Submit Shop Drawings for the following materials and equipment.
 - 1. Valves, Piping, couplings and Fittings
 - 2. Fixtures, Drains and Equipment including Supports
 - 3. Backflow Preventers
 - 4. Access Panels and Covers
 - 5. Insulation
 - 6. Drains, and Hydro Mechanical Specialties
 - 7. Hose Bibs, Wall Hydrants
 - 8. Hangers, Anchors, Guides, and Supports including Seismic Restraints
 - 9. Cleanouts
 - 10. Piping Identification System
 - 11. Water Heating Equipment
 - 12. Air Compressors
 - 13. Water heater and boiler air intake and exhaust breeching including coordinated working drawings of installation.
 - 14. Precast concrete oil/gas separator and access manhole

1.9 COORDINATION DRAWINGS

- A. Before materials are purchased or Work is begun, prepare and submit to the Architect, Coordination Drawings showing the size and location of all equipment and piping lines relevant to the complete system. Ensure that these Drawings are compatible and correctly annotated and cross-referenced at their interfaces (match lines).
- B. Coordination Drawings are for the Contractor's and the Architect's use during Construction and shall not be construed as replacing any Shop or Record Drawings required elsewhere in these Contract Documents.

- C. Detailed procedures for Coordination Drawings are contained in DIVISION 01 - GENERAL REQUIREMENTS of these Contract Documents.

1.10 RECORD DRAWINGS

- A. General: Refer to DIVISION 01 - GENERAL REQUIREMENTS for general requirements for maintaining as-built drawings and submitting final reproducible record documents.
- B. The General Contractor will provide two sets of Drawings to the Plumbing Subcontractor, one set of which shall be maintained at the site and which shall, at all times, be accurate, clear, and complete, showing the actual locations of all equipment and piping as it is being installed. The Record Drawings shall be available to the Architect/Engineer's field representative at all times.
- C. Provide electronic AutoCAD drawings to indicate revisions to piping size and location both exterior and interior; including locations of valves and other equipment requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; concealed equipment, dimensioned to column line; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located.
- D. Include in the Record Drawings any addenda, sketches, and supplementary Drawings issued during the course of construction.
- E. Non-availability of Record Drawings or inaccuracies therein will postpone the final inspection until they are available.
- F. All valves shown on these Drawings shall be numbered with numbers corresponding to those on the valve charts.
- G. All costs related to the foregoing requirements shall be paid by the Plumbing Subcontractor.

1.11 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

- A. Provide operating instructions to the Owner's designated representative with respect to operation functions and maintenance procedures for all equipment and systems installed. At the completion of the project, turn over to the Architect four (4) complete manuals, in three-ring, loose-leaf binders, containing the following:
 - 1. Complete Shop Drawings of all equipment.
 - 2. Operation description for all systems.
 - 3. Names, addresses, and telephone numbers of all suppliers of the system.
 - 4. Preventative maintenance instructions for all systems.
 - 5. Spare parts lists of all system components.
 - 6. Four copies of video of below slab piping.
 - 7. Valve tag chart.
- B. Provide DVD recording of operation and maintenance training sessions and include as part of O & M Manual submittal. Training session video recording and DVDs shall be performed by a professional videographer. Provide indexed table of contents for DVD recording.

1.12 GUARANTEE

- A. Refer to Division 1 of the Contract. Guarantee all work under this Section free from defects in workmanship and materials for a period of one (1) year from the date of final acceptance of the building, as set forth in the Contract. Replace any such defective work developing during this period, unless such defects are clearly the result of bad usage of equipment by others. Where such defective work results in damage to work of other Sections of the Specifications, restore such work to its original condition by mechanics skilled in the affected trade.

1.13 DRAWINGS

- A. All work shown on the Drawings is intended to be approximately correct to scale, but shall be taken in a sense as diagrammatic. Sizes of pipes and general method of running them are shown, but it is not intended to show every offset and fitting. To carry out the true intent and purpose of the plans, furnish all necessary parts to make complete working systems ready for use. The Plumbing Drawings are intended to show the main stacks and risers and may or may not necessarily show all runout piping particularly in lavatories and gang toilet areas. Contractor shall include all runout piping to all referenced scheduled fixtures and equipment appearing on the Plumbing Drawings.
- B. All floor drains installed on this project, including all kitchen floor drains and trough drains, shall be equipped with trap primers. The trap primer and piping is not shown on the drawings and shall be located in the field by the Contractor as dictated by field piping conditions.
- C. The Plumbing Drawings and Specifications are intended to supplement each other so that any details shown on the Drawings and not mentioned in the Specifications, or vice-versa, shall be executed the same as if mentioned in the Specifications and shown on the Drawings.
- D. Refer to the Architectural, Structural, and other Mechanical and Electrical Drawings, which indicate the construction in which this Work shall be installed. Locations shown on the plans shall be checked against the general and detailed Drawings of the construction proper. All measurements shall be taken at the Building.

1.14 VALVE TAGS, NAMEPLATES, AND CHARTS

- A. All valves on pipes of every description shall have neat circular brass valve tags at least 1-1/2 in. in diameter attached with brass hook to each valve stem. Stamp on these valve tags, in letters as large as practical, the number of the valve and the service, such as "H.W., C.W., GAS", for hot water, cold water, and gas respectively. The numbers for each service shall be consecutive. Where valves are located above ACT ceilings, furnish and install valve finder ceiling tack, tack shall be minimum 7/8 in. diameter with 1/2 in. steel point, color as determined by Owner.
- B. All valves on tanks and pumps shall be numbered by 3 in. red metal discs with white numbers 2 in. high, secured to stem of valves by means of small solid link brass chain, to correspond to numbers indicated for valves on the Record Drawings and on two (2) printed detailed lists. These printed lists shall state the numbers and locations of each valve and the fixture or group of fixtures which it controls, and other necessary information such as requiring the opening or closing of another valve or valves when any one valve is to be opened and closed, and shall be prepared in form to meet approval of the Architect, and shall be framed under glass.
- C. Nameplates, catalog numbers, and rating identifications shall be securely attached to Electrical and Mechanical equipment with screws or rivets. Adhesives or cements will not be permitted.

1.15 PIPE MARKER IDENTIFICATION SYSTEM

- A. Mark all piping installed under this Section and at all Access Panels with a marking system in basic colors conforming to those specified in ANSI/ASME A-13.1. Markings shall indicate pipe content and direction of flow. Markers shall be applied at all valves and tee joints, and on straight runs of pipe at every 20 ft.-0 in. on center.
- B. Markers shall be vinyl snap-around pipe type system. Adhesive markings are not acceptable.
- C. Clearly mark potable and non-potable water system with 4 inch wide colored bands, with arrow for direction of flow, every twenty-five (25) feet on center on all piping installed whether it is concealed or exposed and also on both sides of floor and/or wall penetrations. Mark potable water green and non-potable yellow. Within 6 in. of each band identify with letter "Potable C.W.", Non-Potable H.W." Color of letter shall match banding.

1.16 SANITARY, WASTE, VENT, KITCHEN GREASE WASTE AND VENT, GARAGE WASTE AND VENT, AND STORM SYSTEMS

- A. Furnish and install complete Sanitary, Waste, Vent, Kitchen Garage Waste and Vent, and Storm Drainage Systems (all hereinafter called Drainage Systems) to convey wastes from all Soil and Waste Stacks, Fixtures, Equipment, Kitchen Fixtures, and Roof Drains as indicated and/or described in these Plans and Specifications. Urinal waste shall be 2 in. cast iron or sizes indicated on the drawings. Waste piping smaller than 3 in. shall not be used underground. The use of double "Y's" in the horizontal shall not be permitted. All piping shall be installed straight and true and located concealed within building construction.
- B. All horizontal Drainage Systems Piping within the building, 3 in. and smaller, shall be pitched at least 1/4 in. per ft. in the direction of flow. Drainage Piping 4 in. and larger shall be pitched at least 1/8 in. per ft. Make changes in direction of drainage lines with 45 wyes, long turn wyes, or sweep bends.
- C. Furnish and install all cleanouts indicated on the Drawings and/or where required in Drainage Pipes regardless of size so that the distance between cleanouts does not exceed 45 ft. o.c. Cleanouts shall be installed at the base of all risers and at each change of direction.
- D. Refer to drawings for termination points, which generally are connection to existing piping or to 10 feet outside the building.
- E. The Garage Drainage System shall be a complete separate system piped from the interceptor through the roof without interconnection to any other building Drainage System including sanitary waste and vent.

1.17 DOMESTIC WATER SYSTEMS (POTABLE & NON-POTABLE)

- A. Furnish, install, sterilize, and test in accordance with the documents and the Plumbing Code, complete potable and non-potable Domestic Cold, Hot, and Hot Water Recirculating Systems including all piping, valves, low point drains, shock absorbers, hangers, insulation, backflow preventers and water heating equipment. Clearly mark the systems as provided above. This work shall start as indicated on the Drawings.
- B. In general, piping shall pitch upward in the direction of flow with each branch and riser separately valved and with 1/2 in. hose end drain on the outlet side of the valve and at all low points in the system. Install shutoff valves for each battery of fixtures and other valves as necessary to isolate any part of each system.

- C. Install shock absorbers on hot and cold water piping to each fixture. Provide shock absorbers at all quick closing valves and as shown on the Drawings and/or specified.
- D. Install a 1/2 inch hose bibb in each toilet room provided with a floor drain. The hose bibb shall be installed under a lavatory.
- E. Install a 1/2 inch hose bibb in each mechanical room.
- F. Furnish and install a ball valve, balancing valve and check valve at each hot water recirculation line before it connects to another hot water recirculation line.

1.18 COMPRESSED AIR SYSTEM

- A. Furnish and install a complete compressed air system as shown on the drawings and herein specified including all valves, piping, fittings, outlets and any incidentals to make a complete and operable system.
- B. This work includes furnishing and installing the shop air compressor as herein specified, provision of air outlets as detailed on drawings.
- C. Piping shall be run straight and true and shall be rigidly supported from the building construction. All turns and offsets shall be made with fittings as specified elsewhere. Bending of pipe shall not be permitted in this installation.

1.19 EMERGENCY TEMPERED WATER SUPPLY

- A. Furnish, Install, Sterilize and Test utilizing the same materials, methods, etc. as specified above in 1.167. A tempered water supply to service all emergency showers and eye wash units. This piping shall be hung and insulated the same as above. Piping shall start at the tempering valve.

1.20 FUEL GAS SYSTEM

- A. Furnish and install a complete Natural Gas Supply System including pipe, fittings, valves, connections to all gas fired equipment requiring gas, and all accessories and incidentals as indicated or specified. Installation shall be made in accordance with the State Gas Code requirements. Piping shall be installed with an 8 in. long sediment leg at the base of all risers. All changes in direction shall be made with plugged tees for cleaning piping out.
- B. All horizontal Gas Piping shall be pitched not less than 1/4 in. in 15 ft. to prevent traps. Pitch piping to risers. Install an 8 in. long sediment leg at the base of all risers. All changes in direction shall be made with plugged tees for cleaning piping out. All horizontal branch outlet pipes shall be taken from the top or side of horizontal mains and not from the bottom. Install shutoff valves for each battery of equipment and other valves as necessary to isolate any part of each system.
- C. Where interior gas vented appliances are provided provide a battery powered, plug-in type, carbon monoxide detector adjacent to the appliance.
- D. Arrange with the Local Gas Company for the installation of the gas meters, services, and gas pressure regulators. Refer to DIVISION 01 - GENERAL REQUIREMENTS for information regarding Utility Company Charges.
- E. Provide seismic restraints for all gas piping per requirements of the Mass. Building Code. Refer also to Section 230548 and VS-1.

- F. Plumbing Sub-Contractor shall furnish and install all gas vents for all knockdown regulators whether furnished by this Section, HVAC, or any other Section.

1.21 EQUIPMENT FURNISHED BY OTHERS

- A. Miscellaneous items, including but not necessarily limited to the following, shall be furnished and set by others as specified in other SECTIONS of the Documents.
 - 1. Refrigerators
 - 2. Dishwashers
 - 3. Kitchen Equipment
- B. Verify the extent of the connection requirements from the General, Architectural, and Mechanical Plans and Specifications.
- C. The Plumbing Subcontractor shall be responsible in making final connections to all equipment furnished by others, to ascertain complete cross-connection prevention compliance, and to furnish and install vacuum breaker and backflow preventers which may be required to be Code compliant and are not so furnished with the equipment.

1.22 PAINTING

- A. All interior exposed piping is to be painted and all painting, except as noted, will be done by the Painting Subcontractor. All uncovered piping and hangers shall be thoroughly cleaned of rust, oil, and other containments by the Plumbing Subcontractor and left ready to receive primer coat.
- B. Painting for pipe markings shall be done under this Section.
- C. Painting of exterior gas piping at gas meter, on roof, and at rooftop equipment, shall be done under this Section.

1.23 HOISTING EQUIPMENT AND MACHINERY

- A. Unless otherwise specified, all hoisting and rigging equipment and machinery required for the proper and expeditious prosecution and progress of the Work of this Section shall be furnished, installed, operated and maintained in safe condition by each sub-contractor, as specified under Section 015000, TEMPORARY FACILITIES AND CONTROLS.

1.24 STAGING AND SCAFFOLDING

- A. Unless otherwise specified, each sub-contractor shall provide all lifts and man-lifts, and furnish, erect and maintain in safe condition, all staging and scaffolding as specified under Section 015000 Temporary Facilities and Controls, as needed for proper execution of the work of this Section. Staging and scaffolding shall be of adequate design, erected and removed by experienced stage builders having all accident prevention devices required by Federal, state and local laws.

1.25 COMMISSIONING

- A. Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 018100 – General Commissioning Requirements.

- B. Complete installation and startup checks and functional tests according to Section 018100 – General Commissioning Requirements and manufacturers written instructions.
- C. Operational Test: After plumbing systems have been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the startup procedure.
- D. Verify that equipment is installed and commissioned as per requirements of Section 018100 and manufacturers written instructions/requirements.

1.26 BREAKDOWN

- A. Submit a breakdown of the contract price to aid the Architect in determining the value of the work installed as the job progresses.
- B. No requisition will be approved until the breakdown is delivered to the Architect.

1.27 VISIT TO SITE

- A. Prior to submitting a Bid, visit the site of work and become familiar with existing conditions. Any assumptions made are at this Subcontractor's expense.

1.28 ENERGY REBATE PROGRAM

- A. This project has been designed to incorporate equipment approved for energy rebate such as domestic water heaters. Provide actual equipment purchase price to owner to assist filling out forms for utility company rebates.

1.29 TRADE RESPONSIBILITY FOR INTERCONNECTIONS MATRIX

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Boiler and Domestic Water Heater Exhaust Breeching	22 00 00	22 00 00	N/A	N/A	N/A	
Kitchen Emergency Gas Valve	22 00 00	22 00 00	26 00 00	26 00 00	26 00 00	

Notes:

- 1. Division 26 00 00 Contractor shall provide all line-voltage power wiring required for meters; Division 23 00 00 (ATC) Contractor shall provide all low-voltage power wiring required for meters.

1.30 COMMISSIONING

A. GENERAL PROVISIONS

- 1. **Commissioning Agent will be hired by the Plumbing Subcontractor for Commissioning services outlined herein. Plumbing Subcontractor responsible for items to be commissioned shall cooperate and coordinate with the Commissioning Agent and provide necessary information as outlined herein.**

2. All of the Contract Documents, including Drawings, Invitation for Bids and Division 1 - General Requirements, apply to the Work of this Section.
3. Carefully examine all of the Contract Documents for requirements which affect the Work of this Section. The exact scope of Work of this Section cannot be determined without a thorough review of all specification Sections and other Contract Documents.
4. Commissioned systems shall be documented and functional performance tests verified with facility staff participating with on-the-job training, when available, during the functional performance testing.
5. Reference shall be made to the following sections:
 - a. Section 017700: Contract Closeout
 - b. Section 230548: Vibration Control and Seismic Restraint

B. SYSTEMS TO BE COMMISSIONED

1. Domestic Water Heater and appurtenances
2. Plumbing Fixtures

C. COMMISSIONING TEAM

1. The Commissioning Team shall consist of representatives from the following parties involved in the design and construction of this facility:
 - a. Facility Manager/Owner Representative
 - b. Commissioning Firm
 - c. Design Team Representative
 - d. Plumbing Subcontractor Representatives

D. COMMISSIONING DOCUMENTATION

1. Commissioning Documentation shall include the following:
 - a. Commissioning meeting minutes shall be by the Commissioning Agent for documenting regularly scheduled meeting discussions, responsibilities and action agenda due dates.
 - b. Pending issues log for documenting issues identified and/or commissioning activities that are deferred and/or seasonal functional performance tests.
 - c. Maintain current shop drawing log for documenting equipment submittals to be commissioned and associated O&M requirements.
 - d. Utilize static and operational performance test sheets for documentation of system(s) to be commissioned.
 - e. Corrective action log for documenting performance test deficiencies found during the performance testing. Each corrective action shall require a re-test of that deficiency to demonstrate compliance.
 - f. Equipment & System Training Log for documenting Contractor required training of Owner personnel.

E. COMMISSIONING GOALS

1. The goals of the commissioning process are as follows:
 - a. Certification that all noted systems meet the requirements set forth in the design documents for all systems and equipment noted.
 - b. To provide a comprehensive, Commissioning Plan

- c. Provide a Commissioning Plan which defines the trade contractors' responsibilities as part of the commissioning process.
- d. Demonstration of performance of systems commissioned.
- e. Successful project closeout and warranty transition.

F. SCHEDULING OF ACCEPTANCE TESTING WORK

- 1. Static Review: Check procedures shall be conducted immediately after notification that the work of various systems and equipment is installed and the installing contractor has confirmed compliance with the contract documents.
- 2. Operational Performance Testing procedures shall be conducted immediately after notification that the work of the various systems and equipment is operational and that the installing contractor has completed his own tests to confirm compliance with the contract documents.

G. DOCUMENTATION

- 1. Prior to the conducting of static and operational testing procedures, the Commissioning Agent shall obtain the following:
 - a. Project Plans and Specifications including revisions made by addenda, approved alternates, Requests for Information (RFI) and change orders.
 - b. Approved submittals.

H. CONTRACTOR RESPONSIBILITIES

- 1. Mechanical Contractor
 - a. The contractor shall be present as requested by the Commissioning Agent during the acceptance testing procedures of their respective systems and equipment.
 - b. The air and water balancing contractor shall provide all labor and equipment to test HVAC systems as requested by the Commissioning Agent.
 - c. The ATC contractor shall provide all labor and equipment to perform tests and verification procedures i.e.; overriding various control inputs or outputs, manipulating schedules, etc. as required by the Commissioning Agent.
- 2. General Contractor
 - a. The General Contractor shall verify completeness of the building envelope, which may effect proper operation and control of HVAC equipment and systems.
- 3. Owner
 - a. The Owner shall assign maintenance personnel to participate in the commissioning process. The purpose shall be to become familiar with all tested systems as well as instruction on operation and maintenance.
 - b. The Owner shall advise the Automatic Temperature Control Contractor and Commissioning Agent regarding building occupancy, usage, and time schedules.

I. FINAL ACCEPTANCE

1. When all noted systems are found to be operating satisfactorily in accordance with the plans and specifications, then the final commissioning report documenting satisfactory performance shall be prepared and submitted for review and approval.
2. After approval a copy of the commissioning plan and test results shall be included with each copy of the Operations and Maintenance Manuals.

J. ACCEPTANCE PROCEDURES

1. The agent-provided static and operational checklists shall be used to document the results of the testing process.
2. The performance testing process shall be accomplished for all equipment, subsystems, etc. listed in the approved commissioning plan. Complete a checklist for each piece of equipment and/or system noted to ensure documentation specific to each is complete.
3. At the end of the process, every system and all equipment, shall have been proven operational under all normal operational modes, including part and full load, and under abnormal or emergency conditions.

K. VERIFICATION AND DOCUMENTATION

1. As each individual check or test is accomplished, the Commissioning Agent shall observe the physical responses of the system and compare them to the specified requirements to verify the test results.
2. The Commissioning Agent shall record the results of each individual check or test on pre-approved test and report form from the commissioning plan.
3. If any check or test cannot be accomplished due to building structure or other building system deficiencies these deficiencies shall be resolved and corrected by the appropriate parties before completion of the commissioning process.
4. Every check or test for which acceptable performance was not achieved shall be repeated after the necessary corrective measures have been completed. This re-testing process shall be repeated until acceptable performance is achieved.

L. CORRECTIVE MEASURES

1. If acceptable performance cannot be achieved, then the design professional representative and the plumbing subcontractor shall be notified.
2. If inadequate performance is due to equipment deficiencies, then the appropriate contractor shall work with the equipment manufacturer to resolve the problem.
3. If the inadequate performance is due to design deficiencies, then the design professional shall issue appropriate directions to implement the necessary corrective measures.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All materials and equipment furnished under this SECTION shall be new, unused, first quality of a manufacturer of established reputation. Each valve, fitting, section of pipe, and piece of equipment supplied to project shall have cast or indelibly stamped thereon the manufacturer's name, pressure rating where applicable, type, and any other specific information provided by manufacturer. Materials shall conform to Massachusetts Code as a minimum requirement and shall appear on the Massachusetts Approved Plumbing Products list.

2.2 PIPE AND FITTINGS

- A. Pipe and fittings shall conform to the latest A.S.A., A.S.T.M., C.A., and F.S. standards.
- B. All piping installed under this SECTION shall be in accordance with the following:

<u>Service</u>	<u>Material</u>
Underground Domestic Water Service	Type 'K' Copper
Underground Drainage and Vent piping	Service weight cast iron soil pipe-coated bearing collective trademark of the Cast Iron Soil Pipe Institute (CISPI)
Above ground Drainage and Vent, piping 2 in. and larger	No Hub cast iron soil pipe and fittings bearing collective trademark of the CISPI
Above ground drainage, and Vent piping 2 in. and smaller	Type 'L' hard tempered copper tubing
Trap primer piping from Primer to floor drain	Type 'K' soft rolled copper tubing with Swaged ends
Domestic water piping above ground (potable & non-potable) and Pump Force Main Piping	Type 'L' hard tempered copper tubing
Indirect waste piping	Type 'L' hard tempered copper tubing coated with two (2) coats of white epoxy paint
Compress Air Piping & Gas piping above ground	ASTM A-53 Schedule 40 black steel pipe
Gas piping below ground	ASTM A-53 Schedule 40 black steel pipe with fusion bonded epoxy coating Scotchkote 6233 or equal.

- C. Fittings for underground Drainage Piping shall be service weight bell and spigot pattern C.I. soil pipe fittings. Above ground shall be no hub C.I. soil pipe fittings, Massachusetts Standard.
- D. Fittings for sweat drainage piping and force main piping shall be cast bronze or wrought copper of recessed drainage pattern.
- E. Fittings for Type 'L' hard tempered copper tubing for potable and non-potable water piping 2-1/2 inch in size and smaller shall be copper press fittings.

1. Acceptable Manufacturers:

- a. Viega North America,
- b. Ridge Tool Co.
- c. Victaulic

- d. Or equal
 - 2. Material:
 - a. ASTM B88 and ANSI/ASME B16.22. O-rings for copper press fittings shall be EPDM.
 - 3. Installation of copper press fittings and installation are to be made in strict accordance with the manufacturers installation instructions. All tubing is to be reamed prior to the installation of the fitting. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool approved by the manufacturer.
- F. Grooved joint piping systems for domestic water piping 3-inch and larger shall be installed in accordance with the manufacturer's guidelines and recommendations. All grooved couplings, fittings, valves, and specialties shall be the products of a single domestic manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be supplied by the manufacturer. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing. A factory trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Factory trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.
- G. Fittings for compressed air piping shall be threaded malleable iron air pattern fittings for screwed pipe.
- H. Fittings for gas piping 2-inch and smaller shall be threaded malleable iron gas pattern fittings for screwed pipe. All gas piping 2 ½ inch in size and larger shall be welded and shall utilize butt welded steel pipe fittings.
- 2.3 JOINTS
- A. Joints for underground cast iron bell and spigot soil pipe shall be made up with resilient gaskets. Above ground shall be made up of heavy duty – 4 band stainless steel clamps, and gaskets. Couplings shall be in compliance with CISPI 310 and shall bear the mark of NSF International. Couplings shall be Husky “SD 4000”, Clamp - All HI-TORQ 125, Mission “HW”, or equal.
- B. Copper water tubing and fittings shall be assembled with press or grooved fittings depending on pipe size.
- C. Copper waste and vent tubing and force main tubing with sweat fittings shall be assembled with lead free solder, Silverbrite, Oatey, Harris, or equal, and a non-corrosive flux recommended by the manufacturer.
- D. Joints between copper waste/vent tubing and cast iron shall be made with cast iron threaded fittings and copper thread by sweat fittings.
- E. Joints between copper tubing and ductile iron water pipe or at flanged joints to tanks shall be made with a combination iron and brass flange with composition gasket and iron bolts.
- F. Joints at water heaters or other tanks having threaded connections shall be made up with dielectric unions.

- G. Joints between floor or wall flanges and fixtures shall be made with one-piece special molded neoprene gaskets which shall be furnished by the fixture manufacturer.
- H. Threaded pipe joints including plastics shall be made up with teflon tape.
- I. Joints on screwed gas piping shall be made up with thread compound on male threads only. Welded joints shall be made up by certified welders. All joints on piping 2-1/2 in. and larger shall be welded.

2.4 VALVES

- A. Furnish and install valves where indicated on the Drawings or where specified and located so that they may be operated, repaired, or replaced with a minimum effort and repacked under pressure.
- B. The following list of valves is intended only as a guide for type and quality. Valves shall be as manufactured by Apollo, Milwaukee, Nibco, Elkhart, Watts or approved equal.

Shutoff valves	Apollo #94VLF-A lead-free ball valves
Balancing valves	ThermOmegaTech Circuit Solver CS, self-acting thermostatic recirculation balance valve.
Gate valves 4 in. and larger	Jenkins 651-A
Stop and waste valves 1 in. and smaller	Apollo #95LF-203 through #95LF-205, lead-free
Check valves	Walworth #406 SJ
Gas service stops, 2 in. and smaller	Apollo #70-102-07 through #70-108-07 with tee handle
Gas service stops, 2-1/2 in. and larger	Rockwell #143 lubricated plug valve
Drain valves	Apollo #77WLF-HC ball valve with cap and chain 1/2 in. x 3/4 in. hose end
Compressed air line Shutoff valves	Apollo #70-100 Series-threaded ends
Compressed air outlet valves	Apollo #70-100 Series with automatic drain
Backwater Valve (Drainage Systems)	Zurn #Z1095. At below grade installations provide with extension to grade Zurn model Z1095-FC, height as required.

2.5 INSULATION

- A. Insulation for all water piping and all horizontal roof leaders whether concealed or exposed shall be 1 in. thick, heavy density, preformed snap-on insulation equal to Johns Manville Micro-Lok HP, 850 degrees snap-on system. Insulation for cold water piping shall have a factory applied vapor barrier with ends and butts sealed with overlapping 4 in. sealing strips.
- B. Valves, fittings, and the underside of roof drain bodies shall be insulated with pre-formed fiberglass fitting insulation cut from dense fiberglass blanket and covered with pre-molded P.V.C. fitting covers. P.V.C. covers shall overlap the adjoining insulation and shall be secured with pressure sensitive vinyl tape over a vapor barrier adhesive seal at the joints. (Note: Staples or tacks are not permitted on covers).
- C. All insulation shall have self-sealing type, all service jacket (ASJ-SSL) factory applied. At all exposed piping, cover jacket with continuous P.V.C. jacket.
- D. Sealers, solvents, tapes, and adhesives, and mastics used in conjunction with the installation of insulation under this Section shall possess the maximum possible fire safe qualities available and shall be NFPA approved.
- E. Covering shall be applied over clean and dry surfaces. No covering shall be applied until after the approval of all pressure and leakage tests.
- F. Insulation shall be as manufactured by Johns Manville, Inc., Owens-Corning Fiberglass Corporation SSL II-ASJ, or Knauf Insulation 1000. Insulation shall be applied by skilled insulation mechanics in a first class manner.
- G. Emergency Generator Exhaust System shall be insulated with three (3) layers of 2 in. thick calcium silicate block (6 in. total) wired in place and covered with ½ in. thick finishing cement troweled smooth and covered with an 8 oz. Canvas jacket.

2.6 TRAPS

- A. Furnish and install traps with cleanouts on all fixtures and equipment requiring connection to the sanitary system of the same size and material as the pipe on which they occur. Traps installed on threaded pipe shall be recessed drainage pattern.

2.7 DRAIN VALVES

- A. It shall be possible to drain the water from all sections of the Potable and Non-Potable Hot and Cold Water Piping. Furnish and install 1/2 in. x 3/4 in. hose end ball valves with cap and chain. (see 2.4 for model no.)

2.8 SHOCK ABSORBERS

- A. Furnish and install, where shown on Drawings and where required to prevent water hammer, Zurn Manufacturing Company model 1250-XL lead free shock absorbers, or equal, as manufactured by J.R. Smith Manufacturing Company, Watts Manufacturing Company, or equal.
- B. Installation of absorbers shall be as per manufacturer's recommendations.

2.9 PIPING ACCESSORIES

- A. Pressure and Temperature Relief Valves shall be A.S.M.E. rated temperature relief 210 deg. F. double BTU rated, self-closing, as manufactured by Watts Regulator Company or equal by Wilkins, McDonnell and Miller, or equal.
- B. Vacuum reliefs shall be lead free Watts Regulator Company #LFN36 or equal by Wilkins or Lawler.
- C. Temperature gauges shall be 4-1/2 in. diameter dial thermometers, any angle, and range of 30 degrees F. to 240 degrees F. as manufactured by Weiss Instruments, U.S. Gauge, Terrice or equal.
- D. Potable and non-potable Water system pressure gauges shall be 4-1/2 in. diameter with a range of 0 to 160 psi as manufactured by Weiss Instruments, U.S. Gauge, Terrice or equal.
- E. Natural gas system pressure gauges shall be 4 inch diameter with a range of 0 to 30 inches of water as manufactured by Weiss Instruments, U.S. Gauge, Terrice or equal.
- F. Furnish and install where piping crosses building expansion joints on the domestic water piping and gas piping, expansion joints and anchors sized for 1-1/2 in. expansion per one hundred feet. Expansion joints shall be Metraflex "Metraloop", or manufactured by Flexonic Company or Hyspan, or equal. Piping shall be anchored and guided to force the expansion in the proper direction. Domestic water expansion joints shall be NSF approved. Gas expansion joints shall be AGA approved.
- G. Furnish and install where indicated on Drawings, Watts Regulator Company lead free pressure reducing valve and strainer combination size as indicated on the Drawing or equal, as manufactured by Donnelly Products Company or McDonnell and Miller.
- H. Trap primer connections are required on all floor drains to maintain trap seal. The requirement for trap primer connections shall include all floor drains in the kitchen including trough drains furnished by others. Trap primers shall be Precision Plumbing Products, Inc., Model PRO1-500 flow activated prime-pro trap-primer valve or shall, where appropriate, be Zurn, Watts, Smith or equal in-line connections installed on flush valve supply. Electronic trap primer shall be Precision Plumbing Products, Inc. Model MPB-500 mini-prime electronic trap-primer manifold, 120 volt, single phase. Furnish distribution units as required.
- I. At overflow storm drain leader termination points furnish and install vandal proof type 304 stainless steel downspout cover, Zurn model ZS-199-DC-VP, or as manufactured by JR Smith, Watts, or equal. All fasteners shall be stainless steel.

2.10 HYDRANTS AND HOSE BIBB

- A. Wall hydrants shall be Zurn Series Z-1310-PB Ecolotrol cast brass 3/4 in. non-freeze wall hydrant with integral backflow preventer, 3/4 in. hose connections, polished nickel bronze face, loose key handle, brass wall sleeve, and fitted with brass locknut.
- B. Hose bibb shall be T & S Brass or equal model #B-720 modified, chrome plated, 3/4 in. hose end, integral stop, vacuum breaker, modified with lock shield and loose tee handle.
- C. Hydrants shall be manufactured by Zurn, J.R. Smith, Watts, or equal. Hose bibbs shall be manufactured by T&S Brass, Speakman, Chicago, or equal.

2.11 CLEANOUTS

- A. Cleanout plugs on the Sanitary System shall be of heavy cast brass of the screwed type. Plugs shall be full size up to and including 4 inch.
- B. For piping running under floor slab, cleanouts shall be brought up to just under the floor slab level. Furnish and install access cover for all floor-type cleanouts, Zurn ZN-1400 Series with scoriated nickel bronze or by Watts, J.R. Smith, or equal. In the garage area and at exterior locations use Zurn model #Z-1474 cleanout housing set over brass cleanout plug.

2.12 ACCESS DOORS

- A. Furnish Access Doors for access to all concealed control valves, cleanouts, valves, expansion joints, and to all other concealed parts of the Plumbing System that require accessibility for the proper operation and maintenance of the system. These doors shall be installed under the appropriate SECTION of the Specifications as determined by the surface upon which the panels are mounted.
- B. All Access Doors shall be located in a workmanlike manner in closets, storage rooms, and/or other non-public areas, positioned so that the valve or part can be easily reached, and the size shall be sufficient for this purpose (minimum size 12 in. x 16 in.). Furnish Access Doors for each pipe space to permit thorough inspection of same. When access doors are required in corridors, lobbies, or other habitable areas, they shall be located as directed by the Architect.
- C. Refer to Section 083100 - Access Doors and Frames, for all product requirements for furnishing access panels.
- D. Coordinate locations and schedule with the work of trades involved with construction in which access panels will be installed.
- E. Access Door Shop Drawings shall be submitted to the Architect for approval.
- F. All access panels shall be keyed alike. Coordinate keying with other trades.

2.13 SUPPLEMENTARY STEEL, CHANNEL, AND SUPPORTS

- A. Furnish and install all supplementary steel, channels, and supports required for the proper installation, mounting, and support of all equipment.
- B. Supplementary Steel and Channels shall be firmly connected to building construction in a manner approved by the Architect.
- C. The type and size of the Supporting Channels and Supplementary Steel shall be determined by the Plumbing Subcontractor and shall be sufficient strength and size to allow only a minimum deflection in conformance with the manufacturer's requirements for loading.
- D. All Supplementary Steel and Channel shall be installed in a neat and workmanlike manner parallel to the walls, floor, and ceiling construction. All turns shall be made with 90 deg. fittings, as necessary to suit the construction and installation conditions.

2.14 HANGERS, ANCHORS, GUIDES, AND PIERS

- A. All piping shall be supported from the Building Structure by means of approved hangers and supports. Piping shall be supported to maintain required grading and pitching of lines, to prevent vibration, and to secure piping in place, and shall be so arranged as to provide for expansion and contraction.
- B. The spacing for hangers for horizontal piping shall be in accordance with the following:
1. Cast Iron Soil Pipe: 5 ft.-0 in. at the hubs for 5 ft. lengths. For 10 ft. lengths, use one (1) hanger at the hub and one (1) at midpoint of the length. Install cast iron pipe in accordance with CISPI Handbook - latest edition.
 2. Copper Tubing: 6 ft.-0 in. o.c. for 1-1/4 in. and smaller, and 10 ft.-0 in. o.c. for 1-1/2 in. and larger.
 3. Steel Pipe: 10 ft.-0 in. o.c. for 1-1/2 in. and over; 8 ft. - 0 in. for 1-1/4 in.; 6 ft. - 0 in. for 1 in. and smaller.
 4. Polypropylene acid waste: 4 ft.-0 in. o.c.
- C. Hanger rod diameter shall be as follows:

Pipe Size	Rod Diameter
1/2 in. thru 2 in.	3/8 in.
2-1/2 in. and 3 in.	1/2 in.
4 in. and 5 in.	5/8 in.
6 in.	3/4 in.
8 in. and over	7/8 in.

- D. Vertical lines shall be adequately supported at their bases by a suitable hanger placed in the horizontal line near the riser and at every 10 ft. interval.
- E. All Hangers shall be adjustable Clevis Hanger. Hanger rods shall have machine threads. Malleable iron brackets of approved type shall be used along the walls. All Hangers for copper tubing shall be copper plated except where pipe is insulated, in which case, Steel Clevis Hanger and pipe shield shall be used.
- F. Piping shall not be hung from the hangers of other trades.
- G. Provide seismic restraints for all piping per requirements of the MA Building Code and Section 230548. All gas piping shall be seismically restrained.
- H. Hangers shall be manufactured by Grinnell, Carpenter and Paterson, Fee and Mason, or equal.
- I. Wire and strap hangers will not be permitted in this installation.
- J. Install a 14 gauge metal pipe shield between pipe insulation and all pipe hangers. Hangers shall be sized so that the pipe insulation passes through the hanger and is supported on the shield.

2.15 DRAINS

- A. Furnish and install all floor drains and roof drains where shown on the Drawings.
- B. All floor drains in flooring systems without waterproofing membranes shall have galvanized iron clamping rings with 6-pound lead flashing to bond 9 in. in all directions. All drains shall be checked with Architect's Drawings to determine depth of the flashing collar. Brass extension pieces shall be provided if necessary.
- C. All floor drains installed on this project shall be fitted with Automatic Trap Primer Connections. Field determine appropriate location for Trap Primer valve and drain piping.
- D. Drain Schedule:
 - 1. Type "A" – Watts FD-100-A-A6-7, epoxy coated cast iron body floor drain with clamping collar and with 6 in. dia. nickel bronze adjustable strainer head. Trap primer connection.
 - 2. Type "B" – Watts FD-100-B-B8-5-7, epoxy coated cast iron body floor drain, sediment bucket, cast iron heavy duty grate, with 8 in. dia. nickel bronze adjustable strainer head. Trap primer connection
 - 3. Type "C" - Watts #RD700-D-F-K80, cast iron body roof drain, under-deck clamp, aluminum dome, cast iron extension, roof sump receiver. Refer to Architect's Drawings for height of insulation.
 - 4. Type "D" – Watts FD-340-1-5-13, Galvanized heavy duty cast iron body sediment bucket, heavy duty ductile iron secured grate, caulk bottom outlet.
 - 5. Type "E" – Zurn #Z-1995-LD-P-4, 24 inch x 16 inch x 17 inch, white acid resistant coated interior and exterior, steel body with integral anchor flange, less bottom dome, full grate with square center opening, and ½ inch trap primer connection.
 - 6. **Type "F" – Primary Drain - Watts #GRD-610-13-B-D, galvanized cast iron body garden roof drain and flashing clamp, under-deck clamp, roof sump receiver. Refer to Architect's Drawings for height of insulation.**
 - 7. **Type "F" – Overflow Roof Drain - Watts #GRD-610-13-B-D-W, galvanized cast iron body garden roof drain and flashing clamp, under-deck clamp, roof sump receiver, and 4-inch high internal standpipe. Refer to Architect's Drawings for height of insulation.**
- E. Drains shall be of one manufacturer, by Zurn, J.R. Smith, Watts, or equal.
- F. In bathrooms, coordinate all floor drain locations in field with Architect. Drain locations shall not conflict with toilet partition walls.

2.16 PLUMBING FIXTURES

- A. Furnish and install all fixtures and equipment, including supports, connections, fittings, and any incidentals, to make a complete installation in accordance with the Drawings and as specified. This project includes hard wired electronic actuated fixtures. Furnish transformers. Electrical Subcontractor shall wire all the fixtures requiring power.
- B. The Architect shall be final judge as to whether fixtures and trim fulfill the requirements of the Specifications and as to whether they are of suitable quality.
- C. All fixtures requiring hot and cold water shall have the cold water faucet on the right hand side of the fixture and the hot water faucet on the left hand side of the fixture.
- D. Escutcheons shall be furnished and installed on all supplies and traps. Escutcheons shall be one (1) piece chrome plated brass with set screws.

- E. All fixtures shall have the manufacturer's guaranteed label or trademark indicating first quality. All acid resisting enameled ware shall bear the manufacturer's symbol signifying acid resisting material.
- F. Unless otherwise specified, faucets and all exposed fittings shall be chromium plated.
- G. All supply pipes shall run in a reasonable straight vertical line from the stops to faucets. Traps shall be installed perpendicular to walls.
- H. Vitreous china and acid resisting enameled fixtures shall be of one manufacturer by Sloan, American Standard, Toto, or equal. Trim shall be Symmons, Speakman, Chicago, T & S Brass, or equal. Flush valves shall be Sloan, Toto, Zurn, or equal. Water coolers and drinking fountains shall be manufactured by Elkay, Just, Filtrine, or equal. Stainless steel sinks shall be Elkay, Just, Kindred, or equal.
- I. Note: All fixtures and fittings shall be vandal proof mounted, unless specifically noted otherwise.
- J. Carefully coordinate roughing for flush valves so that the dimension from top of fixture to C-L of flush valve is a minimum of 6 in..
- K. Fixture Schedule:
 - 1. P-1 Water Closet:

American Standard AFWall #3351.101, wall hung vitreous china water closet.

Sloan Model G2 8111, exposed sensor operated flushometer, 1.28 gallon per flush, polished chrome.

Olsonite #95-C Lustra solid plastic white open front seat with check hinge.

Zurn 300-pound carrier as required to suit. Carefully coordinate with Architect's plans to fit wall.
 - 2. P-1A Water Closet, Accessible:

Same as specified for P-1 except mounting height shall conform to Accessibility Standards. Refer to Architect's Drawings for the exact location of fixture and mounting height and re-verify during construction with the Field Architect.
 - 3. P-2 Urinal:

American Standard Washbrook #6590.001, wall hung, vitreous china, lavatory.

Sloan Model G2 8186, exposed sensor operated flushometer, 0.50 gallon per flush, chrome plated.

Zurn Z-1222 concealed support.
 - 4. P-2A Urinal, Accessible:

Same as specified for P-2 except mounting height shall conform to Accessibility Standards. Refer to Architect's Drawings for the exact location of fixture and mounting height and re-verify during construction with the Field Architect.

5. P-3 Lavatory (Staff):

American Standard "Decorum" #9024.008EC, wall mounted, 20 in. x 18 in., white vitreous china lavatory, 8-inch centers, punched for concealed arm chair carrier.

American Standard Serin #2064.801, widespread deck mounted faucet, 8-inch centers. Provide Powers LFe480 lavatory mixing valve set for 110 deg F outlet.

McGuire Model 155 WC offset drain with open grid strainer.

McGuire H167 LK (pair) C.P., 3/8 IPS angle supply with loose key stop.

McGuire B-8902 C.P., 1-1/4 in. x 1-1/2 in. cast brass adjustable 'P' trap with cleanout and 17 GA tubing outlet to wall.

6. P-3A Lavatory, Accessible:

American Standard "Decorum" #9024.001EC, wall mounted, 20 in. x 18 in., white vitreous china lavatory, single hole, punched for concealed arm chair carrier.

Sloan SF-2200-PLG-LAM-BDM, deck mounted sensor faucet, plug-in transformer, 0.35 GPM laminar flow, below deck manual mixing valve set for 110 deg F outlet.

McGuire Model 155 WC offset drain with open grid strainer.

McGuire H167 LK (pair) C.P., 3/8 IPS angle supply with loose key stop.

McGuire B-8902 C.P., 1-1/4 in. x 1-1/2 in. cast brass adjustable 'P' trap with cleanout and 17 GA tubing outlet to wall.

Zurn #ZR-1231 floor mounted concealed armchair carrier.

Provide roughing insulation kit on waste outlet, p-trap, and water supplies.

7. P-3B Lavatory (Locker Room):

American Standard "Edgemere" #0545.000, undermount sink, 18-1/2 in. x 16-1/8 in., white vitreous china lavatory.

American Standard Serin #2064.801, widespread deck mounted faucet with pop-up drain, 8-inch centers. Provide Powers LFe480 lavatory mixing valve set for 110 deg F outlet.

McGuire Model 155 WC offset drain.

McGuire H167 LK (pair) C.P., 3/8 IPS angle supply with loose key stop.

McGuire B-8902 C.P., 1-1/4 in. x 1-1/2 in. cast brass adjustable 'P' trap with cleanout and 17 GA tubing outlet to wall.

8. P-4 Electric Water Cooler with Bottle Filler:

Elkay LZS8WSLK, Barrier Free, electric water cooler, #4 satin finish stainless steel bowls, chrome plated bubbler, push button actuator, ADA compliant with cane touch apron, and sensor-activated bottle filling station.

1-1/4 in. x 1-1/2 in. rough p-trap with cleanout; 1/2 in. ball valve stop.

9. P-5 Mop Receptor:

Stern-Williams MTB-2424-BP, 24 in. x 24 in. x 10 in. molded stone mop service basin with stainless steel rim guard on exposed sides, 3 in. caulk connection, stainless steel strainer, splash guard. Plumbing Subcontractor to include caulking and sealant to seal between unit, finished wall and floor.

T&S Brass model B-0665-BSTP service sink fitting, polished chrome, brace to wall, integral screwdriver stops, vacuum breaker, 3/4 in. hose end, 2 in. lever handles, provide 1/2 in. check valve on each supply to fitting with access panel.

Furnish and install 1/2" hot and cold reduced pressure backflow preventer capped for future soap dispenser.

10. P-6 Shower:

American Standard Serin #TU064507, pressure balancing mixing valve with level handle, factory pre-set temperature limit stops, Integral Service Stops with 1.75 GPM flow restrictor, adjustable spray showerhead, with arm and flange.

American Standard Serin #2064.724 shower system kit including 59 in. flexible hose, 24 in. wall mounted slide bracket rod with heavy duty (250 lb) anchors, and American Standard #T064.430 and R422, diverter valve.

Kohler "Archer" K-9397, 48-inch x 36-inch, single threshold acrylic shower base with Kohler K-9132 shower drain.

11. P-6A Shower, Accessible:

American Standard Serin #TU064507, pressure balancing mixing valve with level handle, factory pre-set temperature limit stops, Integral Service Stops with 1.75 GPM flow restrictor, adjustable spray showerhead, with arm and flange.

American Standard Serin #2064.724 shower system kit including 59 in. flexible hose, 24 in. wall mounted slide bracket rod with heavy duty (250 lb) anchors, and American Standard #T064.430 and R422, diverter valve.

Kohler "Archer" K-9396, 36-inch x 36-inch, single threshold acrylic shower base with Kohler K-9132 shower drain.

12. P-7 Sink:

American Standard "Edgewater" #18SB6252211.075, single bowl, 25 in. x 22 in., self-rimming countertop mounted 6-inch deep, 18 ga. type 304 stainless steel sink with rear outlet, single hole punched faucet ledge.

American Standard "Beale" #4931.380, single pull-down kitchen faucet, 1.5 GPM outlet, ceramic disc valve cartridge.

Just J-ADA-35 crumb cup strainer with 1-1/2 in. offset tailpiece and stainless steel ground seat stopper.

1-1/2 in. x 2 in. chrome plated P-trap with cleanout, waste outlet with escutcheon.

Pair of 1/2 in. x 3/8 in. supplies with stops and escutcheons.

The casework includes roughing protection knee guard. Rough tight to wall.

13. P-8 Kitchen Sink:

American Standard "Pekoe" #18DB6291800.075, 29" x 18", double bowl sink, undermount, 6" deep, 18 ga. type 304 stainless steel sink with center outlet; four (4) hole punched faucet ledge.

American Standard "Edgewater" #4932.350, deck mount kitchen faucet, pull down spray, metal lever handle, ceramic disc valve cartridge.

Two Just J-ADA-35 crumb cup strainers with 1-1/2 in. offset tailpiece and stainless steel ground seat stopper.

1-1/2" x 2" chrome plated P-trap with cleanout, waste outlet with escutcheon.

Pair of 1/2" x 3/8" supplies with stops and escutcheons.

14. P-9 Turnout Gear Sink:

Just SB-124-24L, 12" deep standard series, single compartment stainless steel sink, 12" backsplash, 14 ga. type 304 stainless steel sink, 1-5/8" galvanized legs with 1" adjustment, 24" drainboard on left.

Advance Tabco pre-rinse faucet, model K-116, splash mounted faucet, 8 in. centers, spring action flexible swing gooseneck, 2-3/8 inch blade handles, K-114 hand spray.

Crumb cup strainer with 1-1/2 in. tailpiece and stainless steel ground seat stopper.

1-1/2 in. x 2 in. chrome plated P-trap with cleanout, waste outlet with escutcheon.

Pair of 1/2 in. x 3/8 in. supplies with stops and escutcheons.

15. P-10 Lav-Toilet Combi:

Metcraft Model HET3118-45-L/R-FW-B1H-OB-EPE-PE-MS-MA-PH, suicide skirt, 18 in. wide lav/toilet, penal fixture combination, fabricated of type 304, #14 gage Stainless steel, seamless welded construction. Fixture shall be supplied with all necessary mounting hardware to support to connections. Fixture shall include Off-Center mounting and be floor mounted stainless steel bowl including suicide skirt to floor.

Unit shall be individually wasted lavatory and individually wasted water closet and remote concealed flush valves. Provide individual ball valve shutoff at about 5 ft. above floor for cold water and hot water supply per fixture to allow for shutting off the supply to each individual combi in the pipe chase. Unit shall be provided with hot and cold, self-closing metering valve, p-trap, and cleanout. The lavatory shall have remote mixing valve, Leonard TA-F, located in the pipe chase. Combination unit to include paper holder.

Each toilet shall be furnished with a Sloan 603-ESM-1.6-HW-24V concealed mounted flush valve designed to operate at 1.6 gal/flush with two remote push button controllers for each water closet. Locate one flush button per toilet in Booking B119 and one in corresponding Cell Passage. Flush button shall be Sloan model 3375012. Include Sloan MCR-8002 programmable control module. All conduit and wiring for remote flush buttons shall be provided by Division 22. Install conduit and wiring in accordance with the requirements of Division 26. Provide EL-154, 24volt transformer.

The lavatory shall have remote mixing valve located in the pipe chase.

Provide EL-154, 24volt transformer.

16. P-10A Lav-Toilet Combi, Accessible:

Metcraft Model HET3155-L/R-FW-B1H-RB-EPE-PE-MS-MA-FCS, with rear spud, floor mounted wall outlet blowout jet stainless steel institutional water closet less grab bar, elongated bowl, integral stainless steel seat, suicide skirt, hemispherical penal bubbler and hemispherical push button controls, fixture closure shelf, seamless construction, complete with vandal proof mounting hardware. Do not install grab bar.

Unit is to be mounted on masonry walls. Plumbing Sub is to cut all openings in panel utilizing the template furnished with the fixture. Fixture shall be supplied with all necessary mounting hardware to support to connections. The lavatory shall have remote mixing valve, Leonard TA-F, located in the pipe chase.

Each toilet shall be furnished with a Sloan 603-ESM-1.6-HW-24V concealed mounted flush valve designed to operate at 1.6 gallon per flush with two remote push button controllers for each water closet. Locate one flush button per toilet in Booking B119 and one in corresponding Cell Passage. Flush button shall be Sloan model 3375012. Include Sloan MCR-8002 programmable control module All conduit and wiring for remote flush buttons shall be provided by Division 22. Install conduit and wiring in accordance with the requirements of Division 26. Provide EL-154, 24volt transformer.

The lavatory shall have remote mixing valve, Leonard TA-F, located in the pipe chase.

Provide EL-154, 24 volt transformer.

17. P-11 Institutional Shower:

Acorn Penal-Ware #1736ADA-A-SLL-8-BRS-PYY-FSS-GBC, ADA Compliant Cabinet Shower. Cabinet shall be fabricated from 14 gage, type 304 stainless steel. Exposed surfaces shall have a satin finish except the Shower Floor which shall have a slip-resistant, matte finish. ASSE compliant pressure balancing shower valve with ligature resistant and vandal resistant lever handle. Cabinet shall be provided with a horizontally mounted, two-wall grab bar with closure plate, 24" vertical Grab Bar, an integral stainless steel Seat, a Towel Hook and a recessed Soap Dish. Unit shall meet applicable Shower accessibility requirements for ADA, UFAS and ANSI. Cabinet Shower shall be installed according to manufacturer's

18. P-12 Decon Sink:

Just SB-130-24RL, 12" deep standard series, single compartment stainless steel sink, 12" backsplash, 14 ga. type 304 stainless steel sink, 1-5/8" galvanized legs with 1" adjustment, 24" drainboard on right and left.

Advance Tabco pre-rinse faucet, model K-116, splash mounted faucet, 8 in. centers, spring action flexible swing gooseneck, 2-3/8 inch blade handles, K-114 hand spray.

Crumb cup strainer with 1-1/2 in. tailpiece and stainless steel ground seat stopper.

1-1/2 in. x 2 in. chrome plated P-trap with cleanout, waste outlet with escutcheon.

Pair of 1/2 in. x 3/8 in. supplies with stops and escutcheons.

19. P-13 Hose Bibb:

Acorn Series 8109 hot and cold water hose bibb, cast bronze valve body, vacuum breaker, screw driver stops, recessed stainless steel mounting box with locking door. Locate in cell block service chases as indicated on plans.

20. P-14 Clothes Washer:

Symmons No. W-602-X Laundry-Mate Supply and Drain Fixture, recessed mounting box 1/2 in. hot and cold water connections, 2 in. waste connection, integral stops and check valves on supplies.

21. P-15 Emergency Eye Wash:

Haws model 7360BTWC, all stainless-steel barrier free Emergency Eye/Face Wash station, 11 in. stainless steel receptor.

Provide Haws Model 9201EW emergency tempering valve. Mount in surface mounted stainless-steel cabinet.

22. P-16 Laundry Sink:

Just SB-124-24R, 12" deep standard series, single compartment stainless steel sink, 12" backsplash, 14 ga. type 304 stainless steel sink, 1-5/8" galvanized legs with 1" adjustment, 24" drainboard on right.

Advance Tabco pre-rinse faucet, model K-116, splash mounted faucet, 8 in. centers, spring action flexible swing gooseneck, 2-3/8 inch blade handles, K-114 hand spray.

Crumb cup strainer with 1-1/2 in. tailpiece and stainless steel ground seat stopper.

1-1/2 in. x 2 in. chrome plated P-trap with cleanout, waste outlet with escutcheon.

Pair of 1/2 in. x 3/8 in. supplies with stops and escutcheons.

23. P-17 Coffee Point Sink:

American Standard "Edgewater" #18SB6252211.075, single bowl, 25 in. x 22 in., self-rimming countertop mounted 6-inch deep, 18 ga. type 304 stainless steel sink with rear outlet, single hole punched faucet ledge.

American Standard "Beale" #4931.380, single pull-down kitchen faucet, 1.5 GPM outlet, ceramic disc valve cartridge.

Just J-ADA-35 crumb cup strainer with 1-1/2 in. offset tailpiece and stainless steel ground seat stopper.

1-1/2 in. x 2 in. chrome plated P-trap with cleanout, waste outlet with escutcheon.

Pair of 1/2 in. x 3/8 in. supplies with stops and escutcheons.

The casework includes roughing protection knee guard. Rough tight to wall.

24. P-18 Air Hose Reel:

Hannay Reels, Inc. model N716-23-24-15.5G-TR, compressed air hose reel with 75-foot 3/8" hose. Mount with Hannay model 9908.9990 swivel mounting bracket.

25. P-19 Truck Fill Valve:

Water Fill Valves shall be Potter Roemer model 4065 female x male Fire Department Valve. Valves shall be polished chrome plated. Confirm thread with Owner prior to ordering.

2.17 BACKFLOW PREVENTERS

- A. Backflow preventers shall be reduced pressure type furnished complete with shutoff valves, Massachusetts Approved. Backflow preventers 2-1/2 inch and smaller shall be Watts #LF009-QT-S. Backflow preventers 3 inch and larger shall be Watts 957-QT. Backflow preventers shall be lead free, all bronze, complete with strainer and soft seated check valve. Size shall be as indicated on Drawings.
- B. Mount backflow preventer 3 ft.(+/-) above finished floor. Provide indirect waste funnel and run pipe to an air gapped discharge at sink or floor drain. Furnish a spare parts kit and parts list mounted in the vicinity of the device.
- C. Prior to the installation of devices in the name of the Owner file for, pay for, and obtain all required permits and approvals for cross connection control devices from the Authority having Jurisdiction.
- D. Backflow preventers shall be of one manufacturer, by Watts, Wilkins, Beeco, or equal.

2.18 UNION AND NIPPLES

- A. All connections between copper tubing and galvanized piping or between copper tubing and all tanks (such as water heaters, chillers, and similar equipment) shall be made with dielectric unions and nipples.
- B. All connection to Water Heaters, Meters, Pumps, and other equipment requiring maintenance or alteration shall be made up with unions. Unions on brass piping, 2 in. and smaller, shall be brass composition "E" in strict accordance with Federal Specification WW-U-516. On plastic piping, use unions of the same material as the piping.
- C. All close and shoulder nipples shall be corresponding materials as the pipe and shall be extra heavy.

2.19 WATER HEATERS

- A. The potable domestic water heater shall be by Heat Transfer Products, Lochinvar, Camus, or approved equal.
- B. The water heater shall be HTP, Inc., Elite VWH EL-220-N having a modulating input rating of 220,000 Btu/Hour, a recovery capacity of 259 gallons per hour at a 100°F rise and shall be operated on natural gas. The water heater shall be capable of full modulation firing down to 20% of rated input with a turn down ratio of 5:1.

- C. The water heater shall bear the ASME "H" stamp and shall be National Board listed for inputs in excess of 200,000 Btu/Hr. There shall be no banding material, bolts, gaskets or "O" rings in the header configuration. The stainless steel combustion chamber shall be designed to drain condensation to the bottom of the heat exchanger assembly. A built-in trap shall allow condensation to drain from the heat exchanger assembly. The complete heat exchanger assembly shall carry a five (5) year limited warranty.
- D. The water heater shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.10.3 test standard for the US. The water heater shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard. The water heaters shall operate at a minimum of 95% thermal efficiency. The water heaters shall be certified for indoor installation.
- E. The water heater shall be equipped with two terminal strips for electrical connection. A low voltage connection board with data points for safety and operating controls, i.e., Auxiliary Relay, Auxiliary Proving Switch, Alarm Contacts, Runtime Contacts, Manual Reset Low Water Cutoff, Flow Switch, High and Low Gas Pressure Switches, Tank Thermostat, Tank Sensor, Building Management System Signal, Modbus Control Contacts and Cascade Control Circuit. A high voltage terminal strip shall be provided for supply voltage. The high voltage terminal strip plus integral relays are provided for independent control of the Domestic Hot Water Pump and Building Re-circulation Pump.
- F. The water heater shall be installed and vented with a Vertical Vent with vertical Air system with a vertical rooftop termination of the vent with the combustion air being drawn from the roof. The flue shall terminate at the roof top with the manufacturers specified vent termination. A separate pipe shall supply combustion air directly to the water heater from the outside.
- G. Water heater shall have direct spark ignition with electronic supervision firing control system.
- H. Furnish and install condensate neutralizing kit with water heater. Run condensate piping, after neutralized, to the nearest floor drain.
- I. The circulating pump shall be all bronze and operate on a 120 volt, 60 cycle, 1 phase power supply. The pump shall be wired to run with intermittent pump operation.
- J. Furnish and install one vertical water storage tank. Storage tank shall be a Lochinvar Lock-Temp RJA-200 tank having a storage capacity of 200 gallons. The tank shall be constructed with an inner chamber designed to receive all circulation to and from the water heater to eliminate turbulence in the tank. The baffled tank shall supply 80% of tank capacity without a drop in outlet temperature. The storage tank shall be constructed in accordance with ASME requirements. The storage tank shall have a working pressure of 150 psi. The storage tank shall be glass lined and carry a five (5) year limited warranty. The tank shall be constructed with a heavy gauge steel jacket assembly.
- K. The jacket and tank base shall be a water tight construction with a built-in drain pan, complete with a 3/4" drain connection. The Storage Tank shall be completely encased in high density insulation of sufficient thickness to meet the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard. The entire assembly shall be mounted on "I" beam skids to facilitate handling and installation.

- L. Expansion Tank: Furnish and install as shown on plans a 35 gallon(12 gallon acceptance volume), 16" diameter x 45" (high) pre-charged steel thermal expansion tank with a fixed FDA approved butyl bladder. The tank shall have a top NPT stainless steel system connection and a .301" - 32 charging valve connection (standard tire valve) to facilitate the on-site charging of the tank to meet system requirements. The tank must be constructed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code and stamped 150 psi working pressure. Tank shall be Wessels model number TTA-80 or by Amtrol, Taco, or approved equal.

2.20 TEMPERING VALVES

- A. Tempering valves shall be as manufactured by Powers, Acorn Controls, Heat Timer Corp, or equal.
- B. Furnish and install where shown for temperature control at all domestic water heating systems, Powers Intellistation Jr., model LFIS100VL, digital mixing valve. In case of power failure valve shall flow full cold for safety. Provide inlet check-stops, outlet volume/shutoff valve, dial thermometer, and test connection. Valves are to be factory assembled and tested.
- C. Furnish and install a 4 in. diameter thermometer on the outlet side of each tempering valve as manufactured by U.S. Gauge Company, Powers Regulator Company, and/or Trerice Company.

2.21 RECIRCULATING HOT WATER PUMPS

- A. Circulators shall be all-bronze booster type, Grundfos Magna3 40-80 or equal by Bell & Gossett, Taco or approved equal.
- B. Circulators shall be connected to the Building Management System by Division 23.

2.22 AIR INTAKE AND EXHAUST BREECHING, CHIMNEYS AND STACKS

- A. The air intake and exhaust vents shall be double-wall stainless steel, factory-built type for use on condensing appliances.
- B. Maximum temperature shall not exceed 550°F.
- C. Vent shall be listed for an internal static pressure of 6 in. w.g. and tested to 15 in. w.g.
- D. Vent shall be constructed with an inner and outer wall, with a 1 in. annular insulating air space.
 - 1. The inner wall (vent) shall be constructed of AL29-4C superferritic stainless steel, .015 thickness for 4 in.-12 in. diameters and .024 thickness for 14 in.-24 in. diameters.
 - 2. The outer wall (casing) shall be constructed of type 430 stainless steel, .018 thickness for 4 in.-12 in. diameters and .024 thickness for 14 in.-24 in. diameters.
 - 3. Inner and outer walls shall be connected by means of spacer clips that maintain the concentricity of the annular space and allow unobstructed differential thermal expansion of the inner and outer walls.
- E. All parts exposed to the weather shall be stainless steel.
- F. All supports, roof or wall penetrations, terminations, appliance connectors and drain fittings, required to install the vent system shall be included.
- G. Roof penetration pieces shall be UL listed and provided by the vent manufacturer.

- H. All inner vent connections shall be secured by means of profiled connector bands with gear clamp tighteners. Joints shall be sealed with waterproof sealant. Where exposed to weather, the outer closure band shall be sealed to prevent rainwater from entering the space between inner and outer walls.
- I. Vent shall terminate in accordance with installation instructions and local codes.
- J. Manufacturers: Subject to compliance with requirements, provide all steel, insulated, positive pressure double wall vents of one of the following:
 - 1. Metal-Fab, Corr/Guard Model CG
 - 2. Selkirk Heat-Fab Saf-T Vent CI
 - 3. Schebler eVENTplus
 - 4. or equal

2.23 CONDENSATE NEUTRALIZING TUBES

- A. Contractor shall furnish and install condensate neutralizing tubes for new boilers and domestic water heater condensate drains and flue pipe condensate drains.
- B. Neutralizer tubes shall be as manufactured by JJM Boiler Works, Neutra-Safe, Fireside Condensate Neutralizers, or approved equal, and sized according to input rating of each piece of equipment.
- C. The boiler/water heater and flue condensate drains shall not be combined, Provide separate neutralizing tubes for boiler/water heater and flue condensates. All piping shall be per manufacturer's piping diagrams and directions. Secure neutralizing tubes to the floor.

2.24 WATER METER

- A. Furnish and install water meter with inlet strainer in accordance with the standards of the Local Water Department. Coordinate the installation with the water department and include in the Plumbing Bid the cost of the meter. Refer to Part 1 of this section regarding assessments, and the like.

2.25 EMERGENCY GAS SOLENOID VALVE

- A. Emergency gas solenoid valve shall be normally closed FM approved gas solenoid valve ASCO "Red-Hat" Series 8040/8215. Valve shall operate on 120volt power and shall close the gas flow on the main gas feed to the Kitchen cooking equipment. This solenoid valve is furnished and installed by Section 220000.
- B. Gas solenoid valves shall be manufactured by ASCO, QMI, ISIMET, or equal.

2.26 ELEVATOR SUMP PUMP

- A. Furnish and install in each elevator pit a simplex Stancor Traction Minder Elevator System, 2" submersible sewage pump. Pump shall be Stancor WES-50 submersible. Pump shall be rated to provide 50 GPM @ 22' TDH. Pump motors shall be submersible and not less than 0.5 HP, 115Volt, 1phase, 3,450 RPM and 60 HZ.
- B. Controls shall include Stancor Series CB1000-1 single phase simplex controller, three float switches mounted to the discharge pipe with 20' cord, NEMA 4X enclosure, High Water Alarm, Test and Silence selector switch, high water alarm horn with silencer, and one set of isolated dry contacts for remote alarm.

2.27 AIR COMPRESSOR (AC-1)

- A. Furnish and install a tank mounted air compressor with all required accessories to provide an automatic supply of shop air to serve station outlets
- B. Air compressor shall be Quincy Model QGS-7.5, rotary screw air compressor, 21 CFM, 7.5 HP, 480v, 3 phase 60 HZ motor, 60 gallon ASME receiver, compressor-mounted full-function motor starter with a 120 volt control voltage transformer with on-off switches and manual resets, automatic condensate drain, tank mounted pressure gage, service valve and safety valve. Compressor to be supplied with QMF-75 coalescing filter.
- C. Run auto-drain discharge to nearest floor drain.
- D. **Include Quincy QPNC-25 compressed air dryer, 120 v, single phase, and Quincy QCS 100 oil water separator.**

2.28 COMPRESSED AIR REGULATORS

- A. At all compressed air connections furnish and install Parker, series C105/C255, Ingersoll Rand, Control Air, or equal combination air filter and pressure regulator.

2.29 BREATHING AIR COMPRESSOR (AC-2)

- A. Furnish and install a tank mounted breathing air compressor with all required accessories as specified.
- B. Breathing Air compressor shall be Bauer Compressors UNICUS 4i, 10 HP E-3, 480 volt, 13 CFM, breathing air system with P2 B-Securus filtration, 15" HMI touch screen interface, high temperature and low oil shutdown, E-stop button, automatic condensate, stage gauges, automatic cascade, two ASME 6000 storage, three position containment fill station SCBA/SCUBA up to 31".
- C. Include UNICUS 4i RF/REL-9 100-feet reel with gauges and controls, one CO monitor, and RFID SCBA data logger.
- D. Run auto-drain discharge to nearest floor drain.

2.30 TRENCH DRAINS

- A. Furnish and install as shown on the Plumbing Drawings, Zurn Z-812 12" wide pre-sloped trench drainage system. Glass filled polyester fiberglass drain channel with 1/8" per foot bottom slope. All sections modular 10 foot lengths with interlocking ends complete with heavy-duty Dura-Coated steel frame with anchor studs at surface, combination anchor tabs/leveling devices at appropriate locations and extra heavy-duty cast iron grate with lockdowns.

2.31 MANHOLE AND PRECAST CONCRETE OIL/GAS SEPARATOR STRUCTURE

- A. Manholes and precast concrete structures shall be constructed as shown on Drawings. Conform accurately to indicated dimensions.
 - 1. Precast concrete manhole barrel, base, and cone sections shall conform to ASTM C-478 and shall be furnished complete with integral cast aluminum polymer coated steel steps. Sections shall be assembled with Kentseal #2 gaskets, or equal.

2. Brick for constructing channels and adjustments to grade shall be waterstruck sewer brick, Grade 'A' concrete brick conforming to ASTM C-55, or precast concrete grade rings mortared in place.
 3. Cement mortar for parging and for joining brick shall be made of one (1) part portland cement and two (2) parts sand mixed to the proper consistency. Add approximately twenty (20) pounds of hydrated lime for each sack of cement.
 4. Precast concrete structures for oil/gas separator shall be as manufactured by A. Rotondo & Sons, Inc. or equal by Scituate Concrete pipe or Shea precast. Structures shall conform to the form and dimensions shown, be reinforced with ASTM A-615-79 Grade 60 reinforcing steel having a minimum 1" cover, and constructed of 5,000 PSI concrete. All field joints shall be sealed with rubber gasket and shall be grouted with hydraulic cement for watertightness. Design loading for all structures shall meet H-20 wheel loading design
- B. Conform to the Concrete Section of the specification for 4,000 PSI 6% air entrained concrete for all concrete structures for the work of this section. Including reinforcing steel where detailed.
- C. Cast iron manholes, frames, and covers, shall be of the form, dimensions, and manufacture shown on the Contract Drawings. Manhole extensions shall be neatly and accurately brought to dimensions of the base of the frame. Casting shall be of tough gray iron, free from cracks, holes, and cold shuts. All castings shall be made accurately to dimensions and shall be machined to provide even bearing surfaces. Covers must fit the frames in any position and, if found to rattle under traffic, shall be replaced. Filling to obtain tight covers will not be permitted. No plugging, burning-in, or filling will be allowed. All castings shall be carefully coated inside and out with coal tar pitch varnish of approved quality.
- D. Castings shall be as detailed on drawings or castings that appear on the Massachusetts Highway Department approval list for manhole frame & cover castings. Castings shall be by LeBaron Foundry, Neenah Foundry, or Campbell Foundry.

2.32 FIRESTOP SYSTEMS

- A. General: Provide firestopping at all new fire-rated construction where penetrated by the Work of this Section.
- B. Refer to Section 078410 - Firestopping, for all product requirements for maintaining integrity of fire-rated construction at penetrations.

2.33 SCAFFOLDS AND STAGING

- A. General: Trade Contractors shall obtain required permits for, and provide scaffolds, staging, and other similar raised platforms, required to access their Work as specified in Section 01 50 00 - Temporary Facilities and Controls and herein.
1. Scaffolding and staging required for use by this Trade Contractor pursuant to requirements of Section 01 50 00 - Temporary Facilities and Controls shall be furnished, erected, maintained in a safe condition, and dismantled when no longer required, by this Trade Contractor requiring such scaffolding.
 2. Each Trade Contractor is responsible to provide, maintain and remove at dismantling, all tarpaulins and similar protective measures necessary to cover scaffolding for inclement weather conditions other than those required to be provided, maintained and removed by the General Contractor pursuant to MGL (Refer to Section 01 50 00 - Temporary Facilities and Controls and as additionally required for dust control).

3. General Contractor is responsible to provide enclosures required for temporary heat; refer to Section 01 50 00 - Temporary Facilities and Controls.

- a. Furnishing portable ladders and mobile platforms of all required heights, which may be necessary to perform the work of this trade, are the responsibility of this Trade Contractor.

2.34 HOISTING MACHINERY AND EQUIPMENT

- A. All hoisting equipment, rigging equipment, crane services and lift machinery required for the work by this Trade Contractor shall be furnished, installed, operated and maintained in safe conditions by this Trade Contractor, as referenced under Section 01 50 00 - Temporary Facilities and Controls.

2.35 DOMESTIC WATER SUB-METER

- A. **For meters located on piping 3-inch and larger, furnish and install ONICON or equal, model F-3500, Siemens, EKM, or equal, water flow meter at the main water service entrance downstream of the water meter. Furnish 24VDC power supply with plug connection. Coordinate power wiring with Section 260001. Include Onicon N-100 network interface module.**
- B. **For meters located on piping 2-1/2-inch and smaller, furnish and install ONICON or equal, model F-4600, inline ultrasonic water flow meter with backlit display and user interface. Furnish 24VDC power supply with plug connection. Coordinate power wiring with Section 260000.**
- C. **Unit shall be capable of providing BACnet/IP output. Provide all required multi-network routers for IP outputs. All BACnet control wiring shall be by Section 230000.**
- D. **Install meter per manufacturer's installation requirements.**

PART 3 - EXECUTION

3.1 WORKMANSHIP AND INSTALLATION METHODS

- A. All work shall be installed in a first-class manner consistent with the best current practices. All materials shall be securely installed plumb and/or level, and all flush mounted equipment shall have front edge flush with finished wall surface.
- B. All piping shall be installed true to line and grade in the case of underground piping. All piping above ceilings or exposed shall be grouped together, be parallel to each other, and be either parallel or perpendicular to the structure. Utilize gang hangers wherever feasible. Group all valves together where feasible.
- C. Training:
 1. Train the Owner's maintenance personnel on troubleshooting procedures, and servicing and preventative maintenance schedules and procedures.
 2. Schedule training with Owner through the Architect with at least 7 days prior notice.

3.2 WORK COORDINATION AND JOB OPERATIONS

- A. The equipment shall not be installed in congested and possible problem areas without first coordinating the installation of same.
- B. Particular attention shall be directed to the coordination of piping and other equipment installed in the ceiling areas. Coordinate the elevations of all piping in hung ceiling areas to insure adequate space for the installation of recessed lighting fixtures before other mechanical equipment is installed.
- C. Furnish to the General Contractor, and all other Subcontractors, all information relative to the portion of the Plumbing installation that will affect them, sufficiently in advance so that they may plan their work and installation accordingly.
- D. In case of failure to give proper information as indicated above sufficiently in advance, pay for all back-charges for the modification, renovation, and relocation of any portion of the work already performed.
- E. Obtain from the other trades, all information relative to the Plumbing Work to be executed in conjunction with the installation of their respective equipment.

3.3 CUTTING AND CORE DRILLING

- A. Perform all cutting and core drilling operations that are outlined in Part 1 of this SECTION. Throughout the performance of the cutting and coring work, ensure that the structural integrity of the walls, floors, overhead structure, and other structural components, which are to remain, is maintained until permanent work is installed. Prior to any coring or cutting, verify all locations of same with the General Contractor. All cutting and coring is to be performed in accordance with approved Coordination Drawings
- B. Cut all masonry and concrete with an approved diamond blade concrete saw in a neat straight direction, perpendicular to the plane of the wall or floor.
- C. Use a core drilling process which produces clean, sharp edges and the minimum hole size which will accommodate the size of pipe sleeve specified. Submit procedures for cutting thru existing steel beams to Architect for review.
- D. The patching of holes shall be performed by Plumbing Sub-contractor utilizing methods outlined for the finish trade involved. Holes shall be patched to the satisfaction of the Architect.

3.4 CLEANING AND PROTECTION

- A. Protect all materials and equipment during shipment and so as to prevent damage. Water closets, lavatories, and sinks shall be boarded over and all other fixtures shall be protected with pasted on paper. Post notice prohibiting the use of the fixtures prior to completion. Assume full responsibility for protection of work until its completion and final acceptance.
- B. Keep the premises reasonably clean at all times and remove rubbish caused by the Plumbing Work as directed by the Architect.
- C. Upon completion of this work, clean all fixtures and equipment installed herein and replace damaged parts. Failure to fulfill this obligation will result in back-charges for correction of the defective work.

3.5 SLEEVES, INSERTS, AND ESCUTCHEONS

- A. All piping passing through slabs, floors, walls, partitions, foundation walls and grade beams, shall be sleeved and all such sleeves shall be furnished and installed by the Plumbing Subcontractor as detailed on the Drawings and herein specified. Set sleeves in concrete floors and walls as soon as forms are set and before concrete is poured. Core drilling openings shall have a sleeve caulked and grouted in place.
- B. All pipes passing through floor, whether slab-on grade or above grade levels, shall be sleeved with sleeve extending 1 in. above floor. This includes all piping in toilet room pipe space, stairwells, closets, partitions and pre-cast planks.
- C. All sleeves shall be Schedule 40 galvanized steel and shall be reamed. There shall be a minimum of 1 in. annular space between the sleeve and pipe provide greater clearance where seismic requirements dictate. Sleeves on insulated pipe shall be large enough to allow insulation to pass through sleeve. Sleeves on drywall, masonry, or concrete walls and partitions, shall be flush with wall on both sides.
- D. The space between sleeve and pipe in all cases shall be filled with a U.L./F.M. approved caulking compound. This includes pipes concealed in chases and/or partitions.
- E. Inserts where required shall be furnished and set by the Plumbing Subcontractor and where necessary may be drilled or power driven and shall be sized such that the insert will not exceed a depth of penetration of 1 in. into concrete.
- F. Escutcheons: All exposed pipe, uncovered, passing through walls or floors or ceilings shall be fitted with C.P. brass spun or split type escutcheons with approved clamping device for holding in position. Floor escutcheons shall be deep enough to fit over sleeves, fastened to pipe, and extend down to floor.

3.6 TESTING

- A. Test all Work in the presence of the Architect and/or Engineer and as required by Local Codes.
- B. After Soil, Storm, Special Waste, and Vent Piping is in place and before being buried or furred in, plug lower ends and fill the system with water up to the top of stacks. Piping is to be left tight under these conditions and water level shall be maintained intact for the period of at least four (4) hours.
- C. Test all water piping by applying a hydrostatic pressure of 150 PSIG using a pump for this purpose. Make sure that all lines are properly plugged or capped and that air has been vented before applying pressure which shall remain constant without pumping for two (2) hours at least.
- D. Test gas piping per State Gas Code.
- E. Any leaks in joints or evidence of defective pipe on fittings disclosed by test shall be immediately corrected by replacing defective parts with new joints or materials. No makeshift repair effected by caulking threaded pipe with lead wool, application or Wilky or patented compounds will be permitted.
- F. Gas/Oil Separator Manhole Exfiltration Test:
 - 1. Plug pipes in manhole; remove water in manhole; observe plugs over period of not less than 2 hours to ensure there is no leakage into manhole.

2. Fill manhole with water to within 4 inches of top of cover frame. Prior to test, allow manhole to soak from minimum of 4 hours to maximum of 72 hours; after soak period, adjust water level inside manhole to within 4 inches of top of cover frame.
3. Measure water level from top of manhole frame; at end of 4 hour test period, again measure water level from top of manhole frame; there shall be no drop in water level during test period.
4. When unsatisfactory test results are achieved, repair manhole and retest until result meets criteria; repair visible leaks regardless of quantity of leakage.

G. Provide testing report for all systems tested.

3.7 CHLORINATION

- A. Upon completion of the Plumbing Work, thoroughly chlorinate the entire domestic water system before putting same in service. Chlorinate all work in the presence of the Architect and/or Engineer. The chlorinating agent shall be as a solution of sodium hypochlorite. Water shall be fed slowly into the new line with chlorine in the proper amount to produce a dosage of 50 PPM. Open and close all valves while system is being chlorinated.
- B. After the sterilization agent has been applied for 24 hours, pay for an independent testing agency to test for residual chlorine and for presence of bacteria. A residual of not more than 5 PPM shall be required in all parts of the line.
- C. If test show 5 PPM or greater of residual chlorine, flush out system until all traces of the chemical used are removed.
- D. Provide testing report from independent testing agency.

3.8 INSTALLATION OF FIRESTOP SYSTEMS

- A. General: Install firestop systems at all fire-rated construction where penetrated by the Work of this Section.
- B. Refer to Section 078400 - Firestopping, for all installation requirements for maintaining integrity of fire-rated construction at penetrations.

3.9 INSTALLATION OF AIR INTAKE AND EXHAUST BREECHING, CHIMNEYS AND STACKS

- A. VIBRATION CONTROL AND SEISMIC RESTRAINT: Refer to section 230548 and drawing VS-1 for the appropriate support of each piece of equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS-1.
- B. Install all gas vents/intakes in accordance with manufacturer's installation instructions and UL listing. Maintain minimum clearances from combustibles specified in UL listing.
- C. Seal joints between sections of positive pressure vents in accordance with manufacturer's installation instructions, and using only sealants recommended by manufacturer.
- D. Support vents at intervals recommended by the manufacturer to support the weight of the vent and all accessories, without exceeding loading of appliances. Provide guys wires on all vents which terminate through the roof. Typical provide three (3) guy wires for each air intake or exhaust vent penetrating the roof.

- E. Install barometric and thermostatically operated dampers in accordance with manufacturer's instructions. Locate as close to draft hood collar as possible.
- F. Clean breechings internally during installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth.
- G. Temporary Closure: At ends of breechings and chimneys which are not completed or connected to equipment, provide temporary closure which will prevent entrance of dust and debris until installations are completed.

3.10 SEISMIC RESTRAINTS

- A. The independent engineer responsible for design of seismic restraints shall visit the project upon completion of the work to certify the installation is consistent with the approved shop drawings. The certification shall be submitted to the Architect and must precede the closing in of ceilings.

3.11 SYSTEM SHUTDOWNS

- A. Coordinate shutdowns of existing systems with the Owner and submit a written request at least ten working days in advance. Minimize system shut downs as much as possible. Submit a list of all affected areas, the proposed work to be performed, and the expected length of the shut-down including time for retesting.
- B. Provide temporary services to maintain active system during extended shut-downs as required for demolition and construction phasing.

END OF SECTION

SECTION 230000

HVAC
(Filed Sub-Bid Required)

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SECTION 230000

HVAC
(Filed Sub-bid Required)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS – TRADE SUB-BID REQUIRED

- A. Work of this Section requires Trade Sub-Bids and is governed by the provisions of the Massachusetts General Laws (MGL), Public Bidding Law Chapter 149, Sections 44A to 44J inclusive; and applicable Section of the MGL, Public Contract Law Chapter 30 as amended.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section.

1.3 REQUIREMENTS FOR FILING SUB-BIDS

- A. Time, Manner and Requirements for Submitting Sub-Bids:

1. Sub-bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the Public Agency at a time and place as stipulated in the "Instructions to Bidders."
2. Each sub-bid submitted for work under this Section shall be on forms furnished by the Awarding Authority as required by Section 44F of Chapter 149 of the General Laws, as amended.
3. Sub-bids filed with the Awarding Authority shall be accompanied by Bid Bond, Cash, Certified Check, Treasurer's Check, or Cashier's Check issued by a responsible bank or trust company payable to the Town of Ashland in the amount of 5 percent of the sub-bid. A sub-bid accompanied by any other form of bid deposit than those specified will be rejected.

- B. Sub Sub-Bid Requirements:

CLASS OF WORK	PARAGRAPH NUMBERS
Insulation	2.6, 3.6
Sheetmetal & Accessories	2.16, 2.17, 2.18, 2.20, 2.30, 3.16, 3.17, 3.18, 3.19, 3.20, 3.22, 3.26
Automatic Temperature Control	2.31, 3.31
Air & Water Balancing	3.32
Vehicle Exhaust System	2.14, 3.14

If Sub-Bidder intends to perform with persons of his own staff the classes of work listed above, he must nevertheless list his own name therefore, under Paragraph E, of the FORM FOR SUB-BID.

The Work of this Section is shown on the following Drawings: M-001, M-101, M-102, M-103, M-104, M-201, M-202, M-203, M-301, M-302, M-303, M-304, M-305, M-306, M-307, M-308, M-309, M-401, M-402, M-403, VS-1.

1.4 SUMMARY

A. General:

1. The work described herein shall be interpreted as work to be done by the HVAC Subcontractor. Work to be performed by other trades will always be specifically referenced to that trade.
2. Furnish all staging, rigging, temporary support, labor, materials, and perform all operations in connection with the installation of the HVAC work.
3. The building is to be commissioned and this contractor shall provide all labor required to fully test and demonstrate that all systems operate as designed.

B. Without limiting the generality thereof, the work to be performed under this Section includes:

1. Heating Hot Water Piping System with Insulation, Hangers, Valves, etc.
2. Rooftop Air Handling Unit
3. Exhaust Fans
4. Ductwork With Insulation, Hangers, Dampers, etc.
5. HW Unit Heaters and Radiant Panels
6. Pumps, Hydronic Accessories, Tanks, and Equipment Insulation.
7. VAV Terminal Boxes
8. Direct digital automatic temperature controls.
9. Testing, Adjusting & Balancing of all Ducted and Piped Systems and Equipment
10. Chemical Treatment Systems
11. Equipment Nameplates
12. Factory Tests
13. Seismic Restraints & Vibration Isolation (refer to Section 23 05 48)
14. Diffusers, Registers and Grilles
15. Sound Attenuators
16. Refrigerant Piping
17. Roof Curbs (Refer to Section 23 05 48)
18. High Efficiency Condensing Boilers
19. Ductless Cooling Units
20. Heat Recovery System (VRF)
21. CO/ NO2 Gas Detection Systems
22. Refrigerant Leak Detection system
26. Vehicle Exhaust Capture Systems
28. Glycol Make-up Systems
29. Radiant Floor Hot Water Heating & Snow Melt
30. Duct-mounted Coils
31. Constant Volume Dampers

~~C. Related Sections:~~

1. ~~Division 01 Section "Commissioning"~~

1.5 DEFINITIONS

- A. Most terms used within the documents are industry standard. Certain words or phrases shall be understood to have specific meanings as follows:
- B. Provide: Furnish and install completely connected up and in operable condition, ready for the intended use.
- C. Furnish: Purchase and deliver to a specific location within the building or site, ready for unloading, unpacking, assembly, installation, and similar operations.
- D. Install: With respect to equipment furnished by others, install means to receive, unpack, move into position, mount and connect, including removal of packaging materials.
- E. Conduit: Raceways of the metallic type which are not flexible. Specific types as specified.
- F. Connect: To wire up, including all branch circuitry, control and disconnection devices so item is complete and ready for operation.
- G. Subject to Mechanical Damage: Equipment and raceways installed exposed and less than eight feet above finished floor in mechanical rooms or other areas where heavy equipment may be in use or moved.

1.6 RELATED WORK

- A. Cutting & patching beyond the requirements as stated herein is specified in the respective Sections of the trade responsible for furnishing and installing similar new materials.
- B. For temporary controls refer to Section 01 50 00 – TEMPORARY FACILITIES AND CONTROLS.
- C. For flashing of vents through roof and setting of roof curbs and flashing of such, refer to Section 07 62 00 – SHEET METAL FLASHING AND TRIM and Section 07 00 02 Roofing and Flashing.
- D. For excavation and backfill of below grade mechanical and related systems refer to Division 31.
- E. For Structural Steel Framing refer to Section 05 12 00 – STRUCTURAL STEEL FRAMING.
- F. For firestopping referenced in this Section refer to Division 07 for products and installation requirements.
- G. For finished painting of mechanical systems not called for in this Section refer to ~~Section 09 90 00 – PAINTING~~ **Section 09 90 00 – PAINTING AND COATING** and Section 09 00 07 – PAINTING FILED SUB-BID REQUIREMENTS.
- H. For interior concrete work relating to this Section refer to Section 03 30 00 – CAST-IN-PLACE CONCRETE.
- I. For exterior concrete work relating to this Section refer to Section 03 30 00 - CAST-IN-PLACE CONCRETE.
- J. ~~Section 01 81 00 – COMMISSIONING.~~

- K. Furnish access panels and doors for installation in walls, ceiling and floors at locations to permit access for adjustment, removal, replacement and servicing of all concealed equipment, valves, volume dampers, materials, etc. installed under this Section of the specifications.
- L. Access panels will be installed under this Section of the related trades of the finished surfaces in which they are located.
- M. Access panels shall be located in closets, storage rooms and/or other non-public areas if possible, positioned so that the equipment can be easily reached, and the size shall be sufficient for this purpose (min. 16" x 16"). When access panels are required in corridors, lobby or other habitable areas, they will be located as directed by the Owner's Representative.
- N. Access panels shall be per Division 08 spec for products and installation requirements. Required fire resistance of walls and ceilings shall be maintained.

1.7 PRODUCTS FURNISHED, BUT NOT INSTALLED UNDER THIS SECTION

- A. Furnish pipe sleeves for placement into formwork by the Generator Contractor, Refer to ~~Section 03-30-00~~ **Section 03 11 00**.

1.8 PRODUCTS INSTALLED, BUT NOT FURNISHED UNDER THIS SECTION

- A. Install duct-mounted smoke detectors which will be furnished by the Electrical subcontractor. The HVAC Subcontractor shall wire the appropriate fan to shut down upon detection of smoke. The Electrical Subcontractor shall power wire and wire the smoke detector to the fire alarm panel.

1.9 CODES, ORDINANCES, AND PERMITS

- A. Perform all work in accordance with the requirements of the Town of Ashland Building Department, State of Massachusetts Building Code, and applicable State and Federal Laws. Give all requisite notices, file all requisite plans, and obtain all permits required to perform HVAC Work. Pay all fees and include in the Bid. All HVAC equipment shall be installed to meet all State, Local and Federal sound ordinances.
- B. Refer to GENERAL CONDITIONS for local connection and permit fees and information regarding Utility Company back charges.
- C. Codes, laws and standards provide a basis for the minimum installation criteria acceptable. The drawings and specifications illustrate the scope required for this project, which may exceed minimum codes, laws and standards.
- D. Give all notices, file all plans, obtain all permits and licenses, and obtain all necessary approvals from authorities having jurisdiction. No work shall be covered before examination and approval by the Owner's Representative, inspectors, and authorities having jurisdiction. Replace imperfect or condemned work to conform to requirements, satisfactory to Owner's Representative, and without extra cost to the Owner. If work is covered before examination and approval, this Contractor shall pay costs of uncovering and reinstalling the covering, whether it meets contract requirements or not.

1.10 QUALITY ASSURANCE

A. Codes and Standards:

1. HI Compliance: Design, manufacture, and install HVAC pumps in accordance with HI Hydraulic Institute Standards".
2. UL Compliance: Design, manufacture, and install HVAC pumps in accordance with UL 779 "Motor Operated Water Pumps".
3. ANSI Standards: Comply with ANSI A13.1 for pipe, valve, and equipment identification.
4. I=B=R Compliance: Provide boilers that have been tested and rated in accordance with Institute of Boiler and Radiator Manufacturers (I=B=R) "Testing and Rating Standard for Cast Iron and Steel Heating Boiler", and bear I=B=R emblem on nameplate affixed to boiler.
5. ASME Compliance: Construct boilers in accordance with ASME Boiler and Pressure Vessel Code, Section IV "Heating Boilers".
6. UL and NEMA Compliance: Provide boiler ancillary electrical components, which have been listed and labeled UL, and comply with NEMA Standards.
7. FM Compliance: Provide control devices and control sequences in accordance with requirements of Factory Mutual System (FM).
8. IRI Compliance: Provided control devices and control sequences in accordance with requirements of Industrial Risk Insurance (IRI).
9. AMCA Compliance: Test and rate air handling units in accordance with AMCA standards.
10. AGA Compliance: Provide gas controls and devices in accordance with American Gas Associates.
11. ARI Compliance: Test and rate air handling units in accordance with ARI 430 "Standard for Central-Station Air Handling Units", display certification symbol on units of certified models.
12. ASHRAE Compliance: Construct and install refrigerant coils in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration".
13. NFPA Compliance: Provide air handling unit internal insulation having flame spread rating not over 25 and smoke developed rating no higher than 50; and complying with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".
14. UL and NEMA Compliance: Provide electrical components required as part of air handling units, which have been listed and labeled by UL and comply with NEMA standards.
15. NEC Compliance: Comply with National Electrical Code (NFPA 70) as applicable to installation and electrical connections of ancillary electrical components of air handling units.

B. MSS Standard Practices: Comply with the following standards for valves:

1. MSS SP-45: Bypass and Drain Connection Standard
2. MSS SP-67: Butterfly Valves
3. MSS SP-70: Cast Iron Gate Valves, Flanged and Threaded Ends
4. MSS SP-71: Cast Iron Swing Check Valves, Flanged
5. MSS SP-72: Ball Valves with Flanged or Butt-Welding Ends for General Service
6. MSS SP-78: Cast Iron Plug Valves, Flanged and Threaded Ends
7. MSS SP-80: Bronze Gate, Globe Angle and Check Valves
8. MSS SP-84: Steel Valves - Socket Welding and Threaded Ends
9. MSS SP-85: Cast Iron Globe and Angle Valves, Flanged with Threaded Ends
10. MSS SP-92: MSS Valve User Guide

- C. Automatic Temperature Control Contractor Qualifications: Firms specializing in installation of Automatic Temperature control system for not less than 5 years.

1. Codes and Standards:

- a. Electrical Standards: Provide electrical components of control systems which have been UL-listed and labeled, and comply with NEMA standards.
- b. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for control systems.
- c. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

1.11 DISCREPANCIES IN DOCUMENTS

- A. Where Drawings or Specifications conflict or are unclear, advise Architect in writing before Award of Contract. Otherwise, Architect's interpretation of Contract Documents shall be final, and no additional compensation shall be permitted.
- B. Where Drawings or Specifications do not coincide with manufacturer's recommendations, or with applicable codes and standards, alert Architect in writing before installation.
- C. Of the required material, installation, or work can be interpreted differently from drawing to drawing, for between drawings and specs, this contractor shall provide that material, installation, or work which is of the more stringent.
- D. It is the intent of these contract documents to have the contractor provide systems and components that are fully complete and operational and fully suitable for the intended use. There may be situations in the documents where insufficient information exists to precisely describe a certain component or subsystem, or the routing of a system. In cases such as this, where the contractor has failed to notify the Architect of the situation in accordance with Paragraph (A) above, the contractor shall provide the specific component or subsystem with all parts necessary for the intended use, fully complete and operational, and installed in workmanlike manner.

1.12 CONTRACT DRAWINGS

- A. All work shown on the Drawings is intended to be approximately correct to scale, but shall be taken in a sense as diagrammatic. Sizes of ductwork and pipes and general method of running them are shown, but it is not intended to show every offset and fitting which is only possible after final coordination with all sub-contractors and submission of coordination drawings. No additional compensation will be allowed for offsets and fittings not specifically shown on the contract drawings. To carry out the true intent and purpose of the plans, furnish all necessary parts to make complete working systems ready for use.
- B. The HVAC Drawings and Specifications are intended to supplement each other so that any details shown on the Drawings and not mentioned in the Specifications, or vice-versa, shall be executed the same as if mentioned in the Specifications and shown on the Drawings.
- C. Refer to the Architectural, Structural, Plumbing, Mechanical and Electrical Drawings which indicate the construction in which this work shall be installed. Locations shown on the plans shall be checked against the general and detailed Drawings of the construction proper. All measurements must be taken at the building.

1.13 COORDINATION DRAWINGS

- A. Before materials are purchased or work is begun, the respective Subcontractor shall prepare and submit to the Architect Coordination Drawings showing the size, elevation and location of his equipment, fixtures, ductwork, conduit, and piping lines relevant to the complete system. He shall ensure that these drawings are compatible and correctly annotated and cross-referenced at their interfaces.
- B. Coordination drawings are for the Contractor's and the Architect's use during construction and shall not be construed as replacing any shop or record drawings required elsewhere in the Contract Drawings.
- C. All coordination drawings shall be prepared in a large enough scale to accurately identify work of each trade and in addition to each sub-contractors systems, shall also show architectural floor plan, reflected ceiling plan, and structural framing with grid identification.
- D. The coordination drawing shall be started by the sheet metal sub-contractor and after applying all ductwork, the drawing shall be submitted for ductwork approval by the engineer. After approval, the drawing shall be circulated to the remaining sub-contractors for application of their work.
- E. During coordination drawing preparation the sub-contractors shall meet periodically to discuss overall coordination of all sub systems, and shall adjust their systems accordingly. When all drawings are complete the general contractor shall submit to the architect and engineers for review.
- F. Areas of conflict that cannot be resolved between the sub-contractor must be flagged on the drawings with adequate information to assist the architect and engineer in resolving noted issues.
- G. Refer to DIVISION 01 – GENERAL REQUIREMENTS of these Contract Documents for additional procedures relative to the preparation of Coordination Drawings.
- H. Any additional time required to draw and/or re-draw coordination drawings due to conflicts shall be completed at no additional cost to the Owner and/or Project.

1.14 ACCESSIBILITY

- A. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for service and removal of all parts that require replacement or servicing.
- B. Extend all grease fittings to an accessible location.

1.15 ROUGH IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

This Sub-contractor shall disconnect, lower to floor, and stack near-by all noted mechanical systems being removed. The General Contractor shall remove from the building and dispose of in a legal manner. Coordinate with the Architect and G.C.

1.16 NOTIFICATION OF RELATED TRADES

- A. Notify all other trades responsible for installing chases, inserts, sleeves, anchors, louvers, etc. when ready for such installation and for final checking immediately before concrete is placed. Cooperate with such trades to obtain proper installation.
- B. Leave openings in walls for pipes, ducts, etc. for mechanical and electrical work as shown on Drawings or required by layout of mechanical or electrical systems.

1.17 MECHANICAL INSTALLATIONS

- A. Coordinate mechanical equipment and materials installation with other building components.
- B. Verify all dimensions by field measurements.
- C. Arrange for chases, slots, and openings in other building components to allow for mechanical installations.
- D. Coordinate the installation of required supporting devices and sleeves to be set in poured in place concrete and other structural components, as they are constructed.
- E. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing-in the building.
- F. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials.
- G. Where mounting heights are not detailed or dimensioned, install mechanical services and overhead equipment to provide the maximum headroom possible.
- H. Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
- I. Coordinate connection of mechanical system with overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

1.18 CUTTING AND PATCHING

- A. Drilling, coring, cutting, and patching of new and existing structures (through walls, floors, ceiling, etc.) where the largest dimension does not exceed 12" shall be by this Contractor.
- B. Throughout the performance of the cutting and coring work, ensure that the structural integrity of the existing walls, floors, overhead structure, and other structural components, which are to remain, is maintained until permanent work is installed. Prior to any coring or cutting verify all locations of same with the General Contractor. All cutting and coring is to be performed in accordance with approved coordination drawings. All cutting or coring of structural must receive approval of the Architect prior to proceeding.
- C. No additional compensation will be authorized for cutting and patching work that is necessitated by ill-timed, defective, or non-conforming installations.

1.19 SUBMITTALS

- A. Refer to SECTION 01 33 00 – SUBMITTAL PROCEDURES for submittal definitions, requirements, and procedures. The following paragraphs supplement the requirements of Section 01 33 00.
- B. Submittal of Shop Drawings, product data, and samples will be accepted only when submitted by the General Contractor. Data submitted by Sub-contractors and material suppliers directly to the Architect/Engineer will not be processed. Submittals will be electronic unless physical sample are required.
- C. Provide submittals for the following equipment:
 - 1. Valves
 - 2. Meters and Gauges
 - 3. Hangers and Attachments
 - 4. Mechanical Identification
 - 5. Mechanical Insulation
 - 6. Hydronic Piping
 - 7. HVAC Pumps
 - 8. Boilers
 - 9. Terminal Heating Units (electric, gas, hot water)
 - 10. Rooftop Units
 - 11. CO/ NO2 Gas Detection Sensors
 - 12. Power and Gravity Ventilators
 - 13. Metal Ductwork
 - 14. Ductwork Accessories
 - 15. Sound Attenuators
 - 16. Air Outlets and Inlets
 - 17. Heat Recovery Systems (VRF)
 - 18. Ductless Cooling Units
 - 19. Automatic Temperature Controls
 - 20. Air and Water Testing and Balancing
 - 21. Constant Volume Dampers
 - 22. Acoustic Liner
 - 23. Condensate Pumps
 - 24. Refrigerant Piping
 - 25. Variable Air Volume Boxes
 - 26. Refrigerant Leak Detection system
- D. If a Shop Drawing is not accepted after two submissions, a third submission from the same manufacturer will not be considered.
- E. Check Shop Drawings and other submittals to assure compliance with contract documents before submittal to A/E.
- F. Review of Shop Drawings is final and no further changes shall be considered without written application. Shop Drawings review does not apply to quantities, nor relieve this Contractor of his responsibility for furnishing materials or performing his work in full compliance with these Contract Drawings and Specifications. Review of these shop drawings shall not be considered a guarantee of the measurements of this building or the conditions encountered.

1.20 SUBSTITUTIONS

- A. Refer to, ~~SECTION 01 62 00 — SUBSTITUTION REQUEST FORM~~ **SECTION 01 33 01 – SUBSTITUTION REQUEST FORM** for requirements in requesting substitutions. The following paragraphs supplement the requirements of Section 01 60 00.
- B. If materials or equipment are substituted for specified items that alter the systems shown or its physical characteristics, or which have different operating characteristics, clearly note the alterations or difference and call it to the attention of the a/e. Under no circumstances shall substitutions be made unless material or equipment has been successfully operated for at least three consecutive years.
- C. Any modifications to the design, as a result of approving a substitution, shall be the responsibility of this contractor. Any additional cost to this contractor or any other contractor, directly or indirectly, as a result of such substitutions, shall be the responsibility of this contractor.

1.21 PRODUCT LISTING

- A. Prepare listing of major mechanical equipment and materials for the project.
- B. Provide all necessary information.
- C. Submit to the A/E through the General Contractor, within twenty (20) days of signing contract, this listing indicating all equipment and manufacturers, as a part of the submittal requirement. If the product list is not submitted, it will be the responsibility of the sub-contractor to submit one (1) of the three (3) named equal manufacturers.
- D. When two or more items of same material or equipment are required they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, pipe, tube, fittings (except flanged and grooved types), sheet metal, wire, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment units, and similar items used in work, except as otherwise indicated.
- E. Provide products, which are compatible within systems and other connected items.

1.22 NAMEPLATE DATA

- A. Provide permanent operational data nameplate on each item of power operated mechanical equipment, indicating manufacturer, product name, mode, number, serial number, capacity, operating, and power characteristics labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

1.23 DELIVERY, STORAGE AND HANDLING

- A. Refer to Section General Conditions for delivery, storage, and handling of equipment. The following paragraphs supplement the requirements of Section General Conditions.
- B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.
- C. Store equipment and materials off-site. Protect stored equipment and materials from damage.

- D. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

1.24 RECORD DOCUMENTS

- A. Refer to Section 01 77 00 – CLOSEOUT PROCEDURES for requirements for record documents. The following paragraphs supplement the above.
- B. Provide electronic Auto Cad 2014 or newer drawings. Modify electronic Drawings to indicate revisions to piping and ductwork, size and location both exterior and interior; including locations of coils, dampers and other control devices, filters, boxes, and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; concealed equipment, dimensioned to column line; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located. Also provide ATC Drawings showing As-Built conditions indicating point to point wiring from field devices to the control panels as well as floor plans indicating actual controller locations and communication wiring routes, modified sequences, field changes and any additional HVAC items added through change orders, ASI & RFI.

1.25 OPERATION AND MAINTENANCE DATA

- A. Refer to Section 01 77 00 – CLOSEOUT PROCEDURES for procedures and requirements for preparation and submittal of maintenance manuals. The following paragraphs supplement the requirements of Section 01 77 00.
- B. In addition to the information required by Section 01 77 00 for maintenance data, include the following information:
 - 1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
 - 2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shut-down, and emergency instructions; and user summer and winter operating instructions.
 - 3. Maintenance procedures for routine preventative maintenance and trouble-shooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 - 4. Servicing instructions and lubrication charts and schedules.
 - 5. Provide DVD recording of operation and maintenance training sessions and include as part of O & M Manual submittal. Provide indexed table of contents for DVD recording.
 - 6. ATC Drawings/Submittal of As-Built conditions including building CAT6 wiring, field devices, controllers, etc. for a complete as built condition.

1.26 WARRANTIES

- A. The contractor shall provide a one (1) year minimum warrantee on all product (unless otherwise stated in the product specification for a specific product) and labor for work under this section.
- B. Refer to Section General Conditions and Section 01 77 00 CLOSEOUT PROCEDURES for additional procedures and submittal requirements for warranties.

- C. In addition to the one year warranty period against component and/or workmanship defects, the 40 hours of training and the 40 hours of extra programming as it relates to the control system and as indicated in section 23 00 00 paragraph 2.31 & 3.31, the ATC contractor shall provide a seasonal site visit to confirm, verify and modify as required the sequence and/or programming of each piece of equipment to ensure the system is functioning as required and per the sequence of operations. The ATC contractor shall provide 16 labor hours per season (four times within a year, total of 64 hours). During each visit they shall, for each piece of equipment confirm operation and functionality, modify and/or repair any control related issues and/or programming and provide training as requested by the owner. This requirement will ensure the equipment/building is operating properly and efficiently as it cycles through each season. These seasonal site visits shall begin the following season after substantial completion of the project is issued. Upon substantial completion the HVAC contractor shall issue four dates to the engineer of record and owner. Signatures and time logs will be kept by both parties to ensure these visits occur.

1.27 WELDING QUALIFICATIONS

- A. Piping shall be welded in accordance with qualifications procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPV IX. Welding procedures qualified by others, and welders and welding operations qualified by another employer may be accepted as permitted by ASME B31.1. The Owner's Representative shall be notified 24 hours in advance of tests and the tests shall be performed at the work site if practicable. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record. Structural members shall be welded in accordance with Division 01.
- B. When open-flame or spark producing tools such as welding equipment, and the like are required in the process of executing the work, the General Contractor shall be notified not less than twenty four hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant fire watch/fire detail (by the Ashland Fire Department) where work is being performed and until it is completed. This Contractor shall be responsible for obtaining required permit and paying all permit fees and Firewatch detail expenses.

1.28 COMMISSIONING

- ~~A. For Each of the Rooftop Air Handling Units, the VRF system, the Automatic Temperature Control system, and where indicated in the equipment or commissioning specifications, the HVAC contractor shall engage a factory authorized service representative, to perform startup service as per the equipment manufacturer's functional test sheets and requirements of Section 01 81 00 COMMISSIONING.~~
- ~~B. Complete installation and startup checks and functional tests according to Section 01 81 00 COMMISSIONING and manufacturers written instructions.~~
- ~~C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the startup procedure.~~
- ~~D. Verify that equipment is installed and commissioned as per requirements of Section 01 81 00 GENERAL and manufacturer's written instructions/requirements.~~

A. GENERAL PROVISIONS

1. Commissioning Agent will be hired by the HVAC Subcontractor for Commissioning services outlined herein. Subcontractors responsible for items to be commissioned shall cooperate and coordinate with the Commissioning Agent and provide necessary information as outlined herein.
2. All of the Contract Documents, including Drawings, Invitation for Bids and Division 1 - General Requirements, apply to the Work of this Section.
3. Carefully examine all of the Contract Documents for requirements which affect the Work of this Section. The exact scope of Work of this Section cannot be determined without a thorough review of all specification Sections and other Contract Documents.
4. Commissioned systems shall be documented and functional performance tests verified with facility staff participating with on-the-job training, when available, during the functional performance testing.
5. Reference shall be made to the following sections:
 - a. Section 017700: Contract Closeout
 - b. Section 230548: Vibration Control and Seismic Restraint

B. SYSTEMS TO BE COMMISSIONED

1. Systems to be commissioned shall be:
2. Variable Refrigerant Flow (VRF) System
3. Heat Pump Rooftop Units
4. Automatic Temperature Control System

C. COMMISSIONING TEAM

1. The Commissioning Team shall consist of representatives from the following parties involved in the design and construction of this facility:
 - a. Facility Manager/Owner Representative
 - b. Commissioning Firm
 - c. Mechanical Design Team Representatives
 - d. Mechanical Contractor Representatives
 - e. Testing, Adjusting, and Balancing Contractor

D. COMMISSIONING DOCUMENTATION

1. Commissioning Documentation shall include the following:
 - a. Commissioning meeting minutes shall be by the Commissioning Agent for documenting regularly scheduled meeting discussions, responsibilities and action agenda due dates.
 - b. Pending issues log for documenting issues identified and/or commissioning activities that are deferred and/or seasonal functional performance tests.
 - c. Maintain current shop drawing log for documenting equipment submittals to be commissioned and associated O&M requirements.
 - d. Utilize static and operational performance test sheets for documentation of system(s) to be commissioned.
 - e. Corrective action log for documenting performance test deficiencies found during the performance testing. Each corrective action shall require a re-test of that deficiency to demonstrate compliance.

- f. **Equipment & System Training Log for documenting Contractor required training of Owner personnel.**

E. COMMISSIONING GOALS

- 1. **The goals of the commissioning process are as follows:**
 - a. **Certification that all noted systems meet the requirements set forth in the design documents for all systems and equipment noted.**
 - b. **To provide a comprehensive, Commissioning Plan**
 - c. **Provide a Commissioning Plan which defines the trade contractors' responsibilities as part of the commissioning process.**
 - d. **Demonstration of performance of systems commissioned.**
 - e. **Successful project closeout and warranty transition.**

F. SCHEDULING OF ACCEPTANCE TESTING WORK

- 1. **Static Review: Check procedures shall be conducted immediately after notification that the work of various systems and equipment is installed and the installing contractor has confirmed compliance with the contract documents.**
- 2. **Operational Performance Testing procedures shall be conducted immediately after notification that the work of the various systems and equipment is operational and that the installing contractor has completed his own tests to confirm compliance with the contract documents.**

G. DOCUMENTATION

- 1. **Prior to the conducting of static and operational testing procedures, the Commissioning Agent shall obtain the following:**
 - a. **Project Plans and Specifications including revisions made by addenda, approved alternates, Requests for Information (RFI) and change orders.**
 - b. **Approved submittals.**

H. CONTRACTOR RESPONSIBILITIES

- 1. **Mechanical Contractor**
 - a. **The contractor shall be present as requested by the Commissioning Agent during the acceptance testing procedures of their respective systems and equipment.**
 - b. **The air and water balancing contractor shall provide all labor and equipment to test HVAC systems as requested by the Commissioning Agent.**
 - c. **The ATC contractor shall provide all labor and equipment to perform tests and verification procedures i.e.; overriding various control inputs or outputs, manipulating schedules, etc. as required by the Commissioning Agent.**
- 2. **General Contractor**
 - a. **The General Contractor shall verify completeness of the building envelope, which may effect proper operation and control of HVAC equipment and systems.**

3. Owner

- a. The Owner shall assign maintenance personnel to participate in the commissioning process. The purpose shall be to become familiar with all tested systems as well as instruction on operation and maintenance.
- b. The Owner shall advise the Automatic Temperature Control Contractor and Commissioning Agent regarding building occupancy, usage, and time schedules.

I. FINAL ACCEPTANCE

1. When all noted systems are found to be operating satisfactorily in accordance with the plans and specifications, then the final commissioning report documenting satisfactory performance shall be prepared and submitted for review and approval.
2. After approval a copy of the commissioning plan and test results shall be included with each copy of the Operations and Maintenance Manuals.

J. ACCEPTANCE PROCEDURES

1. The agent-provided static and operational checklists shall be used to document the results of the testing process.
2. The performance testing process shall be accomplished for all equipment, subsystems, etc. listed in the approved commissioning plan. Complete a checklist for each piece of equipment and/or system noted to ensure documentation specific to each is complete.
3. Acceptance testing of all devices shall be performed by actual observations of the controlled devices such as dampers, valves, fans, terminal units, etc. Indication of device function from a DDC panel, computer interface, or other remote or indirect method is not acceptable.
4. Functional performance testing shall progress from components to equipment to subsystems to complete systems, in order to identify and correct the root causes of problems before their effect on an entire system is observed. Submit all deficiencies to be corrected to the contractors for immediate correction.
5. At the end of the process, every system and all equipment, shall have been proven operational under all normal operational modes, including part and full load, and under abnormal or emergency conditions.
6. Testing shall be accomplished on each control device. All relays and adapters shall be checked for proper operation. All system interlocks, interconnections, and safety devices shall be checked for proper function.
7. Simulate temporary upsets of systems, such as distribution fault, control loss, setpoint change, equilibrium upset, and component failure, at different operating loads to determine system stability and recovery time.

K. VERIFICATION AND DOCUMENTATION

1. As each individual check or test is accomplished, the Commissioning Agent shall observe the physical responses of the system and compare them to the specified requirements to verify the test results. The actual physical responses of system components shall be observed. Reliance on control signals or other indirect indicators are not allowed. Observe the input and output signals for each control component to confirm correct actions and indication for each physical condition.
2. Verification of the testing, adjusting, and balancing report shall be an integral part of commissioning testing.

3. The Commissioning Agent shall record the results of each individual check or test on pre-approved test and report form from the commissioning plan.
4. If any check or test cannot be accomplished for seasonal reasons, lack of occupancy, or for other reasons, this fact shall be noted along with an indication of when the test shall be scheduled.
5. If any check or test cannot be accomplished due to building structure or other building system deficiencies these deficiencies shall be resolved and corrected by the appropriate parties before completion of the commissioning process.
6. Every check or test for which acceptable performance was not achieved shall be repeated after the necessary corrective measures have been completed. This re-testing process shall be repeated until acceptable performance is achieved.

L. CORRECTIVE MEASURES

1. If acceptable performance cannot be achieved, then the design professional representative and the mechanical contractor shall be notified.
2. If inadequate performance is due to equipment deficiencies, then the appropriate contractor shall work with the equipment manufacturer to resolve the problem.
3. If the inadequate performance is due to design deficiencies, then the design professional shall issue appropriate directions to implement the necessary corrective measures

M. INTERSYSTEM FUNCTIONAL PERFORMANCE TESTS

1. When all individual systems' functional performance has been proved, the interface or coordinated responses between systems shall be checked. The systems involved may be within the overall HVAC work, or they may involve other systems, such as electrical and plumbing systems.
2. The approach to intersystem performance testing shall follow that previously described for systems.
3. Acceptance testing shall not be started on any system until it is documented to be complete by the contractor and/or his subcontractors. If all systems are not fully complete, but some are complete, it is permissible to acceptance test the completed systems first and continue with other systems after they have been completed.

N. **Sample Static and Functional Review checklist:**

1. **ATC:**

Automatic Temperature Control - Static Review Checklist

Project Name: _____	Date: _____

	Check Complete
Guidelines	
Verify all wiring is plenum rated	☐
Verify all wiring terminations are looped at control device	☐
Verify all exposed wiring in occupied areas is run in wiremold or conduit	☐
Verify all wiring in mechanical spaces, boiler room etc. is in conduit	☐
Verify all wiring above ceiling shall follow routing of piping, is bundled and wire tied, supported adequately	☐
Verify all wiring installation procedures are in accordance with Division 16000	☐
Verify permanent operator terminal installed and wired to emergency power	☐
Verify operator terminal receives data link	☐
Verify installation of dial-up modem and telephone connection	☐

Automatic Temperature Control - Operational Performance Test

Project Name: _____	Date: _____			

		PASS	FAIL	N/A
Inspection-Verification Electrical	Electrical connections complete and all data gathering panels	☐	☐	☐
	Individual circuits to each data gathering panel and labeled	☐	☐	☐
	Circuit feeding fixed "PC" is on emergency power	☐	☐	☐
	Data link is communicating between system and each computer	☐	☐	☐
	Electrical contractor sign off by: _____			
Inspection-Verification of Point List	Verify all points for each HVAC RTU (refer to control drawing)	☐	☐	☐
	Verify all points for VRF system (Refer to control drawings)	☐	☐	☐
Inspection-Verification of Sequence of Operation	Heat Pump RTU's	☐	☐	☐
	VRF system	☐	☐	☐
Inspection-Verification of Training	Owner has received 40 hours of training	☐	☐	☐

2. **VRF Indoor Unit:**

VRF Indoor Unit - Static Review Checklist

Project Name: _____

Date: _____

	Check Complete
Guidelines	
Confirm there is safe access to the equipment and around the equipment	☐
Confirm there is adequate access for maintenance service and equipment removal	☐
Have a system flow diagram when starting up the equipment	☐
Refer to Equipment Manufacturer's literature for additional data and requirements	☐
Check adequate condensate drain pan slope	☐
Check condensate pipe slope	☐
Check condensate pipe insulation	☐
Check condensate pipe termination	☐
Check indoor unit isolation valves installed	☐
Verify clean filter	☐
Verify clabinet not damaged or scratched	☐
Verify exterior and interior is clean	☐
Verify vibration isolation installed	☐
Verify seismic restraint installed	☐

VRF Indoor Evaporator- Operational Performance Test

Project Name:

Date:

		PASS	FAIL	N/A
Inspection-Verification Electrical	Electrical Connections Completed	☐	☐	☐
	Disconnect installed	☐	☐	☐
	Overload heater sizes confirmed	☐	☐	☐
	Motor amps: Rated @ _____ Actual @ _____	☐	☐	☐
	Rated @ _____ Actual @ _____	☐	☐	☐
	Rated @ _____ Actual @ _____	☐	☐	☐
	Motor voltage: Rated @ _____ Actual @ _____	☐	☐	☐
	Motor "bumped" to confirm equipment rotation	☐	☐	☐
	Distribution and terminations labeled	☐	☐	☐
	Panel circuit label and/or bar coded	☐	☐	☐
Electrical contractor sign off by: _____				
Inspection-Verification Automatic Controls	Points list completed	☐	☐	☐
	Interlock to automation system confirmed	☐	☐	☐
	Control Contractor sign off by: _____			
Inspection-Verification Equipment Installation	Vibration isolator installed	☐	☐	☐
	Equipment per contract documents/details/shop drawing	☐	☐	☐
	Seismic restraint installed	☐	☐	☐
	Noise level and/or vibration acceptable	☐	☐	☐
	Equipment labeled	☐	☐	☐
	Equipment has been cleaned inside and out	☐	☐	☐
	Piping contractor sign-off by: _____			
Insulation contractor sign off by: _____				
Inspection-Verification Equipment Manufacturer	Manufacturer's start-up sheet completed	☐	☐	☐
	Warranty sheet completed	☐	☐	☐
	Manufacturer sign off by: _____			
Inspection-Verification Pipe (HVAC) Distribution	Installation @ equipment completed	☐	☐	☐
	Connections per contract documents/details	☐	☐	☐
	System has been flushed clean	☐	☐	☐
	System is filled	☐	☐	☐
	Condensate drain piping installation completed	☐	☐	☐
	Piping contractor sign off by: _____	☐	☐	☐
		☐	☐	☐
		☐	☐	☐

3. VRF Outdoor Unit:

VRF Heat Recovery Condenser - Static Review Checklist

Project Name: _____

Date: _____

	Check Complete
Guidelines	
Confirm there is safe access to the equipment and around the equipment	☐
Confirm there is adequate access for maintenance service and equipment removal	☐
Have a system flow diagram when starting up the equipment	☐
Refer to Equipment Manufacturer's literature for additional data and requirements	☐
Check adequate condensate drain pan slope	☐
Verify cabinet not damaged or scratched	☐
Verify exterior and interior is clean	☐
Verify vibration isolation installed	☐
Verify seismic restraint installed	☐

VRF Heat Recovery System- Operational Performance Test

Project Name: _____

Date: _____

		PASS	FAIL	N/A
Inspection-Verification Electrical	Electrical Connections Completed	☐	☐	☐
	Disconnect installed	☐	☐	☐
	Overload heater sizes confirmed	☐	☐	☐
	Motor amps: Rated @ _____ Actual @ _____	☐	☐	☐
	Rated @ _____ Actual @ _____	☐	☐	☐
	Rated @ _____ Actual @ _____	☐	☐	☐
	Motor voltage: Rated @ _____ Actual @ _____	☐	☐	☐
	Motor "bumped" to confirm equipment rotation	☐	☐	☐
	Distribution and terminations labeled	☐	☐	☐
	Panel circuit label and/or bar coded	☐	☐	☐
	Electrical contractor sign off by: _____			
Inspection-Verification Automatic Controls	Points list completed	☐	☐	☐
	Interlock to automation system confirmed	☐	☐	☐
	Control Contractor sign off by: _____			
Inspection-Verification Equipment Installation	Vibration isolator installed	☐	☐	☐
	Equipment per contract documents/details/shop drawing	☐	☐	☐
	Seismic restraint installed	☐	☐	☐
	Noise level and/or vibration acceptable	☐	☐	☐
	Equipment labeled	☐	☐	☐
	Equipment has been cleaned inside and out	☐	☐	☐
	Piping contractor sign-off by: _____			
Inspection-Verification Equipment Manufacturer	Manufacturer's start-up sheet completed	☐	☐	☐
	Warranty sheet completed	☐	☐	☐
	Manufacturer sign off by: _____			
Inspection-Verification Pipe (HVAC) Distribution	Installation @ equipment completed	☐	☐	☐
	Connections per contract documents/details	☐	☐	☐
	System has been flushed clean	☐	☐	☐
	System is filled	☐	☐	☐
	Valves tagged	☐	☐	☐
	Piping contractor sign off by: _____			
...		☐	☐	☐

4. Heat Pump Rooftop Air Handling Unit:

Heat Pump Rooftop Air Handling Unit - Static Review Checklist

Project Name:

Date:

Guidelines

- Confirm there is safe access to the equipment and around the equipment
- Confirm there is adequate access for maintenance service and equipment removal
- Confirm there will not be short-circuiting of exhaust air into air intakes and/or other building openings
- Confirm there are no vents (plumbing, noxious exhaust etc.) within 25' of unit
- Confirm curb is insulated
- Confirm spring isolated seismic spring rail is installed
- Confirm economizer hood and controls are installed
- Confirm duct smoke detector and location
- Confirm installation of condensate drain with trap
- Have a system flow diagram when starting up the equipment
- Refer to Equipment Manufacturer's literature for additional data and requirements
- Confirm unit is fastened properly to structural steel and curb

Check
Complete

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Heat Pump Rooftop Air Handling Unit - Operational Performance Test

Project Name:

Date:

		PASS	FAIL	N/A
Inspection-Verification Electrical	Electrical Connections Completed	☐	☐	☐
	Disconnect installed	☐	☐	☐
	Overload heater sizes confirmed	☐	☐	☐
	Motor amps: Rated @ _____ Actual @ _____	☐	☐	☐
	Rated @ _____ Actual @ _____	☐	☐	☐
	Rated @ _____ Actual @ _____	☐	☐	☐
	Motor voltage: Rated @ _____ Actual @ _____	☐	☐	☐
	Motor "bumped" to confirm equipment rotation	☐	☐	☐
	Distribution and terminations labeled	☐	☐	☐
	Panel circuit label	☐	☐	☐
	VFD installed and operating	☐	☐	☐
	Electrical contractor sign off by: _____			
Inspection-Verification Automatic Controls	Points list completed	☐	☐	☐
	Interlock to automation system confirmed	☐	☐	☐
	Interlock to fire alarm system confirmed	☐	☐	☐
	Outside air damper stroked for full open & close	☐	☐	☐
	Duct static pressure sensor installed and set	☐	☐	☐
	Smoke detector under control	☐	☐	☐
	Discharge air controller installed and set	☐	☐	☐
	Control contractor sign off by: _____			
Inspection-Verification Equipment Installation	Installation on spring isolated rail	☐	☐	☐
	Equipment per contract documents/details/shop drawing	☐	☐	☐
	Noise level and/or vibration acceptable	☐	☐	☐
	Equipment labeled	☐	☐	☐
	Equipment has been cleaned inside and out	☐	☐	☐
Inspection-Verification Equipment Manufacturer	Manufacturer's start-up sheet completed	☐	☐	☐
	Warranty sheet completed	☐	☐	☐
	Additional belts provided	☐	☐	☐
	Owner's training complete	☐	☐	☐
	Manufacturer sign off by: _____			
Inspection-Verification Pipe (HVAC) Distribution	Installation @ equipment completed	☐	☐	☐
	Connections per contract documents/details	☐	☐	☐
	Drain piping installed	☐	☐	☐
Inspection-Verification Sheet Metal Distribution	Installation @ equipment completed	☐	☐	☐
	Connections per contract documents/details	☐	☐	☐
	Turning vanes in first elbow	☐	☐	☐
	Ductwork sound lining installed	☐	☐	☐
	Sheet metal contractor sign off by: _____			
	Insulation contractor sign off by: _____			
Inspection-Verification Testing & Balancing	Final balancing @ equipment completed	☐	☐	☐
	Strainers cleaned and tagged	☐	☐	☐
	New filters installed	☐	☐	☐
	Air (CFM) is per design criteria	☐	☐	☐
	System static pressure is per design criteria	☐	☐	☐
	TAB contractor sign off by: _____			

1.29 TRADE RESPONSIBILITY COORDINATION MATRIX

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Smoke Detectors (Area type)	26 00 00	26 00 00	26 00 00	N/A	26 00 00	
Smoke Detectors (Duct mounted)	26 00 00	23 00 00	26 00 00	23 00 00 (ATC)	26 00 00	
Smoke & Fire/Smoke Dampers	23 00 00	23 00 00	N/A	N/A	N/A	
Smoke & Fire/Smoke Damper Actuators	23 00 00	23 00 00	26 00 00	23 00 00 (ATC)	26 00 00	
Fire Dampers	23 00 00	23 00 00	N/A	N/A	N/A	
VAV Boxes	23 00 00	23 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	2
VAV Box Damper Actuator	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	N/A	
VAV Box DDC Controller	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	N/A	2
Hydronic Control Valves	23 00 00 (ATC)	23 00 00	N/A	23 00 00 (ATC)	N/A	1
Hydronic Control Valve Actuator	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	N/A	1
Sheet Metal Damper	23 00 00	23 00 00	N/A	N/A	N/A	1
Sheet Metal Damper Actuators	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	N/A	1
Natural Gas Energy Meters	22 00 00	22 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3
Electrical Energy Meters	26 00 00	26 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3
Domestic Water Meters	22 00 00	22 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3
HVAC Hydronic Energy Meters	23 00 00	23 00 00 (ATC)	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3
Airflow Measuring Stations	23 00 00	23 00 00	N/A	23 00 00	N/A	

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
DDC Panels	23 00 00 (ATC)	23 00 00 (ATC)	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	4
VFDs at Pumps	26 00 00	26 00 00	26 00 00	23 00 00 (ATC)	N/A	
VFDs at RTU, EFs	23 00 00	23 00 00	26 00 00	23 00 00 (ATC)	N/A	
Elevator Hoistway Vent Damper	23 00 00	23 00 00	N/A	N/A	N/A	
Elevator Hoistway Vent Damper Actuator	23 00 00 (ATC)	23 00 00 (ATC)	26 00 00	23 00 00 (ATC)	26 00 00	
Boiler/DHW/Generator Breeching	22 00 00	22 00 00	N/A	N/A	N/A	
Kitchen Emergency Gas Valve	22 00 00	22 00 00	26 00 00	26 00 00	26 00 00	

Notes:

1. Division 23 00 00 and Division 23 00 00 (ATC) Contractors shall fully coordinate all airflow damper and hydronic valves sizes and quantities.
2. VAV Box power wiring shall be provided by Division 26 00 00 to junction box locations shown on electrical drawings; Division 23 00 00 (ATC) Contractor shall provide final power wiring from junction box to end device location.
3. Division 26 00 00 Contractor shall provide all line-voltage power wiring required for meters; Division 23 00 00 (ATC) Contractor shall provide all low-voltage power wiring required for meters.
4. Division 26 00 00 shall provide power at main DDC Panel. Division 23 00 00 (ATC) shall provide power to all other DDC Panels.

1.30 ENERGY REBATE PROGRAM

- A. This project has been designed to incorporate equipment approved for energy rebate such as boilers, high efficiency motors, rooftop units and heat recovery units. HVAC subcontractor shall review Utility Company requirements prior to submitting shop drawing to ascertain that submittal meets program guidelines. All submitted equipment shall meet utility company rebate program efficiency requirements. HVAC subcontractor shall furnish equipment submittals, related equipment/system pricing data and all required rebate application information, and forms to utility company.

1.31 HAZARDOUS MATERIALS

- A. The HVAC Sub-contractor shall be responsible for removing and legally disposing of any and all hazardous waste associated with HVAC systems, including but not limited to:
 1. All chemical treatment used in flushing out HVAC piping systems.
 2. Un-used excess material such as adhesives used in ductwork and piping installations.
 3. Refrigerant in all AC systems.
 4. Propylene Glycol (where applicable)

5. Items specifically noted on drawings.

1.32 PHASING

- A. The HVAC subcontractor shall construct the subject project in phases as directed by the Architect to suit the project progress schedule, as well as the completion date of the project.
- B. For additional information related to phasing, review the General Conditions and Supplementary Conditions and the Architectural drawings.

1.33 HOISTING EQUIPMENT AND MACHINERY

- A. Unless otherwise specified, all hoisting and rigging equipment and machinery required for the proper and expeditious prosecution and progress of the Work of this Section shall be furnished, installed, operated and maintained in safe condition by each sub-contractor, as specified under Section 015000, TEMPORARY FACILITIES AND CONTROLS.

1.34 STAGING AND SCAFFOLDING

- A. Unless otherwise specified, each sub-contractor shall provide all lifts and man-lifts, and furnish, erect and maintain in safe condition, all staging and scaffolding as specified under Section 015000 Temporary Facilities and Controls as needed for proper execution of the work of this Section. Staging and scaffolding shall be of adequate design, erected and removed by experienced stage builders having all accident prevention devices required by Federal, state and local laws.

PART 2 - PRODUCTS

2.1 ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT (Refer to SECTION 019113 COMMISSIONING for additional contract requirements)

- A. Pursuant to Massachusetts General Laws Chapter 141, a Massachusetts Licensed electrician shall install all low voltage wiring required by this section.
- B. General: The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications.

1. All motors for all mechanical equipment shall be NEMA premium efficiency matching the following and all motors associated with variable frequencies drives shall be inverted duty motor with Aegis bearing protection rings:

HP	RPM	Efficiency
1	1800	85.5 percent
1.5	1800	86.5 percent
2	1800	86.5 percent
3	1800	89.5 percent
5	1800	89.5 percent
7.5	1800	91.0 percent
10	1800	91.7 percent
15	1800	93.0 percent
20	1800	93.0 percent

25	1800	93.6 percent
30	1800	94.1 percent
40	1800	94.1 percent
50	1800	94.5 percent

2. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
3. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.
4. Temperature Rating: Rated for 40 degrees C. environment with maximum 50 degrees C temperature rise for continuous duty at full load (Class F Insulation). All ratings shall be for inverter duty applications.
5. Starting Capability: Frequency of starts as indicated by automatic control system and not less than five evenly time spaced starts per hour for manually controlled motors.
6. Service Factor: 1.15 for poly-phase motors and 1.35 for single phase motors.
7. Motor Construction: NEMA Standard MG 1, general purpose, continuous duty, Design "B", except "C" where required for high starting torque.
8. Frames: NEMA Standard No. 48 or 54; use driven equipment manufacturer's standards to suit specific application.
9. Bearings:
 - a. Ball or roller bearings with inner and outer shaft seals.
 - b. Re-greaseable, except permanently sealed where motor is normally inaccessible for regular maintenance.
 - c. Designed to resist thrust loading where belt drivers or other drives produce lateral or axial thrust in motor.
 - d. For fractional horsepower, light duty motors, sleeve type bearings are permitted.
10. Enclosure Type:
 - a. Open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation.
 - b. Guarded drip-proof motors where exposed to contact by employees or building occupants.
 - c. Weather protected Type I for outdoor use, Type II where not housed.
11. Overload Protection: Built-in thermal overload protection and, where indicated, internal sensing device suitable for signaling and stopping motor at starter.
12. Noise Rating: "Quiet".
13. Efficiency: "Premium Efficient" motors shall have a minimum efficiency as scheduled in accordance with IEEE Standard 112, test method B. If efficiency not specified, motors shall have a higher efficiency than "average standard industry motors", in accordance with IEEE Standard 112, Test Method B.
14. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.
15. Provide AEGIS magnetic bearing protection ring for all inverter rated motors that are controlled by variable speed drives. The bearing protection ring shall channel harmful shaft voltages to ground to protect bearing races from pitting.

- C. Starters, Electrical Devices, And Wiring: (Provided By The HVAC Subcontractor For Each Packaged Piece Of HVAC Equipment Requiring Such):
1. Motor Starter Characteristics:
 - a. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs, or units in hazardous locations which shall have NEC proper class and division.
 - b. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.
 2. Manual Switches shall have:
 - a. Pilot lights and extra position for multi-speed motors.
 - b. Overload Protection: Melting alloy type thermal overload relays.
 3. Magnetic Starters:
 - a. Maintained contact push buttons and pilot lights, properly arranged for single speed or multi-speed operation as indicated.
 - b. Trip-free thermal overload relays, each phase.
 - c. Interlocks, pneumatic switches and similar devices as required for co-ordination with control requirements of Division 23 Controls Sections.
 - d. Built-in 120 volts control circuit transformer, fused from line side, where service exceeds 240 volts.
 - e. Externally operated manual reset.
 - f. Under-voltage release or protection.
 4. Capacitors:
 - a. Individual unit cells.
 - b. All welded steel housing.
 - c. Each capacitor internally fused.
 - d. Non-flammable synthetic liquid impregnant.
 - e. Craft tissue insulation.
 - f. Aluminum foil electrodes.
 - g. KVAR size shall be as required to correct motor power factor to 90 percent or better and shall be installed on all motors one horsepower and larger, that have an uncorrected power factor of less than 85 percent at rated load.
 5. Disconnect Switches:
 - a. Fusible Switches: Fused, each phase; general duty; horsepower rated; non-teasible quick-make, quick-break mechanism; dead front line side shield; solderless lugs suitable for copper or aluminum conductors; spring reinforced fuse clips; electro silver plated current carrying parts; hinged doors; operating lever arranged for locking in the "OPEN" position; arc quenchers; capacity and characteristics as indicated.
 - b. Non-fusible Switches: For equipment two horsepower and smaller, shall be horsepower rated; toggle switch type; quantity of poles and voltage rating as indicated. For equipment larger than two horsepower, switches shall be the same as fusible type.

2.2 VALVES

A. General:

1. Comply with ASME B31.9 for building services piping, and ASME B31.1 for power piping.
2. Valves shall have rising stem, or rising outside screw and yoke stems; except, non-rising stem valves may be used where headroom prevents full extension of rising stems.
3. Pressure and temperature ratings shall be as required to suit system pressures and temperatures.
4. Unless otherwise indicated, provide valves of same size as upstream pipe size. Automatic control valves shall be sized by the ATC Contractor and shall not exceed a 3 PSI drop.
5. Provide the following special operator features:
 - a. Handwheels fastened to valve stem, for valves other than quarter turn, by brass nut on a square-topped stem.
 - b. Lever handle on quarter-turn valves 6" and smaller, except for plug valves. Provide one wrench for every 10 plug valves, and one year's supply of recommended lubricant and sealant.
 - c. Chain-wheel operators for valves 2-1/2" and larger installed 72" or higher above finished floor elevation. Extend chains to an elevation of 5'-0" above finished floor elevation.
 - d. Gear drive operators on quarter-turn valves 8" and larger.
6. Where insulation is indicated or specified, provide extended stems arranged to receive insulation.
7. Bypass and drain connections shall comply with MSS SP-45.
8. End connections shall be as specified in the individual valves specifications.
 - a. Threads: Comply with ANSI B2.1.
 - b. Flanges: Comply with ANSI B16.1 for cast iron ANSI B16.5 for steel, and ANSI B16.24 for bronze valves.
9. Solder-Joint: Comply with ANSI B16.18.
Caution: Where soldered end connection are used, use solder having a melting point below 840° F. for gate, globe, and check valves; below 421° F. for ball valves.

B. Gate Valves:

1. Gate Valves (Heating Hot Water) - 2" and smaller: MSS SP-80; Class 150, body and union bonnet of ASTM B 62 cast bronze, threaded ends, solid disc, bronze alloy stem with less than 6% zinc content, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel.

THREADED		
MANUFACTURER	NRS	RS
Crane:	x	431UB
Jenkins:	x	47CU
Lunkenheimer:	x	3151
Nibco:	T-136	T-134
Stockham:	B-130	B-120
Milwaukee:	141M	1151M

2. Gate Valves (Heating Hot Water) 2-1/2" and larger: MSS SP-70; Class 125 iron body, bronze mounted, with body and bonnet conforming to ASTM A 126 Class B, flanged ends, and "Teflon" impregnated packing and two-piece backing gland assembly.

MANUFACTURER	OS&Y RS	NRS
Crane:	465-1/2	461
Jenkins:	651C	326C
Lunkenheimer:	1430	1428
Nibco:	F-617-0	F-619
Stockham:	G-623	G-612
Milwaukee:	F-2885-M	F-2882-M

C. Ball Valves:

1. Ball Valves (Heating Hot Water) 1" and smaller: Rated for 150 psi saturated steam pressure, 600 psi WOG pressure, 2-piece construction, bronze body conforming to ASTM B 62, standard (or regular) port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide threaded ends for heating hot water, soldered for chilled water.

	THREADED ENDS	SOLDER ENDS
MANUFACTURER		
Milwaukee:	BA-100	BA-150
Conbraco (Apollo)	70-100	70-200
Crane:	9302	9322
Jamesbury:	21-1000TT	x
Jenkins:	900A	902A
Lunkenheimer:	AQ311	x
Nibco:	T-585	S-585
Watts:	B-6000	B-6001
Stockham:	S-216 BR-R-T	S-216 BR-R-S

2. Ball Valves (Heating Hot Water) 1-1/4" to 2": Rated for 150 psi saturated steam pressure, 600 psi WOG pressure; 3-piece construction, bronze body conforming to ASTM B 62, conventional port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide threaded ends for heating hot water, soldered for chilled.

	THREADED ENDS	SOLDER ENDS
MANUFACTURER		
Milwaukee:	BA-300	BA-350
Conbraco (Apollo):	82-100	82-200
Nibco:	T-595-Y	S-595-Y
Watts:	B-6800	B-6801
Stockham:	S-216 BR-R-T	S-216 BR-R-T

For grooved end connections use Victaulic Style 721.

D. Plug Valves:

1. Plug Valves - 2" and smaller: 150 psi WOG, bronze body, straightaway pattern, square head, threaded ends.

MANUFACTURER	
Rockwell:	214.
Lunkenheimer:	454.
Crane:	250.

2. Plug Valves - 2-1/2" and larger: MSS SP-78; 175 psi, lubricated plug type, semi-steel body, single gland, wrench operated, flanged ends.

MANUFACTURER

Rockwell: 305.
Nordstrom: 143.
Serck-Audco: LSW-133-GG.
Homestead: 612.
(8" and larger to be Gear Operated).

E. Globe Valves:

1. Globe Valves (Heating Hot Water) - 2" and smaller: MSS Sp-80; Class 150, body and union bonnet of ASTM B 62 cast bronze, threaded ends, brass or replaceable composition disc, bronze alloy stem with less than 6% zinc content, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel.

MANUFACTURER

Jenkins: 106-B.
Lunkenheimer: 407.
Nibco: T-235-Y.
Stockham: B-22.

2. Globe Valves (Heating Hot Water) - 2-1/2" and larger: MSS SP-85; Class 125 iron body and bolted bonnet conforming to ASTM A 126, Class B; outside screw and yoke, bronze mounted, flanged ends, and "Teflon" impregnated packing and two-piece backing gland assembly.

MANUFACTURER	STRAIGHT BODY	ANGLE BODY
Milwaukee:	F-2981-M	x
Crane:	351	353
Jenkins:	613C	x
Lunkenheimer:	1123	x
Nibco:	F-718-B	x
Stockham:	G-512	G-515

F. Butterfly Valves:

1. Butterfly Valves (Heating Hot Water) - 2-1/2" and larger: MSS SP-67; 200 psi, cast iron body conforming to ASTM A 126, Class B. Valves shall have field replaceable EPDM sleeve, with aluminum bronze disc, stainless steel, and EPDM O-ring stem seals. Sizes 2 through 6" shall have lever operators with locks, and sizes 8 through 24" shall have gear operators with position indicator. Valves on dead end service or requiring additional body strength shall be lug-wafer type, drilled and tapped.

MANUFACTURER	LEVER	WAFER GEAR
Milwaukee:	x	MW-123-E
Center Line:	x	Series A
Crane:	42	x
Keystone:	100	x
Nibco:	WD-20003	WD-20003
Stockham:	LG-512-BS3E	LG-522-BS3E

	LEVER	LUG	GEAR
Milwaukee:	x		ML-123-E
Center Line:	x		Series LT
Crane:	44		x
Keystone:	129		x
Nibco:	LD-20003		LD-20005
Stockham:	LG-712-BS3E		LG-722-BS3E
Grooved Ends:	Victaulic Series 704.		

G. Check Valves:

- Swing Check Valves (Heating Hot Water) - 2" and smaller: MSS SP-80; Class 150, cast bronze body and cap, conforming to ASTM B 62, horizontal swing, with a Teflon disc, and having threaded ends. Valve shall be capable of being repaired while the valve remains in the line.

MANUFACTURER	
Milwaukee:	510T
Crane:	x
Jenkins:	352C
Lunkenheimer:	230-70
Nibco:	T-433-Y
Stockham:	B-321
For grooved connections use Victaulic Series 712.	

- Swing Check Valves (Heating Hot Water) - 2-1/2" and larger: MSS SP-71; Class 125 (Class 175 FM approved for fire protection piping systems), cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, with a bronze disc or cast iron disc with bronze disc ring, and flanged ends. Valve shall be capable of being refitted while the valve remains in the line.

MANUFACTURER	CLASS 125	CLASS 175
Milwaukee:	F-2974-M	x
Crane:	373	375
Jenkins:	624C	477
Lunkenheimer:	1790	x
Nibco:	F-918B	x
Stockham:	G-931	G-940

- Wafer Check Valves (Heating Hot Water) - (Non-Slam): Class 250, cast iron body, replaceable lapped bronze seat, lapped and balanced twin bronze flappers and stainless steel trim. Valve shall be designed to open and close at approximately one foot differential pressure. Twin flappers shall be loaded with a stainless steel torsion spring to minimize flapper drag and assure even non-slam checking action.

MANUFACTURER	
Milwaukee:	1400-2C
Center Line:	CLC
Metraflex:	hexx
Mission:	12HMP
Stockham:	WG970
For grooved connection use Victaulic Series 710 and 711.	

4. Lift Check Valves - 2" and smaller: Class 125, cast bronze body and cap conforming to ASTM B 62, horizontal, lift type valve, bronze disc and threaded ends. Valve shall be capable of being refitted and ground while the valve remains in the line.

MANUFACTURER	HORIZONTAL
Milwaukee:	544
Hammond:	901
Jenkins:	17C
Lunkenheimer:	142

2.3 METERS AND GAUGES

A. Glass Thermometers:

1. General: Provide glass thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
2. Case: Die cast aluminum finished in baked epoxy enamel, glass front, spring secured, 9" long.
3. Adjustable Joint: Die cast aluminum, finished to match case, 180° adjustment in vertical plane, 360° adjustment in horizontal plane, with locking device.
4. Tube and Capillary: Blue Spirit filled, magnifying lens, 1% scale range accuracy, shock mounted.
5. Scale: Satin faced, non-reflective aluminum, permanently etched markings.
6. Stem: Copper-plated steel, or brass, for separable socket, length to suit installation.
7. Range: Conform to the following:
 - a. Hot Water: 30° - 240° F. with 5° F. scale.
8. Manufacturer: Subject to compliance with requirements, provide glass thermometers of one of the following:
 - a. Ernst Gage Co.
 - b. Marshalltown Instruments, Inc.
 - c. Terice (H.O.) Co.
 - d. Weis Instruments, Inc.
 - e. Or equal

B. Thermometer Wells:

1. General: Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2" extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.
2. Manufacturer: Same as thermometers.

C. Pressure Gauges:

1. General: Provide pressure gauges of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
2. Type: General use, 1% accuracy, ANSI B40.1 grade A, phosphor bronze bourdon type, bottom connection.
3. Case: Drawn steel or brass, glass lens, 4-1/2" diameter.
4. Connector: Brass with 1/4" male NPT. Provide protective siphon when used for steam service.
5. Scale: White coated aluminum, with permanently etched markings.

6. Range: Conform to the following:

a. Water: 0 - 100 psi.

50 - 300 psi.

7. Manufacturer: Subject to compliance with requirements, provide pressure gauges of one of the following:

- a. Ametek/U.S. Gauge.
- b. Marsh Instrument Co., Unit of General Signal.
- c. Marshalltown Instruments, Inc.
- d. Trerice (H.O.) Co.
- e. Weiss Instruments, Inc.
- f. Or equal

D. Pressure Gauge Cocks:

- 1. General: Provide pressure gauge cocks between pressure gauges and gauge tees on piping systems. Construct gauge cock of brass with 1/4" female NPT on each end, and "T" handle brass plug.
- 2. Siphon: 1/4" straight coil constructed of brass tubing with 1/4" male NPT on each end.
- 3. Snubber: 1/4" brass bushing with corrosion resistant porous metal disc, through which pressure fluid is filtered. Select disc material for fluid served and pressure rating.
- 4. Manufacturer: Same as for pressure gauges.

E. Annular Element Flow Meters and Fittings:

- 1. General: Provide as indicated, flow metering elements constructed of brass and stainless steel, equipped with readout valves to facilitate connecting of differential pressure meter to flow meter. Equip each readout valve with integral shut-off valve designed to minimize system fluid loss during monitoring process. Provide ball type brass isolation valve. Provide calibrated nameplate with flow meter detailing its flow range through range of differential head pressures. Each element shall be of the bi-directional type having four diametrically opposed sensing ports on both upstream and downstream sides in order to ensure average velocity and static pressure. Elements shall be capable of operating at a maximum temperature of 300° F. and maximum pressure of 250 psig.
- 2. Manufacturer: Subject to compliance with requirements, provide flow meters of one of the following:
 - a. Preso Industries Corp.
 - b. Meriam Instrument.
 - c. Dieterich Standard Corp.
 - d. Or equal

F. Calibrated Balance Valves:

1. General: Provide as indicated, calibrated balance valves equipped with readout valves to facilitate connecting of differential pressure meter to balance valves. Equip each readout valve with integral EPT check valve designed to minimize system fluid loss during monitoring process. Provide calibrated nameplate to indicated degree of closure of precision machined orifice. Construct balancing valve with internal EPT O-ring seals to prevent leakage around rotating element. Provide balance valves with preformed polyurethane insulation suitable for use on heating and cooling systems, and to protect balance valves during shipment.
2. Manufacturer: Subject to compliance with requirements, provide calibrated balance valves of one of the following:
 - a. Bell & Gossett ITT; Fluid Handling Div.
 - b. Taco, Inc.
 - c. Armstrong Pumps Inc.
 - d. Or equal

2.4 HANGERS AND ATTACHMENTS

A. Horizontal-Piping Hangers and Supports:

1. General: Except as otherwise indicated, provide factory-fabricated horizontal piping hangers and supports complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacture for each piping service. Select size of hangers and supports to exactly fit pip size for bare piping, and to insulated piping. Provide copper-plated hangers and supports for copper-piping systems.
 - a. Adjustable Steel Clevises Hangers: MSS Type 1.
 - b. Steel Pipe Clamps: MSS Type 4.
 - c. Pipe Slides and Slide Plates: MSS Type 35, including one of the following plate types:
 - 1) Plate: Unguided type.
 - 2) Plate: Guided type.
 - 3) Plate: Hold-down clamp type.
 - d. Pipe Saddle Supports: MSS Type 36, including steel pipe base-support and cast-iron floor flange.
 - e. Pipe Stanchion Saddles: MSS Tube 37, including steel pip base support and cast-iron floor flange.
 - f. Adjustable Pipe Saddle Supports: MSS Type 38, including steelpipe base support and cast-iron floor flange.
 - g. Single Pipe Rolls: MSS Type 41.
 - h. Adjustable Roller Hangers: MSS Type 43.
 - i. Pipe Roll Stands: MSS Type 44.
 - j. Pipe Rolls and Plates: MSS Type 45.
 - k. Adjustable Pipe Roll Stands: MSS Type 46.

2. Manufacturer: Subject to compliance with requirements, provide hangers and supports of one of the following:
 - a. Carpenter and Patterson, Inc.
 - b. Corner & Lada Co., Inc.
 - c. Elcen Metal Products Co.
 - d. Fee & Mason Mfg. Co.; Div. Figgie International
 - e. ITT Grinnel Corp.
 - f. Or equal

B. Vertical-Piping Clamps:

1. General: Except as otherwise indicated, provide factory-fabricated vertical-piping clamps, complying with MSS SP-58, of one of the following types listed, selected by Installer to suit vertical piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Select size of vertical piping clamps to exactly fit pipe size of bare pipe. Provide copper-plated clamps for copper-piping systems.
 - a. Two-Bolt Riser Clamps: MSS Type 8.
 - b. Four-Bolt Riser Clamps: MSS Type 42.
2. Manufacturer: Subject to compliance with requirements, provide hangers and supports of one of the following:
 - a. Carpenter and Patterson, Inc.
 - b. Corner & Lada Co., Inc.
 - c. Elcen Metal Products Co.
 - d. Fee & Mason Mfg. Co.; Div. Figgie International
 - e. ITT Grinnel Corp.
 - f. Or equal

C. Hanger-Rod Attachments:

1. General: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-pipe hangers and building attachments, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hanger-rod attachments to suit hanger rods. Provide copper-plated hanger-rod attachments for copper-piping systems.
 - a. Steel Turnbuckles: MSS Type 13.
 - b. Swivel Turnbuckles: MSS Type 15.
 - c. Malleable Iron Sockets: MSS Type 16.
2. Manufacturer: Subject to compliance with requirements, provide hangers and supports of one of the following:
 - a. Carpenter and Patterson, Inc.
 - b. Corner & Lada Co., Inc.
 - c. Elcen Metal Products Co.
 - d. Fee & Mason Mfg. Co.; Div. Figgie International

- e. ITT Grinnel Corp.
- f. Or equal

D. Building Attachments:

1. General: Except as otherwise indicate, provide factory-fabricated building attachments complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit building substrate conditions, in accordance with MSS SP-69 and manufacturer's published product information. Select size of building attachments to suit hanger rods. Provide copper-plated building attachments for copper-piping systems.
 - a. Concrete Inserts: MSS Type 18.
 - b. Top Beam C-Clamp: MSS Type 19.
 - c. Side Beam or Channel Clamps: MSS Type 20.
 - d. Center Beam Clamps: MSS Type 21.
 - e. Welded Beam Attachments: MSS Type 22.
 - f. C-Clamps: MSS Type 23.
 - g. Top Beam Clamps: MSS Type 25.
 - h. Side Beam Clamps: MSS Type 27.
 - i. Steel Beam Clamps W/Eye Nut: MSS Type 28.
 - j. Linked Steel Clamps W/Eye Nut: MSS Type 29.
 - k. Malleable Beam Clamps: MSS Type 30.
 - l. Steel Brackets: One of the following for indicated loading:
 - 1) Light Duty: MSS Type 31.
 - 2) Medium Duty: MSS Type 32.
 - 3) Heavy Duty: MSS Type 33.
 - m. Side Beam Brackets: MSS Type 34.
 - n. Plate Lugs: MSS Type 57.
 - o. Horizontal Travelers: MSS Type 58.
 - p. Manufacturer: Subject to compliance with requirements, provide hangers and supports of one of the following:
 - 1) Carpenter and Patterson, Inc.
 - 2) Corner & Lada Co., Inc.
 - 3) Elcen Metal Products Co.
 - 4) Fee & Mason Mfg. Co.; Div. Figgie International
 - 5) ITT Grinnel Corp.
 - 6) Or equal

E. Saddles and Shields:

1. General: Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.
2. Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
3. Protection Shields: MSS Type 40; of length recommended by manufacturer to prevent crushing of insulation.
4. Manufacturer: Subject to compliance with requirements, provide thermal hanger shields of one of the following:
 - a. Elcen Metal Products Co.
 - b. Pipe Shields, Inc.

- c. Carpenter Patterson, Inc.
- d. ITT Grinnel Corp.
- e. Or equal

F. Miscellaneous Materials:

- 1. Metal Framing: Provide products complying with NEMA STD ML 1.
- 2. Steel Plates, Shapes, and Bars: Provide products complying with ASTM A 36.
- 3. Cement Grout: Portland cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.
- 4. Heavy Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.
- 5. Pipe Guides: Provide factory-fabricated guides, of cast semi-steel or heavy fabricated steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

2.5 MECHANICAL IDENTIFICATION

A. Plastic Pipe Markers:

- 1. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1
- 2. Pressure-Sensitive Type: Provide manufacturer's standard pre-printed, permanent adhesive, color-coded, pressure-sensitive vinyl pipe markers, complying with ANSI A13.1
- 3. Insulation: Furnish 1 in. thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125 degrees F (52 degrees C) or greater. Cut length to extend 2 in. beyond each end of plastic pipe marker.
- 4. Small Pipes: For external diameters less than 6 in. (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods:
 - a. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
 - b. Adhesive lap joint in pipe marker overlap.
 - c. Laminated or bonded application of pipe marker to pipe (or insulation).
 - d. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4 in. wide; full circle at both ends of pipe marker, tape lapped 1-1/2 in.

B. Application: Provide pipe labels for the following piping system:

- 1. Heating Hot water supply and return.
- 2. Refrigerant liquid and suction.
- 3. Condensate drain.

C. Valve Tags:

1. Brass Valve Tags: Provide 19-gage polished brass valve tags with stamp-engraved piping system abbreviation in 1/4 in. high letters and sequenced valve numbers 1/2 in. high, and with 5/32 in. hole for fastener.
 - a. Provide 1-1/2 in. diameter tags, except as otherwise indicated.
 - b. Provide size and shape as specified or scheduled for each piping system.
 - c. Fill tag engraving with black enamel.
2. Valve Tag Fasteners: Provide manufacturer's standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.

D. Valve Schedule Frames:

1. General: For each page of valve schedule, provide glazed display frame, with screws for removable mounting on masonry walls. Provide frames of finished hardwood or extruded aluminum, with SSB-grade sheet glass.

E. Plastic Equipment Markers:

1. General: Provide manufacturer's standard laminated plastic, color-coded equipment markers. Conform to the following color code:
 - a. Green: Cooling equipment and components.
 - b. Yellow: Heating equipment and components.
 - c. Yellow/Green: Combination cooling and heating equipment and components.
 - d. Blue: Equipment and components that do not meet any of the above criteria.
2. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
 - a. Equipment label "ID" from schedules.
 - b. Design capacity from schedules.
3. Size: Provide approximate 2-1/2 in. x 6 in. markers for each piece of equipment.
4. Application: Provide equipment labels for the following equipment:
 - a. Boilers
 - b. Pumps
 - c. Expansion Tanks
 - d. Rooftop Units (RTU)
 - e. Indoor Air Handling Units (AHU)
 - f. Exhaust Fans
 - g. Air Cooled Condensing Units
 - h. Terminal Heating Units GAS/HW/ELEC equipped with fans
 - i. Ductless Cooling Unit Systems (locate on inside panel)
 - j. Glycol Feeder
 - k. Air Separator
 - l. Variable Air Volume Boxes (VAV)
 - m. Heat Recovery Unit (located on inside panel)

F. Ductwork Labels:

1. Provide painted stencils or standard laminated plastic, color coded labels for the following systems:
 - a. Supply Ductwork
 - b. Return Ductwork
 - c. Exhaust Ductwork
 - d. Hazardous Exhaust
 - e. Outside Air Ductwork

2.6 MECHANICAL INSULATION

A. Piping Insulation Materials:

1. Glass Wool Piping Insulation:
 - a. Manufacturers:
 - 1) Knauf Insulation; Earthwool 1000 deg. Pipe Insulation with ECOSE Technology
 - 2) Knauf Insulation; Earthwool Redi-Klad 1000 deg. Pipe Insulation with ECOSE Technology
 - 3) Or similar as manufactured by Johns Manville, Manson, or Owens Corning
 - UL/ULC Classified per UL 723 or FHC 25/50 per ASTM E 84; EPD Certified by UL Environment; Living Building Challenge – Declare Red List Free for unjacketed Earthwool Pipe and composite Redi-Klad Pipe; meeting ASTM C 547, Type IV (1000 deg. F.) or Type I (850 deg. F.) ; ASTM C 585; ASTM C 411 and ASTM C 795; Verified to be formaldehyde free by UL Environment.
 - b. Vapor Retarder Jacket: ASJ+/SSL+ conforming to ASTM C 1136 Type I,II, III, IV, &VIII secured with self-sealing longitudinal laps and matching butt strips.
 - c. Redi-Klad Jacket: VentureClad 5-ply weather and abuse resistant with self-sealing lap. Zero permeability per ASTM E 96-05; puncture resistance 35.4 kg (189.3 N) per ASTM D 1000; tear strength 4.3 lb (19.4 N) per ASTM D 624; thickness 14.5 mils (0.0145"); tensile strength 68 lb/inch width [306 N (32 kg)/25 mm]
2. Flexible Unicellular Piping Insulation: ASTM C 534, Type as required.
 - a. Type I - tubular; Type II - sheet. For use between -40 degrees F and 200 degrees F.
3. Encase pipe fittings insulation with one-piece pre-molded PVC fitting covers, fastened as per manufacturer's recommendations.
4. Encase straight pipe insulation, where exposed in occupied areas, using Redi-Klad Pipe Insulation or cover "standard" insulation with one piece 20-mil thick PVC Jacketing. Fasten and seal as per manufacturer's recommendations.
5. Encase exterior piping insulation using Redi-Klad Pipe Insulation or cover "standard" insulation with aluminum jacket with weather-proof construction.
6. Staples, Bands, Wires and Cement: As recommended by insulation manufacturer for applications indicated.
7. Adhesives, Sealants and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

B. Piping Insulation Application and Thickness:

1. Application: Cold Piping (40 Degrees F to Ambient):
 - a. Insulate the following cold HVAC piping systems:
 - 1) Air conditioner condensate drain piping.
 - 2) Refrigerant liquid and suction piping.
 - 3) Geothermal Condenser Water Piping within building
 - b. Insulate piping system specified above with the following type and thickness of insulation:
 - 1) Glass Wool: 1-1/2 in. thick for all pipe sizes.
2. Application: Hot HVAC Piping (to 200 Degrees F)
 - a. Insulate the following hot HVAC piping systems
 - 1) HVAC hot water supply and return piping.
 - 2) Hot gas refrigerant piping.
 - b. Insulate each piping system specified above with the following type and thickness of insulation:
 - 1) Glass Wool: 1-1/2 in. thick for pipe sizes up to and including 1-1/4 in, 2 in. thick for all 1-1/2 in. pipe and larger.
 - 2) Flexible Unicellular: (Refrigerant piping only) 1 in. thick.

C. Insulation on Piping Exposed to Weather: Protect outdoor insulation from weather by installing Redi-Klad Pipe Insulation or adding an outdoor protective finish aluminum jacketing installed to "standard" insulation as recommended by the manufacturer. Insulation thickness shall be increased by one size versus specified pipe insulation thickness.

D. Ductwork and Equipment Insulation Materials:

1. Glass Wool Manufacturers:
 - a. Knauf Insulation
 - b. Or similar as manufactured by CertainTeed, Johns Manville, Manson or Owens Corning
2. Rigid Glass Wool Ductwork Insulation (R-9.1): UL/ULC Classified unfaced, ASJ+, ASJ and FSK; FHC 25/50 per ASTM E 84 for PSK only; meeting ASTM C 612, Type IA and IB; rigid. Verified to be formaldehyde free by UL Environment, Living Building Challenge – Declare Red List Free.
3. Flexible Glass Wool Ductwork Insulation (R-6): UL/ULC Classified; meeting ASTM C 553 Types I, II and III; ASTM C 1136 Type II and ASTM C 1290. UL GREENGUARD Gold Certified; Verified to be formaldehyde free by UL Environment; does not contain polybrominated diphenyl ethers (PBDE) such as Penta-BDE, Octa-BDE or Deca-BDE; Certified to meet all requirements of EUCEB. Flexible, limited combustible.
4. Jackets for Ductwork Insulation: ASTM C 1136 Type II, with vapor barrier.

5. Ductwork Insulation Accessories: Provide staples, bands, wire, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.
 6. Ductwork Insulation Compounds: Provide cements, adhesives, coatings, sealers, protective finishes and similar compounds as recommended by insulation manufacturer for applications indicated.
- E. Ductwork Insulation Application and Thickness:
1. Application: Ventilation and AC System Ductwork:
 - a. Insulate the following ductwork:
 - 1) HVAC supply ductwork between HVAC unit discharge and room terminal outlet.
 - 2) Insulate neck and bells of supply diffusers.
 - 3) HVAC return ductwork between room terminal inlet and HVAC unit inlet.
 - 4) HVAC plenums and unit housing not pre-insulated at factory or lined.
 - b. Insulate each ductwork system specified above with the following type and thickness of insulation:
 - 1) Rigid Glass Wool: In machine rooms, fan rooms, and mechanical spaces insulate all supply air, return air and outside air ductwork with 2 in. thick rigid (minimum R-9.1). All exposed ductwork in occupied areas shall be insulated with same thickness and material.
 - 2) Flexible Glass Wool: 2 in. Nominal Thickness (minimum R-6), application limited to concealed locations which shall include above ceilings, in chases, and shafts.
 - 3) All outside air ductwork and exhaust ductwork between in -line exhaust fan and point of exit in building shall be 2 in. rigid (R-9.1).
 2. Equipment Insulation Materials:
 3. Rigid Glass Wool Equipment Insulation (R-9.1): UL/ULC Classified; unfaced, ASJ+, ASJ and FSK; FHC 25/50 for PSK only; meeting ASTM C 612, Type IA and IB : rigid. Verified by UL Environment to be formaldehyde free, Living Building Challenge – Declare Red List Free.
 4. Flexible Glass Wool Equipment Insulation (R-5): UL/ULC Classified; meeting ASTM C 553 Types I, II and III; ASTM C 1136 Type II and ASTM C 1290. UL GREENGUARD Gold Certified; Verified to be formaldehyde free by UL Environment; does not contain polybrominated diphenyl ethers (PBDE) such as Penta-BDE, Octa-BDE or Deca-BDE; Certified to meet all requirements of EUCB. Flexible, limited combustible.
 5. Flexible Unicellular Equipment Insulation: ASTM C 534, Type as required.
 - TYPE I - TUBULAR.
 - TYPE II - SHEET.
 6. Jacketing material for Equipment Insulation: Provide pre-sized glass cloth jacketing material, not less than 7.8 ounces per square yard, Laminated Self-Adhesive Water and Weather Seal jacketing or metal jacket at Installer's option, except as otherwise indicated.
 7. Equipment Insulation Compounds; Provide adhesives, cements, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.
 8. Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape, corner angles, anchors and stud pins as recommended by insulation manufacturer for applications indicated.

F. Equipment Insulation Application and Thickness:

1. Application: Cold Equipment (Below Space Temperature):

a. Insulate the following cold equipment:

- 1) Drip pan under chilled equipment.
- 2) Expansion Tanks
- 3) Geothermal condenser Water pumps
- 4) Air Separator
- 5) Buffer Tank

b. Insulate each item of equipment specified above with the following type and thickness of insulation:

- 1) Glass Wool: 2 in. thick for cold surfaces above 35 degrees F and 3 in. thick for surfaces 35 degrees F and lower.
- 2) Flexible Unicellular: Same thicknesses as for Glass Wool.

2. Application: Hot Equipment

a. Insulate the following:

- 1) Expansion Tank
- 2) Air Separator
- 3) All Radiant Panels (laid on top of the panel) – Coordinate with unit manufacturer.

b. Insulate each item of equipment specified above with the following type and thickness of insulation:

- 1) Glass Wool 2 in. thick.
- 2) Faced Glass Wool 1 in. thick for radiant panels.

2.7 HYDRONIC PIPING AND ACCESSORIES

A. Manufacturer: Subject to compliance with requirements, provide piping system products from one of the following:

1. Grooved Mechanical Joint Pipe, Fittings and Couplings:

- a. Victaulic Company of America.
- b. Anvil Gruvlok
- c. Grinnell
- d. Or equal

2. Pump Discharge Valves (Triple-Duty Valve):

- a. Bell & Gossett ITT; Fluid Handling Div.
- b. Amtrol, Inc.
- c. Armstrong Pumps, Inc.
- d. Taco, Inc.
- e. Victaulic (Tri-Service Assembly)

- f. Or equal
- 3. Safety Relief Valves:
 - a. Bell & Gossett ITT; Fluid Handling Div.
 - b. Amtrol, Inc.
 - c. Spirax Sarco.
 - d. Watts Regulator Co.
 - e. Or equal
- 4. Pressure Reducing Valves:
 - a. Bell & Gossett ITT; Fluid Handling Div.
 - b. Amtrol, Inc.
 - c. Armstrong Pumps, Inc.
 - d. Taco, Inc.
 - e. Or equal
- 5. Air Vents (Automatic):
 - a. Bell & Gossett ITT; Fluid Handling Div.
 - b. Armstrong Machine Works.
 - c. Hoffman Specialty ITT; Fluid Handling Div.
 - d. Spirax Sarco.
 - e. Or equal
- 6. Air Separators:
 - a. Bell & Gossett ITT; Fluid Handling Div.
 - b. Amtrol, Inc.
 - c. Armstrong Pumps, Inc.
 - d. Taco, Inc.
 - e. Or equal
- 7. Diaphragm-Type Compression Tanks:
 - a. Bell & Gossett ITT; Fluid Handling Div.
 - b. Amtrol, Inc.
 - c. Armstrong Pumps, Inc.
 - d. Or equal
- 8. Pump Suction Diffusers:
 - a. Bell & Gossett ITT; Fluid Handling Div.
 - b. Amtrol, Inc.
 - c. Armstrong Pumps, Inc.
 - d. Taco, Inc.
 - e. Victaulic (style 731-D / W731-D)
 - f. Or equal
- 9. Chemical Feeder:
 - a. Dearborn USA.
 - b. Vulcan Laboratories, Subsidiary of Clow Corp.

- c. York-Shipley, Inc.
- d. Or equal

10. Basket Strainers:

- a. Crane Co.
- b. Metraflex Co.
- c. Spirax Sarco.
- d. Victaulic Company of America. (732/W732/730/W730)
- e. Or equal

B. PIPE AND TUBING MATERIALS

- 1. Copper Tubing: ASTM grade B 88, Type L hard drawn temper copper tubing.
- 2. Copper Tubing: ASMT grade B 88, Type K, annealed copper tubing.
- 3. Steel Pipe: ASTM A-53 grade B, Schedule 40, seamless, black steel pipe, beveled ends.
- 4. CPVC Plastic Pipe: ASTM D 2846, Chlorinated Poly (Vinyl Chloride) (CPVC) pipe.

C. FITTINGS

- 1. Cast-Iron Threaded Fittings: ANSI B16.4, Class 125, standard pattern, for threaded joints. Threads shall conform to ANSI B2.1.
- 2. Malleable-Iron Threaded Fittings: ANSI B16.3, Class 150, standard pattern, for threaded joints. Threads shall conform to ANSI B2.1.
- 3. Steel Fittings: ASTM A 234, seamless or welded, for welded joints.
- 4. Grooved Mechanical Fittings: ASTM A 106, or ASTM A 53/A53M, Type F, E or S, Grade B fabricated steel, or ASTM A 234, Grade WPB forged steel fittings with grooves or shoulders designed to accept grooved end couplings.
- 5. Grooved Rigid Mechanical Couplings: Consist of a two- piece ductile iron housing per ASTM A536, a synthetic rubber gasket of a central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

a. Rigid Couplings:

- 1) Housings 12" and smaller cast with offsetting angled-pattern bolt pads to provide visual confirmation upon metal-to-metal pad contact with no torque requirement. Victaulic Style 107H and Style 07 or equal. Designs that permit spaces at bolt pads or require a torque per manufacturer's written installation instructions not permitted
- 2) Housings 14" and larger cast with wedge-shaped groove profile, lead-in chamfer and flat pad design for metal-to-metal pad contact. Victaulic Style W07 or equal.

b. Flexible Couplings:

- 1) Use in locations where vibration attenuation and stress relief are required. Victaulic Style 177, 77 or W77 or equal. Three flexible couplings may be used in lieu of each flexible connector for vibration attenuation. Couplings shall be placed in close proximity to the vibrating source in accordance with published guidelines.

- c. Flange Adapters: Ductile iron housing, flat face, for use with grooved end pipe and fittings, for mating directly with ANSI Class 125, 150, and 300 flanges. Victaulic Style 741, 743 or W741 or equal.

6. Wrought-Copper Fittings: ANSI B16.22, streamlined pattern.
7. CPVC Plastic Fittings: ASTM D 2846, Chlorinated Poly Vinyl Chloride (CPVC) socket-type fittings and solvent for solvent cemented joints.
8. Cast-Iron Threaded Flanges: ANSI B16.1, Class 125; raised ground face, bolt holes spot faced.
9. Cast Bronze Flanges: ANSI B16.24, Class 150; raised ground face, bolt holes spot faced.
10. Steel Flanges and Flanged Fittings: ANSI B16.5, including bolts, nuts, and gaskets of the following material group, end connection and facing:
 - a. Material Group: 1.1.
 - b. End Connections: Butt Welding.
 - c. Facings: Raised face.
11. Solder Filler Metals: ASTM B 32, 50-50, Tin-Lead, for condenser water, chilled water, and make-up water and drain piping.
12. Solder Filler Metals: ASTM B 32, 95-5 Tin-Antimony, for heating hot water and low pressure steam piping.
13. Brazing Filler Metals: AWS A5.8.
14. Gasket Material: EPDM Thickness, material, and type suitable for fluid to be handled, and design temperatures and pressures.
15. Flexible Connectors: Stainless steel bellows with woven flexible bronze wire reinforcing protective jacket; minimum 150 psig working pressure, maximum 250° F. operating temperature. Connectors shall have flanged, grooved or threaded end connections to match equipment connected; and shall be capable of 3/4" misalignment.
 - a. Three (3) flexible couplings may be used in lieu of each flexible connector for vibration attenuation. Couplings shall be placed in close proximity to the vibrating source in accordance with published guidelines.

D. PIPE SLEEVES AND ESCUTCHEONS

1. General: Provide schedule 40 black steel or 18 gage galvanized pipe sleeve large enough to accept pipe along with specified pipe insulation at each point where pipe penetrates a wall or floor. Sleeve shall be large enough to allow for free movement of pipe however minimized to prevent leakage of smoke and fire during a fire emergency. For all piping exposed to view provide a chrome plated escutcheon that will surround insulation where applicable on pipe for a neat finished appearance. Where piping is concealed above ceilings no escutcheons are required.

E. SPECIAL DUTY VALVES

1. General: General duty valves (i.e., gate, check, ball, and butterfly valves) are specified in Division 23 Section "Valves" Special duty valves are specified in this Article by their generic name; refer to the drawings for specific applications of these valves.

2. Pump Discharge Valves (Triple-Duty Valve): 175 PSIG working pressure, 300° F. maximum operating temperature, cast-iron body, bronze disc and seat, stainless steel stem and spring, and "Teflon" packing. Valves shall have flanged connections and straight or angle pattern as indicated. Features shall include non-slam check valve with spring-loaded weighted disc, and calibrated adjustment feature to permit regulation of pump discharge flow and shutoff.
 - a. In grooved installations, Tri-Service Assemblies may be used in lieu of Triple-Duty Valves. Straight pattern, (300-psi) pressure rating, combination shut-off, throttling, and non-slam check service in one unit. Victaulic Vic®-300 MasterSeal™ or equal, butterfly valve assembled with Series 779 Venturi Check valve or equal, with flow measurement capabilities and Victaulic or equal couplings (style to be determined by system requirements) for 2" through 12". Straight pattern, 230-psig pressure rating combination shut-off, throttling, and non-slam check service in one unit. Victaulic AGS-300 or equal butterfly valve assembled with Series W715 or equal check valve and Victaulic or equal couplings for 14" and larger.
3. Pressure Reducing Valves: Diaphragm operated, cast-iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shut-down, and non-corrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure and have the capability for field adjustment.
4. Safety Relief Valves: 125 psig working pressure and 250° F. maximum operating temperature: designed, manufactured, tested, and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code. Valve body shall be cast-iron, with all wetted internal working parts made of brass and rubber. Select valve to suit actual system pressure and BTU capacity.
5. Combined Pressure/Temperature Relief Valves: Diaphragm operated, cast-iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shut-down, and non-corrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure and have the capability for field adjustment. Safety relief valve designed, manufactured, tested, and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code. Valve body shall be cast-iron, with all wetted internal working parts made of brass and rubber; 125 psig working pressure and 250° F. maximum operating temperature. Select valve to suit actual system pressure and BTU capacity. Provide with fast fill feature for filling hydronic system.

F. HYDRONIC SPECIALTIES:

1. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150 psig working pressure, 240° F. operating temperature; and having 1/4" discharge connection and 1/2" inlet connection.
2. Diaphragm-Type Compression Tanks: Size and number as indicated; construct of welded carbon steel for 125 psig working pressure, 375° F. maximum operating temperature. Separate air charge from flexible diaphragm securely sealed into tank. Provide taps for pressure gage and air charging fitting, and drain fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Tank, with taps and supports, shall be constructed, tested, and labeled in accordance with ASME Pressure Vessel Code, Section VIII, Division 01.

3. Pump Suction Diffusers: Cast-iron or ductile iron body, with threaded connections for 2" and smaller, flanged or grooved connections for 2-1/2" and larger; 175 psig working pressure, 300° F. maximum operating temperature for flanged and 300 psig working pressure, 230F for grooved; and complete with the following features:
 - a. Inlet vanes with length 2-1/2 times pump suction diameter or greater.
 - b. Cylinder strainer with 3/16" diameter openings with total free area equal to or greater than 5 times cross-sectional area of pump suction, designed to withstand pressure differential equal to pump shutoff head.
 - c. Disposable fine mesh strainer to fit over cylinder strainer.
 - d. Permanent magnet, located in flow stream, removable for cleaning.
 - e. Adjustable foot support, designed to carry weight of suction piping.
 - f. Blowdown tapping in bottom; gage tapping in side.
4. Chemical Feeder: (Provide one (1) for each piping system). Bypass type chemical feeders of 5 gallon capacity, welded steel construction; 125 psig working pressure; complete with fill funnel and inlet, outlet, and drain valves.
5. Chemical Treatment
 - a. Furnish the necessary apparatus to provide water treatment to the hot water piping systems as well as the boilers as furnished by New England Systems and Supply, Inc., GE Betz Water Technologies, or other fully capable water treatment organization approved by the Engineer.
 - b. A contract agreement satisfactory in form and substance shall be executed between this HVAC subcontractor and water treatment company to furnish supervisory service to assure the use of the proper chemical treatment thereof. The water treatment company shall perform the following specified services through its agent:
 - 1) Supervise the cleaning and flushing of all systems and the initial introduction of water treatment chemicals.
 - 2) Furnish all required chemicals for the cleaning and proper initial treatment of all systems hereinafter described, together with all necessary testing equipment and reagents for field analysis of the water.
 - 3) Submit a written report of test results of the field analyses to the Engineer when the systems are cleaned and treated with corrosion inhibitors. Submit certificate of completion for all systems indicating that all treatment systems are properly functioning and that the associated systems are properly treated.
 - c. The hot water piping systems shall be cleaned with sufficient chemicals to ensure the removal of all cutting oil, compound, etc. These chemicals shall not be harmful to the various materials of the systems. The treatment company representative shall supervise this operation including the flushing of the system and shall test the final rinsed system to ensure that the remnants of the cleaning solution do not impart alkalinity to the water in excess of 300 PPM.
 - d. Hot water systems shall be treated with sufficient amounts of the proper chemicals to conform to the Dianodic method for corrosion protection. Take various samples of water to assure proper level of chemical treatment.
 - e. Each boiler shall be treated with sufficient amounts of the proper chemicals to provide positive protection against corrosion, scale formation and carry over.
 - f. At the end of the first year of the contract agreement, the chemical treatment company shall provide to the owner and copy to Architect, a log of type, quantity and dosage of treatment and test results of treatment performed through the first year.

- g. Following the first year of service, chemical treatment company shall provide recommended maintenance and treatment schedule to owner and a copy to architect for testing and treating the water. This schedule shall be posted in the boiler room along with the testing and treatment log.
 - h. Upon completion of first year of service, the chemical treatment company shall instruct the owner to the owner's responsibility to test and treat water or to contract with chemical treatment company to perform testing and treatment services.
- 6. Y-Pattern Strainers: Cast-iron body (ASTM A 126, Class B), flanged ends for 2-1/2" and larger, threaded connections for 2" and smaller, bolted cover, perforated Type 304 stainless steel basket, bottom drain connections; 125 psig working pressure.
- 7. Basket Strainers: High tensile cast-iron body (ASTM A 126, Class B), flanged end connections, bolted cover, perforated Type 304 stainless steel basket, bottom drain connections; 125 psig working pressure.
- 8. Grooved-End Strainers:
 - a. Y-Pattern: Ductile iron body ASTM A536, grooved ends for 2" and larger, coupled cover, perforated Type 304 stainless steel basket, bottom drain, 300 psig working pressure.
 - b. T-Pattern: Ductile iron body ASTM A536, grooved ends for 2" and larger, coupled or T-bolt hinged cover, perforated 304 stainless steel basket, bottom drain, up to 750 psig working pressure.
- 9. Grooved-End Expansion for Steel Piping 2" and larger (Water Service):
 - a. 2" Through 6": Packless, gasketed, slip-type expansion joint with grooved end telescoping body for installation with Victaulic Style 107 or 07 rigid couplings. Provides axial end movement to 3", designed for water services up to 230 deg.F and working pressure to 350 psi. Victaulic Style 150 Mover®.
 - b. 2" Through 24": Combination of short nipples and Victaulic Style 177 or 77 flexible couplings joined in tandem for increased expansion. Joint movement and expansion capabilities dependent on number of couplings/nipples used in the joint. Pressure rating dependent on size and style of flexible couplings used. Victaulic Style 155.
 - c. Expansion Loops: Pipe bends and loops in grooved piping systems shall consist of (8) Victaulic Style 177, 77 or W77 flexible couplings, (4) Victaulic 90 deg. elbows, and (3) grooved end pipe spools provided in water systems to +250 deg.F in accordance with the latest Victaulic recommendations for expansion compensation. Rigid couplings shall not be used on loop corners.
 - d. Expansion Joints: Provide pipe expansion joints at all building expansion joints. Utilize a seismic expansion fitting similar to Metra-Flex, Metra Loop Grooved ends or equal. The expansion fitting shall provide absorption in the lateral offset and angular movement.

10. Glycol/Make-up Pump - Provide a packaged automatic glycol solution make up unit consisting of a base, polyethylene reservoir with removable lid and visible solution level scale in gallons, y-stainers, isolation valves, fill pump with a minimum capacity of 5 gpm @ 100 psi discharge, open drip proof motor, pump isolation, check and balancing valves, discharge pressure gauge, motor contactor, pressure control and necessary interconnecting piping. Pump shall be a bronze gear driven design and shall have a standard 120 volt power electrical cord and all necessary controllers and safeties. The unit shall provide alarm outputs for BMS connection.
 - a. **The heating hot water system shall be provided with a propylene glycol concentration of 35%, by weight. The interior geothermal water piping shall be filled by the HVAC Contractor with a propylene glycol concentration of 20%, by weight. Geothermal system fill water shall meet the quality requirements of the VRF manufacturer's specification or the IGSHPA recommended water quality values (2017), whichever is greater.**
11. AIR and DIRT SEPARATORS - Air and dirt removal device shall be constructed of steel. It shall be designed, fabricated and stamped per ASME Section VIII Division 1 with a maximum working pressure of 125 psi at 270 deg.F. Manufacturer shall be holder of ASME U stamp. Manufacturer to have optional 250 psi and 150 psi ASME units available. Units up to three 3-inch in size shall be provided with threaded connections as standard. Units four 4-inch and larger shall be provided with flanged system connections as standard. Inlet and outlet connections to be inline with piping system. Both inlet and outlet to be in the same horizontal and vertical planes. Each air and dirt removal device shall be equipped with a brass conical shaped air venting chamber designed to minimize system fluid from fouling the venting assembly. The air vent shall be able to be closed to allow flushing and purging of dirt via side port without dirt passing through vent on initial system fill. A brass flushing cock shall be located on the side of each separator to facilitate system fast-fill and removal of the floating impurities from the air system interface within the separator. A blow down valve shall be provided by the unit manufacturer on the bottom of each unit to allow blow down and cleaning. On units 2 ½" and smaller the valve and all of its fittings shall be 1". On units three 3" and larger the valve and all openings shall be 2".

2.8 REFRIGERANT PIPING

- A. General: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, temperature ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide materials and products complying with ANSI B31.5 Code for refrigeration piping where applicable; base pressure rating on refrigerant piping system maximum design pressures. Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials used in refrigerant piping systems. Where more than one type of materials and products are indicated, selection is Installer's option.
- B. Material: Provide pipes and pipe fittings in accordance with the following listing:
 1. Tube Size 4-1/8" and Smaller: Copper tube; Type ACR, hard-drawn temper; wrought-copper, solder-joint fittings; brazed joints.
- C. Soldered Joints: Solder joints using silver-lead solder, ASTM B32, Grade 96 TS.
- D. Brazed Joints: Braze joints using American Welding Society (AWS) classification BCUO-4 for brazing filler metal.

- E. Piping Specialties: Provide piping specialties complying with Division-23 "Hydronic Piping" in accordance with the following listing:
1. Pipe escutcheons.
 2. Drip pans.
 3. Sleeves.
 4. Sleeve seals
- F. Refrigerant Valves and Accessories: Special valves required for refrigerant piping include the following types.
1. Globe Shutoff Valves: Forged brass, packed, back seating, winged seal cap, 300 degrees F (149 degrees C) temperature rating, 500 psi working pressure. Provide shut-off valves at all terminal units and equipment for services.
 2. Check Valves: Forged brass, accessible internal parts, soft synthetic seat, fully guided piston and stainless steel spring, 250 degrees F (121 degrees C) temperature rating, 500 psi working pressure.
 3. Manufacturer: Subject to compliance with requirements, provide globe and check valves of one of the following:
 - a. Henry Valve CO.
 - b. Parker Hannifin Corp.; Refrigeration & Air Cond. Div.
 - c. Sporlan Valve Co.
 - d. Or equal
 4. 2-Way Solenoid Valves: Forged brass, designed to conform to ARI 760, normally closed, teflon valve seat, NEMA 1 solenoid enclosure, 24 volt, 60 Hz., UL-listed, ½" conduit adapter, 250 degrees F (121 degrees C) temperature rating, 400 psi working pressure.
 5. Manufacturer: Subject to compliance with requirements, provide solenoid valves of one of the following:
 - a. Alco Controls Div.; Emerson Electric Co.
 - b. Automatic Switch Co.
 - c. Sporland Valve CO.
 - d. Or equal
 6. Refrigerant Strainers: Brass shell and end connections, brazed joints, monel screen, 100 mesh, UL-listed, 350 psi working pressure.
 7. Moisture-Liquid Indicators: Forged brass, single port, removable cap, polished optical glass, solder connections, UL-listed, 200 degrees F (93 degrees C) temperature rating, 500 psi working pressure.
 8. Refrigerant Filter-Driers: Steel shell, ceramic fired desiccant core, solder connections, UL-listed, 500 psi working pressure.
 9. Refrigerant Filter-Driers: Corrosion-resistant steel shell, steel flange ring and spring, wrought copper fittings, ductile iron coverplate with steel cap screws, replaceable filter-drier core, 500 psi working pressure.
 10. Evaporator Pressure Regulators: Provide corrosion-resistant, spring loaded, stainless steel springs, pressure operated, evaporator pressure regulator, in size and working pressure indicated, with copper connections.
 11. Refrigerant Discharge Line Mufflers: Provide discharge line mufflers as recommended by equipment manufacturer for use in service indicated, UL-listed.
 12. Manufacturer: Subject to compliance with requirements, provide refrigeration accessories of one of the following:
 - a. Alco Controls Div.; Emerson Electric CO.

- b. Henry Valve CO.
- c. Parker-Hannifin Corp.; Refrigeration & Air Conditioning Div.
- d. Sporlan Valve Co.
- e. Or equal

2.9 PUMPS

- A. General: Provide factory-tested pumps, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment. Type, size, and capacity of each pump is listed in pump schedule. Provide pumps of same type by same manufacturer.
- B. In-Line Circulator Pumps:
 - 1. General: Provide in-line circulator pumps where indicated, and of capacities as scheduled.
 - 2. Type: Horizontal mount, vertical split case, oil-lubricated, designed for 125 psi working pressure, and 225° F. (107° C) continuous water temperature.
 - 3. Body: Cast-iron, with suction and discharge gauge tapings.
 - 4. Shaft: Hardened alloy steel. Provide shaft grounding rings similar to Aegis or equal.
 - 5. Bearings: Oil-lubricated bronze journal bearings.
 - 6. Seal: Mechanical, with carbon seal ring and ceramic seat.
 - 7. Motor: Non-overloading at any point on pump curve, open, drip-proof, oil-lubricated journal bearings, resilient mounted construction, built-in thermal overload protection on single phase motors.
 - 8. Couplings: Self-aligning, flexible coupling.
 - 9. Impeller: Enclosed type hydraulically and dynamically balanced, and keyed to shaft.
 - 10. Install pumps on channel steel support stands with vibration isolators. Refer to pump piping drawing details for valve and accessory requirements.
 - 11. Manufacturer: Subject to compliance with requirements, provide in-line circulator pumps of one of the following:
 - a. Bell & Gosset ITT; Fluid Handling Div.
 - b. Armstrong Pumps, Inc.
 - c. Taco, Inc.
 - d. Or equal
- C. Frame-Mounted End Suction Pumps:
 - 1. General: Provide frame-mounted end suction pumps where indicated, and of capacities and having characteristics as scheduled.
 - 2. Type: Horizontal mount, single stage, vertical split case, flexible coupling, base mounted, designed for 175 psi working pressure.
 - 3. Casing: Cast iron, 125 psi ANSI flanges, tapings for gage and drain connections.
 - 4. Shaft: Steel with replaceable shaft sleeve. Provide shaft grounding rings similar to Aegis or equal.
 - 5. Bearing: Regreasable ball bearings.
 - 6. Seal: Mechanical, with carbon seal ring and ceramic seat.
 - 7. Motor: Open, dripproof, regreasable ball bearings under motor, motor shall be premium efficiency inverted duty type. Provide AEGIS magnetic bearing protection ring for inverter rated motors that are controlled by variable speed drives. The bearing protection ring shall channel harmful shaft voltages to ground to protect bearing races from pitting.
 - 8. Impeller: Enclosed type, hydraulically and dynamically balanced keyed to shaft and secured with locking screw.
 - 9. Baseplate: Structural steel with welded cross members, and open grouting area.

10. Coupling: Flexible, capable of absorbing torsional vibration, equipped with coupling guard.
 11. Manufacturer: Subject to compliance with requirements, provide frame-mounted end suction pumps of one of the following:
 - a. Bell & Gosset ITT; Fluid Handling Div.
 - b. Armstrong Pumps, Inc.
 - c. TACO
 - d. Or Equal.
- 2.10 HIGH EFFICIENCY, GAS-FIRED CONDENSING BOILER (Refer to SECTION 01 91 13 GENERAL COMMISSIONING REQUIREMENTS for additional contract requirements)
- A. Construction:
1. The boiler shall bear the ASME "H" stamp for 160 psi working pressure and shall be National Board listed. The boiler shall have a fully welded 316L stainless steel, fire tube heat exchanger. There shall be no banding material, bolts, gaskets or "O" rings in the heat exchanger construction. The heat exchanger shall be designed for a single-pass water flow and will drain condensation to the bottom of the vessel. Pressure drop shall be no greater than 2.2 PSI at 75 GPM. The condensate collection basin shall be constructed of welded stainless steel. The complete heat exchanger assembly shall carry a ten (10) year limited warranty.
 2. The boiler shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.13 test standard for the U.S. and Canada. The boiler shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard and the minimum efficiency requirements of the latest edition of the AHRI BTS-2000 Standard. The BOILER shall operate at a minimum of 92% thermal efficiency at full fire as registered with AHRI for the Crest models and 97% combustion and thermal efficiency at full fire as registered with AHRI for the FTXN models. The boiler shall be certified for indoor installation.
 3. The boiler shall be constructed with a heavy gauge steel jacket assembly, primed and pre-painted on both sides. The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assembly, so that integrity of the outer jacket does not affect a proper seal. Two burner/flame observation ports shall be provided. The burner shall be a premix design and constructed of high temperature stainless steel with a woven metal fiber outer covering to provide modulating firing rates. The boiler shall be supplied with a gas valve designed with negative pressure regulation and be equipped with a variable speed blower system, to precisely control the fuel/air mixture to provide modulating boiler firing rates for maximum efficiency. The boiler shall operate in a safe condition at a derated output with gas supply pressures as low as 4 inches of water column. The burner flame shall be ignited by direct spark ignition with flame monitoring via a flame sensor. Boiler manufacturer to provide neutralization kit and condensate trap for each boiler condensate.

B. Controls:

1. The boiler shall utilize a 24 VAC control circuit and components. The control system shall have a liquid crystal touch screen display for boiler set-up, boiler status, and boiler diagnostics. All components shall be easily accessed and serviceable from the front and top of the jacket. The boiler shall be equipped with a temperature/pressure gauge; high limit temperature control with manual reset; ASME certified pressure relief valve set for 50 psi (standard); outlet water temperature sensor; return water temperature sensor; outdoor air sensor, flue temperature sensor; high and low gas pressure switches, low water cut off with manual reset, blocked drain switch and a condensate trap for the heat exchanger condensate drain.
2. The boilers shall feature the "SMART TOUCH™" control or the "SMART SYSTEM" CONTROL with a liquid crystal touch screen display, password security, outdoor air reset, pump delay with freeze protection, pump exercise, domestic hot water prioritization and PC port connection. The boiler shall have alarm contacts for any failure, runtime contacts and data logging of runtime, ignition attempts, ignition failures, and modulation. The boiler shall have a built-in "Cascade" to sequence and rotate the while maintaining modulation of up to eight boilers without utilization of an external controller. The internal "Cascade" function shall be capable of lead-lag, efficiency optimization, front-end loading, and rotation of lead boiler every 24 hours. The boiler shall be capable of controlling isolation valves during heating operation and rotation of open valves in standby operation for full flow applications. The control must come with standard Modbus communication protocol. The boiler shall be provided with a gateway device which will allow integration with BacNet protocols. Boiler manufacturer to provide assistance and coordination with ATC Contractor for point mapping and programming from boiler controller to BMS system.
3. The boiler shall be equipped with two terminal strips for electrical connection. A low voltage connection board with 30 data points for safety and operating controls, i.e., Alarm Contacts, Runtime Contacts, Louver Proving Switch, Tank Thermostat, Remote Enable/Disable, System Supply Sensor, Outdoor Sensor, Tank Sensor, Modbus Building Management System signal and Cascade control circuit. A high voltage terminal strip shall be provided for Supply voltage. Supply voltage shall be 120 volt / 60 hertz / single phase. The boiler may be factory trimmed for optional supply voltages, i.e. 208 volt / 60 hertz / 3 phase, 480 volt / 60 hertz / 3 phase and 600 volt / 60 hertz / 3 phase. The high voltage terminal strip plus integral relays are provided for independent pump control of the System pump, the Boiler pump and the Domestic Hot Water pump. Boiler manufacture to provide boiler pump circulator as scheduled, boiler manufacture to provide pump motor control panel/center with on/off/auto switch with pilot light. Pump power feed by electrical contractor.

C. Gas Train:

1. The gas train shall consist of a pressure regulating elctro-hydraulic proportional air/gas main gas actuator providing a slow opening, fast closing shutoff valve and proportional 1:1 air/gas ration control, a fast closing safety shutoff as pressure regulator with 1 PSI allowable static pressure, and a low gas pressure switch. A factory pre-set combination metering valve and orifice shall be provided for setting combustion parameters. Boiler shall be capable of operating at 4.0" w.c.

D. Manufacturer: Subject to compliance with requirements, provide boilers of one of the following:

1. Lochinvar
2. Aerco
3. Fulton

4. Or Equal.

2.11 ROOF TOP UNITS WITH ENERGY RECOVERY

~~A. SUMMARY~~

1. ~~This section includes units with packaged water source heat pump heating and cooling sections for rooftop installation. Integral Energy Recovery device shall be a rotary air-to-air total enthalpy wheel. Primary heating & cooling source shall be a dedicated Variable Refrigerant Flow Heat recovery system connected to the unit via a refrigerant piping system. A hot water coil with modulating control valve is provided for back-up heat. Airflow arrangement shall be Outdoor Air only. Each unit shall be constructed in a horizontal configuration.~~

~~B. SUBMITTALS~~

1. Product Data: For each type or model include the following:
 - a. ~~Complete fan performance curves for Supply and Exhaust Air, with system operating conditions indicated, as tested on an AMCA Certified Chamber.~~
 - b. ~~Sound performance data for Supply/Return/Exhaust Air, as tested on an AMCA Certified chamber. Include cabinet radiated sound data as tested on an AMCA Certified chamber~~
 - c. ~~Motor ratings, electrical characteristics and motor and fan accessories.~~
 - d. ~~Performance ratings for all DX coils.~~
 - e. ~~Dimensioned drawings for each type of installation, showing isometric and plan views, to include location of attached ductwork and service clearance requirements.~~
 - f. ~~Estimated gross weight of each installed unit.~~
 - g. ~~Installation, Operating and Maintenance manual (IOM) for each model.~~
 - h. ~~Microprocessor Controller (DDC) specifications to include available options and operating protocols. Include complete data on all factory-supplied input/output devices.~~
 - i. ~~AHRI Certified coil performance ratings with system operating conditions indicated. Ratings shall be in accordance with Standard 410.~~
 - j. ~~Color chart including a palette of available standard paint finishes.~~
 - k. ~~Energy wheel performance data for both summer and winter operation.~~

~~C. QUALITY ASSURANCE~~

1. ~~Source Limitations: Obtain unit with all appurtenant components or accessories from a single manufacturer.~~
2. ~~For the actual fabrication, installation, and testing of work under this section, use only thoroughly trained and experienced workers completely familiar with the items required and with the manufacturer's current recommended methods of installation.~~
3. ~~Product Options: Drawings must indicate size, profiles and dimensional requirements of Energy Recovery Unit and are to be based on the specific system indicated. Refer to Division 1 Section "Product Requirements".~~
4. ~~Certifications~~
 - a. ~~Blowers shall be AMCA Certified for air flow.~~
 - b. ~~Entire unit shall be ETL Certified per U.L. 1995 and bear an ETL sticker.~~
 - c. ~~Energy Wheel shall be AHRI Certified, per Standard 1060.~~
 - d. ~~Coils shall be Recognized Components for ANSI/UL 1995, CAN / CSA C22.2 No 236.05. DX.~~

~~D. COORDINATION~~

- ~~1. Coordinate size and location of all building penetrations required for installation of each unit and associated plumbing and electrical systems.~~
- ~~2. Coordinate sequencing of construction of associated plumbing, HVAC, electrical supply with roofing contractor.~~

~~E. EXTRA MATERIALS~~

- ~~1. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.~~

~~a. Filters: Two complete set(s) of MERV 8 & 14 disposable filters for each unit.~~

~~F. Basis of Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:~~

- ~~1. Valent, Annex Air, Addison~~

~~G. Unit Construction:~~

- ~~1. Base: Manufacturer's standard base shall be constructed of minimum 10 gage galvanized steel with 16 gage integral floor pan. All floor seams shall have a raised rib joint. Penetrations through the floor shall have a minimum 3/8" raised rib around each opening. Base shall have a minimum 4" overhang over the top of a roof curb to prevent water infiltration.~~
- ~~2. Panels: Manufacturer's standard casing shall be constructed of minimum 2-inch, foam-injected, double-wall panels.~~
 - ~~a. Individual panels shall be constructed so that there is no metal-to-metal contact between the interior and exterior sheet metal of each panel.~~
 - ~~b. Interior side of panel shall be 22 gage G-90 galvanized steel. Exterior side of panel shall be 22 gage pre-painted steel rated for 1000 hours of salt spray exposure in accordance with ASTM B117 and ASTM D1654.~~
 - ~~c. Insulation shall be 2 lb/ft³ injected foam insulation with a minimum R-value of 12. Foam sheet or fiberglass insulation are not acceptable due to reduced durability of panel and increased chance for rust forming between the panels. Insulation water absorption must be no more than 0.038 lb/ft per ASTM D2842 and show "no growth" per ASTM G21 biocide testing. Interior sheet metal shall encase insulation so that it is not exposed to the airstream.~~
- ~~3. Access doors shall be provided for access to all internal components requiring regular maintenance or inspection. Access door construction and materials shall be identical to unit casing. Access doors shall have galvanized hinges and a minimum of two quarter-turn compression latches with adjustable catches. Access doors shall be sealed with a full-perimeter D-shaped gasket constructed of EPDM sponge rubber.~~
- ~~4. Roof shall be pitched away from access doors and include a minimum 1/2" overhang around the perimeter of the unit.~~

5. ~~Outdoor Air Inlet: Outdoor units shall be provided with a factory provided, field-assembled weather hood with 1/2" aluminum washable filters on the outdoor air inlet. Indoor units shall be provided with duct connections at the outdoor air inlet.~~
6. ~~Unit return shall be up flow.~~
7. ~~Unit discharge shall be down flow.~~
8. ~~Unit shall include lifting eyes on top of unit for use during rigging.~~
9. ~~Motorized dampers — Outside Air and Return Air~~
 - a. ~~Frame shall be constructed of a 16 gage galvanized steel hat channel.~~
 - b. ~~Blades shall be constructed of 16 gage galvanized steel strengthened by three longitudinal 1 inch deep "vee" grooves.~~
 - c. ~~Blades shall be symmetrical relative to its axle pivot point.~~
 - d. ~~Axle bearings shall be synthetic sleeve type and rotate inside extruded holes in the damper frame.~~
 - e. ~~Blade seals shall be extruded vinyl permanently bonded to the appropriate blade edges.~~
 - f. ~~Frame shall include flexible stainless steel compression type jamb seals.~~
 - g. ~~Modulating spring return actuators shall be provided by the factory, installed on the damper, and wired to the control center. Each damper shall have a dedicated actuator. Single actuators with gear trains are not acceptable.~~
 - h. ~~Damper leakage shall be no more than 3 cfm/sq.ft. at 1 in.wg static pressure.~~
10. ~~Exhaust: Gravity backdraft damper with internal bird screen. Indoor units shall have duct flanges for connection to exhaust ductwork.~~

H. ~~DX Cooling Coil:~~

1. ~~Coil shall be rated in accordance to AHRI standards, designed to withstand 250 psig working pressure at 300 degrees F, and pressure tested to 600 psig.~~
2. ~~Coil shall be a minimum of 4 rows deep with maximum fin density of 10 fins per inch.~~
3. ~~Refrigeration systems with more than one circuit shall have interlaced evaporator coils.~~
4. ~~Coil casing shall be constructed of 304 stainless steel.~~
5. ~~Coil tubes shall be constructed of 1/2" diameter, 0.016" thick seamless copper tubing.~~
6. ~~Coil fins shall be constructed of 0.0060" thick aluminum.~~
7. ~~Drain pan~~
 - a. ~~Drain pan shall be constructed of a minimum of 18 gage 201 stainless steel.~~
 - b. ~~Drain pan shall be double sloped to ensure condensate removal from unit.~~
 - c. ~~Drain pan shall extend a minimum of 8" past the evaporator coil to ensure condensate retention.~~

I. ~~Refrigeration — Water Source Heat Pump:~~

1. ~~Unit shall be provided with factory piped, charged, and tested packaged water source heat pump direct expansion refrigeration system.~~

2. ~~All refrigeration systems shall be equipped with two stages of capacity control, each on an independent refrigerant circuit.~~
 3. ~~Refrigeration system shall include microprocessor-based head pressure control logic to maintain refrigerant pressures by actively modulating water flows (Active Head Pressure Control).~~
 4. ~~Refrigeration system shall be provided with thermal expansion valve (TXV) incorporating adjustable superheat.~~
 5. ~~Water to refrigerant heat exchanger~~
 - a. ~~Each independent refrigeration circuit shall be provided with a coaxial water-to-refrigerant heat exchanger. Brazed plate exchangers are not acceptable due to potential damage caused from freezing and increased likelihood of fouling.~~
 - b. ~~Each coaxial heat exchanger shall be provided with factory-supplied, piped, and wired actuated water valve for head pressure control.~~
 - c. ~~On units with multiple circuits, each refrigerant circuit shall be piped with separate water inlets and outlets.~~
 - d. ~~Water connections shall be sweat type.~~
- J. ~~Compressors:~~
1. ~~Compressors shall be hermetic scroll type and include the following items:~~
 - a. ~~Reverse rotation protection.~~
 - b. ~~Oil level adjustment.~~
 - c. ~~Oil filter.~~
 - d. ~~Filter drier~~
 - e. ~~Short cycling control.~~
 - f. ~~High and low pressure limits.~~
 - g. ~~Crankcase heaters.~~
 2. ~~Compressors shall be installed in a separate compartment, above the unit floor, and isolated from the surrounding environment by double wall foam injected panels and access doors.~~
 3. ~~Compressors shall be installed using manufacturer's recommended rubber vibration isolators.~~
 4. ~~Capacity control shall be provided through the use of a single Digital Scroll™ compressor. Additional compressors, if required, shall be fixed stage scroll compressors.~~
- K. ~~Hot Gas Reheat:~~
1. ~~Hot gas reheat coil shall be separated from the evaporator coil by a minimum of 6" in the direction of airflow to prevent the re-evaporation of condensate, provide room for coil cleaning, and allow control system to monitor evaporator coil leaving dew point temperature.~~
 2. ~~Coil shall be rated in accordance to AHRI standards, designed to withstand 250 psig working pressure at 300 degrees F, and pressure tested to 600 psig.~~
 3. ~~Coil casing shall be constructed of 304 stainless steel.~~

- ~~4. Coil tubes shall be constructed of 5/16" diameter, 0.012" thick seamless copper tubing.~~
 - ~~5. Coil fins shall be constructed of 0.0060" thick aluminum fins.~~
 - ~~6. Hot-gas reheat shall be controlled through a factory-supplied and controlled modulating 3-way valve.~~
- ~~L. Direct Drive Supply and Exhaust Airflow Blowers:~~
- ~~1. Fan assemblies shall be direct-drive without the use of belts or adjustable sheaves.~~
 - ~~2. A variable frequency drive (VFD) shall be provided for each fan section. VFD shall be mounted, wired, and programmed by the equipment manufacturer. VFD shall be located in an enclosed compartment outside of the supply or exhaust air stream.~~
 - ~~3. Fan wheel shall be tested in accordance to AMCA 210. Fan speed shall not exceed 2400 RPM.~~
 - ~~4. Fans may be full width or partial width. Fans modified to partial width through the use of banding or other blade reduction method are not acceptable.~~
 - ~~5. Fan motor shall be VFD rated, ODP type, EPACT compliant, and shall be of premium efficiency (PE).~~
- ~~M. Filters:~~
- ~~1. Outdoor air intake hood filters~~
 - ~~a. Filter rack shall accommodate 1" media.~~
 - ~~b. Manufacturer shall provide 1 set of 1" aluminum filter media.~~
 - ~~c. Filter sections shall be accessible from outside the unit and located in the outdoor air intake hood.~~
 - ~~2. Supply air filters~~
 - ~~a. Supply air filter rack shall accommodate factory-provided 4" MERV 14 with leading 2" MERV 8 filters.~~
 - ~~b. Filter sections shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.~~
 - ~~c. Filter section shall include magnehelic gauge and/or dirty filter pressure switch.~~
- ~~N. Electrical:~~
- ~~1. Unit shall be constructed with an integral electrical and control center isolated from supply airflow, exhaust airflow, compressors, and heating elements. The control center shall control all aspects of the unit operation. VFDs with overload protection shall be provided for each fan bank.~~
 - ~~2. Units shall be wired according to NEC and listed per ETL. ETL listing shall cover all components of the ventilator and not be limited to the control panel. All major electrical components shall be UL or ETL listed.~~
 - ~~3. Unit shall have a single point of connection with integral unit mounted disconnect. Panel shall have an SCCR rating of 5 kV.~~
 - ~~4. Units shall be factory wired with a single point power connection.~~

5. ~~Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 7% out of balance on voltage, the voltage is more than 7% under design voltage, or on phase reversal.~~
6. ~~The following items shall be provided and wired within the control center by the factory:~~
 - a. ~~Non fused disconnect.~~
 - b. ~~Sub-circuit fusing.~~
 - c. ~~Low voltage transformers.~~
 - d. ~~Controls as specified in this section.~~
 - e. ~~Control circuit fusing.~~
 - f. ~~Terminal block.~~
 - g. ~~Supply and Exhaust Fan motor Variable Frequency Drives (VFDs).~~
7. ~~Electrical panel must house all high voltage components such as terminal blocks, variable frequency drives, and fuse blocks.~~
8. ~~All electrical power and controls wiring shall run in chase located between unit ceiling and roof to minimize interior wall penetrations and allow for ease of access.~~
9. ~~Options~~
 - a. ~~Control panel shall include a factory supplied and mounted 115V GFCI convenience outlet receptacle with a 12A circuit breaker. Outlet shall be powered by the main power.~~
- Q. ~~Controls:~~
 1. ~~Units shall include factory supplied, mounted, wired, and tested stand alone microprocessor controls.~~
 2. ~~Microprocessor controller shall be factory programmed for discharge air control and use an internal 7 day time clock.~~
 3. ~~Microprocessor controller shall include local liquid crystal display (LCD) for user interface. Microprocessor controller remote LCD shall be mounted in a weather proof enclosure and accessible without exposing the operator to high voltage wiring or having to turn off or circumvent the main disconnect.~~
 4. ~~The following sensors shall be factory supplied, mounted, and wired inside the unit:~~
 - a. ~~Outdoor air humidity sensor.~~
 - b. ~~Outdoor air temperature sensor.~~
 - c. ~~Evaporator coil leaving air temperature sensor.~~
 - d. ~~Supply air filter pressure monitoring switch~~
 - e. ~~Supply Fan, Exhaust Fan, and OA Airflow measuring stations of the thermal dispersion type~~
 5. ~~The following devices shall be factory supplied for field installation and wiring:~~
 - a. ~~Supply air temp temperature sensor.~~
 - b. ~~Wall-mounted room air temperature sensor with manual adjuster.~~
 - c. ~~Wall-mounted room air humidity sensor.~~
 - d. ~~Return Air mounted CO2 sensor.~~

- e. ~~Space static pressure sensor.~~
- f. ~~Supply duct static pressure sensor.~~
- g. ~~Smoke detectors.~~
- h. ~~Source water head pressure control valves (2 total)~~
- 6. ~~Microprocessor controller shall include BACnet IP communications for building management system interface.~~

~~P. FACTORY VERIFICATION TESTING~~

- 1. ~~Unit shall be thoroughly run tested prior to shipment from the factory.~~
- 2. ~~Factory run test report shall be provided at the request of the engineer, contractor, or owner.~~
- 3. ~~Testing Procedures~~
 - a. ~~Unit shall be subjected to and pass a dielectric (hipot) test.~~
 - b. ~~All motorized dampers shall be cycled one full stroke while installed in the unit using the factory provided motorized actuators.~~
 - c. ~~Supply fan~~
 - 1) ~~Visually inspect ramp-up, ramp-down, and rotation direction of fan when enabled.~~
 - 2) ~~Verify fan pressure proving switch operation.~~
 - 3) ~~Measure and record current draw through supply fan motor(s).~~
 - d. ~~Exhaust fan~~
 - 1) ~~Visually inspect ramp up, ramp down, and rotation direction of fan when enabled.~~
 - 2) ~~Verify fan pressure proving switch operation.~~
 - 3) ~~Measure and record current draw through exhaust fan motor(s).~~
 - e. ~~Refrigeration system~~
 - 1) ~~Measure and record subcooling and superheat on circuit A with hot-gas reheat valve closed (0%) after 15 minutes of steady state operation.~~
 - 2) ~~Measure and record subcooling and superheat on circuit A with hot-gas reheat valve open (100%) after 15 minutes of steady state operation.~~
 - 3) ~~Measure and record subcooling and superheat on circuit B after 15 minutes of steady state operation.~~
- 4. ~~Test report shall be provided prior to unit startup and available from the factory upon request.~~

A. PACKAGED WATER SOURCE HEAT PUMP UNITS

- 1. **Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:**
 - a. **Valent, Annex Air, Addison, or Equal**

2. Unit Construction:

- a. **Base:** Manufacturer's standard base shall be constructed of minimum 10 gage galvanized steel with 16 gage integral floor pan. All floor seams shall have a raised rib joint. Penetrations through the floor shall have a minimum 3/8" raised rib around each opening. Base shall have a minimum 4" overhang over the top of a roof curb to prevent water infiltration.
- b. **Panels:** Manufacturer's standard casing shall be constructed of minimum 2-inch, foam-injected, double-wall panels.
 - 1) Individual panels shall be constructed so that there is no metal-to-metal contact between the interior and exterior sheet metal of each panel.
 - 2) Interior side of panel shall be 22 gage G-90 galvanized steel. Exterior side of panel shall be 22 gage pre-painted steel rated for 1000 hours of salt spray exposure in accordance with ASTM B117 and ASTM D1654.
 - 3) Insulation shall be 2 lb/ft³ injected foam insulation with a minimum R-value of 12. Foam sheet or fiberglass insulation are not acceptable due to reduced durability of panel and increased chance for rust forming between the panels. Insulation water absorption must be no more than 0.038 lb/ft per ASTM D2842 and show "no growth" per ASTM G21 biocide testing. Interior sheet metal shall encase insulation so that it is not exposed to the airstream.
- c. **Access doors** shall be provided for access to all internal components requiring regular maintenance or inspection. Access door construction and materials shall be identical to unit casing. Access doors shall have galvanized hinges and a minimum of two quarter-turn compression latches with adjustable catches. Access doors shall be sealed with a full-perimeter D-shaped gasket constructed of EPDM sponge rubber.
- d. **Roof** shall be pitched away from access doors and include a minimum ½" overhang around the perimeter of the unit.
- e. **Outdoor Air Inlet:** Outdoor units shall be provided with a factory provided, field-assembled weather hood with ½" aluminum washable filters on the outdoor air inlet. Indoor units shall be provided with duct connections at the outdoor air inlet.
- f. **Unit return** shall be up flow.
- g. **Unit discharge** shall be down flow.
- h. **Unit** shall include lifting eyes on top of unit for use during rigging.
- i. **Motorized dampers – Outside Air and Return Air**
 - 1) **Frame** shall be constructed of a 16 gage galvanized steel hat-channel.
 - 2) **Blades** shall be constructed of 16 gage galvanized steel strengthened by three longitudinal 1 inch deep "vee" grooves.
 - 3) **Blades** shall be symmetrical relative to its axle pivot point.
 - 4) **Axle bearings** shall be synthetic sleeve-type and rotate inside extruded holes in the damper frame.
 - 5) **Blade seals** shall be extruded vinyl permanently bonded to the appropriate blade edges.
 - 6) **Frame** shall include flexible stainless steel compression-type jamb seals.
 - 7) **Modulating spring-return actuators** shall be provided by the factory, installed on the damper, and wired to the control center. Each damper shall have a dedicated actuator. Single actuators with gear trains are not acceptable.

- 8) **Damper leakage shall be no more than 3 cfm/sq.ft. at 1 in.wg static pressure.**
- j. **Exhaust: Gravity backdraft damper with internal bird screen. Indoor units shall have duct flanges for connection to exhaust ductwork.**
- 3. **DX Cooling Coil:**
 - a. **Coil shall be rated in accordance to AHRI standards, designed to withstand 250 psig working pressure at 300 degrees F, and pressure tested to 600 psig.**
 - b. **Coil shall be a minimum of 4 rows deep with maximum fin density of 10 fins per inch.**
 - c. **Refrigeration systems with more than one circuit shall have interlaced evaporator coils.**
 - d. **Coil casing shall be constructed of 304 stainless steel.**
 - e. **Coil tubes shall be constructed of 1/2" diameter, 0.016" thick seamless copper tubing.**
 - f. **Coil fins shall be constructed of 0.0060" thick aluminum.**
 - g. **Drain pan**
 - 1) **Drain pan shall be constructed of a minimum of 18 gage 201 stainless steel.**
 - 2) **Drain pan shall be double-sloped to ensure condensate removal from unit.**
 - 3) **Drain pan shall extend a minimum of 8" past the evaporator coil to ensure condensate retention.**
- 4. **Refrigeration – Water Source Heat Pump:**
 - a. **Unit shall be provided with factory piped, charged, and tested packaged water source heat pump direct expansion refrigeration system.**
 - b. **All refrigeration systems shall be equipped with two stages of capacity control, each on an independent refrigerant circuit.**
 - c. **Refrigeration system shall include microprocessor-based head pressure control logic to maintain refrigerant pressures by actively modulating water flows (Active Head Pressure Control).**
 - d. **Refrigeration system shall be provided with thermal expansion valve (TXV) incorporating adjustable superheat.**
 - e. **Water-to-refrigerant heat exchanger**
 - 1) **Each independent refrigeration circuit shall be provided with a coaxial water-to-refrigerant heat exchanger. Braze plate exchangers are not acceptable due to potential damage caused from freezing and increased likelihood of fouling.**
 - 2) **Each coaxial heat exchanger shall be provided with factory-supplied, piped, and wired actuated water valve for head pressure control.**
 - 3) **On units with multiple circuits, each refrigerant circuit shall be piped with separate water inlets and outlets.**
 - 4) **Water connections shall be sweat-type.**
- 5. **Compressors:**
 - a. **Compressors shall be hermetic scroll type and include the following items:**
 - 1) **Reverse rotation protection.**

- 2) Oil level adjustment.
 - 3) Oil filter.
 - 4) Filter drier
 - 5) Short cycling control.
 - 6) High and low pressure limits.
 - 7) Crankcase heaters.
 - b. Compressors shall be installed in a separate compartment, above the unit floor, and isolated from the surrounding environment by double wall foam injected panels and access doors.
 - c. Compressors shall be installed using manufacturer's recommended rubber vibration isolators.
 - d. Capacity control shall be provided through the use of a single Digital Scroll™ compressor. Additional compressors, if required, shall be fixed stage scroll compressors.
6. Hot Gas Reheat:
- a. Hot-gas reheat coil shall be separated from the evaporator coil by a minimum of 6" in the direction of airflow to prevent the re-evaporation of condensate, provide room for coil cleaning, and allow control system to monitor evaporator coil leaving dew point temperature.
 - b. Coil shall be rated in accordance to AHRI standards, designed to withstand 250 psig working pressure at 300 degrees F, and pressure tested to 600 psig.
 - c. Coil casing shall be constructed of 304 stainless steel.
 - d. Coil tubes shall be constructed of 5/16" diameter, 0.012" thick seamless copper tubing.
 - e. Coil fins shall be constructed of 0.0060" thick aluminum fins.
 - f. Hot-gas reheat shall be controlled through a factory-supplied and controlled modulating 3-way valve.
7. Direct Drive Supply and Exhaust Airflow Blowers:
- a. Fan assemblies shall be direct-drive without the use of belts or adjustable sheaves.
 - b. A variable frequency drive (VFD) shall be provided for each fan section. VFD shall be mounted, wired, and programmed by the equipment manufacturer. VFD shall be located in an enclosed compartment outside of the supply or exhaust air stream.
 - c. Fan wheel shall be tested in accordance to AMCA 210. Fan speed shall not exceed 2400 RPM.
 - d. Fans may be full width or partial width. Fans modified to partial width through the use of banding or other blade reduction method are not acceptable.
 - e. Fan motor shall be VFD rated, ODP type, EPACT compliant, and shall be of premium efficiency (PE).
8. Filters:
- a. Outdoor air intake hood filters
 - 1) Filter rack shall accommodate 1" media.
 - 2) Manufacturer shall provide 1 set of 1" aluminum filter media.
 - 3) Filter sections shall be accessible from outside the unit and located in the outdoor air intake hood.

b. Supply air filters

- 1) Supply air filter rack shall accommodate factory-provided 4" MERV 14 with leading 2" MERV 8 filters.
- 2) Filter sections shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.
- 3) Filter section shall include magnehelic gauge and/or dirty filter pressure switch.

9. Electrical:

- a. Unit shall be constructed with an integral electrical and control center isolated from supply airflow, exhaust airflow, compressors, and heating elements. The control center shall control all aspects of the unit operation. VFDs with overload protection shall be provided for each fan bank.
- b. Units shall be wired according to NEC and listed per ETL. ETL listing shall cover all components of the ventilator and not be limited to the control panel. All major electrical components shall be UL or ETL listed.
- c. Unit shall have a single point of connection with integral unit mounted disconnect. Panel shall have an SCCR rating of 5 kV.
- d. Units shall be factory wired with a single point power connection.
- e. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 7% out of balance on voltage, the voltage is more than 7% under design voltage, or on phase reversal.
- f. The following items shall be provided and wired within the control center by the factory:
 - 1) Non-fused disconnect.
 - 2) Sub-circuit fusing.
 - 3) Low voltage transformers.
 - 4) Controls as specified in this section.
 - 5) Control circuit fusing.
 - 6) Terminal block.
 - 7) Supply and Exhaust Fan motor Variable Frequency Drives (VFDs).
- g. Electrical panel must house all high voltage components such as terminal blocks, variable frequency drives, and fuse blocks.
- h. All electrical power and controls wiring shall run in chase located between unit ceiling and roof to minimize interior wall penetrations and allow for ease of access.
- i. Options
 - 1) Control panel shall include a factory supplied and mounted 115V GFCI convenience outlet receptacle with a 12A circuit breaker. Outlet shall be powered by the main power.

10. Controls:

- a. Units shall be furnished with a Controls Lite or similar option. The concept of Controls Lite is that the Refrigeration Control, and VFD's are wired to terminal strip where the ATC can control via hard wired points with their field installed controller. The unit controller and all other controls are provided by ATC. The following points will be factory furnished, installed, and wired to a terminal strip for the ATC:

- 1) **OA, RA Damper Actuators**
 - 2) **Start/stop and modulating of Fans**
 - 3) **Enable/disable, staging and modulating gas heat**
 - 4) **Heat wheel start/stop and modulation**
 - 5) **Enable/disable and modulating signal for cooling**
 - 6) **Enable/disable and modulating signal for Hot Gas Reheat**
 - 7) **Supply Fan Air Flow Measuring Station**
 - 8) **Exhaust Fan Air Flow Measuring Station**
 - 9) **Outside Air Flow Measuring Station**
- b. **The refrigeration controller shall control the entire refrigeration portion of the unit and accept the signals from the BMS listed above. The refrigeration controller shall also monitor and control all refrigerant safeties and alarms. The refrigerant controller shall include an interface (Bacnet, etc) for monitoring only of all alarms, pressures, and functionality.**
- c. **VFD's shall be controlled via hardwired signals from the ATC controller for enable/disable, modulation and feedback.**

B. FACTORY VERIFICATION TESTING

1. **Unit shall be thoroughly run tested prior to shipment from the factory.**
2. **Factory run test report shall be provided at the request of the engineer, contractor, or owner.**
3. **Testing Procedures**
 - a. **Unit shall be subjected to and pass a dielectric (hipot) test.**
 - b. **All motorized dampers shall be cycled one full stroke while installed in the unit using the factory-provided motorized actuators.**
 - c. **Supply fan**
 - 1) **Visually inspect ramp-up, ramp-down, and rotation direction of fan when enabled.**
 - 2) **Verify fan pressure proving switch operation.**
 - 3) **Measure and record current draw through supply fan motor(s).**
 - d. **Exhaust fan**
 - 1) **Visually inspect ramp-up, ramp-down, and rotation direction of fan when enabled.**
 - 2) **Verify fan pressure proving switch operation.**
 - 3) **Measure and record current draw through exhaust fan motor(s).**
 - e. **Refrigeration system**
 - 1) **Measure and record subcooling and superheat on circuit A with hot-gas reheat valve closed (0%) after 15 minutes of steady-state operation.**
 - 2) **Measure and record subcooling and superheat on circuit A with hot-gas reheat valve open (100%) after 15 minutes of steady-state operation.**
 - 3) **Measure and record subcooling and superheat on circuit B after 15 minutes of steady-state operation.**
4. **Test report shall be provided prior to unit startup and available from the factory upon request.**

C. QUALITY ASSURANCE

1. **Electrical Components, Devices, and Accessories:** Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. **ASHRAE Compliance:**
 - a. **Applicable requirements in ASHRAE 62.1-2007, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Startup."**
 - b. **Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.**
3. **UL Compliance:**
 - a. **Unit shall be ETL listed per UL standard 1995 and CSA standard C22.2 #236**

D. WARRANTY

1. **Unit Warranty:** Manufacturer's standard form in which manufacturer agrees to repair or replace components of water source heat pump equipment which fail in materials or workmanship within specified warranty period. Warranty period shall begin at startup, or six months after shipment, whichever occurs first:
 - a. **Parts Warranty Period for Packaged Water Source Heat Pump: One (1) year.**
 - b. **Parts Warranty Period for Compressors: Five (5) years.**

2.12 TERMINAL HEATING UNITS (HYDRONIC)

A. Unit Heaters: (Horizontal Type)

1. **General:** Provide horizontal unit heaters in locations as indicated, and of capacities, style, and having accessories as scheduled.
2. **Construction:**
 - a. **Casings:** Construct of steel, phosphatized inside and out, and painted finish with baked enamel. Color by architect. Provide adjustable face air diffuser.
 - b. **Fans:** Construct of aluminum and factory-balance. Design so motor and fan assembly is removable through fan outlet panel.
 - c. **Coils:** Construct of plate-type aluminum fins, mechanically bonded to copper tubes. Design coil for use in steam or hot water applications.
 - d. **Motors:** Provide totally enclosed motors, with built-in overload protection, having electrical characteristics as scheduled.
3. **Manufacturer:** Subject to compliance with requirements, provide horizontal unit heaters of one of the following:
 - a. **Airtherm Mfg. Co.**
 - b. **Rittling**
 - c. **Modine Mfg. Co.**
 - d. **Trane (The) Co.**
 - e. **Or equal**

B. Unit Heaters: (Cabinet Type)

1. General: Provide cabinet unit heaters having cabinet sizes and in locations as indicated, and of capacities, style, and having accessories as scheduled. Include in basic unit chassis, coil, fanboard, fan wheels, housings, motor, and insulation.
2. Construction:
 - a. Chassis: Galvanized steel wrap-ground structural frame with edges flanged.
 - b. Insulation: Faced, heavy density glass fiber.
 - c. Cabinet: 14-ga removable front panel, 16-ga top and side panels. Insulate front panel over entire coil section. Provide access door on coil connection side. Clean cabinet parts, bonderize, phosphatize, and factory finished with baked enamel. Color by architect.
 - d. Water Coils: Construct of 5/8" seamless copper tubes mechanically bonded to configured aluminum fins. Design for 300 psi and leak test at 300 psi under water. Provide same end connections for supply and return.
 - e. Fans: Provide centrifugal, forward curved double width fan wheels constructed of non-corrosive, molded, fiberglass reinforced thermo-plastic material. Construct fan scrolls of galvanized steel.
 - f. Motors: Provide shaded pole motors with integral thermal over-load protection, and motor cords for plug-in to junction box in unit. Provide three speed switch on fan motor.
 - g. Filters: Provide 1" thick throwaway type filters in fiberboard frames.
3. Manufacturer: Subject to compliance with requirements, provide cabinet heaters of one of the following:
 - a. McQuay Inc.
 - b. Rittling
 - c. Trane (The) Co.
 - d. Young Radiator Co.
 - e. Or equal

C. Radiant Heating Panels (RP Type – refer to schedules for additional information/requirements)

1. Radiant Panels shall be manufactured of copper tubing and consisting of header pipes at each end.
2. Tube thicknesses shall be medium pressure – 0.058 inch min. wall thickness.
3. Radiant Panel header pipes shall be square 0.109 inch min. wall thickness and include all necessary supply, return, and air vent connections. Internal baffling shall be provided as required.
4. Piping connections shall be 3/4inch NPT. Air vent connections shall be 1/8 inch NPT taper threaded sockets.
5. Working pressure shall be medium pressure – 85 psi max (Tested at 110 psi)
6. Radiant Panel expansion shall not exceed 0.016 inch per linear foot at 215 degrees F.
7. Radiant Panels shall be cleaned and phosphatized in preparation for the power coat finish.
8. Finish Style and Color of the Panel shall be selected by Architect from available standard or optional colors prior to ordering.
9. Ceiling mounting brackets shall be provided with radiation panels.
10. Radiation Panels shall have the sizes, capacities, and quantities as shown on the plans and schedules.
11. Install panel radiators in accordance with manufacturer's recommendations.

12. Provide manufacturers standard connector and end cap pieces as required to provide a continuous appearance.
13. Manufacturers: Sterling, Vulcan, Sun EI, TWA, or Equal.

2.13 DUCTLESS COOLING UNITS

~~A. Evaporator Ceiling Recessed Unit:~~

1. ~~General: The unit shall be factory assembled, wired and tested. Contained within the unit shall be all factory wiring and internal piping, control circuit board, and fan motor. The unit in conjunction with the wired, wall mounted controller shall have a self diagnostic function, 3 minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be purged with dry nitrogen before shipment from factory.~~
2. ~~Cabinet: The casing shall be ABS plastic factory finish. Cabinet shall be designed for suspension mounting and horizontal operation. The rear cabinet panel shall have provisions for a field installed filtered outside air intake connection.~~
3. ~~Fan: The evaporator fan shall have three high performance, double inlet, forward curve sirocco fans driven by a single motor. The fans shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. The indoor fan shall consist of four (4) speeds: Low, M1, M2 and Hi.~~
4. ~~Vane: There shall be a motorized horizontal vane to automatically direct air flow in a horizontal and downward direction for uniform air distribution. The horizontal vane shall provide a choice of five (5) vertical airflow patterns selected by remote control. There shall also be a set of vertical vanes to provide horizontal swing airflow movement selected by remote control.~~
5. ~~Filter: An outside air filter shall be provided including filter rack by the HVAC/unit manufacture.~~
6. ~~Coil: The evaporator coil shall be of nonferrous construction with pre-coated aluminum strake fins on copper tubing. The multi angled heat exchanger shall have a modified fin shape that reduces air resistance for a smoother, quieter airflow. All tube joints shall be brazed with PhosCopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil.~~

~~B. Evaporator Ducted Unit:~~

1. ~~The Ducted type indoor unit shall be factory assembled, wired and tested. Contained within the unit shall be all factory wiring and internal piping, control circuit board and fan motor. The unit, in conjunction with the wired or wireless wall-mounted controller, shall have a self diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be purged with dry nitrogen before shipment from the factory~~
2. ~~Unit Cabinet: The cabinet shall be space saving, low profile, horizontal, ducted type. Formed cabinet shall be constructed of G-60 galvanized steel with factory applied foam surface insulation to prevent condensation on outer surfaces. The cabinet shall be provided with four mounting brackets to accommodate suspension from threaded rod or structural support located on the side panels in all four corners. Brackets shall be suitable for supporting the weight of the indoor unit. The indoor unit cabinet shall be equipped with a ducted air outlet and ducted rear return air connection. Units shall support an optional Bottom Return Adaptor or selectable rear or bottom return as a standard feature.~~
3. ~~Fan: The indoor fan unit shall be an assembly direct driven by a single motor. Fan shall develop airflow to deliver up to 0.70 inches wg of external static pressure. The indoor fans shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings. The indoor fans shall operate on any of three (3) speeds, High, Mid,~~

- and Low and Auto. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set point and space temperature.
4. ~~Filter: Return air shall be filtered by means of installing filter rack assembly with replaceable 2" MERV 10 pleated filters, filter access panels, and mounting connections for connection to ducted indoor unit.~~
 5. ~~Coil: The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with PhosCopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan and with two (2) 1-9/32" drains shall be provided under the coil. In addition to the two (2) gravity drains, the indoor unit shall be provided with an integral condensate lift mechanism able to raise drain water above the condensate pan. Lift mechanism shall incorporate a safety sensor system to shut down the indoor fan and the compressor in the outdoor unit in the event of high level of condensate in the drain pan. A drain pan level switch, designed to connect to the control board, shall be provided and installed on the condensate pan to prevent condensate from overflowing.~~
 6. ~~Electrical: The electrical power of the unit shall be 208 volts or 230 volts, 1 phase, 60 hertz. The system shall be capable of satisfactory operation within voltage limits of 187 volts to 253 volts.~~

~~C. Evaporator Wall Mounted:~~

1. ~~General: The unit shall be factory assembled, wired and tested. Contained within the unit shall be all factory wiring and internal piping, control circuit board, and fan motor. The unit in conjunction with the wired, wall mounted controller shall have a self-diagnostic function, three-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be purged with dry nitrogen before shipment from factory.~~
2. ~~Cabinet: The casing shall be ABS plastic factory finish. Cabinet shall be designed for suspension mounting and horizontal operation. The rear cabinet panel shall have provisions for a field installed filtered outside air intake connection.~~
3. ~~Fan: The evaporator fan shall have three high performance, double inlet, forward curve sirocco fans driven by a single motor. The fans shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. The indoor fan shall consist of four speeds: Low, M1, M2 and Hi.~~
4. ~~Vane: There shall be a motorized horizontal vane to automatically direct air flow in a horizontal and downward direction for uniform air distribution. The horizontal vane shall provide a choice of five vertical airflow patterns selected by remote control. There shall also be a set of vertical vanes to provide horizontal swing airflow movement selected by remote control.~~
5. ~~Filter: Return air shall be filtered by means of an easily removable washable filter.~~
6. ~~Coil: The evaporator coil shall be of nonferrous construction with pre-coated aluminum strake fins on copper tubing. The multi-angled heat exchanger shall have a modified fin shape that reduces air resistance for a smoother, quieter airflow. All tube joints shall be brazed with PhosCopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil.~~

~~D. Control:~~

1. ~~The control system shall consist of two microprocessors, one on each indoor and outdoor unit, interconnected by a single non-polar two-wire cable. Field wiring shall run directly from the indoor unit to the wall mounted controller with no splices. For A-Control, a three conductor 14 ga. AWG wire with ground shall provide power feed and bi-directional control transmission between the outdoor and indoor units. Where separate power is supplied to the indoor and outdoor units, a two 20 ga. AWG wire shall be run between the units to provide forbid directional control communication. The system shall be capable of~~

automatic restart when power is restored after power interruption. The system shall have self-diagnostics ability, including total hours of compressor run time. Diagnostics codes for indoor and outdoor units shall be displayed on the wired controller panel.

- a. ~~The Wired Remote Controller shall be approximately 5" x 5" in size and white in color with a light green LCD display. The controller shall support a selection from multiple languages for display information. There shall be a built-in weekly timer with up to 8 pattern settings per day. The controller shall consist of an On/Off button, Increase/Decrease Set Temperature buttons, a Cool/Auto/Fan/Dry mode selector, a Timer Menu button, a Timer On/Off button, Set Time buttons, a Fan Speed selector, a Ventilation button, a Test Run button, and a Check Mode button. The controller shall have a built-in temperature sensor. Temperature shall be displayed in either Fahrenheit (deg.F) or Celsius (deg.C), and Temperature changes shall be by increments of 1 deg.F (0.5 deg.C). The controller shall have the capability of controlling up to a maximum of 16 systems, as a group with the same mode and set-point for all, at a maximum developed control cable distance of 1,500 feet (500 meters).~~
- b. ~~The control voltage from the wired controller to the indoor unit shall be 12/24 volts, DC. Field wiring shall run directly from the indoor unit to the wall mounted controller with no splices. Up to two wired controllers shall be able to be used to control one unit.~~

~~E. Outdoor Air Cooled Condensing Unit:~~

- 1. ~~General: The outdoor unit shall be equipped with a control board that interfaces with the indoor unit to perform all necessary operation functions. The outdoor unit shall be capable of operating at 0 deg.F, (-18 deg.C) ambient temperature without additional low ambient controls. The outdoor unit shall be able to operate with a maximum height difference of 100 feet and have maximum refrigerant tubing length of 165 feet between indoor and outdoor units without the need for line size changes, traps or additional oil. The outdoor unit shall be completely factory assembled, piped, and wired. Each unit must be test run at the factory.~~
- 2. ~~Cabinet: The casing shall be constructed from galvanized steel plate, coated with a finished with an electrostatically applied, thermally fused acrylic or polyester powder coating for corrosion protection and have a factory finish. The fan grille shall be of ABS plastic.~~
- 3. ~~Fan: The fan motor shall be of aerodynamic design for quiet operation, and the fan motor bearings shall be permanently lubricated. The outdoor unit shall have horizontal discharge airflow. The fan shall be mounted in front of the coil, pulling air across it from the rear and dispelling it through the front. The fan shall be provided with a raised guard to prevent contact with moving parts.~~
- 4. ~~Coil: The L shaped condenser coil shall be of copper tubing with flat aluminum fins to reduce debris build up. The coil shall be protected with an integral metal guard. Refrigerant flow from the condenser shall be controlled by means of linear expansion valve (LEV) metering orifice. The LEV shall be control by a microprocessor controlled step motor.~~
- 5. ~~Compressor: The compressor shall be a scroll compressor with variable speed inverter technology. The compressor shall be driven by inverter circuit to control compressor speed. The compressor speed shall dynamically vary to match the room load for significantly increasing the efficiency of the system which results in vast energy savings. To prevent liquid from accumulating in the compressor during the off cycle, a minimal amount of current shall be intermittently applied to the compressor motor to maintain enough heat. The outdoor unit shall have an accumulator and high pressure safety switch. The compressor shall be mounted to avoid the transmission of vibration. All compressors shall be provided with a five year warranty.~~

6. ~~Electrical: The electrical power of the unit shall be as indicated on the drawings. The outdoor unit shall be controlled by the microprocessor located in the indoor unit. The control signal between the indoor unit and the outdoor unit shall be pulse signal 24 volts DC. The unit shall have Pulse Amplitude Modulation circuit to utilize 98% of input power supply.~~

~~F. Building Automation System Interface Controls~~

1. ~~Provide BAS system gateway capable of performing the following functions:~~
 - a. ~~Schedule Time Setting~~
 - b. ~~Start/Stop, Temperature Setting, Fan Speed~~
 - c. ~~Available Alarm Contact for Remote Monitoring (Including Condensate Pump)~~
 - d. ~~Communicate with BACNet Compatible BAS System~~
 - e. ~~Controls up to 64 indoor units and outdoor units~~

~~G. MANUFACTURER: Subject to compliance with requirements, provide air handling units of one of the following:~~

1. ~~Mitsubishi~~
2. ~~Johnson Controls~~
3. ~~Daikin~~
4. ~~Or Equal~~

A. GENERAL

1. All units shall be listed and rated by ANSI/AHRI Standard 1230-2010 and meet all minimum IEER performance requirements as scheduled
2. The units shall be CSA approved, ANSI/UL STD 1995 listed and listed by Electrical Laboratories (ETL) and bear the cETL label.
3. All wiring shall be in accordance with the National Electric Code (NEC).
4. The system will be produced in an ISO 9001 and ISO 14001 facility, which are standards set by the International Standard Organization (ISO). The system shall be factory tested for safety and function.

B. SYSTEM DESCRIPTION

1. The variable capacity air conditioning system shall be an Inverter Driven cooling only split system as specified. The system shall consist of an indoor evaporator exclusively matched to an outdoor variable speed rotary compressor condensing unit.
2. The outdoor unit shall be configured for horizontal discharge airflow and complete with a variable speed condenser fan using a single phase power supply.
3. Typical cooling mode operating range shall be between 0°F DB and 122°F DB.
4. Typical heating mode operating range shall be between -4°F WB and 60°F WB.
 - a. This system shall be designed to operate with a maximum refrigerant pipe length of 164 feet with 98 feet maximum vertical difference (or 230 ft with 164 feet maximum vertical difference for units 2.5 tons and above), and without any oil traps or additional equipment. Refrigerant shall be R-410A.

C. REFRIGERANT PIPING

1. Refer and comply to the refrigerant piping specifications.

D. FAN COILS

1. WALL MOUNTED UNIT

- a. Indoor wall-mounted unit shall be a wall mounted fan coil unit for installation onto a wall within a conditioned space. A mildew-proof, polystyrene condensate drain pan and resin net mold resistant filter shall be included as standard equipment.
- b. The indoor unit's sound pressure shall range from 31 dB(A) to 41 dB(A) at low speed measured at 3.3 feet below and 3.3 feet away from the unit.
- c. The unit shall have an auto-swing louver which ensures efficient air distribution, which closes automatically when the unit stops. The remote controller shall be able to set five (5) steps of discharge angle. The front grille shall be easily removed for washing.
- d. The cabinet shall be affixed to a factory supplied wall mounting template and located in the conditioned space.
- e. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
- f. The fan type shall be direct-drive cross-flow with statically and dynamically balanced impeller with high and low fan speeds available.
- g. Units shall be provided with a loose field installed condensate pump.

2. CEILING SUSPENDED ONE-WAY CASSETTE UNIT

- a. Indoor ceiling-suspended unit shall be a ceiling suspended fan coil unit for installation onto a wall or ceiling within a conditioned space.
- b. The indoor unit's sound pressure shall range from 33 dB(A) to 41 dB(A) at low speed measured at 3.3 feet below and 3.3 feet away from the unit.
- c. The unit shall have an auto-swing louver which ensures efficient air distribution, which closes automatically when the unit stops. The remote controller shall be able to set five (5) steps of discharge angle. The front grille shall be easily removed for washing.
- d. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
- e. The indoor unit shall be equipped with a mildew-proof, polystyrene condensate drain pan and a resin net, mold resistant, antibacterial filter.
- f. The fan type shall be direct-drive cross-flow with statically and dynamically balanced impeller with high and low fan speeds available.
- g. Units shall be provided with a loose field installed condensate pump.

E. CONTROLS

1. Fan coil units shall be supplied with Individual Zone Controllers, similar to Daikin model BRC1E73

- a. Remote controllers shall be hard wired by installing contractor.
- b. Controllers shall be able to function as follows:
 - 1) The controller shall have dual or single Cool and Heat setpoints for occupied periods, and independent setback setpoints for unoccupied periods.
 - 2) The controller shall the ability to digitally prohibit individual buttons and functions.
 - 3) The controller shall have a self diagnosis function that constantly monitors the system for malfunctions (total of 80 components).

- 4) **An LCD digital display will allow the temperature to be set in 1°F units.**
- 5) **The controller shall be equipped with a thermostat sensor.**
- 6) **The controller shall have the ability to automatically changeover the mode of operation with dual or single setpoints.**
- 7) **Controller shall have built-in 7 day, weekday plus Saturday Sunday (5+1+1), weekday plus weekend (5+2) and everyday (1) scheduler.**
- 8) **Controller shall have a simple display mode, displaying only the operation mode, the setpoint(s), and the room temperature.**

F. CONDENSING UNIT

1. **The outdoor unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.**
2. **The fan shall be a direct drive, propeller type fan. The motor shall be inverter driven with permanently lubricated bearings**
3. **A fan guard shall be provided on the outdoor unit to prevent contact with fan operation.**
4. **The outdoor coil shall have nonferrous construction with a corrugated fin tube.**
5. **The compressor shall be a rotary swing inverter-driven compressor. Compressor safeties shall include internal thermal overload protection. Refrigeration specialties shall include an accumulator, refrigerant metering device and a four-way reversing valve.**

G. ELECTRICAL

1. **The condensing unit and the indoor units shall have independent 208/230 volts, 1 phase, 60 hertz power.**
2. **The control voltage between the indoor and outdoor unit shall be 16VDC non-shielded 2 conductor cable.**

H. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. **Mitsubishi CityMulti**
2. **LG Variable Refrigerant Flow (VRF) System.**
3. **Daikin AC**
4. **Or Equal**

2.14 VEHICLE EXHAUST SYSTEMS

~~A. Function of the Pneumatic type vehicle exhaust system shall be:~~

1. ~~The exhaust blower will automatically start and evacuate the exhaust gases the moment any vehicle engine connected to the system is started to insure that the engine exhaust fumes do not accumulate in the fire station and are removed immediately.~~
2. ~~As the vehicle leaves the apparatus floor, the flexible 4" diameter exhaust hose equipped with a pneumatically controlled nozzle attached to the vehicle's tailpipe moves toward the exit door along a ceiling mounted aluminum track. A traveling trolley glides along the track with a spring coiled balancer that supports the hose. The balancer keeps the hose away from the exiting apparatus. Mounted to the aluminum track is an uncoupling release valve which automatically releases compressed air from the pneumatic nozzle allowing a smooth uncoupling of the exhaust removal system at the threshold of the exit door regardless of the speed the vehicle may exit the building.~~

3. ~~Upon the vehicles return to the apparatus floor of the fire station, the driver stops the vehicle with the exhaust tailpipe inside the fire station, then the flexible hose equipped with a pneumatic nozzle is attached to the vehicle's exhaust tailpipe and inflated with a manual control by an operator standing in a vertically position at the entrance door. When the vehicle's exhaust tailpipe is connect to the system's nozzle, the exhaust blower will automatically and instantaneously energized to assure total collection of exhaust gases prior to vehicle entering the building. The vehicle can then be positioned in its designated parking position.~~
- ~~B. Source capture emergency vehicle exhaust removal equipment shall be delivered and installed as a Pneumatic Sliding Balancer Track Type System (six 57'-0" rails & one 19'-0" rail) & Vertical Stack Rail (VSR) System equal to the following specifications:~~
1. ~~The track to be extruded aluminum with channel to accept ball bearing rollers of the traveling trolley on bottom side. Rubber impact end stops are to be mounted on each end of the track. The traveling trolley shall be galvanized steel assembly with four upper ball bearing wheels to fit inside track profile and two lower ball bearing wheels to fit on outside of track profile to prevent rocking or shifting of the trolley as it moves along full length of track.~~
 2. ~~Flexible hose shall not exceed 4 inches in diameter for ease of handling and to minimize space requirements on the apparatus floor. Flexible hose greater than 4 inches in diameter are not acceptable. Flexible hose shall be high temperature synthetic rubber impregnated into a high temperature laminated fabric. Flexible hose shall be rated for 400°F continuous, 500°F intermittent temperature to insure durability. Wire helix must be bound and protected in lamination. Hose with exposed wire helix is not acceptable.~~
 3. ~~The pneumatic nozzle must inflate to provide a positive airtight seal around the exhaust tail pipe when connected, to prevent exhaust gases from escaping when the vehicle's engine is accelerated. This is a mandatory requirement.~~
 4. ~~The pneumatic nozzle shall be constructed of high temperature synthetic rubber, vulcanized to high tempter synthetic fabric. A NOMEX inner liner shall be provided as a primary temperature and friction barrier.~~
 5. ~~The nozzle must be universal to accept all vehicle tailpipes up to 6" diameter to allow vehicles to be interchangeable between bays. This will allow all of the vehicles to be parked in any bay. Nozzles that require different sizes for different size vehicle tailpipe are not acceptable because they restrict the location of the vehicles.~~
 6. ~~The tailpipe termination of the vehicle is a 90° angle (perpendicular) to vehicle body to prevent toxic exhaust fumes from being discharged rearward into station after the exhaust system nozzle releases at the door. All tailpipe termination must conform to this configuration.~~
 7. ~~The tailpipe shall not be modified to extend beyond the body of the vehicle nor shall tailpipe be increased in size to accommodate the system nozzle.~~
 8. ~~The manual connection of the nozzle to the tailpipe must be done from an upright standing position without bending over. This is a mandatory requirement is to reduce personnel exposure of the toxic diesel exhaust fumes and prevent personnel from possible burns from handling the nozzle or touching the hot exhaust tailpipe. Additional, personnel bending down to connect the nozzle to the vehicle's tailpipe would be out of view of the driver, which is not acceptable.~~
 9. ~~The manual connection of the nozzle to the tailpipe must be a single operation, from a standing position, without requiring manual attachments or adjustments to other parts of the system. This is a mandatory requirement to eliminate operations that could distract the personnel while the vehicle is moving in to the Fire Station.~~
 10. ~~Flexible hose assembly shall not touch or rub the body of the vehicle. No attachments to the body of the vehicle are permitted. No mechanical attachments or alteration of the vehicle is permitted except for vehicle's tailpipe.~~

11. ~~The transition from to the flexible hose shall be completely seam welded construction to prevent leaks of exhaust fumes. Spot welded construction is not acceptable. The transition is to keep the hose from sagging and excessive fatigue. Transition shall have a metal debris screen to prevent foreign material from damaging the flexible hose or exhaust blower. The transition shall be chrome plated for durability.~~
12. ~~The safety disconnect coupling with adjustable tension release shall completely separate the lower nozzle section from the upper hose assembly in the unlikely event of the exhaust nozzle becomes entangled in the wheels or the under carriage of the vehicle. This is a mandatory requirement to prevent the track or rail supports from being pulled out of the ceiling caused by excessive mechanical tension and strain. The tension of the safety disconnect coupling must be adjustable to accommodate any vehicle. Non-adjustable tension safety disconnect systems are not acceptable. The safety disconnect coupling must be reusable.~~
13. ~~The spring balancer must be enclosed type with stainless steel cable to the support hose assembly during travel along the track.~~
14. ~~Manual inflation/deflation valve shall be sliding type with push button for manual inflation of the pneumatic nozzle. The valve is to incorporate a handle that the operator can easily operate from a standing position to connect pneumatic nozzle to tail pipe. When track mounted pneumatic release valve is activated, valve shall deflate pneumatic nozzle. If the adjustable safety disconnect coupling separates, the valve shall have safety release to deflate pneumatic nozzle automatically.~~
15. ~~The VSR rail shall be 60' long and is to be one piece extruded aluminum to resist corrosion with bottom rubber seals and accept the tapered vertical exhaust stack. Rails assembled with separate top and sides that are fastened together with screws or other mechanical means are not acceptable.~~
16. ~~Exhaust stack catcher shall be constructed of 14 gauge zinc plated steel in a shape of a V-formed box and open underneath, Underside of catcher shall be stiffened with a welded square steel section. This catcher must accommodate the exhaust corner mounted on the vertical exhaust tailpipe of vehicle. Catcher shall automatically position exhaust stack in line with VSR rail. Catcher shall have a minimum acceptance width of 27" and a minimum acceptance height of 6". Catcher shall extend 18" beyond the VSR rail.~~
17. ~~Tapered vertical tailpipe stack shall be ceramic coated steel specially designed to slide into the VSR rail. It shall be secured to the vehicle's vertical tailpipe of the vehicle by means of slotted female end provided on the adapter and compression type clamp.~~
18. ~~VSR Rail mounting shall be free floating side to side and have a minimum travel of 18" from the natural rest position centerline from the exhaust stack. This shall accommodate the use of a sway bar provided with ball bearing trolleys secured to rail by safety links.~~
19. ~~System must be designed to expand to tandem vehicle arrangement by adding to proposed system. Systems that require replacement or major alteration of proposed system to meet tandem arrangement are not acceptable.~~

~~C. Automatic Start Control Panels~~

1. ~~Two (2) control panels shall contain the motor starter, overload, solid state circuit card with timer adjustments from 30 to 360 seconds, fused low voltage transformer, in a NEMA 12 rated key lock electrical enclosure.~~
2. ~~Soft touch AUTO START STOP MANUAL RUN membrane controls shall be on the face of the control panel.~~
3. ~~Control panel must have system indicator LED lights on the soft touch membrane controls. They shall be marked and function as:~~
 - a. ~~AUTO START: This LED shall show the system is in full automatic mode of operation and electrical power is supplied to the control panel.~~

- ~~b. FAN ON: This LED shall show that electrical power is supplied to the exhaust blower.~~
 - ~~c. STOP: This LED shall show the exhaust blower is manually shut down. After three seconds this will return to AUTO START ready mode to prevent the exhaust blower from inadvertently being shut down.~~
 - ~~d. MANUAL RUN: This LED shall show the exhaust blower is operating in a continuous mode until interrupted by the STOP mode being activated.~~
 - ~~e. NO AIRFLOW ALARM: This shall monitor the exhaust blower and advise when the exhaust blower is not operating properly~~
- 4. ~~The low voltage sensors shall signal the start of the exhaust blower. The exhaust blower shall automatically continue to run for as long as the vehicle connected to the system is running.~~
 - 5. ~~Controls that require electrical or pneumatic devices installed on the vehicle to activate the exhaust blower are not permitted. These additional after market devices may cause interference with original equipment and cause a delay in response time.~~

~~D. Exhaust Blowers~~

- 1. ~~Construction shall be class B spark resistance with powder coated steel housing and aluminum wheel with shaft seals.~~

~~E. Air Filtration Devices~~

- 1. ~~An air filtration system shall be designed to reduce the diesel exhaust particulate (soot) from the exhaust blower discharge. The cabinet shall be 20 gauge galvanized steel is 20" wide x 20" high x 49" long with 16" collars on each end and easy access to the filter inside. It shall be supplied with a micro fiberglass bag filter, 20" x 20" x 36" deep.~~

~~F. Warranty~~

- 1. ~~Contractor must warranty all parts and labor of system for a minimum of one (1) years from final date of acceptance. This shall include preventative maintenance; inspection and adjustments on all parts of the system performed every year by the manufacture's factory authorized personnel for the duration of the warranty period.~~

~~G. MANUFACTURER: Subject to compliance with requirements, provide vehicles exhaust capture system(s) of one of the following:~~

- 1. ~~Plymovent~~
- 2. ~~MagnaGrip~~
- 3. ~~Monoxivent~~
- 4. ~~Or Equal~~

A. Function of the Pneumatic type vehicle exhaust system shall be:

- 1. **The exhaust blower will automatically start and evacuate the exhaust gases the moment any vehicle engine connected to the system is started to ensure that the engine exhaust fumes do not accumulate in the fire station and are removed immediately.**

2. As the vehicle leaves the apparatus floor, the flexible 4" diameter exhaust hose equipped with a pneumatically controlled nozzle attached to the vehicle's tailpipe moves toward the exit door along a ceiling mounted aluminum track. A traveling trolley glides along the track with a spring-coiled balancer that supports the hose. The balancer keeps the hose away from the exiting apparatus. Mounted to the aluminum track is an uncoupling release valve which automatically releases compressed air from the pneumatic nozzle allowing a smooth uncoupling of the exhaust removal system at the threshold of the exit door regardless of the speed the vehicle may exit the building.
 3. Upon the vehicles return to the apparatus floor of the fire station, the driver stops the vehicle with the exhaust tailpipe inside the fire station, then the flexible hose equipped with a pneumatic nozzle is attached to the vehicle's exhaust tailpipe and inflated with a manual control by an operator standing in a vertical position at the entrance door. When the vehicle's exhaust tailpipe is connected to the system's nozzle, the exhaust blower will automatically and instantaneously energized to assure total collection of exhaust gases prior to the vehicle entering the building. The vehicle can then be positioned in its designated parking position.
- B. Source capture emergency vehicle exhaust removal equipment shall be delivered and installed as a Pneumatic Sliding Balancer Track Type System (three 57'-0" tracks & four 19'-0" tracks) & one 60'-0" Vertical Stack Rail (VSR) System equal to the following specifications:
1. The track to be extruded aluminum with channel to accept ball bearing rollers of the traveling trolley on bottom side. Rubber impact end stops are to be mounted on each end of the track. The traveling trolley shall be galvanized steel assembly with four upper ball bearing wheels to fit inside track profile and two lower ball bearing wheels to fit on outside of track profile to prevent rocking or shifting of the trolley as it moves along full length of track.
 2. Flexible hose shall not exceed 4 inches in diameter for ease of handling and to minimize space requirements on the apparatus floor. Flexible hose greater than 4 inches in diameter are not acceptable. Flexible hose shall be high temperature synthetic rubber impregnated into a high temperature laminated fabric. Flexible hose shall be rated for 400° (F) continuous, 500°(F) intermittent temperature to ensure durability. Wire helix must be bound and protected in lamination. Hose with exposed wire helix is not acceptable.
 3. The pneumatic nozzle must inflate to provide a positive airtight seal around the exhaust tail pipe when connected, to prevent exhaust gases from escaping when the vehicle's engine is accelerated. This is a mandatory requirement.
 4. The pneumatic nozzle shall be constructed of high temperature synthetic rubber, vulcanized to high tempter synthetic fabric. A NOMEX inner liner shall be provided as a primary temperature and friction barrier.
 5. The nozzle must be universal to accept all vehicle tailpipes up to 6" diameter to allow vehicles to be interchangeable between bays. This will allow all of the vehicles to be parked in any bay. Nozzles that require different sizes for different size vehicle tailpipe are not acceptable because they restrict the location of the vehicles.
 6. The tailpipe termination of the vehicle is a 90° angle (perpendicular) to vehicle body to prevent toxic exhaust fumes from being discharged rearward into station after the exhaust system nozzle releases at the door. All tailpipe terminations must conform to this configuration.
 7. The tailpipe shall not be modified to extend beyond the body of the vehicle nor shall tailpipe be increased in size to accommodate the system nozzle.

8. The manual connection of the nozzle to the tailpipe must be done from an upright standing position without bending over. This is a mandatory requirement as to reduce personnel exposure of the toxic diesel exhaust fumes and prevent personnel from possible burns from handling the nozzle or touching the hot exhaust tailpipe. Additionally, personnel bending down to connect the nozzle to the vehicle's tailpipe would be out of view of the driver, which is not acceptable.
9. The manual connection of the nozzle to the tailpipe must be a single operation, from a standing position, without requiring manual attachments or adjustments to other parts of the system. This is a mandatory requirement to eliminate operations that could distract the personnel while the vehicle is moving in to the Fire Station.
10. Flexible hose assembly shall not touch or rub the body of the vehicle. No attachments to the body of the vehicle are permitted. No mechanical attachments or alteration of the vehicle is permitted except for vehicle's tailpipe.
11. The transition from the flexible hose shall be completely seam-welded construction to prevent leaks of exhaust fumes. Spot welded construction is not acceptable. The transition is to keep the hose from sagging and excessive fatigue. Transition shall have a metal debris screen to prevent foreign material from damaging the flexible hose or exhaust blower. The transition shall be chrome plated or similarly protected for durability.
12. The safety disconnect coupling with adjustable tension release shall completely separate the lower nozzle section from the upper hose assembly in the unlikely event that the exhaust nozzle becomes entangled in the wheels or the under carriage of the vehicle. This is a mandatory requirement to prevent the track supports from being pulled out of the ceiling caused by excessive mechanical tension and strain. The tension of the safety disconnect coupling must be adjustable to accommodate any vehicle. Non-adjustable tension safety disconnect systems are not acceptable. The safety disconnect coupling must be reusable.
13. The spring balancer must be enclosed type with stainless steel cable to the support hose assembly during travel along the track.
14. Manual inflation/deflation valve shall be sliding type with push button for manual inflation of the pneumatic nozzle. The valve is to incorporate a handle that the operator can easily operate from a standing position to connect pneumatic nozzle to tail pipe. When track mounted pneumatic release valve is activated, valve shall deflate pneumatic nozzle. If the adjustable safety disconnect coupling separates, the valve shall have safety release to deflate pneumatic nozzle automatically.
15. The VSR rail shall be 60' long and is to be one piece extruded aluminum to resist corrosion with bottom rubber seals and accept the tapered vertical exhaust stack. Rails assembled with separate top and sides that are fastened together with screws or other mechanical means are not acceptable.
16. Exhaust stack catcher shall be constructed of 14 gauge zinc plated steel in a shape of a V-formed box and open underneath, Underside of catcher shall be stiffened with a welded square steel section. This catcher must accommodate the exhaust corner mounted on the vertical exhaust tailpipe of vehicle. Catcher shall automatically position exhaust stack in line with VSR rail. Catcher shall have a minimum acceptance width of 27" and a minimum acceptance height of 6". Catcher shall extend 18" beyond the VSR rail.
17. Tapered vertical tailpipe stack shall be ceramic coated steel specially designed to slide into the VSR rail. It shall be secured to the vehicle's vertical tailpipe of the vehicle by means of slotted female end provided on the adapter and compression type clamp.
18. VSR Rail mounting shall be free floating side to side and have a minimum travel of 18" from the natural rest position centerline from the exhaust stack. This shall accommodate the use of a sway bar provided with ball bearing trolleys secured to rail by safety links.

19. **System must be designed to expand to tandem vehicle arrangement by adding to proposed system. Systems that require replacement or major alteration of proposed system to meet tandem arrangement are not acceptable.**

C. Automatic Start Control Panels

1. **Two (2) control panels shall contain the motor starter, overload, solid-state circuit card with timer adjustments from 30 to 360 seconds, fused low voltage transformer, each in a NEMA 12 rated key lock electrical enclosure.**
2. **Soft touch AUTO START- STOP - MANUAL RUN membrane controls shall be on the face of the control panel.**
3. **Control panel must have system indicator LED lights on the soft touch membrane controls. They shall be marked and function as:**
 - a. **AUTO START: This LED shall show the system is in full automatic mode of operation and electrical power is supplied to the control panel.**
 - b. **FAN ON: This LED shall show that electrical power is supplied to the exhaust blower.**
 - c. **STOP: This LED shall show the exhaust blower is manually shut down. After three seconds this will return to AUTO START ready mode to prevent the exhaust blower from inadvertently being shut down.**
 - d. **MANUAL RUN: This LED shall show the exhaust blower is operating in a continuous mode until interrupted by the STOP mode being activated.**
 - e. **NO AIRFLOW ALARM: This shall monitor the exhaust blower and advise when the exhaust blower is not operating properly**
4. **The low voltage sensors shall signal the start of the exhaust blower. The exhaust blower shall automatically continue to run for as long as the vehicle connected to the system is running.**
5. **Controls that require electrical or pneumatic devices installed on the vehicle to activate the exhaust blower are not permitted. These additional after market devices may cause interference with original equipment and cause a delay in response time.**

D. Exhaust Blowers

1. **Construction shall be class B spark resistance with powder coated steel housing and aluminum wheel with shaft seals.**

E. Air Filtration Devices

1. **An air filtration system shall be designed to reduce the diesel exhaust particulate (soot) from the exhaust blower discharge. The cabinet shall be 20 gauge galvanized steel is 20" wide x 20" high x 49" long with 16" collars on each end and easy access to the filter inside. It shall be supplied with a micro fiberglass bag filter, 20" x 20" x 36" deep.**

F. Warranty

1. **Contractor must warranty all parts and labor of system for a minimum of one (1) years from final date of acceptance. This shall include preventative maintenance; inspection and adjustments on all parts of the system performed every year by the manufacture's factory authorized personnel for the duration of the warranty period.**

G. **MANUFACTURER: Subject to compliance with requirements, provide vehicles exhaust capture system(s) of one of the following:**

1. **Plymovent**
2. **Magne grip**
3. **Monoxivent**
4. **Or Equal**

2.15 POWER AND GRAVITY VENTILATORS

A. General: Except as otherwise indicated, provide standard prefabricated power and gravity ventilator units of type and size indicated, modified as necessary to comply with requirements, and as required for complete installation.

B. Refer to Division-23 automatic temperature control and control drawings for control sequence.

C. Roof Fans:

1. Type: Centrifugal fan, direct or belt driven as scheduled. Provide aluminum weatherproof housings as scheduled. Provide square base to suit roof curb. Provide permanent split-capacitor type motor for direct driven fans; capacitor-start, induction-run type motor for belt driven fans.
2. Electrical: Provide factory-wired non-fusible type disconnect switch at motor in fan housing. Provide thermal overload protection in fan motor. Provide conduit chase within unit for electrical connection.
3. Bird Screens: Provide removable bird screens, 1/2" mesh, 16-ga. aluminum or brass wire.
4. Gravity Operated Dampers: Provide gravity-actuated, felt edge, louvered dampers in curb bases for all fans scheduled for airflows below 300 CFM.
5. Manufacturer: Subject to compliance with requirements, provide centrifugal roof ventilators of one of the following:
 - a. Greenheck Fan Corp.
 - b. Twin City
 - c. Cook Co., Loren.
 - d. Or equal

D. Centrifugal In-Line Fans (EF)

1. General: Fans shall be of the centrifugal belt or direct driven in-line type. Units shall bear AMCA label.
2. Fan Housing: Shall be of the square design constructed of heavy gauge galvanized steel and shall include square duct mounting collars. Unit shall include two removable access panels located perpendicular to the motor mounting panel. The access panels must be of sufficient size to permit easy access to all interior components.
3. Fan Wheel: Shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.
4. Motors: Shall be heavy duty ball bearing type, carefully matched to the fan load and furnished at the specified voltage, phase, and enclosure. Motors and drives shall be mounted out of the airstream. Motors shall be readily accessible for maintenance.

5. Shafts and Drives: Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. Motor pulleys shall be adjustable for final system balancing. A NEMA 1 disconnect switch shall be provided, factory wired.
6. Gravity Operated Dampers: HVAC contractor shall Provide duct-mounted gravity-actuated, felt edge, louvered dampers for all fans scheduled for airflows below 300 CFM; to be installed as close to the exterior exhaust louver plenum as possible.
7. Manufacturer: Subject to compliance with requirements, provide centrifugal in-line fans of one of the following:
 - a. Greenheck Fan Corp.
 - b. Twin City
 - c. Cook Co., Loren.
 - d. Or equal

E. Roof Hoods (RH):

1. Type: Stationary, natural draft type. Provide weatherproof housings to match power ventilators in materials and finish. Provide square or rectangular base to suit roof curb.
2. Bird Screens: Provide removable bird screens, 1/2" mesh, 16-gal aluminum or brass wire.
3. Gravity Operated Dampers: Provide gravity actuated louvered dampers in curb bases on relief hoods.
4. Manufacturer: Subject to compliance with requirements, provide gravity ventilators of the following:
 - a. Greenheck Fan Corp.
 - b. Twin City
 - c. Cook Co., Loren.
 - d. Or equal

F. Prefabricated Roof Curbs:

1. Manufacturer of ventilating unit shall provide his standard roof curb compatible with unit being provided. Curb shall be insulated and sloped to allow for level installation of device. Provide all necessary nailers, cants, etc. for a complete installation.

2.16 METAL DUCTWORK

- A. Reference Standards: Material, construction and installation shall meet requirements of most recent editions of the following standards and references, except for more stringent requirements specified or shown on Drawings:

Standard	As Applicable To:
SMACNA HVAC Duct	Sheet Metal Ductwork;
Construction Standards	Duct Liners; Adhesives;
Metal and Flexible	Fasteners; Flexible Ductwork.
SMACNA HVAC Air Duct Leakage	Duct Leakage Testing
Test Manual	

SMACNA Fibrous Glass Duct Construction Standards	Fibrous Glass Ductwork; Tapes
SMACNA Thermaoplastic Duct (PVC) Construction Manual	PVC Ductwork
ADC and TIMA Flexible Duct Performance Standards	Flexible Ductwork
NFPA 96	Kitchen Hood Exhaust Ductwork
NFPA 45	Laboratories using chemicals
SMACNA Guidelines for Welding Sheet Metal	Welded Galvanized, Black Iron and Stainless Steel Ductwork

B. General

- Provide supporting and hanging devices necessary to attach entire HVAC system including ductwork and equipment, and to prevent vibration.
- Provide vertical and horizontal supports as required by codes to meet minimum applicable earthquake resistance standards.
- Ductwork shall be free from vibration under all conditions of operation. Dimensions shown on Drawings for lined ductwork are net inside dimensions. Increase ductwork to accommodate lining requirements.
- Pipe or conduit crossing duct:
 - No pipe, conduit, hanger, Architectural element nor structural member shall pass through duct without Designer's written approval.
 - Where it is impossible to re route pipe or conduit and when written approval has been obtained, increase duct size to maintain constant cross sectional area at point of interference. Provide streamlined enclosure for pipe or conduit, as illustrated in SMACNA.
- When making offsets and transformations necessary to accommodate structural conditions, preserve full cross sectional area of ductwork shown on Drawings.
- Ductwork shall have pressure velocity classifications as follow:

DUCT CONSTRUCT- ION CLASS	STATIC PRESSURE RATING	PRESSURE	SMACNA SEAL CLASS	SMACNA LEAKAGE CLASS	VELOCITY
4"	4"	Pos.*	A	3	4000 fpm or less
3"	3"	Pos. or Neg.	A	3	4000 fpm or less
2"	2"	Pos. or Neg.	A	6	2500 fpm or less

1"	1"	Pos. or Neg.	A	6	2500 fpm or less
1/2"	1/2"	Pos. or Neg.	A	6	2000 fpm or less

*for negative pressures over 3" w.g., refer to SMACNA Round and Rectangular Industrial Duct Construction Standards for joint and intermediate reinforcement requirements.

- a. Unless otherwise specified or shown on the drawings, the following pressure classifications shall be used for the types of ductwork listed below:
 - 1) 4" Class: All supply ductwork from discharge of air units to inlets of supply diffusers and/or variable air volume units.
 - 2) 3" Class: All exhaust and system return ductwork. Supply ductwork after the variable air volume units.
 - 3) 2" Class: All other ductwork.
7. Sealing Requirements for Class A, Leakage Class 3 & 6 Galvanized, Non-Welded Aluminum or Non-Welded Stainless Steel Ductwork:
 - a. Transverse Joints
 - 1) During assembly seal all flanged transverse joints with sealing tape of quality equal to Hardcast Inc. 1902-FR. Corners shall be sealed as described by SMACNA and when applicable per manufacturer's published procedures. After sealant has cured, seal entire joint with Hardcast Inc. RTA-50 adhesive on to Hardcast Inc. DT tape or approved equal.
 - 2) Seal all non-flanged transverse joints with Hardcast Inc. RTA-50 adhesive on to Hardcast Inc. DT tape or approved equal.
 - b. Longitudinal Seams
 - 1) Seal all longitudinal seams during ductwork fabrication with Hardcast Inc. Cold Seal 1001 or approved equal.
 - c. Joints and Ductwall Penetrations
 - 1) Seal all duct joints at takeoffs, access doors, damper bearing penetrations, flexible duct connections etc., with Hardcast Inc. Versa Grip 102 or approved equal.
 - 2) Note, access doors and damper rod penetrations shall be equipped with proper hardware for sealing.
8. Support
 - a. Space hangers as required by SMACNA (8 ft max) for horizontal duct on 8 ft. centers, unless concentrated loadings require closer spacing.
 - b. Support vertical duct on each floor or slab it penetrates.
 - c. Supports for ductwork and equipment shall be galvanized unless specified otherwise.

9. Connections

- a. Connect inlets and outlets of air handling units and fans to ductwork with flexible connections unless fan has vibration isolator mounts inside unit with flexible connections and no external vibration isolators. Exception: Do not use flex on life safety smoke exhaust fans.
- b. Indoors, flexible connections shall be neoprene coated fibrous glass fire retardant fabric, by Ventfabrics, or Durodyne. Outdoors, flexible connections shall be Dupont hypalon coated fibrous glass fire, weather, and UV resistant by Ventfabrics or Durodyne.
- c. Secure flexible connections tightly to air handlers with metal bands. Bands shall be same material as duct construction.
- d. Connections from trunk to branch ducts shall be as detailed on Drawings.

10. Construction

- a. No sharp metal edges shall extend into air streams.
- b. Install drive slips on air leaving side of duct with sheet metal screws on 6" centers.
- c. Spin in collars shall NOT be used for branch connections in 3" or higher pressure class ductwork.

11. Joints

- a. Longitudinal lock seams shall be double locked and flattened to make tight joints.
- b. Make transverse joints, field connections, collar attachments and flexible connections to ducts and equipment with sheet metal screws or bolts and nuts. Do not use rivets and staples.

12. Prefabricated Transverse Duct Joints

- a. Transverse joints in galvanized sheet metal ductwork may be made with galvanized gasketed frame and angle duct joint system by Ductmate, TDF, TDC or approved equal. Angles shall be at least 20 gauge. Prefabricated transverse duct joints shall not be used for duct 16 GA. and heavier, nor for duct 23 GA. or lighter.
- b. Secure angles to duct with screws (using clutched arbor) or spot welds spaced as recommended by manufacturer for duct pressure class.

13. Elbows and Bends

- a. Elbows and bends for rectangular ducts shall have centerline radius of 1 1/2 times duct width wherever possible. Elbows for grease exhaust and fume hood exhaust shall be full radius. Vanes or mitered duct are not allowed.
- b. Where centerline radius is less than 1 1/2 times duct width (on supply, return and exhaust ductwork), elbows shall be radius throat (square throat allowed when turning around column or other close objects) with radius heel. For elbows whose width is greater than 48 inches and/or where shown on plans, provide splitter vanes. Install vanes in accordance with SMACNA. Where multiple elbows are separated by less than ten duct diameters use splitter (full length) vanes.
- c. For round ductwork provide stamped elbows, with centerline radii equal to 1 1/2 times duct diameter, or gored elbows as follows:

Elbow Angle	No. of Gores
0 deg. - 36 deg.	2
37 deg. - 72 deg.	3

73 deg. - 90 deg. 5

- d. Elbows for flat oval ducts shall have centerline radii equal to 1 1/2 times duct diameter in plane of bend, or gored elbows with gores as specified for round ducts.

14. Access Panels/Doors

- a. Provide proper pressure and leakage rated, gasketed, duct mounted access panels/doors for the following items with minimum sizes, as indicated. Access doors shall be of double wall construction doors in insulated ducts shall be insulated. Gauges of door materials, no. of hinges, no. and type of door locks shall be as required by the SMACNA Duct Construction Standards. Hinged doors are not acceptable, screwed or bolted access panels are not acceptable. Doors shall be chained to frame with a minimum length of 6" to prevent loss of door. For seal Class A, access doors shall be leakage rated, neoprene gasketed UL 94 HF1 listed, DUCTMATE "sandwich" or approved equal. Door metal shall be the same as the attached duct material. For grease and high temperature ducts, door assembly shall be rated for 2300 deg.F. The minimum sizes are:

- 1) Fire dampers 12" x 12", or larger.
- 2) Combination Fire/Smoke dampers 12" x 12", or larger.
- 3) Smoke dampers 6" x 6" minimum.
- 4) Automatic control dampers 6" x 6" minimum.
- 5) Manual volume dampers 2 sq. ft. and larger 6" x 6" minimum.
- 6) Inlet side to all coils 12" x 12", or larger.
- 7) Suction and discharge sides of inline fans 24" x 24" minimum.
- 8) At additional locations indicated on drawings, or specified elsewhere 12" x 12" minimum.

- b. Generally access doors are not shown on the drawings, but shall be provided in accordance with the above.

15. Extractors shall have adjusting rod and locknut on outside of duct.

16. Connections to roof fans:

- a. Shall be at least 22 ga. galvanized steel soldered watertight.
- b. Solder side seams at least 12" up from bottom.
- c. Provide suitable dielectric gaskets to join dissimilar materials.

17. Plenums and connections to louvers:

- a. Shall be 18 ga. minimum cross broken and properly reinforced with galvanized angle irons to SMACNA requirements.
- b. Shall have bottom and corner seams soldered watertight at least 12" up from bottom.
- c. Shall have neoprene gaskets or other non corrosible material to make connections to louvers watertight.
- d. Shall pitch connection back towards the louver. Provide half coupling drain connection at bottom of plenum unless noted otherwise. Pipe drain to nearest floor drain.
- e. Shall have unused portions of louvers blocked-off with sheet metal; sealed air and water tight; insulated with 2" thick 6 lb. density rigid or board insulation.

18. Duct Pressure Tests

- a. Pressure test all duct classes after takeoffs and wall penetrations are in place and before applying exterior insulation. Correct any leaks.
- b. Pressure and leak test 100% of all duct work with a pressure class of 3" or higher as specified in paragraph 2.20.B.6.a. Duct shall be constructed so there is no joint or structural failure at the test pressure.

19. Duct Leakage Tests

- a. Leak testing method shall be performed as outlined in the SMACNA HVAC Air Duct Leakage Test Manual. As specified in paragraph 2.20.B.6 & a, utilize Sealing Requirements for Class A and Leakage Class 6 for all ductwork. Provide orifice assembly including straightening vanes, orifice plate mounted in straight tube with properly located pressure taps, and U tube manometer or other device as specified by SMACNA. Orifice assembly shall be calibrated accurately and shall come with calibration curve. Leakage classes shall be as previously specified. Submit leak test report (per SMACNA format) for Designer review. Drawings of ductwork tested shall also be submitted with report, indicating presence of takeoffs, wall penetrations, joints, etc.

20. Materials

- a. Sheet metal ducts shall be constructed of hot dipped galvanized sheet metal with G90 Commercial coating according to ASTM 527 unless specified otherwise.
- b. Stainless steel (SS) ductwork shall be 18 gauge for kitchen hoods; and as required by SMACNA for other ducts. Materials shall be 316/No. 4 finish for exposed duct, 304/No. 1 finish for concealed ducts. Joints and seams shall be welded as required by SMACNA Guidelines for Welding Sheetmetal.
- c. Aluminum ductwork shall be Alclad 3003 1414 or alloy 5052 H32, for exhaust fan No. 2 duct system. Thickness as required by the SMACNA duct construction standards with Alloy 6061 bracing angles, and Pittsburgh lock longitudinal corner and double side seaming.
- d. Flexible Ductwork
 - 1) Flexible ductwork, connecting to uninsulated or unlined duct, shall be polyester core with corrosion resistant helical wire reinforcing. The polyester core shall be minimum two ply and shall have a minimum thickness of 0.0017". Flex duct shall be U.L. rated for 6" W.C. positive pressure, 2" W.C. negative pressure with a maximum velocity of 4000 FPM. Flexduct must be listed as a Class 1 Connector according to UL 181 and shall meet the requirements of NFPA 90A maximum ASTM E 84 fire hazard rating shall be 25 flame spread, 50 fuel contributed and 50 smoke developed. Uninsulated flexible duct shall be equivalent to Wiremold, Type WB, or Flexmaster Types 2 and 4 (not type 9).
 - 2) Flexible duct connected to insulated or lined duct shall also be insulated and shall be equivalent to Wiremold Type WK or Flexmaster Types 2 or 4 (not type 9), with 1 1/2", 3/4 lb. density fiberglass insulation and an aluminized reinforced vapor barrier.
 - 3) Submittals shall include data on no. of polyester plies and minimum thickness of polyester core, in addition to other data listed above required to ensure that submitted product meets the requirements of these specifications.

- 4) If flexduct other than the model numbers of the vendors listed above is submitted, a sample of the flex shall be submitted to the Designer. The Designer shall have sole discretion in determining whether the submitted flex is equivalent to that of the named vendors above.
- 5) Unless otherwise indicated, flexible duct shall not exceed 5'-0" long.

C. 2" and Lower Pressure Class Ductwork, Rectangular:

1. Ducts wider than 19" with more than 10 square feet of unbraced panel shall be beaded or cross broken.
2. Internal stiffening struts shall only be used upon prior written approval of the Designer.
3. Make changes in duct size with tapered connections as required by SMACNA. Changes shall NOT exceed 30 deg. from line of air flow. Take off to the diffusers shall be 45 deg. leading edge type or Bellmouth type.
4. Transverse joints shall be TDF/TDC or slip joints; use flat or standing seam according to SMACNA. Where duct size requires standing seam but space restrictions dictate flat seam, notify Designer prior to fabrication.

D. 2" and Lower Pressure Class Ductwork, Round:

1. Joints
 - a. Longitudinal joints shall be spiral seam, butt welded, lap and seam welded, or ACME lock grooved seam. Snap lock seams shall be used on ½" w.g. pressure class duct only.
 - b. Transverse joints shall be beaded sleeve joint or other approved joints listed in SMACNA. Use three or more sheet metal screws at 15" uniform intervals along circumference of joints.
2. Branch fittings shall be conical tee (Buckley or equal) or combination tee as shown in SMACNA.

E. 3" and 4" Pressure Class Ductwork Rectangular

1. Joints
 - a. Joints shall be prefabricated type by TDC, TDF or Ductmate. See Prefabricated Joints paragraph for specific requirements.
2. Duct reinforcement spacing and type shall comply with SMACNA.
3. Ductwork on both sides of transitions shall be run in same horizontal axis.
4. Diverging section slope shall be 1 1/2" per foot or less if possible.
5. Contraction section slope shall not exceed 7" per foot.
6. Takeoffs shall be 45 deg. leading edge type except that Bellmouths (Buckley or equal) may be used for takeoffs to terminal boxes if the distance between the box and point of takeoff is less than 8 ft.
7. Ducts with an aspect ratio greater than 3:1 shall be minimum of 18 gauge unless a thicker gauge is required by SMACNA.

F. 3" and 4" Pressure Class Ductwork, Flat Oval, Single Wall

1. Joints

- a. Ducts shall have spiral lock seams or longitudinal seams. Seams and joints in fittings shall be continuously welded. If coating is damaged during welding, repair joints to prevent corrosion.
- b. Transverse joints shall be slip or flanged.

G. 3" and 4" Pressure Class Ductwork, Round, Single Wall

1. Joints

- a. Longitudinal seams shall be lock spiral, lock longitudinal or butt welded longitudinal.
- b. Transverse joints shall be slip joints. Draw band joints shall be used on longitudinal seam duct only. Loose flange Vanstone joints may be used on ducts over 36" in diameter.
- c. Seams and joints in fittings shall be continuously welded. If coating is damaged during welding, repair joints to prevent corrosion.

2. Branch fittings shall be conical tee or combination tee as detailed in SMACNA.

H. Flexible Rigid Duct

1. Flexible ductwork shall be Flexmaster Triple Lock Buck Duct Flexible Air Duct (insulated) as manufactured by Buckley Associates or equal (617 878 5000). Flexible duct, non insulated, shall be Underwriters Laboratory Listed UL 181 Class 0 air duct and constructed in accordance with NFPA Standards 90A and 90B. It shall have a smoke/flame spread rating of 50/25.
2. Duct shall be made from a tape of dead soft aluminum sheet, spiral wound into a tube and spiral corrugated to provide strength and stability. The joint shall consist of a triple lock mechanically performed without the use of adhesives to make a durable airtight seam. A double lock is not acceptable.
3. Flexible duct connected to insulated or lined duct shall also be insulated. Flexmaster insulated flex shall have a gray Fire Retardant Polyethylene outer jacket with a ½ lb. density, 1 1/2" thick fiberglass insulation blanket, factory wrapped. Flexible Duct, insulated, shall be Underwriters Laboratory Listed and constructed in accordance with NFPA standards 90A and 90B. It shall have a smoke/flame spread rating of 50/25.
4. The flexible duct shall be supported as required.
5. Flexible duct work shall be rated at 12" positive pressure. Duct from 3 to 16" shall have a negative pressure of 12", 8" for duct work 18 and 20.
6. All flexible duct shall be individually cartooned and labeled for delivery to the job site for maximum protection.
7. Submittals shall include data on minimum thickness of aluminum core, in addition to other data listed above, required to ensure that submitted product meets the requirements of these specifications.
8. Provide sealing compound for installation. See further paragraphs in this specification and details for other installation requirements.

I. Volume Dampers

1. Provide Young Regulator manual adjustable rectangular opposed blade dampers for duct heights less than 12" with factory installed locking hand quadrants extended 2" for all dampers installed in externally insulated duct:
 - a. On each supply, return and general exhaust duct take off.
 - b. At each take off to register, grille or diffuser (not all are shown on Drawing).
2. Dampers are manufactured approximately 5/16" smaller in width and 1/8" smaller in height than size of duct in which they are installed; e.g., nominal damper size is 24" x 10"; actual size is approximately 23 11/16" x 9 7/8".
3. Damper frame shall be constructed of #6063 extruded aluminum reinforced channel with minimum thickness of .050". Opposed damper blades shall be #6063 extruded aluminum with minimum thickness of .050" and shall include reinforcing ribs. Each blade shall be supported in the damper frame by individual Teflon axle bearings, and shall be driven by stainless steel connecting slide linkage controlled by 3/8" square steel control shaft.
4. Note: All required volume dampers may not be indicated on drawings but dampers shall be provided as necessary for systems balancing.
5. Dampers 12" and larger in height shall be opposed multi blade equal to Greenheck, Nailor, or Vent Products.
6. Where dampers are inaccessible, use Young Regulator locking type ceiling regulators and miter gear or worm gear for all horizontal dampers. Bearing coupling for bottom duct control may be used for shaft on vertical blade dampers. The 3/8" rod between ceiling regulator and damper shall be provided by contractor.
7. Damper blades shall be two gauges heavier than adjoining ductwork, and shall be riveted to supporting rods. Hem over edges parallel to rods.
8. Brackets shall be galvanized metal, secured to ductwork with sheet metal screw with locking quadrant arms (see seal class section for additional requirements). Provide 2" handle extension for all dampers on externally insulated ductwork.
9. Note: All required volume dampers may not be indicated on Drawings but dampers shall be provided as necessary for system balancing.

J. Automatic Dampers: Install automatic dampers furnished under Automatic Temperature Control Paragraph of this Section, as shown on Drawings, and as specified. Provide sealed wall penetrations for Seal Class A ductwork.

K. Locker Room & Shower Room (any room containing a shower or steam shower) Exhaust or Return Ductwork

1. Ductwork shall be aluminum, of types as detailed in this specification above and constructed in accordance with SMACNA except that Seal Class shall be "A" regardless of duct pressure rating.

L. Branch Duct Take off Fittings

1. Contractor shall provide Buckley Bellmouth Take offs at all branch duct locations.
2. Bellmouth Fitting shall be Model BMD with damper. In areas where sufficient duct height is not available, the contractor shall provide the Buckley Mini mouth fitting, Model M BMD with damper or the flat oval Bellmouth, Model FOBMD with damper.
3. Bellmouths shall be constructed of heavy duty galvanized steel. Bellmouths shall include an air tight Neoprene gasket to ensure a tight fitting with minimal leakage. Pre drilled holes shall be provided for quick mounting. Bellmouth shall be as manufactured by Buckley Associates or equal (617 878 5000).

4. Standard damper hardware to be constructed of 26 gauge galvanized material with a quadrant damper and tight fitting gasketing to ensure minimal leakage at damper pivot points.
5. Optional heavy duty hardware shall be provided at locations of higher static pressure where shown on the drawings.
6. Ninety degree take offs are not permitted on this project..

2.17 DUCTWORK ACCESSORIES

A. Dampers:

1. Low Pressure Manual Dampers: Provide dampers of single blade type or multiblade type, constructed in accordance with SMACNA "HVAC Duct construction Standards".
2. Automatic Control Dampers: Refer to Division-23 section "Automatic Temperature Control" for control dampers; not work of this section.
3. Backdraft Relief Dampers: Provide dampers with parallel blades, counterbalanced and factory-set to relieve at .05" static pressure. Construct blades of 16-ga. aluminum, provide 1/2" diameter ball bearings, 1/2" diameter steel axles spaced on 9" centers. Construct from 2" x 1/2" x 1/8" steel channel for face areas 25 sq. ft. and under: 4" x 1-1/4" x 16 ga. channel for face areas over 25 sq. ft. Provide galvanized steel finish on frame with aluminum touch-up. Provide felted or rubber trim to assure tight, leak-proof seal when closed.
4. Manufacturer: Subject to compliance with requirements, provide dampers of one of the following:
 - a. Air Balance, Inc.
 - b. Airguarde Corp.
 - c. American Warming & Ventilating, Inc.
 - d. Arrow Louver and Damper; Div. of Arrow United Industries, Inc.
 - e. Louvers & Dampers, Inc.
 - f. Penn Ventilator Co.
 - g. Ruskin Mfg. Co.
 - h. Or equal

B. Fire Dampers:

1. Fire Dampers: Provide fire dampers, of types and sizes indicated. Construct casings of 11-ga. galvanized steel. Provide fusible link rated at 160 to 165 degrees F (71 to 74 degrees C) unless otherwise indicated. Provide owner with a spare fusible link for each damper. Provide out of air stream type damper in open position and with positive lock in closed position, and with the following additional features:
 - a. Damper Blade Assembly: Curtain type.
 - b. Blade Material: Steel, match casing.
 - c. Blade Material: Stainless steel.
2. Motor-Driven Fire/Smoke Dampers: Provide line voltage motor-driven fire/smoke dampers in types and sizes indicated on drawings, with casing constructed of 11-ga. galvanized steel with bonded red acrylic enamel finish, fusible link 160 to 165 degrees F (71 to 74 degrees C), unless otherwise indicated, and curtain type stainless steel interlocking blades, with electric motor equipped with instant closure clutch, stainless steel cable damper blade linkage, motor mounting bracket, and 32" long wire leads for connecting to smoke detector, and with the following construction features:
 - a. Unit Assembly: Motor mounted outside air stream.

3. Manufacturer: Subject to compliance with requirements, provide fire dampers of one of the following:
 - a. Air Balance, Inc.
 - b. American Warming & Ventilating, Inc.
 - c. Arrow Louver and Damper; Div. of Arrow United industries, Inc.
 - d. Louvers & Dampers, Inc.
 - e. Penn Ventilator Co.
 - f. Phillips-Aires
 - g. Ruskin Mfg. Co.
 - h. Or equal

C. Turning Vanes:

1. Manufactured Turning Vanes: Provide double thickness airfoil turning vanes constructed of 1-1/2" wide curved blades set at 3/4" o.c., supported with bars perpendicular to blades set at 2" o.c, and set into side strips suitable for mounting in ductwork.
2. Manufacturer: Subject to compliance with requirements, provide turning banes of one of the following:
 - a. Aero Dyne Co.
 - b. Airsan Corp.
 - c. Anemostat Products Div.; Dynamics Corp. of America.
 - d. Barber-Colman Co.
 - e. Duro Dyne Corp.
 - f. Environmental Elements Corp.; Subs, Koppers Co., Inc.
 - g. Hart & Cooley Mfg. Co.
 - h. Register & Grille Mfg. Co., Inc.
 - i. Souther, Inc.
 - j. Or equal

D. Duct Hardware:

1. General: Provide duct hardware, manufactured by one manufacturer for all items on project, for the following:
 - a. Test Holes: Provide in ductwork at fan inlet and outlet, and elsewhere as indicated, duct test holes, consisting of slot and cover, for instrument tests.
 - b. Quadrant Locks: Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12". Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.
2. Manufacturer: Subject to compliance with requirements. Provide duct hardware of one of the following:
 - a. Ventbabs, Inc.
 - b. Young Regulator Co.
 - c. Or equal

E. Duct Access Doors:

1. General: Provide duct access doors of a size as required to service and maintain device in duct. Provide on (1) access door at each control damper, humidifier, coil, fire damper, and any device that requires attention.

2. Construction: Construct of same or greater gauge as ductwork served, provide insulated doors for insulated ductwork. Provide flush frames for uninsulated ductwork, extended frames for externally insulated duct. Provide one side hinged, other side with one handle-type latch for doors 12" high and smaller, 2 handle-type latches for larger doors.
3. Manufacturer: Subject to compliance with requirements, provide duct access doors of one of the following:
 - a. Air Balance, Inc.
 - b. Duro Dyne Corp.
 - c. Register & Grille Mfg. Co., Inc.
 - d. Ruskin Mfg. Co.
 - e. Ventfabrics, Inc.
 - f. Zurn Industries, Inc.; Air Systems Div.
 - g. Or equal

F. Flexible Connectors:

1. General: Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibration of connected equipment.
2. Manufacturer: Subject to compliance with requirements, provide flexible connections of one of the following:
 - a. American/Elgen Co.; Energy Div.
 - b. Duro Dyne Corp.
 - c. Flexaust (The) Co.
 - d. Ventfabrics, Inc.
 - e. Or equal

2.18 ACOUSTIC DUCT LINING

- A. Lining for Rectangular Metal Ducts: All ducts, where shown or noted on the drawings, shall be lined with 1 ½ in. thick (R-6 min. performance) liner similar to Johns Manville "Permacote Linacoustic RC" fiberglass duct liner with factory-applied surface and edge coating. The lining can be less than 2" thick as long as code minimum R-6 is met. The liner shall meet the Life Safety Standards as established by NFPA 90A and 90B, FHC 25/50 and Limited Combustibility and the airstream surface coating should contain an immobilized, EPA-registered, anti-microbial agent so it will not support microbial growth as tested in accordance with ASTM G21 and G22. The duct liner shall conform to the requirements of ASTM C 1071, with an NRC not less than .75 as tested per ASTM C 423 using a Type "A" mounting, and a thermal conductivity no higher than .24 at 75EF mean temperature.
- B. Material Handling and Storage: Liner shall be kept clean and dry during transportation, storage and installation. Care should be taken to protect the liner from exposure to the elements or damage from mechanical abuse.
- C. Manufacturer: Subject to compliance with the above provide duct sound lining in accordance with the above performance criteria description.

2.19 SOUND ATTENUATORS (SA)

- A. General: Provide factory-fabricated and tested duct silencers as indicated, select with performance characteristics which match, or exceed those indicated on schedule.

- B. Casings: Construct of sheet metal, with gauge and seam construction equal or greater than that recommended by SMACNA-Duct Construction Standards for ductwork of same size and pressure class; but not less than 18-gauge for outer casing and 22-gauge for inner casing.
- C. Acoustic Fill: Provide inorganic mineral or glass fiber filler material, inert, vermin and moisture proof, of sufficient density to obtain specified acoustic performance. Pack under not less than 5% compression to eliminate voids due to vibration and settling.
- D. Acoustic Performance: Provide silencer ratings that have been determined in such to reverberative room test facility. Test silencer with air flow in both directions through silencer, in accordance with ASTM E477, "Methods of Testing Duct Liner Materials and Prefabricated Silencers for Acoustical and Airflow Performance."
 - 1. For acoustic ratings, include Dynamic Insertion Loss and Self Noise Power Levels for both forward flow (air and noise in same direction) and reverse flow (air and noise in opposite directions) with airflow of at least 2,000 FPM face velocity.
- E. Aerodynamic Performance: Provide silencers with static pressure loss equal to or less than that scheduled.
- F. Certification: Provide certified test data on Dynamic Insertion Loss, Self-Noise Power Levels, and Aerodynamic Performance. Conduct all rating tests at same facility. Open testing facility for inspection by Architect/Engineer if requested.
- G. Manufacturers: Subject to compliance with requirements, provide duct silencers of one of the following:
 - 1. Industrial Acoustics Co.
 - 2. Aeroacoustic Corporation
 - 3. Vibro-Acoustics
 - 4. Price
 - 5. Or equal

2.20 AIR OUTLETS AND INLETS

- A. Ceiling Air Diffusers:
 - 1. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation. Stamped face diffusers will not be acceptable.
 - 2. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw, drop and noise criteria ratings for each size device as listed in manufacturer's current data.
 - 3. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.

4. Types: Provide ceiling diffusers of type, capacity, throw, blow and with accessories as listed on diffuser schedule.
 - a. Ceiling Diffusers shall be of the restricted multi-orificed jet induction and air mixing type consisting of louver sections with built-in diffusing vanes. The vanes shall be arranged to discharge air from adjacent louvers at an angle of 45 degrees in opposite directions to insure rapid mixing of primary and room air. Diffusing vanes shall be welded and mechanically fastened to the adjacent louver sections to make a rigid unit. The vanes shall extend to the discharge edges of the louvers. Where louver sections join the core frame, the louver ends shall be welded to the core frame. The leaving edge of each louver shall be hemmed and the louver ends shall be rounded and hemmed before welding to the core frames.
 - b. Diffusers shall be fabricated of aluminum or steel-welded construction, and shall be provided with a removable core permitting easy access to the neck connection. The diffuser neck shall extend no less than 1" above the core to accommodate an internal duct connection to prevent leakage into the ceiling space.
 - c. Finish shall be baked enamel. Color as selected by A/E.
 - d. Diffusers shall be steel of the fixed louvered face type with a minimum of four vaned assemblies. The louvered face shall be removable. The diffuser neck shall be sized to fit outside of the duct. Access to damper adjustment shall be provided through the face of the diffuser.
 - e. Diffusers shall be finished with a baked enamel color as selected by A/E.
5. Manufacturer: Subject to compliance with requirements, provide diffusers of one of the following:
 - a. Tuttle & Bailey Agitair Series "RC"
 - b. Metalaire – "5000 IV"
 - c. Nailor
 - d. Price Industries
 - e. Or equal

B. Wall Registers And Grilles:

1. General: Except as otherwise indicated, provide manufacturer's standard registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
2. Performance: Provide registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device and listed in manufacturer's current data.
3. Compatibility: Provide registers and grilles with border styles that are compatible with adjacent systems, and that are specifically manufactured to fit into wall and ceiling construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of construction which will contain each type of register and grille.
4. Types: Provide registers and grilles of type, capacity, and with accessories and finishes as listed on register and grille schedule:
5. Pattern: Register and grille patterns shall have style as identified on Drawings:
6. Accessories:
 - a. Plaster Frame: Perimeter frame designed to act as plaster stop and register or grille anchor. Provide where required.
 - b. Operating Keys: Tools designed to fit through register or grille face and operate volume control device and/or pattern adjustment.

7. Finish: Register and Grille Finishes shall be baked enamel color as selected by the Architect.
8. Manufacturer: Subject to compliance with requirements, provide registers and grilles of one the following:
 - a. Tuttle & Bailey Agitair (Air Devices)
 - b. Carnes Co.
 - c. Titus Products Div.; Philips Industries, Inc.
 - d. Price Industries
 - e. Or equal

C. Ceiling Registers and Grilles:

1. General: Except as otherwise indicated, provide manufacturer's standard "Egg-Crate" type registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
2. Compatibility: Provide registers and ceiling grilles with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling construction.
3. Types: Provide registers and grilles of type, capacity, and with accessories and finishes as listed on register and grille schedule.
4. Register and Grille Materials:
 - a. Aluminum Construction: Manufacturer's standard extruded aluminum frame and core.
5. Register and Grille Faces:
 - a. 1/2" x 1/2" "Egg-Crate" with 1" border frame.
6. Register and Grille Finishes shall be baked enamel color as selected by the Architect.
7. Manufacturer: Subject to compliance with requirements, provide registers and grilles of one of the following:
 - a. Tuttle & Bailey Agitair (Air Devices)
 - b. Carnes Co.
 - c. Titus Products Div.; Philips Industries, Inc.
 - d. Price Industries
 - e. Or equal

D. Security Grilles

1. Furnish and install risk resistant perforated steel maximum security (supply/return) grilles of the sizes and mounting types indicated on the plans and outlet schedule. Grilles shall be 3/16 in. hot rolled steel faceplate with maximum 1/8 in. perforated staggered holes with 40% free area. The grille is to be attached to a wall sleeve of 3/16 in. hot rolled steel with a rear mounting frame for a concealed and secure fastening. The grille shall be painted with a powder coat process and be finished in white. Paint finish shall pass 500 hours of salt spray exposure with no measurable creep in accordance with ASTM D1654 and 1000 hours with no rusting or blistering as per ASTM D610 and ASTM D714.

2. Manufacturer: Subject to compliance with requirements, provide registers and grilles of one of the following:
 - a. KEES
 - b. Price Industries
 - c. Titus Products Div.; Philips Industries, Inc.
 - d. Or equal

2.21 ~~VARIABLE REFRIGERANT FLOW (VRF) EQUIPMENT (WATER TO REFRIGERANT SIMULTANEOUS COOL/HEAT)~~

~~A. System Description~~

1. ~~Per the equipment schedule, the variable capacity, water-cooled, heat pump heat recovery air conditioning system basis of design is Mitsubishi Electric CITY MULTI VRF (Variable Refrigerant Flow) zoning system(s). Contractor bidding an alternate manufacturer does so with full knowledge that that manufactures product may not be acceptable or approved if alternate product does not fully meet specification requirements and that contractor is responsible for all specified items; requirements and intents of plans and specifications without further compensation.~~
2. ~~Simultaneous heating/cooling (heat recovery) systems shall consist of a water to refrigerant cooled unit, BC (Branch Circuit) Controller (or comparable branch devices), multiple indoor units, and an integral DDC (Direct Digital Controls) system. Each indoor unit or group of indoor units shall be capable of operating in any mode independently of other indoor units or groups. System shall be capable of changing mode (cooling to heating, heating to cooling) with no interruption to system operation. To ensure owner comfort, each indoor unit or group of indoor units shall be independently controlled and capable of changing mode automatically when zone temperature strays 1.8 degrees F from set point for ten minutes.~~
3. ~~No additional branch circuit controllers (or comparable branch devices) than shown on the drawings/schedule may be connected to any one water to refrigerant unit. Contractor bidding alternate manufacturer(s) requiring additional branch devices assumes responsibility for additional all costs & placement considerations and are required to identify additional costs & installation time required with their equipment price.~~

~~B. Quality Assurance~~

1. ~~Units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label.~~
2. ~~All wiring shall be in accordance with the National Electrical Code (N.E.C.).~~
3. ~~The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).~~
4. ~~All units must meet or exceed the 2010 Federal minimum efficiency requirements and the ASHRAE 90.1 efficiency requirements for VRF systems. Efficiency shall be published in accordance with the Air Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 1230.~~
5. ~~System start-up supervision shall be a required service to be completed by the manufacturer or a duly authorized, competent representative that has been factory trained in system configuration and operation. The representative shall provide proof of manufacturer certification indicating successful completion within no more than two (2) years prior to system installation. This certification shall be included as part of the equipment and/or controls submittals.~~

~~C. Delivery, Storage and Handling~~

1. ~~Unit shall be stored and handled according to the manufacturer's recommendation.~~

~~D. Warranty~~

1. ~~The units shall be covered by the manufacturer's limited warranty for a period of one (1) year parts and seven (7) year compressor to the original owner from date of installation.~~
2. ~~Installing contractor shall meet manufacturer requirements to obtain extended manufacturer's limited parts and compressor warranty for a period of ten (10) years to the original owner from date of installation. This warranty shall not include labor.~~
3. ~~Manufacturer shall have demonstrated a minimum of fifteen (15) years continuous experience providing VRF systems in the U.S. market.~~
4. ~~All manufacturer submittal, technical and service manuals must be readily available for download by any local contractor should emergency service be required. Registering and sign-in requirements which may delay emergency service reference are not allowed.~~
5. ~~The VRF system shall be installed by a contractor with extensive install and service training with the equipment provided. The mandatory contractor service and install training should be performed by the manufacturer.~~

~~E. Simultaneous Heating/Cooling (Heat Recovery), Water to Refrigerant Cooled Units~~

1. ~~General: The outdoor unit modules shall be water to refrigerant cooled, direct expansion (DX), multi-zone units used specifically with VRF components described in this specification and on the drawings. The outdoor unit modules shall be equipped with a single compressor which is inverter driven and multiple circuit boards all of which must be manufactured by the branded VRF manufacturer. Each outdoor unit module shall be completely factory assembled, piped and wired and run tested at the factory.~~
 - a. ~~Water to refrigerant unit systems may be comprised of multiple modules with differing capacity if a brand other than basis of design is proposed. All units requiring a factory supplied twinning kits shall be piped together in the field, without the need for equalizing line(s). If an alternate manufacturer is selected, any additional material, cost, and labor to install alternate units shall be incurred by the contractor. Contractor responsible for ensuring alternative brand compatibility in terms of availability, physical dimensions, weight, electrical requirements, piping costs, etc.~~
 - b. ~~Water to refrigerant unit shall have a sound rating no higher than 58 dB(A) individually or 60 dB(A) twinned. If an alternate manufacturer is selected, any additional material, cost, and labor to meet published sound levels shall be incurred by the contractor.~~
 - c. ~~Refrigerant lines from the outdoor unit to the BC (Branch Circuit) Controller or comparable branch devices shall be insulated in accordance with the installation manual.~~
 - d. ~~The water to refrigerant unit shall have the capability of installing the main refrigerant piping through the front of the unit. Contractor bidding alternative manufacturer(s) assumes responsibility for ensuring compliance with required space and service clearances with no changes to existing spaces.~~
 - e. ~~The water to refrigerant unit shall have an accumulator with refrigerant level sensors and controls.~~
 - f. ~~The water to refrigerant unit shall have a freeze protection mode. Additionally, each module must include a field installed flow switch sensor to shut the unit off in the event of water flow failure.~~
 - g. ~~The water to refrigerant unit shall have a high pressure safety switch, over-current protection, crankcase heater and DC bus protection.~~
 - h. ~~VRF system shall meet performance requirements per schedule and be within piping limitations & acceptable ambient temperature ranges as described in~~

- ~~respective manufacturers' published product catalogs. Non-published product capabilities or performance data are not acceptable.~~
- ~~i. The water source unit shall be capable of continuous operation in heating or cooling mode with entering supply water temperature range between 23 deg.F and 113 deg.F without external, field-installed bypass valves.~~
 - ~~j. The water source unit shall have 0-10V output signal or two position valve closure interlock available for conformance with IECC requirements.~~
 - ~~k. The water source units are intended for installation indoors with an ambient temperature between 32oF DB and 104oF DB.~~
 - ~~l. The water source unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained. Oil return sequences must be enabled only during extended periods of reduced refrigerant flow to ensure no disruption to correct refrigerant flow to individual zones during peak loads. Systems which might engage oil return sequence based on hours of operation risk oil return during inopportune periods are not allowed. Systems which rely on sensors (which may fail) to engage oil return sequence are not allowed.~~
2. Unit Cabinet:
- ~~a. The cabinet(s) shall be fabricated of hot dip galvanized steel sheet for corrosion resistance.~~
 - ~~b. The water source systems can be mounted side-by-side or stacked (with proper structural supports) depending on selected connection locations.~~
3. Inverter Cooler
- ~~a. The water source unit shall have an internal direct expansion type inverter cooler. The inverter cooler shall provide cooling for all internal cabinet components eliminating the need for cabinet ventilation along with associated clearance requirements and additional space cooling load.~~
 - ~~b. Alternate systems without integral cooling for internal cabinet components shall require additional indoor unit(s) sized for total heat rejection of water source unit and additional outdoor unit capacity must be added to account for load. Submitted efficiency data must be corrected to reflect system capacity reduction due to cooling capacity applied to heat rejected by HVAC equipment.~~
4. Refrigerant and Refrigerant Piping
- ~~a. R410A refrigerant shall be required for systems.~~
 - ~~b. Polyolester (POE) oil widely available and used in conventional domestic systems shall be required. Prior to bidding, manufacturers using alternate oil types shall submit material safety data sheets (MSDS) and comparison of hygroscopic properties for alternate oil with list of local suppliers stocking alternate oil for approval at least two weeks prior to bidding.~~
 - ~~c. Refrigerant piping shall be phosphorus deoxidized copper (copper and copper alloy seamless pipes) of sufficient radial thickness as defined by the VRF equipment manufacturer and installed in accordance with manufacturer recommendations.~~
 - ~~d. All refrigerant piping must be insulated with 1/2" closed cell, CFC-free foam insulation with flame Spread Index of less than 25 and a smoke development Index of less than 50 as tested by ASTM E 84 and CAN / ULC S-102. R value of insulation must be at least 3.~~

- ~~e. Refrigerant line sizing shall be in accordance with manufacturer specifications. Future changes to indoor unit styles or sizes must be possible without resizing/replacing refrigerant piping to any other branch devices or indoor units.~~

5. ~~Water-Refrigerant Heat Exchanger Coil and Connections:~~

- ~~a. The water-source heat exchanger shall be a cross-flow, stainless steel brazed plate heat exchanger. The channel plate shall be constructed from AISI 316 SS. The Frame/Pressure plate shall be constructed from AISI 304 SS. The brazing material shall be pure copper.~~
- ~~b. The heat exchanger shall be rated for a maximum of 2.0 MPa (290 psi).~~
- ~~c. Water connections on unit shall utilize standard national pipe thread (NPT) connections as is standard for US piping. Alternate pipe thread standards which may appear physically similar but require adapters are not allowed.~~
- ~~d. The water source unit shall be approved for use in a closed water loop system.~~

6. ~~Compressor:~~

- ~~a. Each water source unit module shall be equipped with only inverter driven scroll hermetic compressors. Non inverter driven compressors, which may cause inrush current (demand charges) and require larger generators for temporary power shall not be allowed.~~
- ~~b. Compressor shall have an inverter to modulate capacity. The capacity for each compressor shall be variable with a minimum turndown not greater than 24%.~~
- ~~c. The compressor shall be equipped with an internal thermal overload.~~
- ~~d. Field-installed oil equalization lines between modules are not allowed. Prior to bidding, manufacturers requiring equalization must submit oil line sizing calculations specific to each system and module placement for this project.~~

7. ~~Controls:~~

- ~~a. The water source unit shall be an integral part of the system & control network described in Part 4 and react to heating/cooling demand as communicated from connected indoor units over the control circuit. Required field-installed control voltage transformers and/or signal boosters shall be provided by the manufacturer.~~
- ~~b. The unit shall have the capability of 4 levels of demand control for each refrigerant system based on external input.~~
- ~~c. The unit shall have the capability of interlocking operation of the water circuit and error detection.~~

8. ~~Electrical:~~

- ~~a. The outdoor unit electrical power shall be 208/230 volts, 3-phase, 60 hertz per equipment schedule.~~
- ~~b. The watersource unit shall be controlled by integral microprocessors.~~
- ~~c. The control circuit between the indoor units, BC Controller and the watersource unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.~~

~~F. Branch Circuit (BC) Controllers as Required for Simultaneous Heat/Cool Systems~~

1. ~~General~~

- ~~a. BC (Branch Circuit) Controllers (or comparable branch devices) shall include multiple branches to allow simultaneous heating and cooling by allowing either hot gas refrigerant to flow to indoor unit(s) for heating or subcooled liquid refrigerant to flow to indoor unit(s) for cooling. Refrigerant used for cooling must always be subcooled for optimal indoor unit LEV performance; alternate branch devices which do not include controlled refrigerant subcooling risk bubbles in liquid supplied to indoor unit LEVs and are not allowed.~~
 - ~~b. BC Controllers (or comparable branch devices) shall be equipped with a circuit board that interfaces to the controls system and shall perform all functions necessary for operation. The unit shall have a galvanized steel finish and be completely factory assembled, piped and wired. Each unit shall be run tested at the factory. This unit shall be mounted indoors, with access and service clearance provided for each controller. BC Controllers (or comparable branch devices) shall be suitable for use in plenums in accordance with UL1995 ed 4.~~
2. BC Unit Cabinet:
 - ~~a. The casing shall be fabricated of galvanized steel.~~
 - ~~b. Each cabinet shall house a liquid-gas separator and multiple refrigeration control valves.~~
 - ~~c. The unit shall house two tube in tube heat exchangers.~~
3. Refrigerant Piping (specifications in addition to those for outdoor unit):
 - ~~a. All refrigerant pipe connections shall be brazed.~~
 - ~~b. Future changes to indoor unit quantities or sizes served by BC Controller or comparable branch device must be possible with no piping changes except between the branch device and indoor unit(s) changing. Systems which might require future piping changes between branch device and outdoor unit if changes to indoor unit quantities or sizes are made are not considered equal and are not allowed.~~
4. Refrigerant valves:
 - ~~a. Service shut-off valves shall be field provided/installed for each branch to allow service to any indoor unit without field interruption to overall system operation.~~
5. Condensate Management:
 - ~~a. BC Controller (or comparable branch device) must have integral resin drain pan or insulate refrigeration components with removable insulation that allows easy access for future service needs. Cabinets filled with solid foam insulation do not allow for future service and are not allowed.~~
6. Electrical:
 - ~~a. The unit electrical power shall be 208/230 volts, 1 phase, 60 Hertz. The unit shall be capable of satisfactory operation within voltage limits of 187-228 (208V/60Hz) or 207-253 (230/60Hz).~~
 - ~~b. The BC Controller shall be controlled by integral microprocessors~~
 - ~~c. The control circuit between the indoor units and outdoor units shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.~~

~~G. Indoor Evaporator Units~~

1. ~~General:~~

- ~~a. The evaporator shall be an indoor unit with style as scheduled on the drawings section and shall have a modulating linear expansion device and a flat front. The unit shall be used with the water cooled unit and BC Controller. The unit shall support individual control using manufacturer's DDC controllers.~~

2. ~~Indoor Unit~~

- ~~a. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.~~

3. ~~Unit Cabinet:~~

- ~~a. All casings, regardless of model size, shall have the same white finish~~
~~b. Multi directional drain and refrigerant piping offering four (4) directions for refrigerant piping and two (2) directions for draining shall be standard.~~
~~c. There shall be a separate back plate which secures the unit firmly to the wall.~~

4. ~~Fan:~~

- ~~a. The indoor fan shall be an assembly with one or two line flow fan(s) direct driven by a single motor.~~
~~b. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.~~
~~c. A manual adjustable guide vane shall be provided with the ability to change the airflow from side to side (left to right).~~
~~d. A motorized air sweep louver shall provide an automatic change in airflow by directing the air up and down to provide uniform air distribution.~~

5. ~~Filter:~~

- ~~a. Return air shall be filtered by means of an easily removable, washable filter.~~

6. ~~Coil:~~

- ~~a. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.~~
~~b. The tubing shall have inner grooves for high efficiency heat exchange.~~
~~c. All tube joints shall be brazed with phos-copper or silver alloy.~~
~~d. The coils shall be pressure tested at the factory.~~
~~e. A condensate pan and drain shall be provided under the coil.~~
~~f. Both refrigerant lines to the indoor units shall be insulated in accordance with the installation manual.~~

7. ~~Electrical:~~

- ~~a. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.~~

- ~~b. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz)~~

8. Controls:

- ~~a. This unit shall use controls provided by the manufacturer to perform functions necessary to operate the system. Please refer to this guide specification for details on controllers and other control options.~~
- ~~b. The unit shall be able to control external backup heat.~~
- ~~c. The unit shall have a factory built in receiver for wireless remote control~~
- ~~d. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.~~
- ~~e. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8 deg.F - 9.0 deg.F adjustable dead band from set point.~~
- ~~f. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.~~
- ~~g. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.~~

~~H. Controls~~

1. Overview

~~a. General:~~

- ~~1) The Manufacturer's Controls Network (MCN) shall be capable of supporting remote controllers, centralized controllers, an integrated web based interface, graphical user workstation, and system integration to Building Management Systems via BACnet®.~~

2. Electrical Characteristics

~~a. General:~~

- ~~1) The MCN shall operate at 30VDC. Controller power and communications shall be via a common non-polar communications bus.~~

~~b. Wiring:~~

- ~~1) Control wiring shall be installed in a daisy chain configuration from indoor unit to indoor unit, to the BC controller (main and subs, if applicable) and to the outdoor unit. Control wiring to remote controllers shall be run from the indoor unit terminal block to the controller associated with that unit.~~
- ~~2) Control wiring for the Smart ME remote controller shall be from the remote controller to the first associated indoor unit (TB-5) M-NET connection. The Smart ME remote controller shall be assigned an M-NET address.~~
- ~~3) Control wiring for the Simple MA and Wireless MA remote controllers shall be from the remote controller (receiver) to the first associated indoor unit (TB-15) then to the remaining associated indoor units (TB-15) in a daisy chain configuration.~~
- ~~4) Control wiring for centralized controllers shall be installed in a daisy chain configuration from outdoor unit to outdoor unit, to the system controllers~~

(centralized controllers and/or integrated web based interface), to the power supply.

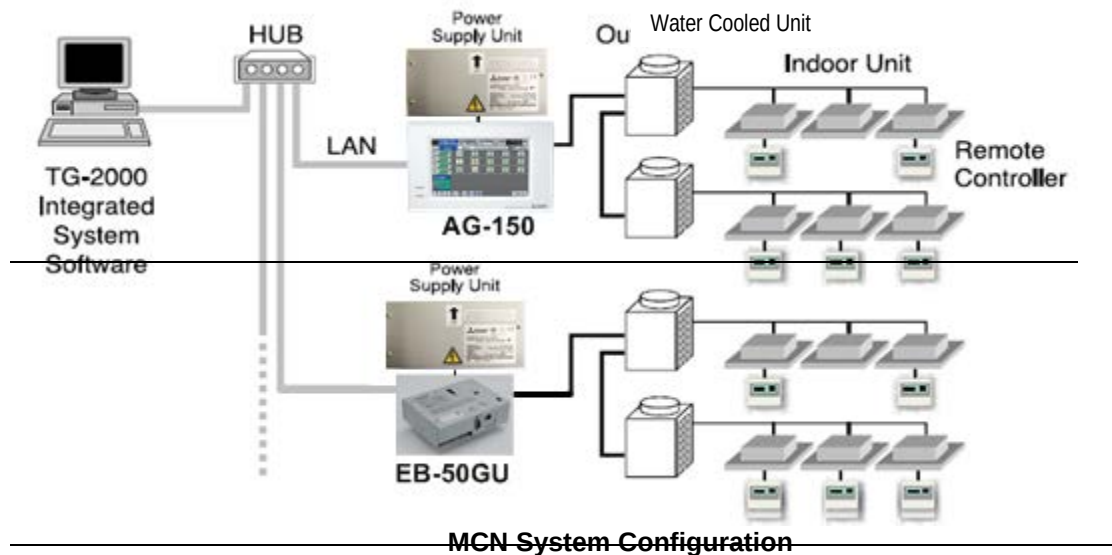
- 5) ~~The AE-200, AE-50, and EB-50GU centralized controller shall be capable of being networked with other AE-200, AE-50, and EB-50GU centralized controllers for centralized control.~~

c. ~~Wiring type:~~

- 1) ~~Wiring shall be 2 conductor (16 AWG), twisted, stranded, shielded wire as defined by the Diamond System Builder output.~~
- 2) ~~Network wiring shall be CAT-5 with RJ-45 connection.~~

3. ~~Manufacturer's Controls Network~~

- a. ~~The Manufacturer's Controls Network (MCN) consists of remote controllers, centralized controllers, and/or integrated web based interface communicating over a high speed communication bus. The Manufacturer's Controls Network shall support operation monitoring, scheduling, occupancy, error email distribution, personal web browsers, tenant billing, online maintenance support, and integration with Building Management Systems (BMS) using BACnet® interfaces. The below figure illustrates a sample MCN System Configuration.~~



- b. ~~MCN: Remote Controllers Backlit Simple MA Remote Controller (PAC-YT53CRAU)~~

- 1) ~~The Backlit Simple MA Remote Controller (PAC-YT53CRAU) shall be capable of controlling up to 16 indoor units (defined as 1 group). The Backlit Simple MA Remote Controller shall be compact in size, approximately 3" x 5" and have limited user functionality. The Backlit Simple MA supports temperature display selection of Fahrenheit or Celsius. The Backlit Simple MA Remote Controller shall allow the user to change on/off, mode (cool, heat, auto (R2/WR2-Series only), dry, setback (R2/WR2-Series only) and fan), temperature setting, and fan speed setting and airflow direction. The Backlit Simple MA Remote Controller shall be able to limit the set temperature range from the Backlit Simple MA. The Backlit Simple MA Remote controller shall be capable of night setback control with upper and lower set temperature settings. The room temperature shall be sensed at~~

- either the Backlit Simple MA Remote Controller or the Indoor Unit dependent on the indoor unit dipswitch setting. The Backlit Simple MA Remote Controller shall display a four-digit error code in the event of system abnormality/error.
- 2) ~~The Backlit Simple MA Remote Controller shall only be used in same group with Wireless MA Remote Controllers (PAR-FL32MA-E / PAR-FA32MA-E) or with other Backlit Simple MA Remote Controllers (PAC-YT53CRAU), with up to two remote controllers per group.~~
 - 3) ~~The Backlit Simple MA Remote Controller shall require no addressing. The Backlit Simple MA Remote Controller shall connect using two-wire, stranded, non-polar control wire to TB15 connection terminal on the indoor unit. The Simple MA Remote Controller shall require cross-over wiring for grouping across indoor units.~~

PAC-YT53CRAU (Backlit Simple MA Remote Controller)			
Item	Description	Operation	Display
ON/OFF	Run and stop operation for a single group	Each Group	Each Group
Operation Mode	~~Switches between Cool/Drying/Auto/Fan/Heat/Setback. Operation modes vary depending on the air conditioner unit. Auto and Setback mode are available for the R2/WR2-Series only.~~	Each Group	Each Group
Temperature Setting	~~Sets the temperature from 40 deg.F — 95 deg.F depending on operation mode and indoor unit.~~ ~~Separate COOL and HEAT mode set points available depending on central controller and connected mechanical equipment.~~	Each Group	Each Group
Fan — Speed Setting	~~Available fan speed settings depending on indoor unit.~~	Each Group	Each Group
Air — Flow Direction Setting	~~Air flow direction settings vary depending on the indoor unit model.~~	Each Group	Each Group
Permit — / Prohibit Local Operation	~~Individually prohibit operation of each local remote control function (Start/Stop, Change operation mode, Set temperature, Reset filter).~~ ~~*1: Centrally Controlled is displayed on the remote controller for prohibited functions.~~	N/A	Each Group *1
Display Indoor Unit — Intake Temp	~~Measures and displays the intake temperature of the indoor unit when the indoor unit is operating.~~	N/A	Each Group
Display Backlight	~~Pressing the button lights up a backlight. The light automatically turns off after a certain period of time. (The brightness settings can be selected from Bright, Dark, and Light off.)~~	N/A	Each Unit
Error	~~When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed~~	N/A	Each Unit
Test Run	~~Operates air conditioner units in test run mode.~~ ~~*2 The display for test run mode will be the same as for normal start/stop (does not display “test run”).~~	Each Group	Each Group *2
Ventilation Equipment	~~Up to 16 indoor units can be connected to an interlocked system that has one LOSSNAY unit.~~	Each Group	N/A
Set Temperature Range Limit	~~Set temperature range limit for cooling, heating, or auto mode.~~	Each Group	Each Group

4. Centralized Controller (Web-enabled)

a. AE-200 Centralized Controller

- 1) The AE-200A Centralized Controller shall be capable of controlling a maximum of two hundred (200) indoor units across multiple CITY MULTI outdoor units with the use of three (3) AE-50A expansion controllers. The AE-200A Centralized Controller shall be approximately 11-5/32" x 7-55/64" x 2-17/32" in size and shall be powered with an integrated 100-240 VAC power supply. The AE-200A Centralized Controller shall support system configuration, daily/weekly scheduling, monitoring of operation status, night setback settings, free contact interlock configuration and malfunction monitoring. When being used alone without the expansion controllers, the AE-200A Centralized Controller shall have five basic operation controls which can be applied to an individual indoor unit, a collection of indoor units (up to 50 indoor units), or all indoor units (collective batch operation). This basic set of operation controls for the AE-200 Centralized Controller shall include on/off, operation mode selection (cool, heat, auto (R2/WR2-Series only), dry, setback (R2/WR2-Series only) and fan), temperature setting, fan speed setting, and airflow direction setting. Since the AE-200A provides centralized control it shall be able to enable or disable operation of local remote controllers. In terms of scheduling, the AE-200A Centralized Controller shall allow the user to define both daily and weekly schedules (up to 24 scheduled events per day) with operations consisting of ON/OFF, mode selection, temperature setting, air flow (vane) direction, fan speed, and permit/prohibit of remote controllers.

AE-200 (Centralized Controller)			
Item	Description	Operation	Display
ON/OFF	Run and stop operation.	Each Block, Group or Collective	Each Group or Collective
Operation Mode	Switches between Cool/Dry/Auto/Fan/Heat. (Group of Lossnay unit: automatic ventilation/vent-heat/interchange/normal ventilation) Operation modes vary depending on the air conditioner unit. Auto mode is available for the R2/WR2-Series only.	Each Block, Group or Collective	Each Group
Temperature Setting	Sets the temperature from 57 deg.F — 87 deg.F depending on operation mode and indoor unit.	Each Block, Group or Collective	Each Group
Fan Speed Setting	Available fan speed settings depending on indoor unit.	Each Block, Group or Collective	Each Group
Air Flow Direction Setting	Air flow direction settings vary depending on the indoor unit model. *1. Louver cannot be set.	*1 Each Block, Group or Collective	Each Group

AE-200 (Centralized Controller)			
Item	Description	Operation	Display
Schedule Operation	Annual/weekly/today schedule can be set for each group of air conditioning units. Optimized start setting is also available. *1. The system follows either the current day, annual schedule, or weekly, which are in the descending order of overriding priority. Twenty-four events can be scheduled per day, including ON/OFF, Mode, Temperature Setting, Air Direction, Fan Speed and Operation Prohibition. Five types of weekly schedule (seasonal) can be set. Settable items depend on the functions that a given air conditioning unit supports.	*2. Each Block, Group or Collective	Each Group
Optimized Start	Unit starts 5 – 60 minutes before the scheduled time based on the operation data history in order to reach the scheduled temperature at the scheduled time.	Each Block, Group or Collective	Each Block, Group or Collective
Night Setback Setting	The function helps keep the indoor temperature in the temperature range while the units are stopped and during the time this function is effective.	Each Group	Each Group
Permit / Prohibit Local Operation	Individually prohibit operation of each local remote control function (Start/Stop, Change operation mode, Set temperature, Reset filter). *3. Centrally Controlled is displayed on the remote controller for prohibited functions.	Each Block, Group or Collective	*3. Each Group
Room Temp	Displays the room temperature of the group. Space temperature displayed on the indoor unit icon on the touch screen interface.	N/A	Each Group
Error	When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed *4. When an error occurs, the LED flashes. The operation monitor screen shows the abnormal unit by flashing it. The error monitor screen shows the abnormal unit address, error code and source of detection. The error log monitor screen shows the time and date, the abnormal unit address, error code and source of detection	N/A	*4. Each Unit or Collective
Outdoor Unit Status	Compressor capacity percentage and system pressure (high and low) pressure (excludes S-Series)	Each ODU	Each ODU
Connected Unit Information	MNET addresses of all connected systems	Each IDU, ODU and BG	Each IDU, ODU and BG
Ventilation Equipment	This interlocked system settings can be performed by the master system controller. When setting the interlocked system, use the ventilation switch the free plan LOSSNAY settings between “Hi”, “Low” and “Stop”. When setting a group of only free plan LOSSNAY units, you can switch between “Normal ventilation”, “Interchange ventilation” and “Automatic ventilation”.	Each Group	Each Group
Multiple Language	Other than English, the following language can be chosen. Spanish, French, Japanese, Dutch, Italian, Russian, Chinese, and Portuguese are available.	N/A	Collective

AE-200 (Centralized Controller)			
Item	Description	Operation	Display
External Input /Output	By using accessory cables you can set and monitor the following: Input By level: "Batch start/stop", "Batch emergency stop" By pulse: "batch start/stop", "Enable/disable remote controller" Output: "start/stop", "error/Normal" *5. Requires the external I/O cables (PAC-YG10HA-E) sold separately.	*5 Collective	*5 Collective

- 2) ~~All AE-200A Centralized Controllers shall be equipped with two RJ-45 Ethernet ports to support interconnection with a network PC via a closed/direct Local Area Network (LAN) or to a network switch for IP communication to up to three AE-50A expansion controllers for display of up to two hundred (200) indoor units on the main AE-200A interface.~~
- 3) ~~The AE-200A Centralized Controller shall be capable of performing initial settings via the high resolution, backlit, color touch panel on the controller or via a PC browser using the initial settings.~~
- 4) ~~Standard software functions shall be available so that the building manager can securely log into each AE-200A via the PC's web browser to support operation monitoring, scheduling, error email, interlocking and online maintenance diagnostics. Additional optional software functions of personal browser for PCs and MACs and Tenant Billing shall be available but are not included. The Tenant Billing function shall require TG-2000 Integrated System software in conjunction with the Centralized Controllers.~~

b. ~~AE-50A Expansion Controller~~

- 1) ~~The AE-50A Expansion Controller shall serve as a standalone centralized controller or as an expansion module to the AE-200A Centralized Controller for the purpose of adding up to 50 indoor units to either the main touch screen interface of the AE-200A. Up to three (3) AE-50A expansion controllers can be connected to the AE-200A via a local IP network (and their IP addresses assigned on the AE-200A) to the AE-200A to allow for up to two hundred (200) indoor units to be monitored and controlled from the AE-200A interface.~~
- 2) ~~The AE-50A expansion controllers have all of the same capabilities to monitor and control their associated indoor units as the features specified above. Even when connected to the AE-200A and configured to display their units on the main controller, the individual indoor units connected to the AE-50A can still be monitored and controlled from the interface of the AE-50. The last command entered will take precedence, whether at the wall controller, the AE-50A or the AE-200A Centralized Controller.~~

5. ~~Control Network: System Integration~~

- a. ~~The Control Network shall be capable of supporting integration with Building Management Systems (BMS) via BACnet® interfaces.~~

- ~~b. BAC HD150: BACnet® Interface. The Mitsubishi Electric HVAC BACnet® interface, BAC-HD150, shall be compliant with BACnet® Protocol (ANSI/ASHRAE 135-2004) and be Certified by the (BTL) BACnet® Testing Laboratories. The BACnet® interface shall support a maximum of 50 indoor units. Operation and monitoring points include, but are not limited to, on/off, operation mode, fan speed, prohibit remote controller, filter sign reset, alarm state, error code, and error address. HVAC contractor and ATC Contractor shall coordinate BMS system protocol requirements for integration into the new Building Management System.~~
- ~~i. Manufacturers: Subject to compliance with requirements, provide products by one of the following:~~
- ~~1. Mitsubishi CityMulti (*See Paragraph J)~~
 - ~~2. LG Variable Refrigerant Flow (VRF) System. (*See Paragraph J)~~
 - ~~3. Daikin AC~~
 - ~~4. Or Equal.~~
- ~~J. *Written prior approval required for alternate VRF System Manufacturer.~~
- ~~K. Written prior approved alternate manufacturer is required to coordinate any changes from the basis of design with all associated trades. Any additional costs associated with the alternate equipment shall be covered by the HVAC contractor or equipment manufacturer. No additional costs shall be incurred by the owner.~~
- ~~L. Shop drawings shall be submitted in accordance with 013300. Submittals should include equipment cutsheet information, proposed piping design layout and list of materials. Submittals shall be prepared by an authorized system designer and distributor.~~

A. GENERAL

- 1. All units shall be listed and rated by ANSI/AHRI Standard 1230-2010 and meet all minimum IEER performance requirements as scheduled.**
- 2. The units shall be ANSI/UL STD 1995 listed and listed by Electrical Testing Labs (ETL) and bear the cETL label.**
- 3. All wiring shall be in accordance with the National Electric Code (NEC).**
- 4. The system will be produced in an ISO 9001 and ISO 14001 facility, which are standards set by the International Standard Organization (ISO). The system shall be factory tested for safety and function.**

B. SYSTEM DESCRIPTION

- 1. VRF system shall automatically vary the target evaporating and condensing temperatures based on building load and weather conditions to increase part load efficiency (Variable Refrigerant Temperature). The condensing unit shall also feature customizable operating modes which allows for the manual setting of target evaporating and condensing temperatures.**
- 2. Heat Recovery: System shall permit simultaneous heating and cooling of each indoor unit. Multiple indoor units connected to a single branch selector port shall operate in the same mode (heating or cooling), similar to a two pipe heat pump system. Refer to the controls section of this specification for any central controller and/or mode switchover sequence that may be required.**

C. START-UP AND WARRANTY

1. Installing contractor must be certified by VRF manufacturer. The bidders shall be required to submit training certification proof with bid documents and submittal documents.
2. The manufacturer shall provide a factory trained service technician to start-up each unit. Manufacturer shall provide instruction to the owners' personnel on proper unit operation and maintenance.
3. The warranty period on all parts and compressors shall commence on the date of initial start-up and shall continue for a period of Ten (10) years not to exceed one hundred and twenty six (126) months from date of shipment. Proper maintenance of the equipment shall be conducted by certified technicians as per the manufacturer or manufacturer's representative requirements. Maintenance logs shall be supplied by the owner upon request.
4. All manufacturer warranty shall be for parts only. All diagnosis and labour warranty shall be carried out by installing contractor as per the warranty requirements of this project.

D. REFRIGERANT PIPING

1. Refer and comply to the refrigerant piping specifications, including the special considerations for VRF refrigerant piping section.
2. Standard T style joints are not acceptable for a variable refrigerant volume system. Manufacturer specific Y joints shall be supplied by the VRF manufacturer.

E. FAN COILS

1. Fan coils shall monitor and maintain the unit superheat (cooling mode) or subcooling (heating mode) using a computerized PID control. Internal unit components shall be factory wired and piped, and complete with electronic proportional expansion valve, flare connections, condensate drain pan, self-diagnostics, and auto-restart function.
2. **4 WAY FLAT CEILING CASSETTE UNIT**
 - a. Indoor unit model FXZQ shall be a ceiling cassette fan coil unit with a variable speed direct drive DC type fan for installation into the ceiling cavity, equipped with an air panel grill. It shall be a four-way air distribution type with fresh white or silver, impact resistant washable decoration panel. The supply air is distributed via motorized louvers which can be horizontally and vertically adjusted from 0° to 90°.
 - b. The indoor unit's sound pressure shall range from 25.5 dB(A) to 33 dB(A) at low speed measured at 5 feet below the unit.
 - c. The 4-way supply air flow shall be capable of field modification to 2-way or 3-way airflow to accommodate various installation configurations including corner installations.
 - d. The decoration panel shall be a low-profile design, extending only 5/16" below the ceiling without any overlap with neighboring ceiling tiles, allowing for installation directly adjacent to other ceiling components such as lights, diffusers, and sprinklers, etc.
 - e. Return air shall be through the concentric panel, which includes a resin net mold resistant filter. The indoor units shall be equipped with a condensate pan and a factory-mounted condensate pump with up to 21" of lift, and have a built-in safety shutoff and alarm.

- f. Three auto-swing positions shall be available to choose from, which include standard, draft prevention and ceiling stain prevention.
- g. The fan shall have a variable speed direct drive DC motor with a statically and dynamically balanced impeller with 3 user-selectable fan speeds. The automatic fan speed mode shall allow the fan to vary between 5 speeds based on space load.

F. CONDENSING UNIT

- 1. The condensing unit shall be factory assembled in North America and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of inverter scroll compressors, motors, fans, heat exchanger, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, liquid receiver (heat recovery only) and suction accumulator.
- 2. The system will automatically restart operation after a power failure and will not cause any settings to be lost.
- 3. The unit shall incorporate an auto-charging feature to ensure proper refrigerant charge.
- 4. The following safety devices shall be included on the condensing unit: high pressure sensor and switch, low pressure sensor, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter, and anti-recycling timers.
- 5. The inverter scroll compressors shall be high efficiency reluctance DC (digitally commutating), hermetically sealed, variable speed type. Temperatures and pressures shall be read every 20 seconds and calculated. With each reading, the compressor capacity (INV frequency) shall be controlled to eliminate deviation from target value. Non inverter-driven compressors shall not be accepted.
- 6. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. Upon complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
- 7. The compressors' motors shall have a cooling system using discharge gas, to avoid sudden changes in temperature resulting in significant stresses on winding and bearings.
- 8. Inverter board shall be refrigerant-cooled to prevent inefficient and unstable operation that can result from air-cooled inverter boards due to varying ambient conditions.
- 9. The compressor shall be internally isolated to avoid the transmission of vibration.
- 10. In the case of multiple condenser modules, operation hours of the compressors shall be balanced by means of the Duty Cycling Function.
- 11. **WATER-COOLED VRV-IV T-SERIES 8,10,12 TON CONDENSING UNITS:**
 - a. The condenser heat exchanger shall be a stainless brazed plate type designed for closed loop applications. The heat exchanger shall use 1-1/4" FPT inlet / outlet piping and shall be rated for a maximum system water pressure of 536.6 psi.
 - b. System shall be designed for operating water temperatures of 14°F-113°F. Minimum entering water temperature for cooling operation is 23°F. Any system designed with water temperatures that can reach below 50°F shall include provisions for glycol antifreeze.
 - c. Units sized 8-12 ton shall contain one compressor, 16-24 ton units shall contain a minimum of two compressors, and 26-36 ton units shall contain a minimum of 3 compressors.

- d. Heat generated by the compressor, inverter board, and any other components shall be rejected to the refrigerant loop via an internal DX heat exchanger, removing the need for mechanical room ventilation or cooling considerations. Manufacturers with external heat rejection from the unit shall be responsible to air-condition the mechanical room.
- e. Condensing units shall allow for stacked installation with minimum spacing. Combined height shall not exceed 6.8ft for double-stacked units and 10.3ft for triple-stacked units.
- f. Condensing units shall be supported along their front and back base rails. Four point supports only on the four corners is not acceptable. Neoprene strips (for floor mounted units) or rubber grommets (for hung units) shall be used for vibration isolation.
- g. The system shall be equipped with variable water flow control logic as standard. Each unit shall send a 2-9V DC output signal to flow control valve(s) or variable speed pump(s).
- h. Each condensing unit water-loop shall be complete with field supplied, installed and wired flow proving switches, wired into each condensing unit module. Flow proving switches shall be set for a minimum of 13 GPM, or 21 GPM for glycol applications.
- i. Each condensing unit water-loop shall also be installed with a field supplied strainer, pressure independent balancing valve, and manual ball valve.
- j. Compressors shall be fully accessible and removable from the front access panel of the unit. The electrical box shall be hinged and allow access to key internal components, including the compressor, without fully disassembling the outer casing.

G. BRANCH SELECTOR BOX

1. Selector box cabinets shall have a galvanized steel plate casing and shall house multiple electronic expansion valves and a sub-cooling loop. The unit shall contain sound absorption thermal insulating material made of flame and heat resistant foamed polyethylene.
2. Branch selector boxes shall not require drain pan and drain connections. Manufacturers with branch selector boxes requiring secondary drain pans and drain connections shall coordinate with the installing contractor at no extra cost to the owner.
3. Manufacturers with branch selector box sizes, arrangements, or locations that differ from what is specified shall make the necessary arrangements to ensure their alternative branch selector boxes both fit in the space and that ASHRAE 15 compliance is still met.
4. Manufacturers shall provide sound data for all branch selector boxes. If sound data is unavailable or exceeds the values below, or if branch boxes make use of solenoid valves instead of electronic expansion valves, necessary precautions shall be taken. Precautions shall include the supply and install of sound blankets, or the relocation of branch boxes away from the occupied spaces, or extra insulation to the ceilings and walls around the branch selector boxes, all at no extra cost to the owner.

Model	Voltage	MCA	Operating Sound	Max Sound	WxHxD	Weight
		A	dB(A)	dB(A)	inch	lbs
BSQ36TVJ	230V 1ph	0.1	35	40	15.3x8.1x12.8	27
BSQ60TVJ	230V 1ph	0.1	41	45	15.3x8.1x12.8	27
BSQ96TVJ	230V 1ph	0.1	41	45	15.3x8.1x12.8	33
BS4Q54TVJ	230V 1ph	0.4	38	45	14.6x11.7x18.9	49
BS6Q54TVJ	230V 1ph	0.6	39	47	22.8x11.7x18.9	68

Model	Voltage	MCA	Operating Sound	Max Sound	WxHxD	Weight
		A	dB(A)	dB(A)	inch	lbs
BS8Q54TVJ	230V 1ph	0.8	39	47	22.8x11.7x18.9	73
BS10Q54TVJ	230V 1ph	1.0	40	48	32.3x11.7x18.9	101
BS12Q54TVJ	230V 1ph	1.2	40	48	32.3x11.7x18.9	106

H. LOCAL CONTROLS

1. Fan coil units shall be supplied with individual zone controllers, similar to Daikin model BRC1E73
 - a. Zone controllers shall be hard wired by installing contractor.
 - b. Controllers shall be able to function as follows:
 - 1) The controller shall have single and dual setpoints for occupied periods, and independent setback setpoints for unoccupied periods.
 - 2) The controller shall have the ability to digitally prohibit individual buttons and functions, including custom mode selection.
 - 3) The controller shall have a self diagnosis function that constantly monitors the system for malfunctions.
 - 4) The controller shall be equipped with a thermostat sensor.
 - 5) Controller shall have built-in 7 day, weekday plus Saturday Sunday (5+1+1), weekday plus weekend (5+2) and everyday (1) scheduler.

I. CENTRAL CONTROLS

1. Provide an advanced multi-zone controller for installation in a common area as shown on the plans, equal to Daikin iTouch Manager. The controller shall have a 10" LCD touch screen display with the following screen views and functionalities :
2. Central control of set points, schedules, fan speeds, heat/cool mode, and of setback (override) temperature settings during unoccupied periods.
3. Adjustable temperature limits to restrict local wall mounted thermostat setpoint ranges.
4. Visible and audible alarm indication of any system malfunctions with error code.
5. Tiered hierarchy allowing for control of fan coil units independently or as a group.
6. Remotely disable individual functions of the wall mounted zone controllers.
7. Web enabled for remote access from PC, tablet or portable device and automatic alert and error emails.
8. The following two automatic changeover methods shall be available. One shall be selected upon commissioning.
 - a. Averaging Method – the central controller shall sum up the difference between room temperatures and set points for all indoor units in the system. Once this delta reaches the primary changeover deadband of $\pm 2^{\circ}\text{F}$ (adjustable), the central controller shall change over the system automatically.

- b. **Voting Method** – The central controller shall evaluate the difference between individual room temperatures and set points, and only include a fan coil in the algorithm if the difference has passed the primary dead band for more than the guard timer, or past the secondary dead band. Heating priority option shall be available.
 - 1) For both automatic changeover options, a weight (0-3) can be added to each indoor unit. The automatic changeover algorithm shall use this weighting to prioritize changeover for the more heavily weighted fan coils.
 - 2) Upon any changeover, a guard timer shall prevent another changeover for a period of 15, 30, or 60 (default) minutes.
 - 3) The guard timer shall be ignored by a change of setpoint manually from either the central controller or the remote controller, by schedule, or if the secondary deadband is reached with either of the automatic changeover algorithms. The secondary changeover deadband shall be the sum of the primary changeover deadband (adjustable) $\pm 1^{\circ}\text{F}$ (adjustable)
- 9. **“3D” Floor plan graphic layout**
 - a. The central controller shall have the capability for site floor plans to be uploaded as a background to create a graphics interface. Background shall be project specific floor plans rendered in “2D” or “3D”.
 - b. Floor plan layout shall be displayed both on the local central controller, as well as accessible from the web.
 - c. Floor plan will include capability to control indoor unit, and auxiliary inputs / outputs, such as designated lighting control, as follows:
 - d. Up to 4 status points to be assigned to the control point icon (room name, room temperature, set point, and mode).
 - e. Status and control points to display on corresponding location of zone served on floor plan.
 - f. Digital input and output icons will display On/Off status.
 - g. Analog input icons will display analog value.
 - h. Up to 60 floor layout sections shall be possible depending on project scope.
- 10. **BACnet Server**
 - a. The iTM BACnet Server Gateway Option shall be capable of making the iTouch Manager work as a BACnet gateway using the BACnet/IP protocol. The iTM BACnet Server Gateway Option shall be capable of exposing indoor unit management points as BACnet objects to the BMS.
 - b. The iTM BACnet Server Gateway Option shall allow the following functions:
 - 1) Support Change of Value (COV) notifications.
 - 2) Provide unique virtual BACnet device identification number (ID) for every indoor unit group address.
 - 3) The iTM BACnet Server Gateway Option shall be capable of being configured as a foreign device. It shall be capable of communicating across BACnet Broadcast Management Devices (BBMD) in different subnet networks.

- c. **In addition to the standard BACnet VRF points, the Building Management System shall monitor and/or control the following BACnet objects for indoor units:**
 - 1) **Occupancy Mode : Unoccupied, Occupied, Standby**
 - 2) **Cooling and heating setpoints during occupied and unoccupied modes.**
 - d. **The Building Management System may choose to monitor and control the following BACnet objects linked to iTM control logic:**
 - 1) **Enable/Disable iTM Schedule operation.**
 - 2) **Enable/Disable iTM Auto Changeover Operation.**
 - 3) **Set Timed Override Minutes - Monitor and configure timer extension for the indoor unit on iTM (30, 60, 90, 120, 150, 180 minutes)**
 - 4) **System forced off - Enable/Disable all emergency stop programs that are registered on the iTM.**
 - e. **The BMS shall have the ability to utilize scheduling functions on the iTouch Manager.**
 - f. **The BMS shall have the ability to utilize automatic changeover function on the iTouch Manager, removing the need to program automatic changeover sequences on the BMS.**
 - g. **VRF manufacturer shall commission the BACnet server. BMS contractor shall provide VRF manufacturer with static IP address and instance number for commissioning. IP connection shall be by BMS contractor.**
 - h. **All programming for monitoring and control of VRF system via the BACnet server shall be by BMS contractor, as per the Sequence of Operation.**
- J. **Manufacturers: Subject to compliance with requirements, provide products by one of the following:**
- 1. **Mitsubishi CityMulti (*See Paragraph J)**
 - 2. **LG Variable Refrigerant Flow (VRF) System. (*See Paragraph J)**
 - 3. **Daikin AC**
 - 4. **Or Equal.**

2.22 VARIABLE AIR VOLUME BOX (VAV)

- A. **General:** Provide factory-fabricated and tested air terminals as shown on drawings, selected with performance characteristics which match or exceed those indicated on schedule.
- B. **Casings:** Construct of die-cast aluminum or sheet metal of the following minimum thicknesses:

	Steel	Aluminum
1. Upstream Pressure Side:	22-ga.	0.032 in.
2. Downstream Pressure Side;	22-ga.	0.025 in.
3. Provide hanger brackets for attachment of supports.		

4. Linings: Line inside surfaces of casings with hospital grade lining material meeting ASTM Standard C1071 to provide acoustic performance, thermal insulation, and to prevent condensation on outside surfaces of casing. Provide minimum thickness of 1 in.. Secure lining to prevent delamination, sagging or settling. Seal edges of lining to prevent fraying.
 - a. Cover liner surfaces and edges with mylar, foil or perforated metal.
5. Leakage: Construct casings such that when subjected to 0.5-in w.g. pressure for low pressure units, and 3.0-in w.g. pressure for high pressure units, total leakage does not exceed 4 percent of specified air flow capacity with outlets sealed and inlets wide open. Construct air dampers such that when subjected to 6.0-in w.g. inlet pressure with damper closed, total leakage does not exceed 10 percent of specified air flow capacity.
- C. Air Dampers: Construct of materials that cannot corrode, do not require lubrication, nor require periodic servicing. Provide maximum volume dampers, pressure independent that are calibrated in cfm, factory-adjusted, and marked for specified air capacities. Provide mechanism to vary air volume thru damper from minimum to maximum, in response to signal from thermostat.
- D. Controls: Provide controls accurate to 1.5 deg. F(0.8 deg. C) and adjustable from 65 deg. F (22 deg. C) to 85 deg. F (29 deg. C).
 1. ATC Contractor to provide and field install DDC controls, compatible with automatic temperature control system specified in other Division-23 sections. All testing and commissioning shall be completed in field.
- E. Identification: Provide label on each unit indicating Unit Number, cfm range, cfm factory-setting, and calibration curve (if required).
- F. Coils: Provide the following coils as indicated on Drawings and schedule:
 1. Hot Water Heating Coils: Provide heating coils constructed of copper tubes and aluminum fins with galvanized steel casing.
- G. Silencer:
 1. Silencer section shall consist of 22ga solid metal casing, 22ga perforated liners, and absorptive acoustic fiberglass liner.
 2. Acceptable methods of silencer construction shall be button lock, Pittsburgh lock, and welds. In situations where these methods are not feasible, rivets can be used. Screws or other mechanical fasteners on the silencer will not be acceptable.
 3. The silencer noses and perforated liners shall be rigidly fastened to the casing of the silencer on both the top and bottom.
 4. The silencer section acoustic media shall be shot free inorganic glass fiber with long, resilient fibers, bonded with thermosetting resin, and contain 50 percent recycled media. Glass fiber shall be packed with a minimum 10 percent compression to eliminate voids and settling; density shall consistent with that used to generate catalog test data. Combustion ratings for acoustical media shall be equal to or less than the combustion ratings noted below when tested in accordance with ASTM E84, UL713, and NFPA 255:
 - a. Flame Spread Classification: 25
 - b. Smoke Development Rating: 50

- H. Manufacturer: Subject to compliance with requirements, provide variable air volume boxes of one of the following:

1. Price
2. Carnes Co.
3. Titus Products Div.
4. Or equal

2.23 CONDENSATE DISCHARGE PUMPS

- A. General: Provide where indicated, condensate pumps of capacity as scheduled, to be field installed in various air handling equipment drain pans, consisting of ABS housing, pump, check valve, safety switch, and thermal overload protection. Factory assembled unit must be UL/CSA listed.

B. High-Capacity Pumps

1. Reservoir: Construct of ABS plastic with a 3/10 capacity volume.
2. Pump: 25 GPH@15TDH vertical type pump with stainless steel motor shaft, rustproof, ABS volute, with safety switch.
3. Housing and Cover: Each shall be ABS plastic.
4. Manufacturers: Subject to compliance with requirements, provide high-capacity condensate pump of Little Giant or approved equal.

C. Low-Capacity Pumps

1. Pump: 8 GPH@33TDH reciprocating piston pump direct discharge with no storage reservoir.
2. Detection Unit: Low-maintenance filter free with a three level float (on/off/alarm).
3. Pump Housing and Detection Unit: Each shall be ABS plastic.
4. Manufacturers: Subject to compliance with requirements, provide low-capacity condensate pump of Sauermann or approved equal.

2.24 RADIANT FLOOR/ SNOW MELT HEATING SYSTEM

A. Pex Pipe and Fittings

1. Basis-of-Design Product: Subject to compliance with requirements, provide Viega LLC; or comparable product by one of the following:
 - a. FlorHeat Company (The).
 - b. Heat Innovations Inc.
 - c. Infloor Radiant Heating Inc.
2. Pipe Material:
 - a. PEX tubing and fittings shall maintain a quality control program in accordance with ISO 9001 or NSF International in the manufacturing plant to assure that the tubing and fittings are continually being produced to the required standard.
 - b. Tubing shall be silane cross-linked high density polyethylene as per ASTM F876/F877 and CSA B137.5.
 - c. Tubing includes four layers.
 - 1) First layer: Cross-linked, high density polyethylene.

- 2) Second layer: Adhesive.
 - 3) Third layer: Ethylene vinyl alcohol layer (EVOH oxygen barrier).
 - 4) Fourth layer: Polyethylene to protect the EVOH layer from damage.
 - d. Certified to NSF 14 and 61.
 - e. Tubing will have 6 month UV protection.
 - f. Certified to UL 263 ULC S101 for floor and wall assemblies.
 - g. Certified to ASTM E84 and ULC S102.2 Flame Spread (FS)/Smoke Developed (SD) (25/50).
3. See discussion in the Evaluations about oxygen barrier in "Oxygen Barrier" Paragraph below. The referenced standard is the only standard used by plastic-tubing manufacturers that describes how to test and measure oxygen diffusion in plastic tube. It is a German national standard; see the Evaluations for information about where it can be obtained.
 4. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F according to DIN 4726.
 5. Retain "Bronze Fittings" or "Polymer Fittings" paragraph below to meet Project requirements.
 6. Bronze Fittings: PEX Press Fittings manufactured from UNS [C83600] [C87700] [C87710] copper alloy, meeting the requirements of ASTM F 877 tested as a system with PEX-type tubing.
 - a. PEX Press Sleeve: Manufactured out of a 304 grade or better stainless steel, and have three view holes with an attached sleeve to ensure proper PEX tubing insertion.
 - b. Attached sleeve fitting will incorporate a tool locator ring that shall be in place while making a proper press connection.
 - c. PEX Press connection shall be made with a Viega supplied ratcheting PEX Press hand tool or PEX Press power tool.
 7. Pressure/Temperature Rating: PEX High-Density Cross-linked polyethylene tubing shall meet the standard grade hydrostatic pressure ratings from the Plastic Pipe Institute in accordance with TR-4/03. The following three ratings are required:
 - a. 200 deg F at 80 psi
 - b. 180 deg F at 100 psi.
 - c. 73.4 deg F at 160 psi.
- B. Distribution Manifolds
1. Stainless Manifold with Balancing Valves and Flow Meters: Minimum NPS 1 1/4.
 - a. Manifolds shall be made of 304 Stainless Steel with nickel-plate valve necks on select models.
 - b. Flow meters, balancing valves, and shut off valves are integrated on manifold.
 - c. Air bleeders and two purge valves are to be integrated on manifold.
 - d. Manifolds have 1 inch NPT removable end caps and 1 1/4 inch Union connections.
 - e. Galvanized steel bracket supplied by Manufacturer.
 - f. Select manifold cabinet based on manifolds, accessories and fittings added.
 - g. Accept optional powerheads for individual zone control.
 - h. Manifold is suitable to receive all SVC connections.

- i. Flow Meters for Stainless Manifolds:
 - 1) Visual Flow Indicator: Visible indication in a clear plastic cap at top of valve.
 - 2) Body Brass: Nickel plated.
 - 3) Internal Parts: Plastic, EPDM.
 - 4) Inlet Connection: NPS 1/2, 1/2 inch with o-ring.
 - 5) Measure Range: 0 - 2 gpm.
 - 6) Handle Style: Rotating ring with lockable cap, no memory stop to retain set position if used for shut off.
 - 7) CWP Rating: 100 psi.
 - j. Thermometers:
 - 1) Mount on connection.
 - 2) Case: Stainless steel, 2 inch diameter.
 - 3) Element: Bimetal coil element.
 - 4) Movement: Mechanical, connecting element and pointer.
 - 5) Dial: White aluminum, black lettering.
 - 6) Pointer: Aluminum, black.
 - 7) Window: Instrument glass, NS 33 polycarbonate.
 - 8) Connector: Rigid, back type.
 - 9) Accuracy: Plus or minus 2 percent of range.
 - k. Maximum Operating Pressure: 100 psi.
 - l. Maximum Operating Temperature: 180 deg F.
2. Balancing Valves for Stainless Manifolds:
- a. Body: Brass, nickel plated.
 - b. Valve Spindle: Brass, EPDM.
 - c. Inlet Connection: NPS 1/2, 1/2 inch with o-ring.
 - d. Operator: Allen Wrench - 5 mm.
 - e. CWP Rating: 145 psi.
 - f. Maximum Operating Pressure: 100 psi
 - g. Maximum Operating Temperature: 180 deg F
3. Manual Air Vents:
- a. Body: Brass, nickel-plated.
 - b. Operator: Key furnished with valve, or screwdriver bit.
 - c. Inlet Connection: NPS 1/2.
 - d. Maximum Operating Pressure: 100 psi.
 - e. Maximum Operating Temperature: 180 deg F
4. Main Shutoff Valves for Stainless Manifolds:
- a. Field installed on supply and return connections.
 - b. Two-piece body.
 - c. Body: Brass nickel-plated body.
 - d. Ball: Full port chrome-plated brass.
 - e. Seals: PTFE.
 - f. Stem: Brass with 2 Buna-N o-rings and blowout proof assembly.
 - g. CWP Rating: 100 psig
 - h. Maximum Operating Temperature: 180 deg F

C. Piping Specialties

1. Cable ties are used to tie piping to reinforcing wire or bars in concrete floors.
2. Plastic Zip Ties:
 - a. Self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
 - b. Minimum Width: 0.17 inch.
 - c. Tensile Strength: 75 lb, minimum.

D. Preassembled Stations

1. Basis-of-Design Product: Subject to compliance with requirements, provide Viega LLC; or comparable product by one of the following:
 - a. FlorHeat Company (The).
 - b. Heat Innovations Inc.
 - c. Infloor Radiant Heating Inc.
2. ~~Enhanced Mixing Station:~~
 - ~~a. Enhanced Mixing Station Maximum Operating Pressure: 100 psi.~~
 - ~~b. Enhanced Mixing Station Maximum Operating Temperature: 180 deg F.~~
 - ~~c. Connecting Options: Viega PEXPress, ProPress or Copper.~~
 - ~~d. Mixing Station Piping Material: Type L Copper, ASTM B 88.~~
 - ~~e. Circulator:~~
 - ~~1) Circulator Material: Cast iron.~~
 - ~~2) Circulator Flow Range: 0 - 17.5 U.S. GPM.~~
 - ~~3) Circulator Head Range: 0 - 19 ft.~~
 - ~~4) Circulator Motor: Permanently magnetized circulator motor, Single Phase, 120 V.~~
 - ~~5) Circulator Temperature Range: 36 to 230 deg F.~~
 - ~~6) Circulator Settings: 7 settings, 3 fixed speeds, 3 constant pressures, and 1 AutoADAPT™.~~
 - ~~7) Circulator Maximum Discharge Pressure: 150 psi.~~
 - ~~f. Diverting Valve:~~
 - ~~1) Diverting Valve Body: Bronze.~~
 - ~~2) Diverting Valve Seals: EPDM.~~
 - ~~3) Diverting Valve Maximum Differential Pressure: 7.3 psi.~~
 - ~~4) Diverting Valve Cv 7.6.~~
 - ~~g. Ball Valve:~~
 - ~~1) Ball Valve: Two piece bronze body.~~
 - ~~2) Ball Valve Ball: 316 stainless steel ball, full port.~~
 - ~~3) Ball Valve Seals: EPDM sealing elements.~~
 - ~~4) Ball Valve Stem Seals: EPDM.~~
 - ~~5) Ball Valve Press Ends: With engineered leak path.~~
 - ~~6) Ball Valve Operating Temperature: 0 to 250 deg F.~~
 - ~~7) Ball Valve Maximum Operating Pressure: 200 psi.~~
 - ~~8) Ball Valve: 600 WOG.~~

~~9) Ball Valve Handles: Metal with standard sticker indicators for supply and return.~~

3. ~~Enhanced Mixing Station will be equipped with a 0-10V actuator that will tie into the BAS system~~

E. Controls

1. Temperature-control devices and sequence of operations are specified in the automatic temperature controls section of this specification.

F. Warranty

1. Manufacturer warranty shall include the following:
- a. In the event that manufacturer determines that the failure or leak and any resulting damages were the result of a manufacturing defect in the products covered by the warranty and occurred during the first ten years of the time period covered by the warranty, the manufacturer will reimburse the property owner for reasonable repair or replacement charges resulting from the failure or leak and, additionally will reimburse damages to personal property resulting from the failure or leak.
 - b. Radiant heat pipe manufacturer shall warranty the tubing under normal conditions of use and properly maintained, will be free from failure caused by manufacturing defect for a period of thirty (30) years from date of installation, when properly installed by contractors trained by manufacturer.
 - c. PEX Press fittings, when installed with ViegaPEX Barrier and FostaPEX tubing, will be free from failure caused by manufacturing defect for a period of thirty (30) years from date of installation. This also includes protected PEX Press fitting in a slab.
 - d. Manifolds and panels used in the system will be free from manufacturing defect for a period of five (5) years.
 - e. Controls, mixing stations, or electrical components sold by manufacturer shall be free from manufacturing defect for a period of two (2) years from date of installation.

2.25 CO/NO2 DETECTION AND CONTROL

A. Control Panel

1. The control panel shall provide continuous monitoring of the designated gas levels in the assigned area and control the ventilation system via digital outputs in accordance with all applicable codes and standards.
2. The control panel shall have the ability to interface via analog or digital outputs to any compatible electronic analog control, DDC/PLC control or automation system. Provide an upward communication BACnet protocol for BMS interface.
3. The control panel shall have the capability to accept any combination of 4-20 mA transmitters provided by the controller manufacturer.
4. The control panel shall accept up to 16 analog inputs with four (4) digital inputs. Each analog input can have five (5) trip/set-points.
5. There shall be five (5) relay outputs for every four (4) analog inputs and two (2) independent 4-20 mA outputs available. The outputs shall be programmable in the field. Each of the sensing points is readily addressable to either of the (2) analog outputs by selecting the Minimum, Maximum, or Average value.

6. The alarm shall be acknowledged by an external manual reset switch via the digital input or through the control panel menu.
7. The control panel shall have status indicator LED's located on the front; Red = Fail, Yellow = Alarm.
8. The control panel shall include a two line, backlit LCD display of 16 characters, at 1 digit resolution.
9. The controller shall be NRTL performance tested and certified to ANSI/UL 2017.
10. The contractor shall supply the PolyGard® Series MGC2-16 analog controller, by INTEC Controls (a Relevant Solutions brand); or approved equal.

B. Carbon Monoxide (CO) Sensor/Transmitter

1. The carbon monoxide sensor/transmitter shall provide monitoring of the carbon monoxide levels in the parking garage and control the ventilation system via the control panel in accordance with all applicable codes and standards.
2. The sensors shall be electrochemical type. The sensor/transmitter shall have plug-in technology for ease of troubleshooting and replacement of both the element and the printed circuit board. Solid-state sensing devices shall not be acceptable.
3. The sensor range shall be 0-250 ppm carbon monoxide. A microprocessor-based transmitter shall generate a proportional 4-20 mA output signal. The wiring between the transmitter and the control panel shall be a 2-wire, twisted and shielded, 4-20mA, 17-28 VDC configuration. Each sensor/transmitter shall cover between 5,000 and 10,000 square feet of the garage floor and placement shall be applied strategically and appropriately per floor plan requirement.
4. The sensor shall have stability and resolution of ± 3 PPM of reading, repeatability of $\pm 3\%$ of reading, and a response time of 50 seconds to a 90% step change. The long-term output drift shall not exceed more than 0.4% of signal loss per month. The permissible ambient working temperature shall be 14°F to 122°F (-10°C to 50°C) and permissible ambient humidity shall be 15 to 95% RH, non-condensing. The sensor shall require no routine maintenance other than periodic calibration. Its life expectancy shall be 5 years of normal service. The manufacturer shall provide a two 2-year warranty for materials and workmanship, and a 12-month warranty on the sensing element under normal exposure.
5. The sensor/transmitter printed circuit board shall have the capability of adding up to (2) alarm relays with individual setpoints for local control or status indication.
6. The sensor/transmitter shall be contained in a NEMA 4X metal enclosure. The enclosure for the sensor/transmitter shall be installed on walls or columns approximately 5 feet above the floor.
7. The output signal from the sensor/transmitter shall be a direct input to the control panel. All sequences of fan and alarm control, including time delay functions to prevent hunting of ventilation fans shall be a part of the control panel.
8. If the level of Carbon Monoxide reaches 25 PPM in the area of detection, the low alarm shall activate and the exhaust fans will be started. If the level of CO increases to 100 PPM, the high alarm shall activate.
9. The sensor/transmitter shall be NRTL performance tested and certified to ANSI/UL 2075.
10. The contractor shall supply the PolyGard® Series LC-1112 CO sensor/transmitter, by INTEC Controls (a Relevant Solutions brand); or an approved equal.

C. Nitrogen Dioxide (NO2) Sensor/Transmitter:

1. The Nitrogen Dioxide sensor/transmitter shall provide monitoring of the Nitrogen Dioxide levels present in diesel exhaust in the parking garage and control the ventilation system via the Control panel in accordance with all applicable codes and standards.

2. The sensors shall be electrochemical type. The sensor/transmitter shall have plug-in technology for ease of troubleshooting and replacement of both the sensing element and the printed circuit board. Solid-state sensing devices shall not be acceptable.
3. The sensor range shall be 0-10 ppm Nitrogen Dioxide. A micro-processor-based transmitter shall generate a polarity protected, proportional 4-20 mA output signal. The wiring between the transmitter and the Control panel shall be a 2-wire, twisted and shielded, 4-20mA, 17-28 VDC configuration. Each sensor/transmitter shall cover between 4,000 and 6,000 square feet of the garage floor and placement shall be applied strategically and appropriately per floor plan requirement.
4. The sensor shall have an accuracy and resolution of ± 0.1 PPM of reading, repeatability of $\pm 2\%$ of reading, and a response time of less than 40 seconds to a 90% step change. The sensor drift shall not exceed more than 2% signal loss per month. The permissible ambient working temperature shall be 14°F to 104°F (-20°C to 40°C) and the permissible ambient humidity shall be 15 to 95% RH, non-condensing. The sensor shall require no routine maintenance other than periodic calibration. Its life expectancy shall be 2 years of normal service. The manufacturer shall provide a two 2-year warranty for materials and workmanship, and a 12-month warranty on the sensing element under normal exposure.
5. The sensor/transmitter shall be contained in a NEMA 4X enclosure. The enclosure with the sensor/transmitter shall be installed on walls or columns approximately 1.5 ft. above the floor.
6. The sensor/transmitter shall have the capability of adding up to (2) relays as a separate component to the printed circuit board of the sensor.
7. The output signal from the sensor/transmitter shall be a direct input into the digital control building automation system. All sequences of fan and alarm control, including time delay functions to prevent hunting of ventilation fans shall be a part of the Control panel.
8. If the level of NO₂ reaches 2 PPM, the low alarm shall activate. If the level of NO₂ increases to 5 PPM, the high alarm shall activate.
9. The contractor shall supply the PolyGard® Series AT-1130 NO₂ sensor/transmitter, by INTEC Controls (a Relevant Solutions brand); or an approved equal.

D. Supplier:

1. The contractor shall supply all gas monitoring and control system by one manufacturer. The MGC-Series control panel, all associated gas transmitters and the SPC controller and associated gas transmitters are the basis of design by INTEC Controls (a Relevant Solutions brand), or approved equal.

E. Warranty:

1. The manufacturer shall provide a two 2-year warranty for materials and workmanship, and a 12-month warranty on the sensing element under normal exposure.

F. System:

1. The MGC2-16 shall monitor the following:
 - a. Heated Parking 131: [5x] Carbon Monoxide and [5x] Nitrogen Dioxide sensors/transmitters
 - b. Maintenance Bay 132: [1x] Carbon Monoxide and [1x] Nitrogen Dioxide sensors/transmitter.
 - c. Wash Bay 133: [1x] Carbon Monoxide and [1x] Nitrogen Dioxide sensors/transmitter.

- G. Manufacturer: Subject to compliance with requirements, provide gas detection system of one of the following:
1. Intec
 2. Honeywell
 3. Automation Components Inc.
 4. Or equal

2.26 CONSTANT VOLUME DAMPERS

- A. Provide Adjustable Constant Airflow Regulators by American ALDES Ventilation Corporation, or equal. The constant volume dampers shall operate solely on duct pressure and require no external power supply. Each regulator shall be capable of being field adjusted to the required airflow setpoint, as indicated on the schedule, by manual adjustment of the control device using an Allen/Hex key. The device shall be rated for use in air temperatures ranging from -22 deg. to 212 deg.F (-30 deg. to 100 deg.C).
- B. Constant volume dampers shall be capable of maintaining constant airflow within $\pm 10\%$ for nominal airflow > 60 CFM (100 m³/h) and ± 5 CFM (10 m³/h) for nominal airflow < 60 CFM (100 m³/h) throughout the target operating pressure range of 0.2 to 4.0 in. w.g. (50 to 1000 Pa). differential pressure. Sound power levels shall not exceed those for each size and CFM rating as scheduled.
- C. The device is constructed of a laser-welded, galvanized steel body, a translucent plastic control device, and a double-lip airtightness seal around the circumference to ensure a tight, no-leak fit. The integral control device shall be comprised of an aluminum damper and a stainless steel spring and shaft fitted to PTFE (polytetrafluoroethylene) bearings. A pneumatic piston damper prevents overshoot and oscillation of the control damper and ensures an accurate response and control behavior.
- D. All Adjustable Constant Airflow Regulators will require no maintenance and must be warranted for a period of no less than five (5) years. The Adjustable Constant Airflow Regulators shall be installed in tight ducting systems in accordance with all applicable codes and manufacturer's instructions.

2.27 ACCESS DOORS

- A. Furnish Access Doors for access to all concealed control valves, motor operated dampers, fire doors, and to all other concealed parts of the HVAC System that require accessibility for the proper operation and maintenance of the system. These doors shall be installed under the appropriate SECTION of the Specifications as determined by the surface upon which the panels are mounted.
- B. All Access Doors shall be located in a workmanlike manner in closets, storage rooms, and/or other non-public areas, positioned so that the valve or part can be easily reached, and the size shall be sufficient for this purpose (minimum size 12" x 16"). Furnish Access Doors for each pipe space to permit thorough inspection of same. When access doors are required in corridors, lobbies, or other habitable areas, they shall be located as directed by the Architect.
- C. Access doors shall be prime painted and completed with cylinder lock and two (2) keys as manufactured by Acudor, Inland Steel Products Company "Milcor", or Walsh-Hannon-Gladwin, Inc., "Way Lector". Type shall be as follows:
- | | |
|----------------------------|----------------|
| 1. Acoustical Tile Ceiling | Acudor AT-5020 |
| 2. G.W.B. Surfaces | Acudor DW-5040 |

3.	Masonry Construction	Acudor UF-5000
4.	Fire Rated Construction	Acudor FB-5060

D. Access Door Shop Drawings shall be submitted to the Architect for approval.

2.28 FIRESTOPPING AND SEALANTS

A. General

1. All firestop products and systems shall be designed and installed so that the basic sealing system will allow the full restoration of the thermal and fire resistance properties of the barrier being penetrated with minimal repair if penetrants are subsequently removed. For applications where combustible penetrants are involved, i.e. insulated and plastic pipe, a suitable intumescent material must be used.
2. This section specifically addresses pipe, duct, cable, and wiring penetrations of fire wall firestops and smoke stops for all bearing and non-bearing walls and floors assemblies.

B. References

1. American Society For Testing and Materials Standards (ASTM):
 - a. ASTM E 814: Standard Test method For Fire Tests of Through-Penetration Firestops
 - b. ASTM E84: Standard Test Method For Surface Burning Characteristics of Building Materials
2. Underwriters Laboratories Inc.:
3. UL 1479 Fire Tests of Through-Penetration Firestops
 - 1) UL 723 Surface Burning Characteristics of Building Materials
- b. UL Fire Resistance Directory:
 - 1) Through Penetration Firestop Device (XHJI)
 - 2) Fire Resistive Ratings (BXUV)
 - 3) Through Penetration Firestop Systems (XHEZ)
 - 4) Fill, Void, or Cavity Material (XHHW)

C. Definitions

1. Firestopping: The use of a material or combination of materials in a fire-rated structure (wall or floor) where it has been breached, so as to restore the integrity of the fire rating on that wall or floor.
2. System: The use of a specific firestop material or combination of materials in conjunction with a specific wall or floor construction type and a specific penetrant(s), constitutes a "System".
3. Barrier: Any bearing or non-bearing wall or floor that has an hourly fire and smoke rating.
4. Through-Penetration: Any penetration of a fire-rated wall or floor that completely breaches the barrier.
5. Membrane-Penetration: Any penetration in a fire-rated wall that breaches only one side of the barrier.

6. Construction Gaps: Any gap, joint, or opening, whether static or dynamic, where the top of a wall may meet a floor; wall to wall applications, edge to edge floor configurations; floor to exterior wall; or any linear breach in a rated barrier. Where movement is required, the firestopping system must comply with UL2079 for dynamic joints.

D. Quality Assurance

1. Firestopping systems (materials and design):
 - a. Shall conform to both Flame (F) and Temperature (T) ratings as required by local building codes and as tested by nationally accepted test agencies per ASTM E814 or UL 1479 fire tests in a configuration that is representative of field conditions.
 - b. The F rating must be a minimum of one (10 hour but not less than the fire resistance rating of the assembly being penetrated. T rating when required by code authority shall be based on measurement of the temperature rise on penetrating item(s). the fire test shall be conducted with a minimum positive pressure differential of 0.01 inches of water column.
 - c. For joints, must be tested to UL2079 with movement capabilities equal to those of the anticipated conditions.
2. Firestopping materials and systems must be capable of closing or filling through openings created by 1) the burning or melting of combustible pipes, cable jacketing, or pipe insulation materials, or 2) deflection of sheet metal due to thermal expansion (electrical & mechanical duct work).
3. Firestopping material shall be asbestos and lead free and shall not incorporate nor require the use of hazardous solvents.
4. Firestopping sealants must be flexible, allowing for normal pipe movement.
5. Firestopping materials shall not shrink upon drying as evidenced by cracking or pulling back from contact surfaces.
6. Firestopping materials shall be moisture resistant, and may not dissolve in water after curing.
7. All firestopping materials shall be manufactured by one manufacturer (to the maximum extent possible).
8. Installation of firestopping systems shall be performed by a contractor (or contractors) trained or approved by the firestop manufacturer.
9. Material used shall be in accordance with the manufacturer's written installation instructions.

E. Materials

1. Intumescent Firestop Sealants and Caulks:
 - a. STI SpecSeal S100 and S500 Sealant
 - b. 3M Fire Barrier Caulk CP25WB+
2. Latex Firestop Sealant:
 - a. STI SpecSeal LC150 Sealant
3. Silicone Firestop Sealants and Caulks:
 - a. STI SpecSeal Pensil 100 and 300
 - b. 3M Fire Barrier Silicone Sealants

4. Firestop Putty:
 - a. STI SpecSeal Firestop Putty Bars and Pads
 - b. 3M Fire Barrier Moldable Putty
5. Firestop Collars:
 - a. STI SpecSeal Firestop Collars
 - b. 3M Fire Barrier PPD's
6. Wrap Strips:
 - a. SpecSeal Wrap Strip
 - b. 3M Fire Barrier FS195 Wrap Strip
7. 2-Part Silicone Firestop Foam:
 - a. STI SpecSeal Pensil 200
 - b. 3M Fire Barrier 2001 Silicone Foam
8. Firestop Mortar:
 - a. STI SpecSeal Mortar
9. Composite Board:
 - a. 3M Barrier Sheet Material
10. Accessories:
 - a. Forming/Damming Materials: Mineral Fiberboard or other type as per manufacturer recommendation.

2.29 DUCT MOUNTED HOT WATER COIL

A. Design Pressures and Temperatures

1. Coil shall be designed to withstand the following maximum operating pressures and temperatures:
 - a. Water Coils - 250 psig / 300 deg. F

B. Fins

1. Coils shall be plate fin type construction providing uniform support for all coil tubes. Coils are to be manufactured with die-formed aluminum or copper fins with self spacing collars which completely cover the entire tube surface.
 - a. Thickness - 0.0060" +/- 5% unless specified otherwise
 - b. Tube Holes:
 - a. 0.625 diameter spaced 1.5 inch equilaterally
 - b. 0.500 diameter spaced 1.25 inch equilaterally
 - c. 0.375 diameter spaced 1.0 inch equilaterally
 - d. fins/inch 0.625 diameter coils 6 through 14 fins / inch
 - e. 0.500 diameter coils 6 through 16 fins / inch

- f. 0.375 diameter coils 10 through 20 fins / inch All fins have a tolerance of +/- 4%

C. Tubing

- 1. Tubing and Return Bends - Standard pressure - constructed from UNS12200 seamless copper conforming to ASTM B75, ASTM B251, and ASTM B743.
- 2. Copper Tube Temper - Light annealed with a maximum grain size of 0.040 mm and a maximum hardness of Rockwell 65 on the 15T scale.
- 3. Tube Expansion - Mechanically expanded to form an interference fit with the fin collars without decreasing tube wall thickness.
- 4. Minimum Thickness:
 - a. 0.016 inch for 0.500 and 0.375 inch tubing
 - b. 0.020 inch for 0.625 inch tubing unless specified otherwise

D. Casing (Endplates and Side Plates)

- 1. Shall be made from one of the following materials:
 - a. Copper 0.093 inch thick meeting ASTM B152
 - b. 16 or 14 Gauge, stainless steel meeting ASTM A240
 - c. 16 or 14 Gauge, G90 Galvanized steel meeting ASTM A653
- 2. Sheet metal breaks - Bent to 90 deg. +/- 2 deg. unless specified otherwise Formed tube collars are designed so that the expansion surface is 0.100" and the ends are re-flared to prevent raw metal edge from contacting copper tubes.

E. Testing Requirements

- 1. Coils shall be submerged in water and tested with dry nitrogen.
 - a. Water Coils are tested to 450 psig

F. Headers

- 1. Headers shall be constructed from UNS 12200 seamless copper conforming to ASTM B75, ASTM B88 and ASTM B251.
- 2. Water Coil Headers - Equipped with optional factory installed manual air vents and drains placed at the highest and lowest points.
- 3. End caps (1.625" and larger) - Die formed and installed on the inside diameter of the header such that the landed surface area is three times the header wall thickness.
- 4. End caps (Less than 1.625) - Flat copper sheet stock circle sheared, stamped or punched to header diameter and installed on the header ends.

G. Connections

- 1. Male Pipe Thread (MPT) and constructed from red brass conforming to ASTM B43 or schedule 40 steel.
- 2. Male Pipe thread (MPT) or Female pipe thread (FPT) and constructed from copper
- 3. Sweat Connection constructed from UNS 12200 seamless copper conforming to ASTM B75 and ASTM B251

H. Brazing

1. High temperature filler metals shall be used for all brazed joints. Filler metal will contain at least 5% silver.

I. Certification

1. Acceptable coils are to have AHRI Standard 410 certification and bear the AHRI symbol. Non-certified coils or coils outside AHRI's rating range will be considered if the manufacturer is a current member of the AHRI air-cooling and air-heating coils certification program and the coils have been rated in accordance with AHRI Standard 410.
2. Acceptable coils are to be Intertek Recognized Components, and are eligible to bear the ETL Listed Mark.

J. Manufacturer: Subject to compliance with requirements, provide heating coils of one of the following:

1. Greenheck
2. Multitherm
3. Rothmann
4. Or equal

2.30 EXTRUDED ALUMINUM RAIN RESISTANT WALL LOUVERS

A. Air Construction Requirements

1. Louvers shall be model EHH-401 as manufactured by Greenheck, or an approved equal. Louver frame shall be 4 inch deep channel style with 0.081 inch extruded aluminum wall thickness. Louver blades shall be horizontal stationary style located on approximate 2 inch centers with 0.081 inch extruded aluminum wall thickness. Bird screen shall be internally mounted 0.75 inch x 0.051 inch flattened expanded aluminum. Finish of all materials shall be mill only. The Louvers shall be AMCA certified louvers

B. Performance Requirements

1. Louvers shall be AMCA Licensed when tested in accordance with AMCA 500-L Air Performance and Water Penetration test procedures. Free area for size 48 inch x 48 inch louver shall not be less than 6.72 square feet (42%). Airflow resistance at 1000 feet per minute free area intake velocity shall not be greater than 0.19 inch water gauge pressure drop. Airflow resistance at 1000 feet per minute free area exhaust velocity shall not be greater than 0.2 inch water gauge pressure drop. Beginning point of water penetration is above 1250 feet per minute free area intake velocity.
2. Louvers shall be designed and manufactured to withstand a minimum 25 pound per square foot wind load.

C. Provide the following Manufacturer's Options:

1. 70% Kynar Paint (AAMA 2605)
2. Clear Anodize (204-R1 Class II, or 215-R1 Class I)
3. Clip angles
4. 0.5 inch x 0.047 inch square stainless steel wire cloth bird screen

- D. Manufacturer: Subject to compliance with requirements, provide louvers of one of the following:
1. Greenheck
 2. Ruskin
 3. Carnes
 4. Or equal

2.31 AUTOMATIC TEMPERATURE CONTROLS (DDC)

A. Basic Components and Systems:

1. General: Provide control products in sizes and capacities indicated, consisting of dampers, thermostats, clocks, sensors, controllers, and other components as required for completed installation. Except as otherwise indicated, provide manufacturer's standard materials and components as published in their product information, designed and constructed as recommended by manufacturer and as required for application indicated. All equipment and systems shall be installed by certified factory trained contractors with the following functional and construction features.
2. The building automation system shall be based on the latest version of the Niagara platform and shall be on an open protocol BACnet system infrastructure that integrates diverse systems and devices (regardless of manufacturer, communication standard ie BACnet, Lon, Modbus or software) into a unified platform that can be read and written to and easily managed in real time using a standard Web browser. Systems not developed on a Niagara BACnet protocol are unacceptable. The building automation system shall not require licensing fees and shall be licensed indefinitely to the Owner for use at the project site.
3. ATC manufacturer shall provide written confirmation that installing ATC Contractor is an authorized dealer and service provider. The ATC system provided must be capable of being serviced by three or more local authorized vendors/contractors.
4. The BMS Graphics shall include all new HVAC & Lighting Systems and all points communicable by the new DDC controllers provided by the ATC contractor and equipment manufacturer(s).
5. Provide all required control wiring including CAT6 Ethernet wiring for any controllers requiring Ethernet connectivity. Terminate Ethernet cable in MDF and IDF closets on patch panels proceed under Technology Section 27 00 00.
6. The ATC control and building EMS system shall have the following attributes with characteristics and performance as specified within this Specification section, related Electrical and Plumbing section specifications and the Control Diagram drawings:
 - a. Sensors and components as follows:
 - 1) Indication and trending of damper and valve commanded positions.
 - 2) Sensors to monitor indoor CO2.
 - 3) Sensors to monitor and trend (create trend logs) controlled variables at the operator interface. Control variables may include air and/or water flow, temperature, pressure, CO2, humidity and pump or fan speed. Relevant multiplexed data from microprocessors located in chillers, boilers, variable speed drives and other equipment with multiplexing capabilities may be used in lieu of specifying separate sensors.

- 4) All densely occupied spaces, with occupant density of 25 people or more per 1000 s.f. must be provided with CO2 sensors per LEED IEQ C1 requirements. Provide multi functioning sensors with temperature, humidity and CO2 for each classroom space, gym, cafeteria, media center, wood shop, life skills rooms, special needs, or similarly occupied space.
- b. Points matrix – including all hardwired input and output devices connected to the automation system, all set points, upper and lower control limits.
 - c. Trend capabilities – including a trend point list and preprogrammed sample of point (performed by controls contractor), sample rate, storage interval, upload interval, custom trend abilities, alarms, and automated trend data review and notification (automated diagnostics).
 - d. System architecture – capable of allowing sampling of these points to facilitate building commissioning and diagnostics without significantly affecting system performance.
 - e. Data storage system – with adequate capacity to record trend data for use by building operators. Data export requirements must facilitate user-friendly data access and manipulation.
 - f. Operator interface – designed for remote/web access, monitoring requirements, trend-log reporting and diagnosing building problems through a user-friendly interface. This includes providing a visual (non-text based) operations and reporting interface to facilitate rapid system assessment that utilizes color-coding, diagrams of floor plans and graphing capabilities.
 - g. The remote access shall use a web browser only and not require a VPN with remote desktop application.
7. Electric Wiring: All electric wiring and wiring connections, either line voltage or low voltage, from the emergency electric panels to the ATC panels, and from the ATC related panels to the individual control devices i.e. rooftop units, exhaust fans, boilers, chillers, valves, and dampers required for the installation of the control system, as herein specified shall be provided by the control contractor unless specifically shown on the electrical drawings or called for in the electrical specifications.
 - a. The wiring installation shall be in accordance with National and Local Codes and with the Electrical portion of these specifications. All wiring shall be run concealed wherever possible. Exposed wiring in occupied areas shall be run in raceways. Raceways shall be Wiremold 200 series with all elbows, raceways, covers, mounting stops, box extensions and wiring for a complete and neat installation. All wiring located in mechanical spaces, boiler rooms, and fan rooms shall be installed in metal conduit
 - b. All wiring above ceilings, in boiler rooms, and all mechanical spaces shall follow routing of piping and where not possible shall be in conduit. All exposed wire shall be bundled and wire tied and shall be supported to adjacent piping. Draped and free floating wire will not be allowed.
 - c. All terminations of wire at control devices shall be looped and supported adequately.
 - d. All wiring shall comply with the requirements of the electrical section of the specification.

B. Controls Systems Wiring

1. All conduit raceways, wiring, accessories and wiring connections required for the installation of the Controls Systems shall be provided by the Controls Contractor except as shown on the Electrical Drawings. All wiring shall comply with the requirements of applicable portions of the Electrical Section 26 00 10 and all local and national electric codes and the requirements of the AHJ.
2. All Controls Systems wiring materials and installation methods shall comply with the original equipment manufacturer recommendations and standards.
3. The sizing type and provision of cable, conduit, cable trays and raceways shall be the design responsibility of the Controls Contractor.
4. Class 2 Wiring
 - a. All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.
 - b. Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 5ft. from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines.
5. Class 2 signal wiring and 24VAC power may be run in the same conduit. Power wiring 120VAC and greater shall not share the same conduit with Class 2 signal wiring.
6. Perform circuit tests using qualified personnel only. Provide necessary instruments and equipment to demonstrate that:
 - a. All circuits are continuous and free from short circuits and grounds.
 - b. All circuits are free from unspecified grounds; that resistance to ground of all circuits is no less than 50 megaohms.
 - c. All circuits are free from induced voltages.
7. Provide complete testing for all cables and wiring. Provide all equipment, tools, and personnel as necessary to conduct these tests.
8. Provide for complete grounding of all signal and communication cables, panels and equipment so as to ensure integrity of Controls Systems operation. Ground cabling and conduit at panel terminations. Do not create ground loops.

C. Line Voltage Power Sources

1. 120-volt AC circuits for the Controls Systems shall be taken by the Controls Contractor from electrical emergency panelboards and circuit breakers as designated on the electrical drawings.
2. Circuits used for the Controls Systems shall be dedicated to these Controls Systems and shall not be used for any other services.
3. Controls DDC terminal unit controllers may use 120-volt AC power from motor power circuits.

D. Controls Systems Raceways

1. All wiring shall be installed in conduit or raceway except as noted elsewhere in the Specification. Minimum conduit size 3/4 in.
2. Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used only if reviewed and accepted by the Architect.
3. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the supporting surface.

4. UL/ULC Listed Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 ft. in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls and for final connection to equipment.

E. Penetrations

1. Firestopping for all penetrations used by dedicated Controls Systems conduits and raceways shall be by other trades.
2. All openings in fire proofed or fire stopped components shall be closed by other trades using approved fire resistive sealant.
3. All wiring passing through penetrations, including walls, shall be in sleeves, conduit or enclosed raceway.
4. No penetrations through building structural elements, slabs, ceilings and walls shall be made before receipt of written approval from the Architect.

F. Controls Systems Identification Standards

1. Node Identification: All nodes shall be identified by a permanent label fastened to the outside of the enclosure. Labels shall be suitable for the node environmental location.
2. Cable shall be labeled at every termination with cross-referencing to record documentation.
3. Raceway Identification: Exposed covers to junction and pull boxes of the FMS raceways shall be identified at primary points.
4. Wire Identification: All low and line voltage wiring shall be identified by a number, as referenced to the associated shop and record drawing, at each termination.
5. Wires and cabling shall not be spliced between terminations. Cable shields shall be single end grounded – typically at the panel end outside the panel.
6. Suggested color coding, for use at the Contractors option, are:

a.	Analog Input Cable	Yellow
b.	Analog Output Cable	Tan
c.	Binary Input Cable	Orange
d.	Binary Output Cable	Violet
e.	24 VAC Cable	Gray
f.	General Purpose Cable	Natural
g.	Tier 1 Comm Cable	Purple
h.	Other Tier Comm Cable	Blue
i.	Ethernet cable	Blue
7. Provide permanent identification labels at all valve and damper actuators to indicate open and closed positions.

G. Field Panel And Device Installations And Locations

1. The Controls Systems panels, enclosures and cabinets shall be located as coordinated with the Architect at an elevation of not less than 2 ft. from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
2. All field devices shall be installed per the manufacturer recommendation and in accessible locations as coordinated with the Architect.
3. Panels to be located in damp areas or areas subject to condensation shall be mounted with wall standoffs.
4. Conduit configurations entering or leaving panels and devices shall be such as to preclude condensation traps.

H. Networking Communications

1. The design of the BAS shall consist of stand-alone DDC Controllers. The network architecture shall consist of multiple levels for communication efficiency, a campus-wide (Management Level Network) Ethernet network based on TCP/IP protocol, high performance peer-to-peer building level network(s) and DDC Controller floor level local area networks with access being totally transparent to the user when accessing data or developing control programs.
2. System shall communicate with a BACnet network over Ethernet or BACnet/IP (according to Annex J). The intent is to use the system provided under this contract to communicate with control systems and/or devices provided by other vendors. A PICS must be provided describing the BACnet, ANSI/ASHRAE 135-95, implementation. The product shall be Network Application Engine level 1 controllers with field equipment controller for level 2 controllers no substitutions. Minimum system functionality must include monitoring, commanding, and alarming for daily operator functions from a common workstation.
 - a. System shall have the capability to be an OPC Client and Server for dynamic communication with OPC Clients or Servers over an Ethernet network. At a minimum, the following must be supported:
 - 1) Data Access 1.0 (96), 1.0A (97) and 2.0 (11/98)
 - 2) Alarms & Events 1.0 (1/99)
3. Network Switches
 - a. Provide HP ProCurve 2910 al series 2910-48G al 48 ports network switch Brocade, Cisco or equal in MDF/IDF rooms as required.
4. Ethernet Wiring
 - a. Ethernet wiring shall be CAT6 UTP cable plenum rated. CAT6 UTP cables shall conform to ANSI/TIA/EIA-568-B1, B2, B3 Commercial Building Telecommunications Cabling Standard (latest amendment and including all applicable addenda) and ISO/IEC 11801 (International) Generic Cabling for Customer Premises standard (latest amendment and including all applicable addenda).
5. Building Data Network:
 - a. All operator devices either network resident shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the network. No hardware or software limits shall be imposed on the number of devices with global access to the network data at any time.
 - b. The network shall support a minimum of 100 DDC controllers and PC workstations
 - c. The system shall support integration of third party systems (fire alarm, security, lighting, PLC, chiller, boiler) via panel mounted open protocol processor. This processor shall exchange data between the two systems for interprocess control. All exchange points shall have full system functionality as specified herein for hardwired points.
 - d. Field panels must be capable of integration with open standards including Modbus, BACnet, and Lonworks as well as with third party devices via vendor protocols.
 - e. The Building Network shall use the TCP/IP over Ethernet. All devices must:
 - 1) Auto-sense 10/100/1000 Mbps networks.

- 2) IP Address will be assigned by Owner's IT staff.
- 3) DNS and Gateway IP address will be provided by Owner's IT staff. A VLAN will be setup by Owner's IT staff.
- 4) Allow access using Telnet.

I. DDC Controller Floor Level 2 Network

1. This level communication shall support a family of application specific controllers and shall communicate with the network through DDC Controllers for transmission of global data.

J. DDC & HVAC Mechanical Equipment Controllers

1. The DDC and HVAC Mechanical Equipment Controllers shall reside on the Building Level Network.
2. DDC and HVAC Mechanical Equipment Controllers shall use the same programming language and tools. DDC and HVAC Mechanical Equipment Controllers which require different programming language or tools on a network are not acceptable.
3. DDC and HVAC Mechanical Equipment Controllers which do not meet the functions specified are not acceptable.

K. DDC Controller

1. DDC Controllers shall be a 16-bit stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point I/O schedule. Each controller shall support a minimum of three Floor Level Application Specific Controller Device Networks.
2. Each DDC Controller shall have 72 Megabytes of memory to support its own operating system and databases, including:
 - a. Control processes
 - b. Energy management applications
 - c. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
 - d. Historical/trend data for points specified
 - e. Maintenance support applications
 - f. Custom processes
 - g. Operator I/O
 - h. Dial-up communications
 - i. Manual override monitoring
3. Each DDC Controller shall support firmware upgrades without the need to replace hardware.
4. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.
5. DDC Controllers shall provide a serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

6. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller via local, point discrete, on-board hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points.
 - a. Switches shall be mounted either within the DDC Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.
 - b. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.
7. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door.
8. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.
9. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
 - a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V
 - b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact
 - c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power
 - d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)
 - e. Isolation shall be provided at all peer-to-peer panel's AC input terminals to suppress induced voltage transients consistent with:
 - 1) IEEE Standard 587-1980
 - 2) UL 864 Supply Line Transients
 - 3) Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)
10. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 60 days.
 - a. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.
 - b. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.
11. Provide a separate DDC Controller for each AHU or other HVAC system as indicated in Section 3.02. It is intended that each unique system be provided with its own point resident DDC Controller.

L. HVAC Mechanical Equipment Controllers

1. HVAC Mechanical Equipment Controllers shall be a 12-bit stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors.
2. Each HVAC Mechanical Controller shall have 72 Megabytes of memory to support its own operating system and databases, including:
 - a. Control processes
 - b. Energy management applications
 - c. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
 - d. Historical/trend data for points specified
 - e. Maintenance support applications
 - f. Custom processes
 - g. Operator I/O
 - h. Remote communications
3. HVAC Mechanical Equipment Controllers shall provide a serial data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals.
4. HVAC Mechanical Equipment Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.
5. Each HVAC Mechanical Equipment Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all components. The HVAC Mechanical Equipment Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.
6. In the event of the loss of normal power, there shall be an orderly shutdown of all HVAC Mechanical Equipment Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.
 - a. Upon restoration of normal power, the HVAC Mechanical Equipment Controller shall automatically resume full operation without manual intervention.
 - b. Should HVAC Mechanical Equipment Controller memory be lost for any reason, the user shall have the capability of reloading the HVAC Mechanical Equipment Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.

M. DDC and HVAC Mechanical Equipment Controller Resident Software Features

1. General:
 - a. The software programs specified in this Section shall be provided as an integral part of DDC and HVAC Mechanical Equipment Controllers and shall not be dependent upon any higher level computer for execution.
 - b. All points shall be identified by up to 30 character point name and 16 character point descriptor. The same names shall be used at the PC workstation.
 - c. All digital points shall have user defined two-state status indication (descriptors with minimum of eight characters allowed per state (i.e. summer/winter).

2. Control Software Description:
 - a. The DDC and HVAC Mechanical Equipment Controllers shall have the ability to perform the following pre-tested control algorithms:
 - 1) Two-position control
 - 2) Proportional control
 - 3) Proportional plus integral control
 - 4) Proportional, integral, plus derivative control
 - 5) Automatic tuning of control loops
3. DDC and HVAC Mechanical Equipment Controllers shall provide the following energy management routines for the purpose of optimizing energy consumption while maintaining occupant comfort.
 - a. Start-Stop Time Optimization (SSTO) shall automatically be coordinated with event scheduling. The SSTO program shall start HVAC equipment at the latest possible time that will allow the equipment to achieve the desired zone condition by time of occupancy. The SSTO program shall also shut down HVAC equipment at the earliest possible time before the end of the occupancy period, and still maintain desired comfort conditions.
 - 1) The SSTO program shall operate in both the heating and cooling seasons.
 - It shall be possible to apply the SSTO program to individual fan systems.
 - The SSTO program shall operate on both outside weather conditions as well as inside zone conditions and empirical factors.
 - 2) The SSTO program shall meet the local code requirements for minimum outside air while the building is occupied.
 - b. Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or groups of points according to a stored time.
 - 1) It shall be possible to individually command a point or group of points.
 - 2) For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start or stop within that group.
 - 3) The operator shall be able to define the following information:
 - Time, day
 - Commands such as on, off, auto, and so forth.
 - Time delays between successive commands.
 - There shall be provisions for manual overriding of each schedule by an appropriate operator.
 - 4) It shall be possible to schedule events up to one year in advance.
 - Scheduling shall be calendar based.
 - Holidays shall allow for different schedules.

- Enthalpy switchover (economizer) The Energy Management Control Software (EMCS) will control the position of the air handler relief, return, and outside air dampers. If the outside air dry bulb temperature falls below changeover set point the EMCS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly changeover to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.
 - Temperature-compensated duty cycling.
 - o The DCCP (Duty Cycle Control Program) shall periodically stop and start loads according to various patterns.
 - o The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.
 - Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.
 - Night setback control: The system shall provide the ability to automatically adjust setpoints for night control.
 - The Peak Demand Limiting (PDL) program shall limit the consumption of electricity to prevent electrical peak demand charges.
 - o PDL shall continuously track the amount of electricity being consumed, by monitoring one or more electrical kilowatt-hour/demand meters. These meters may measure the electrical consumption (kWh), electrical demand (kW), or both.
 - o PDL shall sample the meter data to continuously forecast the demand likely to be used during successive time intervals.
 - o If the PDL forecasted demand indicates that electricity usage is likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads.
 - o Once the demand peak has passed, loads that have been shed shall be restored and returned to normal control.
4. DDC and HVAC Mechanical Equipment Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
- a. A single process shall be able to incorporate measured or calculated data from any and all other DDC and HVAC Mechanical Equipment Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC and HVAC Mechanical Equipment Controllers on the network. Database shall support 30 character, English language point names, structured for searching and logs.
 - b. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
 - c. DDC and HVAC Mechanical Equipment Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task orientated information from the user manual.
 - d. DDC and HVAC Mechanical Equipment Controller shall be capable of comment lines for sequence of operation explanation.

5. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC and HVAC Mechanical Equipment Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC and HVAC Mechanical Equipment Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
 - a. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
 - b. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller) to provide full flexibility in defining the handling of system alarms. Each DDC and HVAC Mechanical Equipment Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
 - c. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs based on time (after hours destinations) or based on priority.
 - d. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.
 - e. In dial-up applications, operator-selected alarms shall initiate a call to a remote operator device.
6. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the I/O summary.
 - a. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC and HVAC Mechanical Equipment Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of 1 minute to seven days shall be provided. Each DDC and HVAC Mechanical Equipment Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a sufficient number of data samples. All trend data shall be available for transfer to a Workstation without manual intervention.
 - b. DDC and HVAC Mechanical Equipment Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary.
 - 1) Loop tuning shall be capable of being initiated either locally at the DDC and HVAC Mechanical Equipment Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.
7. DDC and HVAC Mechanical Equipment Controllers shall be capable of automatically accumulating and storing run-time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points, as specified in the point I/O schedule.

8. The peer to peer network shall allow the DDC and HVAC Mechanical Equipment Controllers to access any data from or send control commands and alarm reports directly to any other DDC and HVAC Mechanical Equipment Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC and HVAC Mechanical Equipment Controllers shall send alarm reports to multiple workstations without dependence upon a central or intermediate processing device. The peer to peer network shall also allow any DDC and HVAC Mechanical Equipment Controller to access, edit, modify, add, delete, back up, and restore all system point database and all programs.
9. The network shall allow the DDC and HVAC Mechanical Equipment Controllers to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control the points that the operator is authorized for. All other points shall not be displayed on the PC workstation or portable terminal (e.g. all base building and all tenant points shall be accessible to any base building operators, but only tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.

N. Floor Level Network Application Specific Controllers (FEC)

1. Each DDC Controller shall be able to extend its performance and capacity through the use of remote application specific controllers (FECs) through Floor Level LAN Device Networks.
2. Each FEC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each FEC shall be a microprocessor-based, multi-tasking, real-time digital control processor. Each FEC shall be capable of control of the terminal device independent of the manufacturer of the terminal device.
3. Terminal Equipment Controllers:
 - a. Provide for control of each piece of equipment, including, but not limited to, the following:
 - 1) Variable Air Volume Terminal Boxes (with and without heating coils)
 - 2) Heating Coils
 - 3) Fin Tube Radiation
 - 4) Convectors
 - 5) Radiant Heating Panels
 - 6) Unit Heaters, Cabinet Unit Heaters
 - b. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 24V floating control, 3-15 psi pneumatic, 0-10v, allowing for interface to a variety of modulating actuators.
 - c. All controller sequences and operation shall provide closed loop control of the intended application. Closing control loops over the FLN, BLN or MLN is not acceptable.

O. Local User Display

1. Where specified in the sequence of operation or points list, the controllers on the peer to peer building level network shall have a display and keypad for local interface. A keypad shall be provided for interrogating and commanding points in the controller.
 - a. The display shall use the same security password and access rights for points in the display as is used in the associated controller.
 - b. The LCD display shall be a minimum of a 2 line 40 character display.
 - c. The LCD display shall include the full point name, value (numeric, digital or state text),
 - d. point priority and alarm status on one screen.
 - e. The LCD shall dynamically update the value, priority, and alarm status for the point being displayed.
 - f. The display shall be mounted either on the door of the enclosure or remote from the controller.

P. Field Devices

1. Provide instrumentation as required for monitoring, control or optimization functions.
2. Room Temperature Sensors
 - a. Office and classroom spaces shall be provided with digital room sensors with day / night override button, and setpoint slide adjustment. The setpoint slide adjustment can be software limited by the automation system to limit the amount of room adjustment. Public areas such as corridors, entry areas, vestibules, restrooms and storage rooms shall have chrome cover plate without adjustment or occupied/unoccupied capability. Temperature sensors located in gymnasiums and locker rooms shall be provided with tamper proof guard. All temperature sensors shall be BACnet compatible network type.

Temperature monitoring range	+20/120 deg. F -13 deg. to 49 deg. C)
Output signal	Changing resistance
Accuracy at Calibration point	+0.5 deg. F (+/- 0.3 deg. C)
Set Point and Display Range	55 deg. to 95 deg. F (13 deg. to 35 deg. C)
 - b. Liquid immersion temperature:

Temperature monitoring range	+30/250 deg. F (-1 deg. /121 deg. C)
Output signal	Changing resistance
Accuracy at Calibration point	+0.5 deg. F (+/-0.3 deg. C)
 - c. Duct (single point) temperature:

Temperature monitoring range	+20/120 deg. F (-7 deg. /49 deg. C)
Output signal	Changing resistance
Accuracy at Calibration point	+0.5 deg. F (+/-0.3 deg. C)
 - d. Duct Average temperature:

Temperature monitoring range	+20 deg.+120 deg.F(-7 deg./+49 deg. C)
Output signal	4 – 20 mA DC
Accuracy at Calibration point	+0.5 deg. F (+03 deg. C)
Sensor Probe Length	25 ft. L (7.3m)

- e. Outside air temperature:
 - Temperature monitoring range -58deg.+122deg.F(-50deg.Cto 50deg.C)
 - Output signal 4 – 20 mA DC
 - Accuracy at Calibration point +0.5 deg. F (+/-0.3 deg. C)
- 3. Liquid Differential Pressure Transmitter
 - Ranges
 - 0-5/30 in. H2O
 - 0-25/150 in. H2O
 - 0-125/750 in. H2O
 - Output 4 – 20 mA DC
 - Calibration Adjustments Zero and span
 - Accuracy +/-0.2 percent of span
 - Linearity +/-0.1 percent of span
 - Hysteresis +/-0.05 percent of span
- 4. Differential pressure:
 - a. Unit for fluid flow proof shall be Penn P74.
 - Range 8 to 70 psi
 - Differential 3 psi
 - Maximum differential pressure 200 psi
 - Maximum pressure 325 psi
 - b. Unit for air flow settings.
 - c. Set point ranges:
 - 0.5 in. WG to 1.0 in. WG (124.4 to 248.8 Pa)
 - 1.0 in. WG to 12.0 in. WG (248.8 to 497.6 Pa)
- 5. Static pressure sensor:
 - Range
 - 0 to .5 in.WG (0 to 124.4 Pa)
 - 0 to 1 in.WG (0 to 248.8 Pa)
 - 0 to 2 in. WG (0 to 497.7 Pa)
 - 0 to 5" in.WG (0 to 1.2 kPa)
 - 0 to 10" WG (0 to 2.5 kPa)
 - Output Signal 4 – 20 mA VDC
 - Combined static error 0.5 percent full range
 - Operating Temperature -40 deg. to 175 deg. F (-40 deg. C to 79.5 deg. C)
- 6. Air Pressure Sensor:
 - Range: 0 to 0.1 in. water (0 to 24.9 Pa)
 - 0 to 0.25 in. water (0 to 63.2 Pa)
 - 0 to 0.5 in. water (0 to 124.5 Pa)
 - 0 to 1.0 in. water (o to 249 Pa)
 - 0 to 2.0 in water 90 to 498 Pa)
 - 0 to 5.0 in. water (0 to 1.25 kPa)
 - 0 to 10.0 in. water (0 to 2.49 kPa)
 - Output signal 4 to 20 mA
 - Accuracy +1.0 percent of full scale

7. Humidity Sensors: All room/zone humidity sensors shall be BACnet compatible network type.
Range 0 to 100 percent RH
Sensing Element Bulk Polymer
Output Signal 4 – 20 mA DC
Accuracy At 77 deg. F (25 deg. C) + 2 percent RH
Humidistat:
Range 0 to 100 percent RH
Sensing Element Bulk Polymer
Output Signal 4 – 20 mA DC
Accuracy At 77 deg. F(25 deg. C) + 2 percent RH
8. Insertion Flow Meters (Equal to-Onicon F-5300)
Sensing Method Impedance Sensing
Accuracy + 2 percent of Actual Reading
Maximum Operating Pressure 400 PSI
Output Signal 4 – 20 mA
Bi-directional where required.
9. Pressure to Current Transducer
Range 3 to 15 psig (21 to 103 kPa) or
3 to 30 psig (21 to 207 kPa)
Output signal 4 – 20 mA
Accuracy + 1 percent of full scale (+ 0.3 psig)
10. Carbon Dioxide Sensor : All room/zone CO₂ on duct mounted sensors shall be BACnet compatible network type and shall have a minimum 5 year calibration period.
Range 0 to 1500 ppm
Accuracy 20+ ppm
CO₂ sensors located in gymnasiums and locker rooms shall be provided with tamper proof guard.
11. Control Valves (all control valves shall have electric actuators with position feedback to provide confirmation of valve position).
 - a. Electric Control

Rangeability	40:1
Flow Characteristics	Modified. Equal percentage
Control Action	Normal open for hot water with fail open spring return
Medium	Steam, water, glycol
Body Type	Screwed ends 2 in. and smaller, flanged Valves 2½ in. and larger
Body Material	Bronze
Body Trim	Bronze
Stem	Stainless Steel

Actuator

0-10 VDC, 4-20 MA

24 VAC/120VAC – Modulating for all hot water valves.

- b. All automatic temperature control valves in water lines shall be provided with Characterized throttling plugs and shall be sized for minimum 25 percent of the system pressure drop or five psi, whichever is less.
 - 1) Positive positioning relays shall be provided on pneumatic control when required to provide sufficient power for sequencing.
 - 2) Two position valves shall be line size.

12. Damper Actuators

- a. Electric control shall be direct coupled actuators with position feedback to BMS.
- b. Damper actuators shall be Brushless DC Motor Technology with stall protection, bi-directional, fail safe spring return, all metal housing, manual override, independently adjustable dual auxiliary switch.
 - 1) The actuator assembly shall include the necessary hardware and proper mounting and connection to a standard ½ in. diameter shaft or damper blade.
- c. Actuators shall be designed for mounting directly to the damper shaft without the need for connecting linkages.
- d. All actuators having more than 100 lb-in torque output shall have a self-centering damper shaft clamp that guarantees concentric alignment of the actuator's output coupling with the damper shaft. The self-centering clamp shall have a pair of opposed "v" shaped toothed cradles; each having two rows of teeth to maximize holding strength. A single clamping bolt shall simultaneously drive both cradles into contact with the damper shaft.
- e. All actuators having more than a 100 lb-in torque output shall accept a 1 in. diameter shaft directly, without the need for auxiliary adapters.
- f. All actuators shall be designed and manufactured by Belimo or approved equal using ISO900 registered procedures, and shall be Listed under Standards UL873 and CSA22.2 No. 24-93 I.

Q. Miscellaneous Devices

- 1. Thermostats (Stand-alone electric type - only where specified or indicated on drawings)
 - a. Room thermostats shall be of the gradual acting type with adjustable sensitivity.
 - b. They shall have a bi-metal sensing element capable of responding to a temperature change of one-tenth of one degree. (Provide all thermostats with limit stops to limit adjustments as required.)
 - c. Thermostats shall be arranged for either horizontal or vertical mounting.
 - d. In the vertical position thermostat shall fit on a mullion of movable partitions without overlap.
 - e. Mount the thermostat covers with tamper-proof socket head screws.

2. Fire stats:
 - a. Provide manual reset, fixed temperature line voltage type with a bi-metal actuated switch.
 - 1) Switch shall have adequate rating for required load.
3. Electronic Airflow Measurement Stations and Transmitters (Where indicated on Control Drawings).
 - a. Provide air flow moving stations as shown on drawings.
 - b. Stations – each insertion station shall contain an array of velocity sensing elements and straightening vanes. The velocity sensing elements shall be of the RTD or thermistor type. The sensing elements shall be distributed across the duct cross section in a quality to provide accurate readings. The resistance to airflow through the airflow measurement station shall not exceed 0.08 in. water gage at an airflow of 2,000 fpm. Station construction shall be suitable for operation at airflow of up to 5,000 fpm over a temperature range of 40 to 120 degrees F, and accuracy shall be plus or minus 3 percent over a range of 125 to 2,500 fpm scaled to air volume. Each transmitter shall produce a linear, temperature compensated 4 to 40 mA DC, output corresponding to the required velocity pressure measurement. Provide local readout on unit.
 - c. Fan inlet airflow sensing
 - 1) Where mounted into controllable pitch axial inlet bells, or inlet cones of centrifugal fans, the traverse probe assemblies shall be complete with all necessary end mounting plates and master takeoff fittings. All mounting bolts, lock washers and nuts; interconnecting tubing and compression fittings to be provided by the installing contractor.
 - 2) Primary flow elements shall not be used on fan inlet applications where the narrowest diameter of the inlet cone is under ten in. without prior approval. Fan inlet sensors shall not be used on fans having inlet guide vanes. The use of only one static element and one total pressure element on fan inlets is prohibited. Fan primary elements shall not exceed .562 in. in diameter on fans having inlet cone diameters less than 30 in..
 - 3) Fan inlet airflow sensing similar to Ebtron GTx116F or Paragon Controls model FE-1050.
 - d. Electronic Transducers
 - 1) Provide individual differential static pressure and airflow transducers, selected for the required range of each of the above primary elements, and in accordance with the following:
 - 2) The transducer(s) shall be solid-state electronic type, with infinite output resolution, capable of performing dedicated static pressure and air volume control functions. Microprocessor based transducers with time-sharing of multiple square root extractors and/or controllers are not acceptable.
 - 3) Each transducer's output shall not be affected by direction of mounting (attitude) or external vibrations, and shall be furnished with a factory-calibrated range that matches the application.

- 4) Airflow transducers shall be provided with an integral dual scale indicating meter operating independent of all other control devices. The top scale shall indicate the measured air volume in units of cubic ft. per minute (CFM), and the bottom scale shall indicate the air velocity in units of ft. per minute (FPM).
 - The meter shall be a differential pressure type that is diaphragm actuated, and is to be flush mounted on the enclosure door.
 - The meter shall be calibrated to an accuracy of +2 percent of span.
- 5) Transducer performance shall be equal to or better than the following:
 - Accuracy: +/- 0.5 percent F.S. (Terminal Point) / +/- 0.35 percent F.S. (BFSL)
 - Temperature Effects: <0.03 percent F.S./deg F
 - Over-pressure: 5 PSIG Proof / 10 PSIG Burst
 - Response: <0.25 seconds for full scale input
 - Noise Filtration: Low Pass Filter, factory set @ 3.2Hz
- 6) Each transducer shall be selected for its respective duty. Supply, Exhaust and/or Return Airflow Transducers shall provide analog output signal linear to air volume that are factory set for a full scale value equal to 110 percent of the maximum design capacity of the flow measuring element served for variable air volume applications, or 200 percent of the design operating value for constant volume applications.
- 7) Airflow transducers for operating velocities below 1266 ft. per minute shall provide the following features:
 - Local electronic indication of the measure airflow rate.
 - The indicating meter shall be one-half in. high, three and one half digit light emitting diode (LED) type.
 - The LED shall indicate the measured air volume in engineering units of cubic ft. per minute (CFM).
 - Automatic zeroing circuit that shall maintain the transducer output to within 0.1 percent of value, and shall be field configurable for frequency of activation between one and seventy two hours.
 - The transducer output shall be locked and maintained at the last given output value during the automatic zeroing period so as not to interrupt the automatic control process.
 - The meter shall be auto calibrated to an accuracy of +/- 1 count.
 - Transducer accuracy shall be +/- 0.25 percent F.S. (Terminal Point) / +/- 0.15 percent F.S. (BFSL)

4. Current Sensing Relay:

- a. Provide solid-state, adjustable, current operated relay. Provide a relay which changes switch contact state in response to an adjustable set point value of current in the monitored A/C circuit.
- b. Adjust the relay switch point so that the relay responds to motor operation under load as an "on" state and so that the relay responds to an unloaded running motor as an "off" state. A motor with a broken belt is considered an unloaded motor.
- c. Provide for status device for all fans and pumps.

5. ~~Refrigerant Monitoring System~~

- a. ~~The refrigerant gas monitor shall be a single zone type, designed for continuous monitoring of CFC, HFC, HCFC levels; specifically R-134A for this application, confirm and verify with chiller manufacturer. The refrigerant gas detector shall~~

~~have three adjustable alarm levels with relay outputs to designate leak, spill and evacuation concentrations. The gas detector and monitor shall provide a system fault relay output and a 4-20 mA output for integration with remote monitoring equipment or a building automation system.~~

- ~~b. An alarm strobe/horn combination shall be mounted inside the chiller mechanical room and outside the door in the school hallway leading to the mechanical room. Upon a refrigerant alarm condition, these alarms will show a red strobe light and audible alarm notifying building occupants of the alarm. The alarm shall be surface mounted at a height above reach of occupants.~~
- ~~c. At the door leading to the mechanical room, a sign shall be mounted with the text: ACCESS RESTRICTED TO AUTHORIZED PERSONNEL. The lettering shall be red characters on a white background; all of the same size font. Sign shall be a minimum of 8"H x 15"W.~~
- ~~d. Refrigerant gas monitoring:~~
- ~~e. A refrigerant gas monitoring as specified herein shall be installed by the ATC contractor to monitor any refrigerant gas leaks at all times.~~
- ~~f. If the refrigerant gas monitor shall detect a leak, via the FMCS, an alarm shall be sent to the Owners central operations station.~~
- ~~g. In addition, the monitoring system shall send signals to simultaneously shut down all boilers, shut down any domestic hot water heaters, shut down any domestic hot water heater, shut down the chiller, open the make-up air dampers and start the mechanical room exhaust fan.~~
- ~~h. Upon any refrigerant alarm condition, both combination strobe lights/horns shall annunciate notifying building occupants of the alarm condition.~~
- ~~i. The equipment that has been shut down shall remain off until the cause of the leak has been determined by the Owners personnel, is remedied and/or it is deemed by the Owner to be safe to return to normal operations.~~

5. Refrigerant Monitoring System

- a. The refrigerant gas monitor shall be a single zone type, designed for continuous monitoring of CFC, HFC, HCFC levels; specifically R-410A for this application, confirm and verify with VRF manufacturer. The refrigerant gas detector shall have two adjustable alarm levels with relay outputs to designate leak and evacuation concentrations. The gas detector and monitor shall provide a system fault relay output and a 4-20 mA output for integration with remote monitoring equipment or a building automation system.**
- b. A sensor with alarm strobe/horn combination shall be mounted inside each dorm room. Upon a refrigerant alarm condition, these alarms will show a red strobe light and audible alarm notifying building occupants of the alarm. Audible alarm may be enabled/disabled via dip switch or BMS command.**
- c. Refrigerant gas monitoring:**
 - 1) A refrigerant gas monitoring system as specified herein shall be installed by the ATC contractor to monitor any refrigerant gas leaks at all times.**
 - 2) If the refrigerant gas monitor shall detect a leak, via the BMS, an alarm shall be sent to the Owners central operator work-station and the BMS shall disable the VRF system.**
 - 3) Upon any refrigerant alarm condition, both combination strobe lights/horns shall annunciate notifying building occupants of the alarm condition.**

- 4) **The equipment that has been shut down shall remain off until the cause of the leak has been determined by the Owners personnel, is remedied and/or it is deemed by the Owner to be safe to return to normal operations.**
 - 5) **The basis of design refrigerant detection system is based on "Bacharch" Model MVR-300 space sensors.**
6. Manufacturer: Subject to compliance with requirements, provide an Automatic Temperature Control System as manufactured by:
- a. Siemens
 - b. Johnson Controls FX
 - c. StruxureWare
 - d. Or equal

2.32 FREESTANDING EQUIPMENT SUPPORT SYSTEM

A. Manufacturers:

1. Acceptable Manufacturer: PHP Systems/Design, Bigfoot Systems, Erico Caddy Pyramid Systems, Eberl Iron Works, or equal.
2. Requests for substitutions will be considered in accordance with provisions of Section 01 60 00.

B. Applications: Base size and spacing shall be designed by the weight of the supported item, the anticipated live load and the bearing capacity of roof insulation. HVAC contractor to coordinate approved equipment with support manufacturer.

1. Equipment Platform Access:

- a. Support Spacing: Per manufacturer's recommendation.
- b. Bases High Density Polypropylene plastics with additives for UV protection.
- c. Substructure: 12 gauge back-to-back channel G-1012A, or approved equal supported directly from the bases.
- d. Grating: Mill-galvanized carbon steel in accordance with ASTM A525:
 - 1) Gauge 14-ga. Steel
 - 2) Section Width: 12 inches (305 mm) (standard)
 - 3) Channel Height: 2 inches (51 mm) (standard)
 - 4) Flange Options: FM
 - 5) Flange Options: MM
 - 6) Surface Condition: MG-traction grip
 - 7) Surface Condition: MS-smooth
 - 8) All substructures shall be galvanized steel. Spring nuts, and bolts for spring nuts will be electro-plated.

C. Materials:

1. Portable Support System: Engineered, portable system specifically designed for installation without the need for roof penetrations, or flashings, and without causing damage to the roofing membrane.
 - a. Design system using high density, high impact polypropylene bases with carbon black, anti-oxidants for UV protection, and steel framing of 1-5/8 inch (41 mm) B22TH or 1-7/8 inch (48 mm) BTS22TH for support.
 - b. Custom design system to fit piping, conduits, equipment, or walkways to be installed and actual conditions of service and loading.
 - c. Piping Supports: Provide suitable hangers and supports.
 - d. Duct and Equipment Supports: Factory fabricated to support exact duct sizes and equipment to be installed.
 - e. Walkways and Platforms: Provide galvanized slotted metal grating, in configurations as indicated, and tubular handrails where indicated.
2. Bases: Injection molded high density, high impact polypropylene with UV-inhibitors and anti-oxidants, conforming to the following:
 - a. Moisture Content: Negligible.
 - b. Shrinkage/Swelling Due to Moisture: Negligible.
 - c. Density: 55.8 lb/cu ft (894 kg/cu m).
 - d. Insect Resistance: No known insect damage potential.
 - e. Chemical Resistance (oil, brake fluid, gasoline, diesel, antifreeze, battery acid, and sulfuric acid) No visual or physical change apparent.
 - f. Flammability: No ignition after 10 minutes, 25 kW/m, when tested in accordance with ASTM D 1929.
 - g. Sized as required by loading conditions and as indicated on the drawings.
 - h. Shop fabricated with inserts for square tubing or threaded rods as required.
 - i. Color: Integral black color as molded.
 - j. Bases for Mechanical Attachment: Sealant chamber around penetration point, with injection port for sealing after fastening; beveled lip for sealant bead around entire diameter.
 - k. Do not use bases containing carbonated plastics, press molded recycled rubber and plastics, steel, stainless steel, or any injection molded threaded receivers.
3. Steel Framing:
 - a. Channel Types: 1-5/8 inch (41.3 mm) B22TH or 1-7/8 inch (47.6 mm) BTS22H, as required for loading conditions.
 - b. Thickness: 12 gauge (2.7 mm).
 - c. Form: Roll-formed 3-sided or tubular channel, perforated with 9/16 inch (14.3 mm) holes at 1-7/8 inch (47.6 mm) centers on three sides.
 - d. Finish: Hot dip galvanize in accordance with ASTM A 123 after fabrication, free of roughness, whiskers, unsightly spangles, icicles, runs, barbs, sags, droplets, and other surface blemishes.
 - e. Do not use tubing or tube steel.
4. Pipe Supports and Hangers: Conform to MSS SP-58 and MSS SP-69 and as follows:
 - a. Fabricated of carbon steel where framing is carbon steel; fabricated of stainless steel where framing is stainless steel; finished same as framing.

- b. Sizes 2-1/2 inch (63 mm) and smaller: Single roller supports for piping subject to expansion and contraction; 3-sided channels and pipe clamps.
 - c. Sizes 3 inch (76 mm) and larger: Rollers, clevis hangers, or band hangers, to allow for expansion and contraction without movement of the bases or framing.
- 5. Accessories: Clamps, bolts, nuts, washers, and other devices as required for a complete system.
 - a. Carbon Steel: Hot-dip galvanized in accordance with ASTM A 153/A 153M.
 - b. Stainless Steel: Mill finish.
 - c. For Mechanical Fastening to Deck: On wood and steel decks, use bolts with steel plate to attach to deck; on concrete decks use threaded rods and adhesive anchors, with rod embedded at least 1-3/4 inches (44 mm) into concrete.

PART 3 - EXECUTION

3.1 ATTIC STOCK

A. Rooftop Units

- 1. Four additional complete extra sets of pre and final filters for each RTU for attic stock. All these filters indicated above including the four sets of attic stock are additional to those provided for flush out and indoor air quality requirements per LEED requirements.
- 2. Provide one spare set of belts for each belt-driven air handling unit.
- 3. Obtain receipt from Owner that attic stock provided.

B. Power and Gravity Ventilators

- 1. Furnish to Owner, with receipt, one spare set of belts for each belt driven power ventilator

C. Ductwork Accessories

- 1. Furnish extra fusible links to owner, one link for every 10 installed of each temperature range; obtain receipt.

D. Unit Heaters

- 1. Furnish to Owner, with receipt, (2) spare sets of filters per each unit.

E. Ductless Cooling Units

- 1. Furnish to Owner, with receipt, (2) spare sets of filters per each indoor unit.

F. Condensate Discharge Pumps

- 1. Furnish to Owner, with receipt, (10) new condensate pumps to attic stock.

3.2 INSTALLATION OF VALVES

- A. Examine valve interior through the end ports, for cleanliness, freedom from foreign matter and corrosion. Remove special packing materials, such as blocks used which prevents disc movement during shipping and handling.

- B. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the position in which it was shipped.
- C. Examine threads on both the valve and the mating pipe for form (out-of-round or local indentation) and cleanliness.
- D. Examine mating flange faces for conditions which might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size and material, and for freedom from defects and damage.
- E. Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.
- F. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select valves with the following ends or types of pipe/tube connections:
 - 1. Copper Tube 2" and smaller (Heating Hot Water and Low Pressure Steam): Solder ends.
 - 2. Steel Pipe Sizes 2" and smaller: Threaded or grooved-end.
 - 3. Steel Pipes Sizes 2-1/2" and larger: Grooved-end or welded.
- G. Valve Installation:
 - 1. Locate valves for easy access and provide separate support where necessary.
 - 2. Install valves and unions for each fixture and item of equipment in a manner to allow equipment removal without system shut-down. Unions are not required on flanged devices.
 - 3. Install valves in horizontal piping with the stem at or above the center of the pipe.
 - 4. Installation of Check Valves: Install for proper direction of flow as follows:
 - a. Swing Check Valves: Install in horizontal position with hinge pin level.
 - b. Wafer Check Valves: Install between 2 flanges in horizontal or vertical position.
 - c. Lift Check Valves: Install in piping line with stem upright and plumb.
- H. Threaded Connections:
 - 1. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
 - 2. Align threads at point of assembly.
 - 3. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).
 - 4. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.
- I. Flanged Connections:
 - 1. Align flanges surfaces parallel.
 - 2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using a torque wrench.

J. Grooved Connections:

1. Installation shall be in accordance with the latest published instructions from the manufacturer.

K. Field Quality Control:

1. Testing: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks; replace valve if leak persists.

L. Adjusting and Cleaning:

1. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare to receive painting or insulation.

3.3 INSTALLATION OF METERS AND GAUGES

A. Installation of Temperature Gauges:

1. General: Install temperature gauges in vertical upright position, and tilted so as to be easily read by observer standing on floor.
2. Temperature Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure Cap.

B. Installation of Pressure Gauges:

1. General: Install pressure gauges in piping tee with pressure gauge located on pipe at most readable position.
2. Pressure Gauge Cocks: Install in piping tee with snubber. Install siphon for steam pressure gauges.

C. Installation of Flow Measuring Fittings:

1. General: Install flow measure fittings in piping systems located in accessible locations.

D. Adjusting and Cleaning:

1. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.
2. Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked or broken windows, repair any scratched or marred surfaces with manufacturer's touch-up paint.

3.4 INSTALLATION OF HANGERS & ATTACHMENTS

- A. Vibration Control and Seismic Restraint: Refer to section 23 05 48 and drawing VS-1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 23 05 48 and drawing VS-1.

- B. Examine areas and conditions under which supports and anchors are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

- C. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) proper placement of inserts, anchors, and other building structural attachments.
- D. Prior to installation of hangers, supports, anchors, and associated work, Installer shall meet at project site with Contractor, installer of each component of associated work, inspection and testing agency representatives (if any), installers of other work requiring coordination with work of this section and Architect/Engineer for purposes of reviewing material selections and procedures to be followed in performing the work in compliance with requirements specified.
- E. Install building attachments at required locations within concrete or on structural steel for proper piping support. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert securely to forms. Where concrete with compressive strength less than 2500 psi is indicated, install reinforcing bars through the openings at the tops of inserts.
- F. Install hangers, supports, clamps, and attachments to support piping properly from building structure; comply with MSS SP-69. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Install supports with maximum spacings complying with MSS SP-69. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.
 - 1. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.
 - 2. Prevent electrolysis in support of copper tubing by the use of hangers and supports which are copper plated, or by other recognized industry methods.
 - 3. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
 - 4. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.
 - 5. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31 Pressure Piping Codes are not exceeded.
 - 6. Insulated Piping: Comply with the following installation requirements:
 - a. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ANSI B31.
 - b. Shields: For pipe sizes up to and including 4" provide heavy gauge shield at each hanger point.
 - c. Saddles: For all pipe sizes over 4" provide saddle at each hanger point. Completely fill void in saddle with loose insulation.
- G. Install anchors at proper locations to prevent stresses from exceeding those permitted by ANSI B31, and to prevent transfer for loading and stresses to connected equipment.
- H. Fabricate and install anchor by welding steel shapes, plates, and bars to piping and to structure. Comply with ANSI B31 and with AWS standards.

- I. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.
- J. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe-runs, at intermediate points in pipe-runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.
- K. Provide concrete housekeeping bases for all floor-mounted equipment. Size bases to extend minimum of 4" beyond equipment base in any direction; and 4" above finished floor elevation. Construct of reinforced concrete, roughen floor slab beneath base for bond, and provide steel rod anchors between floor and base. Locate anchor bolts using equipment manufacturer's templates. Chamfer top and edge corners.
- L. Provide structural steel stands to support equipment not floor mounted or hung from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks mounted on steel stands.
- M. Adjusting and Cleaning:
 - 1. Hanger Adjustment: Adjust hangers so as to distribute loads equally on attachments.
 - 2. Support Adjustment: Provide grout under supports so as to bring piping and equipment to proper level and elevations.
 - 3. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.5 INSTALLATION OF MECHANICAL IDENTIFICATION

- A. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.
- B. General: Install pipe markers of the following type on each system indicated to receive identification, and include arrows to show normal direction of flow:
 - 1. Plastic pipe markers, with application system as indicated. Install on pipe insulation segment where required for hot non-insulated pipes.
- C. Locate pipe markers and color bands as follows wherever piping is in or above occupied spaces or corridors, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
 - 1. Near each valve and control device.
 - 2. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
 - 3. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.
 - 4. At access doors, manholes and similar access points which permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced intermediately at maximum spacing of 50' along each piping run, except reduce spacing to 25' in congested areas of piping and equipment.
 - 7. On piping above removable acoustical ceilings.

D. Valve Identification:

1. General: Provide valve tag on every valve, cock, and control device in each piping system; exclude check valves, valves within factory-fabricated equipment units, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.
2. Mount valve schedule frames and schedules in machine rooms where indicated or, if not otherwise indicated, where directed by Architect/Engineer.

E. Mechanical Equipment Identification:

1. General: Install engraved plastic laminate sign or plastic equipment marker on or near each major item of mechanical equipment and each operational device, as specified herein if not otherwise specified for each item or device.
2. Lettering Size: Minimum 1/4" high lettering for name of unit where viewing distance is less than 2' - 0", 1/2" high for distances up to 6' - 0", and proportionately larger lettering for greater distances. Provide secondary lettering of 2/3 to 3/4 of size of the principal lettering.

F. Adjusting and Cleaning:

1. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.
2. Cleaning: Clean face of identification devices, and glass frames of valve charts.

3.6 INSTALLATION OF MECHANICAL INSULATION

A. Installation of Piping Insulation:

1. Insulation Omitted: Omit insulation on hot piping within radiation enclosures or unit cabinets; on cold piping within unit cabinets provided piping is located over drain pan; on heating piping beyond control valve, located within heated space; on condensate piping between steam trap and union; and on unions, flanges, strainers, flexible connections, and expansion joints. (Couplings in mechanical grooved systems will be insulated.)
2. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.
3. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance tests.
4. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete run. Do not use cut pieces or scraps abutting each other.
5. Clean and dry pipe surfaces prior to insulating. Butt installation joints firmly together to ensure a complete and tight fit over surfaces to be covered.
6. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.
7. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.
8. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.
9. Butt pipe insulation against pipe hanger insulation inserts. For hot pipes, apply 3" wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3" wide vapor barrier tape or band.

B. Installation of Ductwork Insulation:

1. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its indented purpose.
2. Install insulation materials with smooth and even surfaces.
3. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
4. Maintain integrity of vapor-barrier on ductwork insulation, and protect it to prevent puncture and other damage.
5. Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise indicated.
6. Lined Ductwork: Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed.

C. Protection and Replacement:

1. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.
2. Protection; Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

3.7 INSTALLATION OF HYDRONIC PIPING AND ACCESSORIES

A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS-1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS-1.

B. Piping Installations:

1. Locations and Arrangements: Drawings indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design consideration. So far as practical, install piping as indicated.
2. Install piping at a uniform grade of 1" in 40' upward in the direction of flow.
3. Make reductions in pipe sizes using eccentric reducer fitting installed with the level side up.
4. Install branch connections to mains using Tee fittings in main with take-off out the bottom, except for up-freed risers which shall have take-off out the top of the main line.
5. Install unions in pipes 2" and smaller, adjacent to each valve, at final connections of each piece of equipment, and elsewhere as indicated. Unions are not required on flanged or grooved devices.
6. Install flanges or grooved joint couplings on valves, apparatus, and equipment having 2-1/2" and larger connections.
7. Install strainers on the supply side of each control valve, pressure reducing valve, pressure regulating valve, solenoid valve, inline pump, and elsewhere as indicated. Install nipple and ball valve in blow down connection of strainers 2" and larger.
8. Anchor piping to ensure proper direction of expansion and contraction. Expansion loops and joints are indicated on the Drawings
9. Install pipe sleeves at all wall and floor penetrations.
10. Install escutcheons at all exposed pipe wall penetrations.
11. Provide Dielectric couplings or waterways at all dissimilar piping/valve connections.

C. Pipe Applications:

1. Copper Tubing: Use Type L, drawn copper tubing with wrought copper fittings and solder joints for 2" and smaller, above ground, within building. Use Type K, annealed temper copper tubing for 2" and smaller without joints, below ground or within slabs. ~~Mechanical fittings (crimp or flair) are not permitted.~~
2. Steel Pipe: Use steel pipe with threaded joints and fittings for 2" and smaller, and with welded joints for 2-1/2" and larger.
3. Steel Pipe: Use mechanical grooved end steel pipe and mechanical couplings and fittings, valves and accessories. All grooved system components including grooving tools shall be of the same manufacturer.
4. **Fittings for Type 'L' hard tempered copper tubing for heating hot water piping 2 inch in size and smaller may be copper press fittings.**
 - a. **Acceptable Manufacturers: Viega North America, Elkhart Products Corporation, Victaulic Or equal**
 - b. **Material: ASTM B88 and ANSI/ASME B16.22. O-rings for copper press fittings shall be EPDM.**
 - c. **Installation of copper press fittings and installation are to be made in strict accordance with the manufacturer's installation instructions. All tubing is to be reamed prior to the installation of the fitting. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool approved by the manufacturer.**

D. Grooved Pipe Ends and Fittings:

1. Roll Groove pipe ends in accordance with the latest published instructions from manufacturer of grooved couplings.
2. Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. All grooved system components shall be of same manufacturer. Use grooved-end fittings and rigid or flexible, where required, grooved-end-pipe couplings. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by the grooved coupling manufacturer. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
3. Training
 - a. The grooved coupling manufacturer's (the "manufacturer") factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and installation of groove joints products.
 - b. IACET/Training: A factory trained manufacturer's representative (direct employee) shall provide on-site training of contractor's field personnel in the use of grooving tools, application of groove, and product installation in compliance with the following:
 - 1) Manufacture must be accredited by the International Association for Continuing Education and Training (IACET).
 - 2) IACET Accredited Provider status demonstrates that the manufacture complies with the ANSI/IACET standard, which is recognized internationally as a standard of excellence in instructional practices.

4. Inspection

- a. A manufacturer's factory trained representative shall periodically visit the job site and review the installation for best practices. The installing Contractor shall correct any identified deficiencies.
- b. The grooved fittings manufacturer's product that has been examined and has not met the visual inspection criteria for proper installation must be corrected and re-examined by Inspection Services prior to the completion of the project. Any Victaulic product that has not been corrected or was not examined will not be considered as part of the successful completion of Inspection Services.

5. Application

- a. Upon completion of the manufacturer's inspection of the installation and any identified corrections, the manufacturer may provide the Owner or purchaser with a limited warranty on manufacturer's products.

E. Valve Applications:

1. General Duty Valve Applications: The Drawings indicate valve types to be used. Where specific valve types are not indicated the following requirements apply:
 - a. Shut-Off Duty: Use gate, and ball, valves.
 - b. Throttling Duty: Use globe, ball, and plug valves.
2. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage.
3. Install pump discharge valves with stem in upward position; allow clearance above stem for check mechanism removal.
4. Install safety relief valve on hot water generators, and elsewhere as required by ASME Boiler and Pressure Vessel Code. Pipe discharge to floor without valves. Comply with ASME Boiler and Pressure Vessel Code Section VIII, Division 1 for installation requirements.
5. Install pressure reducing valves on hot water generators, and elsewhere as required to regulate system pressure.

F. Hydronic Specialties Installation:

1. Install automatic air vents at high points in the system, heat transfer coils, and elsewhere as required for system air venting. Install air vents with cocks such that vents can be removed without draining system.
2. Install combination separator/strainer in pump suction lines. Run piping to compression tank with 1/4" per foot (2%) upward slope towards tank. Install blowdown piping with gate valve; extend to nearest drain.
3. Install pump suction diffusers on pump suction inlet, adjust foot support to carry weight of suction piping. Install nipple and ball valve in blowdown connection.
4. Install shot-type chemical feeders in each hydronic system; in upright position with top of funnel not more than 48" above floor. Install feeder in bypass line, off main using globe valves on each side of feeder and in the main between bypass connections. Pipe drain, with ball valve, to nearest equipment drain.

5. Install diaphragm-type compression tanks as indicated. Vent and purge air from hydronic system, charge tank with proper air charge to suit system design requirements.
 - a. In the absence of details provide support from the floor or structure above sufficient for the weight of water assuming a full tank of water. Do not overload building components and structural members.

G. Field Quality Control:

1. Preparation for Testing: Prepare hydronic piping in accordance with ASME B 31.9 and as follows:
 - a. Leave joints including welds uninsulated and exposed for examination during the test.
 - b. Provide temporary restraints for expansion joints which cannot sustain the reactions due to test pressure. If temporary restraints are not practical, isolate expansion joints from testing.
 - c. Flush system with clean water. Clean strainers.
 - d. Isolate equipment that is not to be subjected to the test pressure from the piping. If a valve is used to isolate the equipment, its closure shall be capable of sealing against the test pressure without damage to the valve. Flanged joints at which blinds are inserted to isolate equipment need not be tested.
 - e. Install relief valve set at a pressure no more than 1/3 higher than the test pressure, to protect against damage by expansion of liquid or other source of overpressure during the test.
2. Testing: Test hydronic piping as follows:
 - a. Use ambient temperature water as the testing medium, except where there is a risk of damage due to freezing. Another liquid may be used if it is safe for workmen and compatible with the piping system components.
 - b. Use vents installed at high points in the system to release trapped air while filling the system. Use drains installed at point for complete removal of the liquid.
 - c. Examine system to see that equipment and parts that cannot withstand test pressures are properly isolated. Examine test equipment to ensure that it is tight and that low pressure filling lines are disconnected.
 - d. Subject piping system to a hydrostatic test pressure which at every point in the system is not less than 1.5 times the design pressure. The test pressure shall not exceed the maximum pressure for any vessel, pump, valve, or other component in the system under test. Make a check to verify that the stress due to pressure at the bottom of vertical runs does not exceed either 90% of specified minimum yield strength, or 1.7 times the "SE" value in Appendix A of ASME B31.9, Code for Pressure Piping, Building Services Piping.
 - e. After the hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connection for leakage. Eliminate leaks by tightening, repairing, or replacing components as appropriate, and repeat hydrostatic test until there are no leaks.

H. ADJUSTING AND CLEANING:

1. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.

2. Chemical Treatment: Provide a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.

3.8 INSTALLATION OF REFRIGERANT PIPING AND ACCESSORIES

- A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS-1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS-1.
- B. Piping Installations:
 1. Locations and Arrangements: Drawings indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, and other design consideration. So far as practical, install piping as indicated.
 2. Install pipe sleeves at all wall and floor penetrations.
 3. Install escutcheons at all exposed pipe wall penetrations.

3.9 INSTALLATION OF HVAC PUMPS

- A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS-1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS-1.
- B. General: Install HVAC pumps where indicated, in accordance with manufacturer's published installation instructions, complying with recognized practices to ensure that HVAC pumps comply with requirements and serve intended purposes.
- C. Access: Provide access space around HVAC pumps for service as indicated, but in no case less than that recommended by manufacturer.
- D. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 260000 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
- E. Adjusting and Cleaning:
 1. Alignment: Check alignment, and where necessary, realign shafts of motors and pumps within recommended tolerances by manufacturer, and in presence of manufacturer's service representative.
 2. Start-Up: Lubricate pumps before start-up. Start-up in accordance with manufacturer's instructions.
 3. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.10 INSTALLATION OF HIGH EFFICIENCY, GAS FIRED CONDENSING BOILER

- A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS-1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS-1.
- B. General: Install boilers in accordance with manufacturer's installation instructions, in accordance with State and Local Code requirements. Install units plumb and level, to tolerance of 1/8" in 10' - 0" in both directions. Maintain manufacturer's recommended clearances around and over boilers.
- C. Support: Install boilers on 4" thick concrete pad, 4" larger on each side than base of unit.
- D. Electrical Work: Install electrical devices furnished by manufacturer but not specified to be factory mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 - 1. Verify that electrical work installation is in accordance with manufacturer's submittal and installation requirements of Division 260000 sections. Do not proceed with equipment start-up until electrical work is acceptable to equipment Installer.
- E. Gas Piping: Connect gas piping to boiler, full size of boiler gas train inlet, provide union with sufficient clearance for burner removal and service.
- F. Hot Water Piping: Connect supply and return boiler tapplings as indicated, with shutoff valve and union or flange at each connection.
- G. Regulator Vents: Provide 3/4" vent from each main and pilot regulator. Each vent shall terminate outdoors per code requirements.
- H. Breeching: Connect breeching to boiler outlet, full size of outlet. Route as indicated.
- I. Flush and clean boilers upon completion of installation, in accordance with manufacturer's start-up instructions.
- J. Hydrostatically test assembled boiler and piping in accordance with applicable sections of ASME Boiler and Pressure Vessel Code.
- K. Arrange with National Board of Boiler and Pressure Vessel Inspectors for inspection of boiler piping, observation of hydrostatic testing, and for certification of completed boiler units.
- L. Start-up boilers, in accordance with manufacturer's start-up instructions, and in presence of boiler manufacturer's start up representative. Test controls, and demonstrate compliance with requirements. Adjust burner for maximum burning efficiency. Replace damaged or malfunctioning controls and equipment.
- M. Owner's Instructions: Provide services of manufacturer's technical representative for 4-hour day to instruct Owner's personnel in operation and maintenance of boilers and hot water distribution system.
- N. Schedule training with Owner, provide at least 7-day notice to Contractor and Engineer of training date.

3.11 INSTALLATION OF ROOFTOP UNITS W/ ENERGY RECOVERY

- A. Vibration Control and Seismic Restraint: Refer to section 23 05 48 and drawing VS-1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 23 05 48 and drawing VS-1.
- B. General: Install rooftop energy recovery units where indicated, in accordance with equipment manufacturer's published installation instructions, and with recognized industry practices, to ensure that units comply with requirements and serve intended purposes.
- C. Coordination: Coordinate with other work, including ductwork, floor construction, roof decking, and piping, as necessary to interface installation of air-handling units with other work.
- D. Access: Provide access space around air handling units for service as indicated, but in no case less than that recommended by manufacturer.
- E. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
- F. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment Installer.
- G. Duct Connections: Provide ductwork, accessories, and flexible connections as indicated.
- H. Grounding: Provide positive equipment ground for air-handling unit components.
- I. Testing: Upon completion of installation of energy recover units, start-up and operate equipment to demonstrate capability and compliance with requirements. Field correct malfunctioning units, than retest to demonstrate compliance.
- J. Startup Services
 - 1. Manufacturer's Supervision: A factory-trained service representative of the manufacturer will supervise the unit startup and application specific calibration of control components.
 - a. The single packaged unit will not be operated for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings are lubricated, and fan has been test run under observation.
 - b. After the single packaged unit is installed, the variable speed drive will be field commissioned by a factory trained and employed service technician.
- K. Provide two complete extra sets of filters for each air handling unit. Install new filters at completion of air handling system work, and prior to testing, adjusting, and balancing work. Obtain receipt from Owner that new filters have been installed.
- L. Provide one spare set of belts for each belt-driven air handling unit, obtain receipt from Owner that belts have been received.

3.12 INSTALLATION OF TERMINAL HEATING UNITS (HYDRONIC)

- A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS-1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS-1.
- B. Installation of Finned Tube Radiation: (Hydronic)
 - 1. General: Install finned tube radiation as indicated, and in accordance with manufacturer's installation instructions.
 - 2. Locate finned tube radiation as indicated, run cover wall-to-wall unless otherwise indicated. Provide butt caps, splice joints, "Z" bends etc. for a complete installation.
 - 3. Install access panels centered in front of each shutoff valve, balancing cock, steam trap, or temperature control valve.
- C. Installation of Convectors: (Hydronic)
 - 1. General: Install convectors as indicated, and in accordance with manufacturer's installation instructions.
 - 2. Locate convectors as indicated, coordinate with other trades to assure correct recess size for recessed convectors.
- D. Installation of Horizontal Unit Heaters: (Hydronic)
 - 1. General: Install unit heaters as indicated, and in accordance with manufacturer's installation instructions.
 - 2. Uncrate units and inspect for damage. Verify that nameplate data corresponds with unit designation.
 - 3. Hang units from building substrate, not from piping. Mount as high as possible to maintain greatest headroom possible unless otherwise indicated.
 - 4. Support units with rod-type hangers anchored to building substrate.
 - 5. Install piping as indicated.
 - 6. Protect units with protective covers during balance of construction.
- E. Installation of Radiant Panels & Radiation Wall Units:
 - 1. Install components level and plumb. Maintain sufficient clearance for normal services, maintenance, or in accordance with construction drawings.
 - 2. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Verify that controls and control enclosure are accessible.
 - b. Verify that control connections are complete to control valves as needed.
 - c. Verify that any identification tags are visible.
 - d. Verify that controls respond to inputs as specified.
 - 3. Connections
 - a. Piping installation requirements are specified in other Division 23 Sections. Drawings indicated general arrangement of piping, fittings, and specialties.
 - b. Install piping adjacent to radiant panels to allow for service and maintenance.

- c. In addition to Division 23 Section "Hydronic Piping", connect copper tubing to supply with shut-off valve, strainer, control valve, and union or flange, and return pipe with balancing valve and union or flange.
- 4. Field Quality Control
 - a. Perform the following field tests and inspections and prepare test reports:
 - 1) Leak Test: After installation, fill water tubes and test for leaks. Repair leaks and retest until no leaks exist.
 - 2) Operational Test: After electrical circuitry has been energized, start units to conform to proper unit operation.
 - 3) Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - b. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field assembled components and equipment installation, including connections, and to assist in field testing. Report any findings in writing.
 - c. Remove and replace malfunctioning units and retest as specified above.
- 5. Cleaning and Protection
 - a. Clean all visible surfaces of equipment; touch up as required.
 - b. Protect all units before, during and after installation. Damaged materials due to improper protection shall be cause for rejection.
- 6. Construction Phase Services
 - a. Manufacturer or factory-authorized representative shall visit the site regularly during the installation process to ensure proper means and methods are being employed. Bid shall include the cost of a minimum of two (2) such visits.
 - b. Manufacturer or factory-authorized representative shall provide start-up and training services to owners/staff to adjust, operate, and maintain radiant panels.
- F. Installation of Cabinet Unit Heaters (Hydronic):
 - 1. General: Install cabinet heaters as indicated, and in accordance with manufacturer's installation instructions.
 - 2. Coordinate with other trades to assure correct recess size for recessed units.
 - 3. Install piping as indicated.
 - 4. Protect units with protective covers during balance of construction.
- G. Installation of Fan-Coil Units: (Hydronic/Vertical Upright)
 - 1. General: Install fan-coil units as indicated, and in accordance with manufacturer's installation instructions.
 - 2. Coordinate with other trades to assure correct recess size for recessed units.
 - 3. Install piping as indicated.
 - 4. Protect units with protective covers during balance of construction.

H. Adjusting and Cleaning:

1. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.
2. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
3. Install new filter units for terminals requiring same.

3.13 INSTALLATION OF DUCTLESS COOLING UNIT SYSTEMS

A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS-1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS-1.

B. General:

1. Verify all dimensions by field measurements. Verify roof structure, mounting supports, wall structure, and membrane installations are completed to the proper point to allow installation of wall mounted and roof mounted units. Examine rough-in for refrigerant piping systems to verify actual locations of piping connections prior to installation. Do not proceed until unsatisfactory conditions have been corrected.
2. Install equipment in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

C. Field Quality Control:

1. Provide the services, to include a written report, of a factory authorized service representative to examine the field assembly of the components, installation, and piping and electrical connections.
2. Charge systems with refrigerant and oil, and test for leaks. Repair leaks and replace lost refrigerant and oil.
3. Provide oil separators and suction accumulators as required and install per manufactures installation instructions and recommendations.
4. Provide additional refrigerant charge as required per the manufactures for pipe lengths exceeding manufactures published data.

D. Demonstration:

1. Provide the services of a factory authorized service representative to provide start-up service and to demonstrate and train the Owner's maintenance personnel as specified below.
2. Start-up service: Place units into operation and adjust controls and safeties. Replace damaged or malfunctioning components and controls.

E. Training:

1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures.
2. Schedule training with Owner through the Architect/Engineer with at least 7 days prior notice.

3.14 INSTALLATION OF VEHICLE EXHAUST SYSTEMS

- ~~A. Equipment shall be installed by factory-approved personnel only.~~
- ~~B. All ductwork shall be in accordance with SMACNA requirements.~~
- ~~C. Copies of factory tests and certifications shall be provided prior to shipping equipment to the site.~~
- ~~D. Equipment to be field tested by authorized personnel in the presence of the Owner and the Engineer. Results of field test shall be documented and submitted to the Owner and the Engineer.~~
- ~~E. All equipment herein shall come with a 1-year warranty. The Contractor shall provide any repairs and replace any equipment as needed during the warranty period to ensure trouble free operation.~~
- ~~F. The Contractor shall train the Owner in the operation of the equipment. Training shall be at least two hours.~~
- ~~G. The general scope of the work is described only above and on the drawings, and not all components are specified. The Contractor shall be responsible for providing all material, equipment, and labor needed in order to provide a complete and operable system.~~
- ~~H. Exhaust system vents shall be routed tight to the structure, through the roof, to the locations shown on the mechanical drawings, as approved by the Engineer. Vent discharge locations on the roof shall be equipped with up blast type end units to blast the exhaust straight up so exhaust does not accumulate near the roof surface.~~
- ~~I. All reels shall be supported from the ceiling on framing system shown on the structural drawings.~~
- ~~J. Duct work to connect the exhaust blower to the hose assembly or multiple hose assemblies must be round industrial spiral duct, defined in SMACNA Industrial Duct Construction to prevent deflection under use.~~
- ~~K. Duct work to be of the taper design to maintain constant velocities without the need for dampers to balance the system.~~
- ~~L. All joints must be double-lipped EPDM rubber seal type conforming to SMACNA's Class 3 leakage standards, sealed with a mechanical joint seal or welded to provide a positive leak proof seal. Ductwork joints that do not conform to the above are not acceptable.~~
- ~~M. The size and gauge of the ductwork shall be in strict accordance of the manufacture specifications to insure proper operation for the specific exhaust removal system(s) being bid that meets the above characteristics and comply with applicable industry standards and local, state and federal regulations and codes.~~
- ~~N. The Automatic Temperature Controls contractor shall mount the vehicle exhaust control panels 4' 6" above the finish floor in the apparatus bay.~~
- ~~O. The Automatic Temperature controls contractor shall wire the 24 volt pressure sensors provided by the vehicle exhaust system manufacturer with two conductor 18-gauge wire. Wire complete from the 24-volt pressure sensors to the control panel.~~

- A. **Equipment shall be installed by factory-approved personnel only.**
- B. **All ductwork shall be in accordance with SMACNA requirements.**
- C. **Copies of factory tests and certifications shall be provided prior to shipping equipment to the site.**
- D. **Equipment to be field tested by authorized personnel. Results of field test shall be documented and submitted to the Owner and the Design Team.**
- E. **All equipment herein shall come with a 1-year warranty. The Sub-Sub-Contractor shall provide any repairs and replace any equipment as needed during the warranty period to ensure trouble free operation.**
- F. **The Sub-Sub-Contractor shall train the Owner in the operation of the equipment. Training shall be at least two hours.**
- G. **The general scope of the work is described only above and on the drawings, and not all components are specified. The Sub-Sub-Contractor shall be responsible for providing all material, equipment, and labor needed in order to provide a complete and operable system.**
- H. **Exhaust system vents shall be routed tight to the structure, through the roof, to the locations shown on the mechanical drawings, as approved by the Engineer. Vent discharge locations on the roof shall be equipped with up-blast type end units with integral backdraft damper to blast the exhaust straight up so exhaust does not accumulate near the roof surface.**
- I. **All reels shall be supported from the building structural steel.**
- J. **Duct work to connect the exhaust blower to the hose assembly or multiple hose assemblies must be round industrial spiral duct, defined in SMACNA Industrial Duct Construction to prevent deflection under use.**
- K. **Duct work to be of the tapered self-balancing design to maintain constant velocities without the need for dampers to balance the system.**
- L. **All joints must be double-lipped EPDM rubber seal type conforming to SMACNA's Class 3 leakage standards, sealed with a mechanical joint seal or welded to provide a positive leak proof seal. Ductwork joints that do not conform to the above are not acceptable.**
- M. **The size and gauge of the ductwork shall be in strict accordance with the manufacturer's specifications to ensure proper operation for the specific exhaust removal system(s) designed that meets the above characteristics and comply with applicable industry standards and local, state and federal regulations and codes.**
- N. **The Automatic Temperature Controls contractor shall mount the vehicle exhaust control panels 4' 6" above the finish floor in the apparatus bay.**
- O. **The Automatic Temperature controls contractor shall wire the 24-volt pressure sensors provided by the vehicle exhaust system manufacturer with two conductor 18-gauge wire. Wire complete from the 24-volt pressure sensors to the control panel.**

3.15 INSTALLATION OF POWER AND GRAVITY VENTILATORS

- A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS-1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS-1.
- B. General: Except as otherwise indicated or specified, install ventilators in accordance with manufacturer's installation instructions and recognized industry practices to insure that products serve the intended function.
- C. Coordinate ventilator work with work of roofing, walls and ceilings, as necessary for proper interfacing.
- D. Ductwork: Connect ducts to ventilators in accordance with manufacturer's installation instruction, and details on drawings.
- E. Roof Curbs: Furnish roof curbs to roofing Installer for installation.
- F. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 - 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections. Verify proper rotation direction of fan wheels. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
- G. Remove shipping bolts and temporary supports within ventilators. Adjust dampers for free operation.
- H. Testing: After installation of ventilators has been completed, test each ventilator to demonstrate proper operation of unit at performance requirements specified. When possible, field correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected.
- I. Cleaning: Clean factory-finished surface. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
- J. General: Furnish to Owner, with receipt, one spare set of belts for each belt driven power ventilator.

3.16 INSTALLATION OF METAL DUCTWORK

- A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS-1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS-1.

B. Installation of Metal Ductwork:

1. General: Assemble and install ductwork in accordance with recognized industry practices which will achieve air-tight (5% leakage for systems rated 3" and under; 1% for systems rated over 3") and noiseless (no objectionable noise) systems, capable of performing each indicated service. Install each run with minimum number of joints. Align ductwork accurately with internal surface smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true-to-shape and to prevent buckling. Support vertical ducts at every floor.
2. Sealing: All ductwork joints and seams shall be sealed with flexible duct sealer to assure an airtight installation.
3. Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gauge as duct. Overlap opening on 4 sides by at least 1-1/2". Fasten to duct and substrate.
 - a. Where ducts pass through fire-rated floors, walls, or partitions, provide firestopping between duct and substrate.
4. Coordination: Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system.
5. Installation: Install metal ductwork in accordance with "SMACNA HVAC Duct Construction Standards".

C. Installation of Duct Liners:

1. General: Install duct liners in accordance with SMACNA "HVAC Duct Construction Standards".

D. Installation of Flexible Ducts:

1. Maximum Length: For any duct run using flexible ductwork, do not exceed 4'-0" extended length.
2. Installation: Install in accordance with Section II of SMACNA's, "HVAC Duct Construction Standards, Metal and Flexible".

E. Installation of Kitchen Exhaust Ducts:

1. General: Fabricate joints and seams with continuous welds for watertight construction. Provide for thermal expansion of ductwork through 2000 degrees F (1093 degrees C) temperature range. Install without dips or traps which may collect residues. Provide access openings at each change in direction, locate on sides of duct 1-1/2" minimum from bottom, and fitted with grease-tight covers of same material as duct.
2. Kitchen exhaust hood ductwork shall be fabricated and installed in full accordance with the requirements of NFPA Bulletin 96. Duct work shall be fabricated of 16 gauge minimum thickness, black steel with all joints welded. Duct shall be properly attached to exhaust hoods and fans. Required clean-out access doors shall be installed in the vertical face of the ductwork. Only opposed blade dampers may be used in kitchen make-up air duct work requiring balancing.

F. Field Quality Control:

1. Leakage Tests: After each duct system, which is constructed for duct classes over 3" is completed, test for duct leakage in accordance with SMACNA "HVAC Air Duct Leakage Test Manual". Repair leaks and repeat tests until total leakage is less than 1% of system design air flow.

G. Equipment Connections:

1. General: Connect metal ductwork to equipment as indicated, provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, and/or equipment containing rotating machinery.

H. Adjusting and Cleaning:

1. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.
2. Strip protective paper from stainless ductwork surfaces, and repair finish wherever it has been damaged.
3. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until final connections are to be completed.
4. Balancing: Refer to Division 23 section "Testing, Adjusting, and Balancing" for air distribution balancing of metal ductwork. Seal any leaks in ductwork that become apparent in balancing process.

3.17 INSTALLATION OF DUCTWORK ACCESSORIES

- A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.
- B. Install turning vanes in square or rectangular 90 degree elbows in supply, return, and exhaust air systems, and elsewhere as indicated.
- C. Install splitter damper with adjusting rod in each supply branch. Install according to detail on drawings.
- D. Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter.
- E. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.
- F. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.
- G. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

- H. Furnish extra fusible links to owner, one link for every 10 installed of each temperature range; obtain receipt.

3.18 INSTALLATION OF ACOUSTIC DUCT LINING

- A. Installation: All portions of duct designed to receive duct liner shall be completely covered. The smooth, black coated surfaces shall face the airstream. All liners shall be cut to assure tight, overlapped corner joints. The top pieces shall be supported by the side pieces. The liner shall be adhered to the sheet metal with full coverage of an approved adhesive that conforms to ASTM C 916, and all exposed leading edges and transverse joints shall be coated with Permacote factory-applied or field-applied edge coating and shall be neatly butted without gaps. Shop or field cuts shall be liberally coated with "Schuller SuperSeal Edge Treatment" or approved adhesive. The liner shall be additionally secured with mechanical fasteners. The pin length should be such as to hold the material firmly in place with minimum compression of the material.

3.19 INSTALLATION OF SOUND ATTENUATORS

- A. VIBRATION CONTROL AND SEISMIC RESTRAINT: Refer to section 230548 and drawing VS-1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS-1.
- B. General: Install sound attenuators as indicated, and in accordance with manufacturer's installation instructions.
- C. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer.
- D. Upon completion of installation test and demonstrate that sound attenuators, and duct connections to sound attenuators, are leak tight.

3.20 INSTALLATION OF AIR OUTLETS AND INLETS

- A. General: Install air outlets and inlets in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended function.
- B. Locate ceiling air diffusers, registers, and grilles, as indicated on general construction "Reflected Ceiling Plans". Unless otherwise indicated, locate units in center of acoustical ceiling module.

3.21 INSTALLATION OF VARIABLE REFRIGERANT FLOW (VRF) EQUIPMENT

- A. Vibration Control: Provide vibration control per building code and manufacturers recommendations.

B. General:

1. Verify all dimensions by field measurements. Verify roof structure, mounting supports, wall structure, and membrane installations are completed to the proper point to allow installation of wall mounted and roof mounted units. Examine rough-in for refrigerant piping systems to verify actual locations of piping connections prior to installation. Do not proceed until unsatisfactory conditions have been corrected.
2. Install equipment in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

C. Field Quality Control:

1. Provide the services, to include a written report, of a factory authorized service representative to examine the field assembly of the components, installation, and piping and electrical connections.
2. Charge systems with refrigerant and oil, and test for leaks. Repair leaks and replace lost refrigerant and oil.

D. Demonstration:

1. Provide the services of a factory authorized service representative to provide start-up service and to demonstrate and train the Owner's maintenance personnel as specified below.
2. Start-up service: Place units into operation and adjust controls and safeties. Replace damaged or malfunctioning components and controls.

E. Training:

1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures.
2. Schedule training with Owner through the Architect/Engineer with at least 7 days prior notice.

3.22 INSTALLATION OF VARIABLE AIR VOLUME BOXES

- A. Vibration Control And Seismic Restraint: Refer to section 230548 and drawing VS-1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS-1.
- B. General: Install variable air volume boxes as shown on drawings, and in accordance with manufacturer's installation instructions.
- C. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer.

3.23 INSTALLATION OF CONDENSATE DISCHARGE PUMPS

- A. Examine areas and conditions under which pumps are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.
- B. Installation of Equipment
 - 1. General: Install equipment in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in drain pans and locations indicated, and maintain manufacturer's recommended clearances.
 - 2. Accessories: Install equipment accessories not installed at factory.
 - 3. Connections: Connect discharge piping as indicated and terminate where indicated on the contract documents.
 - 4. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to electrical installer.
 - 5. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
- C. Field Quality Control
 - 1. General: Start-up equipment, in accordance with manufacturer's start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
- D. Closeout Procedures
 - 1. Training: Instruct Owner's personnel in operation and maintenance of condensate discharge pumps.

3.24 INSTALLATION OF RADIANT FLOOR HEATING

- A. EXAMINATION
 - 1. The installing contractor shall examine the tubing, manifolds, stations, fittings, and controls for any visible defects. There shall be no visible defects on products used in installation. Any products with defects shall be rejected and returned.
- B. PREPARATION
 - 1. Tubing shall be cut with Viega tubing cutters or other cutters that ensure the tubing will be cut square. Tubing shall be cut square to permit proper joining with the fittings and manifolds.
- C. INSTALLATION
 - 1. Tubing and manifolds shall be installed as per engineering's CAD drawings. Manufacturer to provide a heat loss and complete design prior to ordering for review and approval by Engineer.

2. Tubing: Tubing used shall be provided by manufacturer and handled with general care. Tubing shall not be exposed to excessive UV light, harmful substances, excessive heat, sharp objects and any other potentially harmful situations. Tubing shall be laid out taking into account the minimum bending radius. Tubing shall be sleeved at all floor and slab penetrations. Tubing shall be secured by plastic zip ties, or plastic clips approved by manufacturer. At no time should a metallic clip or tie be used to secure tubing.
3. Manifolds/Stations: Manifolds used shall be provided by manufacturer and installed per installation manual. Tubing shall be connected to manifolds using the recommended SVC press fittings or compression fittings with split compression ring. Connections of manifolds to stations shall be done with the recommended fittings or adapters.
4. Controls: Controls should be installed by a licensed electrician. Refer to manufacturer's installation manuals for correct programming and hook-up of controls.
5. Freeze Protection: System should be protected from freezing at all times. If system is installed and pressure tested in an unfinished building during heating season, air or the proper glycol mixtures should be used to prevent any freeze damage. Insulation may be used in exposed areas. Glycol mixtures may also be needed in systems that are not used year-round and may be exposed to freezing temperatures.

D. FIELD QUALITY CONTROL

1. Pressure testing: Air or water may be used for testing the system for leaks. Pressurize system to 60 psi and cap off. Be sure to keep system pressurized while finish flooring is installed over it to ensure tubing is not damaged during this step.

3.25 INSTALLATION OF CO/NO2 DETECTION AND CONTROL

A. Inspection:

1. General: Examine areas and conditions under which gas monitoring and control system shall be installed. Related items shall be examined as well.

B. Control Sequence:

1. The controller shall operate according to the specifications recommended by the manufacturer. The operation shall be as follows:
 - a. The controller shall be calibrated to the desired set-points before operation.
 - b. The controller shall continuously detect the surrounding air for any traces of the gas detected.
 - c. When the first set-point is reached, the sensor shall activate the low alarm on the controller and the corresponding devices, such as the exhaust fans, dampers, etc.
 - d. If the gas level continues to increase to the second set-point, the high alarm shall activate with the corresponding devices, such as the audio/visual alarm, etc.
 - e. The sensor shall continue to trace the specified gas and will not disable the alarm until the gas level is dropped a significant percentage below the alarm set-points.

C. Training:

1. A minimum of three hours of on-site product training is recommended.

D. Operation and Maintenance Manuals:

1. The operation and maintenance manuals shall contain all information necessary for the operation, maintenance, replacement, installation, and parts procurement for the entire gas detection system. This documentation shall include specific part numbers.

E. Calibration:

1. Calibration shall not be necessary to verify system operation. The user shall verify signal transmission from the sensor to the control panel by applying the appropriate test gas to the corresponding sensor. The calibration kit can be used for system verification or sensor calibration when required. One calibration kit per gas to be monitored shall be provided by the installing contractor and turned over as part of their close out documentation to the building owner.

3.26 INSTALLATION OF CONSTANT VOLUME DAMPERS

- A. General: Install variable air volume boxes as shown on drawings, and in accordance with manufacturer's installation instructions. Utilize recognized industry practices to ensure that products serve intended function.
- B. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for future adjustments, but in no case less than that recommended by manufacturer.

3.27 INSTALLATION OF ACCESS DOORS

- A. General: Install access doors in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended function.
- B. All access doors shall be located in a workmanlike manner in closets, storage rooms, and/or other non-public areas, positioned so that the item or part can be easily reached, and the size shall be sufficient for this purpose (minimum size 12" x 16"). Furnish access doors to permit thorough inspection. When access doors are required in corridors, lobbies, or other habitable areas, they shall be located as directed by the Architect.

3.28 INSTALLATION OF FIRESTOPPING AND SEALANTS

A. Examination

1. Examine the areas and conditions where firestops are to be installed and notify the architect of conditions detrimental to the proper and timely completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected by the contractor in a manner acceptable to the architect and in accordance with Section 07 84 13.
2. Verify that environmental conditions are safe and suitable for installation of firestop products.
3. Verify that all pipe, conduit, cable, and other items which penetrate fire-rated construction have been permanently installed prior to installation of firestops.

B. Installation

1. General:

- a. Installation of firestops shall be performed by an applicator/installer qualified and trained by the manufacturer. Installation shall be performed in strict accordance with manufacturer's detailed installation procedures.
 - b. Apply firestops in accordance with fire test reports, fire resistance requirements, acceptable sample installations, and manufacturer's recommendations.
 - c. Unless specified and approved, all in conjunction with through-penetrants shall remain intact and undamaged and may not be removed.
 - d. Seal holes and penetrations to ensure an effective smoke seal.
 - e. In areas of high traffic, protect firestopping materials from damage. If the opening is large, install firestopping materials from damage. If the opening is large, install firestopping materials capable of supporting the weight of a human.
 - f. Insulation types specified in other sections shall not be installed in lieu of firestopping material specified herein.
 - g. All combustible penetrants (e.g. non-metallic pipes or insulated metallic pipes) shall be firestopped using products and systems tested in a configuration representative of the field condition.
2. Dam Construction: When required to properly contain firestopping materials within openings, damming or packing materials may be utilized. Combustible damming material must be removed after appropriate curing. Noncombustible damming materials may be left as a permanent component of the firestop system.

C. Field Quality Control

1. Prepare and install Firestopping system in accordance with manufacturer's printed instructions and recommendations.
2. Follow safety procedures recommended in the Material Safety Data Sheets.
3. Finish surfaces of firestopping which are to remain exposed in the completed work to a uniform and level condition.
4. All areas of work must be accessible until inspection by the applicable Code Authorities.
5. Correct unacceptable firestops and provide additional inspection to verify compliance with this specification.
6. Cleaning
7. Remove spilled and excess materials adjacent to firestopping without damaging adjacent surfaces.
8. Leave finished work in neat, clean condition with no evidence of spill overs or damage to adjacent surfaces.

3.29 INSTALLATION OF DUCT MOUNTED HOT WATER COIL

- A. Vibration Control and Seismic Restraint: Refer to Section 230548 and Drawing VS-1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in Section 230548 and Drawing VS-1.
- B. General: Install unit heaters as indicated, and in accordance with manufacturer's installation instructions.
- C. Uncrate units and inspect for damage. Verify that nameplate data corresponds with unit designation.

- D. Hang units from building substrate, not from piping. Mount as high as possible to maintain greatest headroom possible unless otherwise indicated.
- E. Support units with rod-type hangers anchored to building substrate.
- F. Install piping as indicated.
- G. Protect units with protective covers during balance of construction.
- H. Adjusting & Cleaning:
 - 1. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.
 - 2. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
- I. HVAC subcontractor shall own Replacement of construction filters with balancing filters during the balancing operations. Replace balancing filters with new filters immediately prior to occupancy. Also provide four additional complete extra sets of pre and final filters for attic stock. All these filters indicated above including the four sets of attic stock are additional to those provided for flush out and indoor air quality requirements per LEED requirements. Obtain receipt from Owner that new filters have been installed at substantial completion and attic stock provided.

3.30 INSTALLATION OF EXTRUDED ALUMINUM RAIN RESISTANT WALL LOUVERS

- A. HVAC Contractor is responsible for installation of Louvers in accordance with the following:
 - 1. Examination
 - a. Inspect areas to receive louvers. Notify the Architect of conditions that would adversely affect the installation or subsequent utilization of the louvers. Do not proceed with installation until unsatisfactory conditions are corrected.
 - b. Notify Architect of unsatisfactory preparation before proceeding.
 - 2. Preparation
 - a. Clean opening thoroughly prior to installation.
 - b. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.
 - 3. Installation
 - a. Install louvers at locations indicated on the drawings and in accordance with manufacturer's instructions.
 - b. Install louvers plumb, level, in plane of wall, and in alignment with adjacent work.
 - c. Install joint sealants as specified in Section 079200.
 - 4. Cleaning
 - a. Clean louver surfaces in accordance with manufacturer's instructions.
 - b. Touch-up, repair or replace damaged products before Substantial Completion.

3.31 INSTALLATION OF AUTOMATIC TEMPERATURE CONTROLS (DDC):

A. Installation of Control Systems:

1. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.
2. Control Wiring: Install control wiring, without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with National Electrical Code.
 - a. Install circuits over 25-volt with color-coded No. 12 wire in electric metallic tubing.
 - b. Install circuits under 25-volt with color-code No. 18 wire with 0.031" high temperature 105° F. (41° C) plastic insulation on each conductor and plastic sheath over all.
 - c. Install electronic circuits with color-coded No. 22 wire with 0.023" polyethylene insulation on each conductor with plastic-jacketed copper shield over all.
 - d. Install low voltage circuits, located in concrete slabs and masonry walls, or exposed in occupied areas, in electrical conduit.
 - e. Power sources from lighting circuits and wall outlets shall not be used to power DDC controllers.
3. Controllers and safety devices:
 - a. All safety devices such as freezestats, duct mounted heat detectors, smoke detectors, etc., shall be hard wired to shut down the fans independently. Provide audible alarm with silence switch as well as DDC indication.
 - b. Humidifier controls shall be hard wired through fan proof flow differential switch and starter auxiliary contacts to disable humidifier system on fan shutdown. Provide DDC indication.
 - c. All supply, return and exhaust fans shall be provided with pressure differential switches. Current sensing devices, starter axillary contacts, and relay contacts are unacceptable proof of fan operation.
 - d. Primary and standby pumps shall be selectable through the DDC control system. Provide local pilot light to indicate selected pump as well as alarm and silence switch for failed pump. Provide differential pressure switch to prove flow.

B. Adjusting and Cleaning:

1. Start-Up: Start-up, test, and adjust pneumatic control systems in presence of manufacturer's authorized representative. Demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
2. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
3. Final Adjustment: After completion of installation, adjust thermostats, control valves, motor and similar equipment provided as work of this section.
 - a. Final adjustment shall be performed by specially trained personnel in direct employ of manufacturer of primary temperature control system.

C. Closeout Procedures:

1. Owner's Instructions: Provide services of manufacturer's technical representative for one 8-hour day to instruct Owner's personnel in operation and maintenance of control systems, and 40 hours of onsite instruction on running and basic troubleshooting of DDC control system.
2. Validation: The automatic temperature control contractor shall completely check out, calibrate and test all connected hardware and software to insure that the system performs in accordance with the approved specifications and sequence of operation submitted.
 - a. Witnessed validation demonstration shall consist of:
 - 1) Execute digital and analog commands in English and graphic mode.
 - 2) Demonstrate all specified diagnostics.
 - 3) Demonstrate scan, update, and alarm responsiveness.
3. Training:
 - a. All training shall be by the automatic temperature control contractor and shall utilize specified manuals and as-build documentation.
 - b. Operator training shall include:
 - 1) Sequence of Operation review.
 - 2) Sign on-Sign off.
 - 3) Modifying warning limits, alarm limits and start-stop times.
 - 4) System initialization.
 - 5) Use of Portable Operators Terminal.
 - 6) Troubleshooting of sensors (determining bad sensors).
 - 7) Point disable/enable.
 - 8) Software review of Sequence of Operation programs.
 - 9) Modification of control programs.
 - 10) Add/Delete/Modify data points.
 - 11) Use of diagnostics.
 - 12) Review of initialization.
 - c. Training shall be for Owner-designated personnel at the subject site, and shall be scheduled by the Owner with two week notice.

D. Installation of Gas Detection & Monitoring System:

1. This system is provided as an Emergency Vehicle exhaust system for noxious vehicle exhaust harmful to occupant's health. This system has not been designed to replace and should not be used as a substitute for the primary Vehicle exhaust system provided by the owner.
2. Provide sensors in the quantities and locations indicated on contract documents. Sensors shall be mounted in accordance with the manufacturer's recommendations and fully capable of monitoring Carbon Monoxide and Nitrogen Dioxide levels of each garage indicated in the specifications.

3. In the event the CO/NO₂ sensors detect levels indicated in the specifications, the sensors shall activate the associated exhaust fan and run continuously until CO/NO₂ levels in the occupied spaces return down to an acceptable safe level for the occupants.
 - a. All sensors shall be calibrated and installed in accordance with the manufacturer's recommendations.
4. Provided start services for Emergency Vehicle exhaust systems.

3.32 TESTING, ADJUSTING, BALANCING, AND COMMISSIONING

A. Requirements:

1. Requirements include verification of HVAC system operation, measurement of all system capacity, and establishment of the quantities of the mechanical systems as required to meet specifications, and recording and reporting the results.
2. Commission, test, adjust and balance the following mechanical systems:
 - a. Supply air systems.
 - b. Return air systems.
 - c. Exhaust air systems.
 - d. Outside air systems.
 - e. Hydronic heating systems.
 - f. Verify temperature control system operation.
3. Do not include:
 - a. Testing boilers and pressure vessels for compliance with safety code.
 - b. Installation of adjusting and balancing devices. If devices must be added to achieve proper adjusting and balancing. Contact Mechanical Contractor and the Engineer for direction.

B. Report:

1. Format: Report forms shall be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data in reinforced, vinyl, three-ring binders. Provide binding edge labels with the project identification and a title descriptive of the contents. Divide the contents of the binder into the below listed divisions, separated by divider tabs:
 - a. General Information and Summary.
 - b. Air Systems.
 - c. Hydronic heating and cooling systems.
 - d. Temperature Control Systems.

2. Contents: Provide the following minimum information, forms and data:

- a. General Information and Summary: Inside cover sheet to identify testing, adjusting, and balancing agency, Contractor, Owner, Architect, Engineer, and Project. Include addresses, and contact names and telephone numbers. Also include a certification sheet containing the seal and name address, telephone number, and signature of the Certified Test and Balance Engineer. Include in this division a listing of the instrumentation used for the procedures along with the proof of calibration.
- b. The remainder of the report shall contain the appropriate forms containing as a minimum, the information indicated on the standard report forms prepared by the AABC for each respective item and system.
- c. Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the project.

C. Quality Assurance:

1. An independent testing, adjusting, and balancing agency certified by the AABC or NEBB as a Test and Balance Engineer in those testing and balancing disciplines required for this project.
2. Codes and Standards:
 - a. AABC: "National Standards For Total System Balance".
 - b. ASHRAE: ASHRAE Handbook, 1984 Systems Volume, Chapter 37, Testing, Adjusting, and Balancing.
3. Pre-Balancing Conference: Prior to beginning of the testing, adjusting, and balancing procedures, schedule and conduct a conference with the Architect/Engineer and Mechanical Contractor. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting, and balancing.
4. System Operation: Systems shall be fully operational prior to beginning procedures. All new automatic temperature controls shall be fully operational. Test, adjust and balance the air systems before refrigerant systems. Test, adjust and balance air conditioning systems during summer season, and heating systems during winter season, including at least a period of operation at outside conditions within 5 deg. F. wet bulb temperature of maximum summer design condition, and within 10 deg.F. dry bulb temperature of minimum winter design condition. Take final temperature reading during seasonal operation.

D. Preliminary Procedures:

1. Air Systems:
 - a. Obtain drawings and become thoroughly acquainted with the systems.
 - b. Compare drawings to installed equipment and field installations.
 - c. Walk the system from the system air handling equipment to terminal units to determine variations in installation.
 - d. Check filters for cleanliness.
 - e. Check all dampers (volume and fire) for correct and locked position, and temperature control for completeness of installation before starting fans.
 - f. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a cross check with required fan volumes.

- g. Determine best locations in main and branch ductwork for most accurate duct traverses. Traverses shall be performed in each supply and return duct main and sub-mains for each AHU and return air fan.
 - h. Place outlet dampers in the full open position.
 - i. Prepare schematic diagrams of system "as-built" ductwork and piping layouts to facilitate reporting.
 - j. Verify lubrication of all motors and bearings.
 - k. Check fan belt tension.
 - l. Check fan rotation.
 - 2. Hydronic Systems:
 - a. Open valves to full open position. Close coil bypass valves.
 - b. Remove and clean all strainers.
 - c. Examine hydronic systems and determine if water has been treated and cleaned.
 - d. Check pump rotation.
 - e. Check expansion tanks to verify noted air pressure and that the system is completely full of water.
 - f. Check air vents at high points of system and determine if all are installed and operating freely.
 - g. Set temperature controls so all coils are calling for full flow.
 - h. Check operation of automatic bypass valves.
 - i. Check and set operating temperatures of chillers, boilers, and heat exchangers to design requirements.
 - j. Verify lubrication of all motors and bearings.
 - 3. Measurements:
 - a. Provide all required instrumentation to obtain proper measurements, calibrated to the tolerance specified in the referenced standards. Instruments shall be properly maintained and protected against damage.
 - b. Provide instruments meeting the specifications of the referenced standards.
 - c. Use only those instruments which have the maximum field measuring accuracy and are best suited to the function being measured.
 - d. Apply instrument as recommended by the manufacturer.
 - e. Use instruments with minimum scale and maximum subdivisions and with scaled ranges proper for the value being measured.
 - f. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than 5%. When measuring a single point, repeat readings until 2 consecutive identical values are obtained.
 - g. Take all reading with the eye at the level of the indicated value to prevent parallax.
 - h. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.
 - i. Take measurements in the system where best suited to the task.
- E. Performing Commissioning, Testing, Adjusting, and Balancing:
- 1. Test, adjust and balance all noted systems according to SMACNA standards and as follows:
 - a. Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards.
 - b. Cut insulation and ductwork for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.

- c. Patch insulation, ductwork, and housings, using materials identical to those removed.
 - d. Seal ducts and test for and repair leaks.
 - e. Seal insulation to re-establish integrity of the vapor barrier.
 - f. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.
 - g. Retest, adjust and balance system subsequent to significant system modifications, and resubmit test results.
 - 2. System Deficiencies:
 - a. The Balancing Contractor shall advise the Mechanical Contractor and the Engineer of all system deficiencies in writing. Report all motors not running, missing dampers, inoperative valves and controls, lack of access, etc.
 - b. Upon completion of system deficiencies, Balancing Contractor shall balance and record data.
 - c. Any re-balancing required to meet the desired CFM or modified CFM due to system modifications or owner changes shall be provided at no additional costs to the project/owner.
 - d. The Balancing Sub-subcontractor shall provide the necessary sheave and belt changes to motors and fans as required to achieve the desired CFM at no additional costs to the project/owner.
 - F. Subject to compliance with the above requirements and certifications, provide the services of air and water testing and balancing of one of the following:
 - 1. Thomas Young – Marion, MA
 - 2. Leonhardt Co. – Wellesley, MA
 - 3. Arden Engineering – Pawtucket, RI
 - 4. American Testing And Balancing – South Boston, MA
 - 5. Air Balance Inc. – Woburn, MA
 - 6. Regional Air Balance Co. – Norwood, MA
 - 7. Tekon Technical Consultants – Rochester, NH
- 3.33 FREESTANDING EQUIPMENT SUPPORT SYSTEM
- A. Examination:
 - 1. Verify that roofing system is complete and that roof surfaces are smooth, flat, and ready to receive work of this section.
 - 2. Verify that roof surface temperature is at minimum 60 deg.F (15.5 deg.C) for proper adhesive performance.
 - B. Preparation:
 - 1. Clean surfaces of roof in areas to receive portable support bases.
 - a. Sweep loose gravel from gravel surfaced roofs.
 - b. Remove dirt, dust, oils, and other foreign materials.
 - 2. Use care in handling portable support system components during installation, to avoid damage to roofing, flashing, equipment, or related materials.

C. Installation:

1. Equipment Support Systems:

- a. Locate bases and support framing as indicated on drawings and as specified herein. Provide complete and adequate support of all piping, ducting, and conduit; whether or not all required devices are shown.
- b. The use of wood for supporting piping is not permitted.
- c. Provide support spacing so deflection of piping does not exceed $1/240$ of span.
- d. Install framing at spacing indicated, but in no case at greater than 10 feet (3 m) on center.
- e. Accurately locate and align bases.

2. Manufacturer of existing or new roofing system as to the type of isolation pads required between the roof and base.

- a. Set isolation pads in adhesive, if required by manufacturer's instructions.
- b. Place bases on isolation pads.
- c. Adhere or mechanically attach, if required by code.
- d. Where applicable, replace gravel around bases.

3. Set framing posts into bases and assemble framing structure as indicated.

4. Use galvanized fasteners for galvanized framing and stainless steel fasteners for stainless steel framing.

D. Field Quality Control:

1. When requested by the Architect, provide a factory-trained representative of the manufacturer to visit the site while the work is in progress to assure that the installation conforms to the manufacturers design and installation requirements.

E. Cleaning and Protection:

1. Remove all packaging, unused fasteners, adhesive and other installation materials from the project site.
2. Remove adhesive from exposed surfaces of supports and bases, and leave the work area in clean condition.
3. Provide protection as required, leaving the work area in undamaged condition at the time of completion of work.

END OF SECTION

SECTION 260010

ELECTRICAL
(Filed Sub-Bid Required)

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END OF INDEX

SECTION 260010
ELECTRICAL
(Filed Sub-Bid Required)

PART 1 - GENERAL

1.1 FILING OF FILED SUB-BIDS

- A. The work of this section shall be included in the Electrical Filed Sub-Bid. Refer to Section 26 00 01: ELECTRICAL FILED SUB BID SUMMARY for additional requirements.

1.2 REQUIREMENTS FOR FILING SUB-BIDS

- A. Time, Manner and Requirements for Submitting Sub-Bids:

1. Sub-bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the Public Agency at a time and place as stipulated in the "Instructions to Bidders."
2. Each sub-bid submitted for work under this Section shall be on forms furnished by the Awarding Authority as required by Section 44F of Chapter 149 of the General Laws, as amended.
3. Sub-bids filed with the Awarding Authority shall be accompanied by Bid Bond, Cash, Certified Check, Treasurer's Check, or Cashier's Check issued by a responsible bank or trust company payable to the Town of Ashland in the amount of 5 percent of the sub-bid. A sub-bid accompanied by any other form of bid deposit than those specified will be rejected.

- B. Sub Sub-Bid Requirements:

Class of Work	Section Number
Communications	27 00 00
Integrated Electronic Security System	28 00 00
Emergency Responder Radio Signal Amplification System (BDA System)	Paragraph 2.28

If Sub-Bidder intends to perform with persons of his own staff the classes of work listed above, he must nevertheless list his own name therefore, under Paragraph E, of the FORM FOR SUB-BID.

- C. The Work of this Section is shown on the following Drawings: E001, E002, E003, E004, E005, E101, E102, E103, E201, E202, E203, E204, E300, E301, E302, E303, E304, E305, E306, E307, E308, E309, E400, E401, E402, E403, E500, E501, E502, E503, T001, T101, T102, T103, T200, T300, VS-1.

The Sub-Bid Contractor shall also examine all other Drawings and all other Sections of the Specifications for requirements therein affecting the Work of this Section, not just those pertaining to this Sub-trade.

1.3 ALTERNATES

- A. Refer to Section 01 23 00 for Alternates affecting this section.

1.4 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.5 GENERAL REQUIREMENTS

- A. The Conditions of the Contract and General Requirements of the Project Manual apply to this Subcontractor, material suppliers, and all other persons furnishing labor and materials under this Section. The General Conditions, and applicable parts of Division 01 are included as part of this Section.
- B. Examine all Project Specifications and Drawings for requirements which affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.
- D. The following definitions apply to the Drawings and Specifications:
 - 1. Furnish: The term "furnish" is used to mean "supply and deliver to the Project Site, ready for unloading, unpacking, assembly, installation, and similar operations".
 - 2. Install: The term "install" is used to describe operations at the Project Site including actual "unloading, unpacking, assembly, erection, piecing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations".
 - 3. Provide: The term "provide" is used to mean "furnish and install, complete and ready for the intended use".
 - 4. Installer: An "installer" is the Contractor or an entity engaged by the Contractor, either as an employee, Subcontractor, or Sub-Subcontractor for performance of a particular construction activity, including installation, erection, application, and similar operations. Installers are required to be experienced in the operations they are engaged to perform.
- E. When open-flame or spark producing tools such as blow torches, welding equipment, and the like are required in the process of executing the work, the General Contractor shall be notified not less than twenty four (24) hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant non-working fire watch where work is being performed until it is completed.

1.6 DESCRIPTION OF WORK

- A. Work described herein shall be interpreted as work to be done by the Electrical Sub-Contractor. Work to be performed by other trades will be referenced to a particular contractor.
- B. Provide all labor, materials, tools, and equipment, including scaffolding, to complete the installation of the electrical system. Install, equip, adjust, and put into operation the respective portions of the installation specified, and so interconnect various items or sections of work in order to form a complete and operating whole. Systems may be referenced in singular or plural terms, also refer to drawings to confirm quantities.

C. The work shall consist of, but shall not necessarily be limited to the following:

1. Primary, secondary and low tension ductbanks, manholes, and handholes.
2. Secondary distribution equipment, including distribution panels, metering, motor controls, variable frequency drives, panelboards, including feeders and subfeeders.
3. Fire alarm system, addressable type.
4. Emergency power system, including diesel fueled emergency generator, emergency lighting and exit signs.
5. Lighting systems exterior and interior fixtures, and a complete automated addressable lighting control system with all sensors occupancy, daylight, photosensors, switches and Bacnet BMS integration.
6. All raceway systems, including boxes, couplings, and fittings.
7. All branch circuit wiring systems, including wiring devices and plates.
8. Excavation and backfill within building foundation walls for any underground raceways.
9. Connections for all building equipment, including mechanical, plumbing, fire protection, elevator, Owner furnished equipment, and the like.
10. Drilling, coring, and cutting of holes for electrical conduit systems, and equipment. Where the electrical contractor requires the G.C. to provide cutting and patching the E.C. shall reimburse the G.C. for the work done. Any cutting caused by the E.C. that causes delay due to poor coordination of the sequencing of work shall be reimbursed by the contractor performing the work.
11. Systems Identification.
12. Scaffolding, Rigging, and Staging required for all Electrical Work under (8) Eight ft. in height. Refer to Section 01 50 00 – Temporary Facilities and Controls.
13. Firestopping for all Electrical Systems. Refer to Section 07 84 00 – Firestopping.
14. Provide Seismic Restraints for all Electrical Systems conforming to the requirements of Section 23 05 48 which Section is herein incorporated by reference.
15. Coordination Drawings and BIM coordination.
16. Lightning Protection System.
17. Uninterruptible Power Supply, UPS System.
18. Communications system provisions including 120 volt power sources, cable tray, j-hooks, raceways and backboxes for Communications Systems as shown on drawings and specified in Section 27 00 00, Communications.
19. Integrated Electronic Security System provisions, IESS including 120 volt power sources, cable tray, j-hooks, raceways, and backboxes for security systems as shown on drawings and specified in Section 28 00 00 – Integrated Electronic Security System.
20. Demolition of existing site electrics.
21. Sealing of all penetrations through walls, slabs, partitions, that are not fire rated.
22. Emergency Responder radio signal amplification system, BDA System. Provisions, including 120 volt power sources, raceways, and backboxes, fire alarm interface and monitoring as shown on drawings and specified in Paragraph 2.28 of Section 26 00 10.
23. Power wiring to Variable Frequency Drives, refer to Section 230923 Automatic Temperature Controls.
24. Two-way Communications call boxes system.
25. Water Alert Leak Detection System
26. Provisions for Photovoltaic System as indicated on plans.
27. Temporary light and power, refer to Section 01 50 00 – Temporary Facilities and Controls.
28. Automated Lighting Control System, including start-up, programming, and coordination with Owner for the schedules and scene programs.
29. Access Doors and frames - Refer to Section 08 31 13.
30. All testing of equipment installed.
31. Alternates affecting this section
32. Any other item of work hereinafter specified or indicated on electrical drawings.

1.7 DEFINITIONS

- A. Most terms used within the documents are industry standard. Certain words or phrases shall be understood to have specific meanings as follows:
1. Reviewed: When used to convey Designer's action on General Contractor's submittals, applications and requests, "reviewed" is limited to Designer's duties and responsibilities as stated in the Conditions of the Contract.
 2. Directed: A command or instruction by Designer. Other Terms including "requested", "authorized", "selected", "approved", "required" and "permitted" have the same meaning as "directed".
 3. Indicated: Requirements expressed by graphic representations or in written form on Drawings, in Specifications, and in other Contract Documents. Other terms including "shown", "noted", "scheduled" and "specified" have the same meaning as "indicated".
 4. Regulations: Laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, and rules, conventions and agreements within the construction industry that control performance of the Work.
 5. Furnish: Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation and similar operations.
 6. Install: Operations at Project site including unloading, temporarily storing, unpacking, assembling, erecting, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning and similar operations.
 7. Conduit: Raceways of the metallic type which are not flexible. Specific types as specified.
 8. Connect: To wire up, including all branch circuitry, control and disconnection devices so item is complete and ready for operation.
 9. Subject to Mechanical Damage: Equipment and raceways installed exposed and less than eight feet above finished floor in mechanical rooms or other areas where heavy equipment may be in use or moved.
 10. Provide: Furnish and install completely connected up and in operable condition.
- B. General: Basic Contract definitions are included in the Conditions of the Contract including, but not limited to, the following:
1. The Designer (the Architect-of-Record or Engineer-of-Record as applicable.)
 2. The Owner's Project Manager.
 3. The General Contractor.

1.8 ITEMS TO BE FURNISHED ONLY

- A. Furnish the following items for installation under designated sections.
1. Duct smoke detectors and duct carbon monoxide detectors with sampling tube, Section 230000 – HVAC.
 2. Manholes and handholes – installed by Site Contractor.
 3. Access Doors and Frames - Section 08 31 00.
 4. Pre-cast pole bases to be installed by Site contractor.
 5. Pre-cast transformer pad to be installed by Site contractor

1.9 ITEMS TO BE WIRED ONLY

- A. Install the following items furnished under designated sections.
1. Specialty Backboxes for Communications, Security, and Audio/Visual, i.e; Speakers.: Division 27 and Division 28.
 2. Electronic faucet control transformers, Section 22 00 00 – Plumbing.
 3. Projection screens, SECTION 11 52 13.

4. Motorized shades, SECTION 12 24 13.

1.10 RELATED WORK

- A. The following related work is to be performed under designated sections.

1. Temp. Controls – SECTION 01 50 00 - TEMPORARY FACILITIES AND CONTROLS.
2. Excavation and Backfill: DIVISION 31 – EARTHWORK (except within building foundation).
3. Concrete pads, and Duct Envelopes: DIVISION 03 - CONCRETE.
4. Insulation - SECTION 07 21 00 – THERMAL INSULATION.
5. Finish Painting: SECTION 09 91 13 – EXTERIOR PAINTING; SECTION 09 91 23 – INTERIOR PAINTING.
6. Payment for energy for temporary light and power shall be made by General Contractor. Refer to SECTION 01 50 00, TEMPORARY FACILITIES AND CONTROLS.
7. Automatic Temperature Control: SECTION 230000 - HEATING, VENTILATING & AIR CONDITIONING.
8. Hardware: SECTION 08 71 00 – DOOR HARDWARE
9. Communications System Equipment and Wiring: SECTION 27 00 00 – COMMUNICATIONS.
10. Integrated Electronic Security System, IESS Equipment and Wiring – Section 28 00 00 – INTEGRATED ELECTRONIC SECURITY SYSTEM.
11. Temporary Light and Power – Section 01 51 00 - TEMPORARY UTILITIES.
12. Fire stopping: Section 07 84 00 – FIRESTOPPING.
13. Scaffolding, Rigging, and Staging required for all Electrical Work over (8) Eight ft. in height. Refer to section 01 50 00 – TEMPORARY FACILITIES AND CONTROLS.
14. Emergency Responder Radio Communications System, BDA equipment and wiring: Paragraph 2.28 of Section 26 00 10.

1.11 CONTRACT COST BREAKDOWN

- A. Submit a breakdown of contract price to aid Architect in determining value of work installed as job progresses.

1.12 INSPECTION OF SITE

- A. Electrical bidders will be permitted to inspect site. Failure to inspect existing conditions or to fully understand work which is required shall not excuse Electrical Subcontractor from his obligations to supply and install work in accordance with specifications and the drawings and under all site conditions as they exist.

1.13 CONTRACTOR'S REPRESENTATIVE

- A. Retain a competent representative on the project.

1.14 COOPERATION

- A. Work shall be carried on under usual construction conditions, in conjunction with other contractors work. Cooperate with other contractors, coordinate work and proceed in a manner as not to delay progress.
- B. Before proceeding, examine all construction drawings and consult other contractors to coordinate installation and avoid interference.

- C. In case of dispute, the Architect will render a decision in accordance with General and Supplementary General Conditions.

1.15 CODES, ORDINANCES, AND PERMITS

- A. Codes and Ordinances:

All material and work provided shall be in accordance with all applicable codes including the following codes and standards as most recently amended.

State Building Code

Massachusetts Electric Code, 2020 Edition

State Department of Public Safety

NFPA 101 Life Safety Code

NFPA Standards

NEMA TCB 2-2017

Standards of the Underwriters Laboratories (UL)

Occupational Safety and Health Act (OSHA)

Americans with Disabilities Act (ADA)

Energy Conservation Code

Motorola R56 Standard

Town of Ashland

- B. Where contract documents indicate more stringent requirements than codes, the contract documents shall take precedence.
- C. Permits: Be responsible for filing documents, and securing of inspection and approvals. Pay all permit fees.
- D. Refer to INSTRUCTIONS TO BIDDERS. Utility company backcharges related to permanent service will be paid by Owner.

1.16 ELECTRICAL ROOMS OR SPACES

- A. Be responsible for ensuring that the dedicated space and clearances required in the NEC, Sections 110-26 are maintained for all electrical equipment.
- B. Call other contractors' attention to the requirements contained in the above mentioned code sections, prior to the installation of equipment by other contractors, in order to ensure no violations.

1.17 SUBMITTALS

- A. Refer to Supplementary General Conditions for information relative to submission of shop drawings. Submittals shall be electronic in PDF format. No equipment shall be installed prior to approval.
- B. Notwithstanding any restrictions upon contractor proposed substitutions, should apparatus or materials be permitted by Architect to be substituted for those specified for good cause, and such substitution necessitates changes in or additional connections, piping, supports, or construction, same shall be provided. Assume cost and entire responsibility thereof.
- C. Submit the following samples:
 - 1. Lighting fixtures as may be requested.
 - 2. Other items as may be requested.
- D. Refer to Section 01 30 00 – Submittal procedures, for requirements.

1.18 GUARANTEE

- A. All parts of the work shall be guaranteed for a period of one year from the date of acceptance of the job by Owner. If during that period of general guaranty, any part of the work fails, becomes unsatisfactory, or does not function properly due to any fault in material or workmanship whether or not manufactured or job built, the Owner shall upon notice from owner promptly proceed to repair or replace such faulty material or workmanship without expense to owner, including cutting, patching, and painting, or other work involved, and including repair or restoration of any damaged sections of the premises resulting from such faults.
- B. In the event that a repetition of any one defect occurs indicating the probability of further failure and which can be traced to faulty design, material, or workmanship, then repair or replacement shall not continue to be made but the fault shall be remedied by a complete replacement of the entire defective unit.
- C. In addition to the general guaranty, obtain and transmit to owner any guaranties or warranties from manufacturers of specialties, but only as supplementary to the general guaranty which will not be invalidated by same.

1.19 ELECTRICAL CHARACTERISTICS

- A. In general, and unless specifically indicated otherwise, all building service, heating, ventilating, air conditioning, and plumbing equipment shall be of the following characteristics:
 - 1. Motors up to and including 1/3 HP shall be suitable for 120 volts, one phase operation.
 - 2. Motors larger than 1/3 HP shall be suitable for 480 volts, three-phase operation.
 - 3. Electric heating equipment 4.0 KW and less shall be suitable for 277 volt single-phase operation. Over 4.0 KW shall be 480 volt, three phase.
- B. Power Factor: All equipment provided rated greater than 1,000 watts and lighting equipment greater than 15 watts with an inductive reactance load component shall have a power factor of not less than 90 percent under rated load conditions.

1.20 TEMPORARY ELECTRICAL SUPPORT FACILITIES

- A. Refer to Section 01 30 00 – ADMINISTRATIVE REQUIREMENTS.

- B. Refer to Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS.
- C. Provide own field office and/or storage facilities which shall be located as directed by the Architect. Provide all tools, equipment, ladders, and temporary construction required for execution of the work.
- D. All scaffolding, ladders, and other temporary construction shall be rigidly built in accordance with all local and state requirements, and shall be removed upon completion.

1.21 INSPECTIONS AND TESTS

- A. Inspection: If inspection of materials installed shows defects, such defective work, materials, and/or equipment shall be replaced and inspection and tests repeated.
- B. Tests: Make reasonable tests and prove integrity of work and leave electrical installation in correct adjustment and ready to operate. All panels shall have phases balanced as near as practical. A consistent phase orientation shall be adhered to at all terminations.

1.22 ENERGY REBATE PROGRAM

- A. This project has been designed to incorporate equipment approved for energy rebate such as fixtures, performance lighting, building lighting controls, and VFDs. Meet with Utility Company prior to lighting shop drawing submittal to ascertain that submittal meets program guidelines. Fixtures shall be DLC listed or equivalent. Assist Owner and Engineer in effort to obtain utility rebates the Owner is eligible for. Equivalent lighting fixtures which meet DLC shall require lighting vendor to submit shop drawings to utility company for approval. It is the intent of this project to Qualify for incentives which requires an additional 30 days of reported kWh saved and six months of lighting energy use data as reported by the system post-insallation.

1.23 RECORD DRAWINGS

- A. Refer to Section 01 70 00 – EXECUTION AND CLOSEOUT REQUIREMENTS for additional requirements. Provide two sets of black or blue line on white drawings to maintain and submit record drawings, one set shall be maintained at site and which shall be accurate, clear, and complete showing actual location of all equipment as installed. Record drawings shall be updated at least monthly. Record drawings shall show outlet from which homeruns are taken, and location of all junction boxes and access panels. These drawings shall be available to Architect/Engineer field representative.
- B. Any addenda sketches and supplementary drawings issued during course of construction shall be incorporated in drawings.
- C. At completion, submit an accurate checked set of drawings.
- D. After approval of these drawings, photo reproductions of original tracings shall be revised to incorporate changes, including addenda sketches and supplementary drawings. Fitup drawings for tenant areas shall also be revised in the same manner. These "as-built" photo reproductions shall be certified as correct and delivered to the Architect along with two (2) sets of black line prints and Auto CAD files on thumb drive of all changes.

1.24 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

- A. Operating Instructions: Refer to Section 01 78 00 - Furnish operating instructions to Owner's designated representative with respect to operations, functions and maintenance procedures for equipment and systems installed. Cost of such instruction up to a full three (3) days of Electrical Subcontractor's time shall be included in contract. Cost of providing a manufacturer's representative at site for instructional purposes shall also be included.
- B. Maintenance Manuals:
 - 1. At completion of the project, provide four copies of complete manuals containing the following:
 - a. Complete shop drawings of equipment.
 - b. Operation description of systems.
 - c. Names, addresses, and telephone numbers of suppliers of systems.
 - d. Vendors' P.O. numbers for equipment installed.
 - e. Preventive maintenance instructions for systems.
 - f. Spare parts list of system components.
 - 2. All information shall be in one binder.

1.25 COORDINATION DRAWINGS

- A. Refer to Division 01 – General Requirements, before materials are purchased or work is begun, prepare and submit to the Architect, Coordination Drawings showing the size and location of all equipment and piping lines relevant to the complete system. Ensure that these Drawings are compatible and correctly annotated and cross-referenced at their interfaces.
- B. The General Trades Contractor shall be responsible for the coordination of all mechanical Plumbing, fire protection and electrical work. Before materials are fabricated or work begun, he shall submit to the Architect complete Coordination NavisWorks file and whatever medium the subcontractor uses to transmit shop drawing information to the field.
- C. The NavisWorks model represents what must be installed. Any deviation from the model will be noted and incorporated into the drawings both paper and 3D. If field installation management decides to deviate from the detailed coordination drawings, they are under responsibility for all collisions, schedule, or financial issues caused by the deviation.
- D. If two systems are found to have an issue that was not previously resolved in the model and both systems were drawn dimensionally correct and to origin, the issue will be resolved by a meeting of the field supervision to decide the best course of action. If an error in the 3D drawings has caused the issue, the subcontractor with erroneous drawings will be under the responsibility to find a solution.
- E. The Subcontractors will be solely responsible for Quality Control and the assurance that field installation matches shop drawings.
- F. Coordination Drawings shall indicate the necessary offsets for all ductwork, piping, conduit, and other items to clear the work of all other trades and to maintain the required ceiling height and partition layout. Each subcontractor shall indicate both top and bottom elevations of their equipment taking into account hangers, flanges, and other accessories.

G. Prepare Coordination Drawings as follows:

1. The General Trades Contractor shall require the HVAC Subcontractor to prepare original Drawings showing all his/her equipment, ducts, and piping.
2. The General Trades Contractor shall then require the PLUMBING Subcontractor to indicate all Plumbing piping and heating lines.
3. The General Trades Contractor shall then require the FIRE PROTECTION Subcontractor to indicate all his/her equipment and piping.
4. The General Trades Contractor shall then require the ELECTRICAL Subcontractor to indicate all his/her equipment and conduit.
5. The General Trades Contractor shall resolve conflicts and then submit these Drawings to the Architect for review.

H. Coordination Drawings shall bear the signature of all Subcontractors involved indicating that all space conditions have been satisfactorily resolved. In addition, the Drawings shall bear the Contractor's stamp bearing the notation "Drawings Have Been Checked and Coordinated With All Trades". Drawings without these notations will not be accepted by the Architect.

I. If any space conflicts cannot be resolved by the Contractor, he shall immediately notify the Architect and request disposition of the conflict.

J. Coordination Drawings are for the Contractor's and Architect's use during construction and shall not be construed as replacing any Shop, "As-Built", or Record Drawings required elsewhere in these Contract Documents.

K. Architect's review of Coordination Drawings shall not relieve the Contractor from his overall responsibility for coordination of all work performed pursuant to the Contract or from any other requirement of the Contract.

L. Refer to Section 01 78 00 – CLOSEOUT SUBMITTALS for further requirements and procedures.

1.26 RETURN AIR PLENUM

A. All wiring above suspended ceilings shall be "UL Listed" plenum rated cable or wiring shall be installed in conduit.

1.27 COMMUNICATIONS AND IESS SYSTEM, AND BDA SYSTEM PROVISIONS

A. The work shall be so performed so that the progress of the entire building construction, including all other trades, shall not be delayed and not interfered with. Materials and apparatus shall be installed as fast as conditions of the building will permit and must be installed promptly when and as directed.

1. The Electrical Contractor shall be responsible for furnishing and installing: conduits from each door strike, latch, mag lock, door contact, electric closures, card reader, etc. to an accessible ceiling space. Provide power and fire alarm interface at each power supply, door controller requiring same.

B. Responsibilities of the Communications System, and BDA System Contractors: The Communications System Contractor and BDA System Contractor, will be responsible for furnishing, installing, wiring, programming, troubleshooting, training and warranty service of all cabling, terminal equipment, headend equipment, as specified in Section 27 00 00, 28 00 00, and Paragraph 2.28 of Section 26 00 10 for completely operational systems.

- C. The work shall be so performed so that the progress of the entire building construction, including all other trades, shall not be delayed and not interfered with. Materials and apparatus shall be installed as fast as conditions of the building will permit and must be installed promptly when and as directed.
- D. Responsibilities of the Electrical Contractor: The Electrical Contractor shall be responsible for furnishing and installing all related building preparation including, but not limited to: outlet boxes with plaster rings, 120 volt, power, surface raceways, conduits with bushings, conduit stubs with bushings, sleeves with bushings (all conduits, stubs, sleeves, etc. shall be brought to an accessible ceiling of the same floor), backboxes, plaster rings, pull strings, j-hooks (every 5 feet along main paths to communications closets), bonding, grounding, core drilling, cutting, environmental seals, seismic supports, etc., for a completely operational system, as specified. Special backboxes furnished Security System Contractor and Communications System Contractor, shall be installed by Electrical Contractor.
 - 1. The Electrical Contractor shall be responsible for furnishing and installing: conduits from each door strike, latch, mag lock, door contact, electric closures, card reader, etc. to an accessible ceiling space. Provide power and fire alarm interface at each power supply, door controller requiring same.
- E. Responsibilities of the Communications System Contractors: The Communications System Contractor will be responsible for furnishing, installing, wiring, programming, troubleshooting, training and warranty service of all cabling, terminal equipment, headend equipment, as specified in Section 27 00 00 for a completely operational system.
- F. Responsibilities of the Integrated Electronic Security Systems (IESS) Contractor will be responsible for furnishing, installing, wiring, programming, trouble shooting, training, and warranty service of all cabling, terminal equipment, and head-end equipment for a completely operational system.
- G. Keep fully informed as to the shape, size and position of all openings required for all apparatus and give information in advance to build openings into the work.
- H. All distribution systems which require pitch or slope such as plumbing drains, steam and condensate piping shall have the right of way over those which do not. Confer with other trades as to the location of pipes, ducts, lights and apparatus and install work to avoid interferences.
- I. Coordinate exact locations and roughing in dimensions of all work before installation and make all final connections as required. Any changes required to avoid interference or to provide adequate clearances for Code and maintenance requirements shall be made at no additional costs.
- J. Structural elements of the project shall not be relocated, altered or changed to accommodate the work without written authorization from the Architect.
- K. Work that is installed before coordination with other trades, or that causes interference with the work of other trades shall be changed to correct condition.
- L. Obtain a complete set of Project Drawings and Specifications for coordination and to determine the full scope of work.
- M. Attend project coordination meetings to coordinate work of this Section, work of other trades and project and phasing retain a complete set of Project Drawings and Specifications for coordination and to determine the full scope of work.

1.28 TEMPORARY LIGHT & POWER

A. Refer to Section 01 50 00– TEMPORARY FACILITIES AND CONTROLS.

1.29 TRADE RESPONSIBILITY FOR INTERCONNECTIONS MATRIX

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Smoke Detectors (Area type)	26 00 10	26 00 10	26 00 10	230000 (ATC)	26 00 10	
Smoke Detectors & Carbon Monoxide Detectors (Duct mounted)	26 00 10	230000	26 00 10	230000 (ATC)	26 00 10	
Smoke & Fire/Smoke Dampers	230000	230000	N/A	N/A	N/A	
Smoke & Fire/Smoke Damper Actuators	230000	230000	26 00 10 & 230000 (ATC)	230000 (ATC)	26 00 10	2
Fire Dampers	230000	230000	N/A	N/A	N/A	
VAV Boxes	230000	230000	26 00 10	230000 (ATC)	N/A	2
VAV Box Damper Actuator	230000 (ATC)	Box Mfr	230000 (ATC)	230000 (ATC)	N/A	2
VAV Box DDC Controller	230000 (ATC)	Box Mfr	230000 (ATC)	230000 (ATC)	N/A	2
Hydronic Control Valves	230000 (ATC)	230000	N/A	230000 (ATC)	N/A	1
Hydronic Control Valve Actuator	230000 (ATC)	23 09 23	230000 (ATC)	230000 (ATC)	N/A	1
Sheet Metal Damper	230000	230000	N/A	N/A	N/A	1
Sheet Metal Damper Actuators	230000 (ATC)	23 09 23	230000 (ATC)	230000 (ATC)	N/A	1
Natural Gas Energy Meters	220000	220000	26 00 10 & 230000 (ATC)	230000 (ATC)	N/A	3
Electrical Energy Meters	26 00 10	26 00 10	26 00 10 & 230000 (ATC)	230000 (ATC)	N/A	3

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Domestic Water Meters	220000	220000	26 00 10 & 230000 (ATC)	230000 (ATC)	N/A	3
HVAC Hydronic Energy Meters	230000	230000 (ATC)	26 00 10 & 230000 (ATC)	230000 (ATC)	N/A	3
Airflow Measuring Stations	230000 (ATC)	230000 (ATC)	N/A	230000 (ATC)	N/A	
DDC Panels	230000 (ATC)	230000 (ATC)	26 00 10 & 230000 (ATC)	230000 (ATC)	N/A	4
VFDs at RTU, MAU, AHU, HV & ERV	23 00 00	23 00 00	26 00 00 & 23 00 00	23 00 00 (ATC)	N/A	5
VFDs at EFs & Pumps	26 00 00	26 00 00	26 00 00	23 00 00 (ATC)	N/A	6
Elevator Hoistway Vent Damper	230000	230000	N/A	N/A	N/A	
Elevator Hoistway Vent Damper Actuator	230000 (ATC)	230000 (ATC)	26 00 10	230000 (ATC)	26 00 10	
Boiler/DHW/ Intake & Exhaust Breeching	220000	220000	N/A	N/A	N/A	
Generator Exhaust Breeching	220000 (if gas fired) 220000 (if diesel fired)	220000 (if gas fired) 230000 (if diesel fired)	26 00 10	26 00 10	26 00 10	
Kitchen Emergency Gas Valve	220000	220000	26 00 10	26 00 10	26 00 10	

Notes:

1. Division 230000 and Division 230000 (ATC) Contractors shall fully coordinate all airflow damper and hydronic valves sizes and quantities.
2. Smoke Damper and VAV Box power wiring shall be provided by Division 26 00 10 to junction box locations shown on electrical drawings; Division 230000 (ATC) Contractor shall provide final power wiring from junction box to end device location.
3. Division 26 00 10 Contractor shall provide all line-voltage power wiring required for meters; Division 230000 (ATC) Contractor shall provide all low-voltage power wiring required for meters.
4. Division 26 00 10 shall provide power at main DDC Panel. Division 230000 (ATC) shall provide power to all other DDC Panels.

5. Power wiring for RTU, HV, MAU, AHU & ERV shall be a single point connector made by the Electrical Contractor (26 00 00). Integral wiring and connections shall be provided by Division 23 00 00.
6. Division 26 00 10 shall provide VFDs for all EFs and pumps with exception to EFs and/or pumps provided with ECM motors. ECM motors are specified in Division 23 00 00 and provided by Division 23 00 00 coordinate with mechanical schedules and specifications.

1.30 SUSTAINABLE DESIGN INTENT

- A. The proposed project is intended to be certified as a LEED "Gold" building per the LEED for Schools 2009 rating system. As a result, the documentation requirements for each credit, as described in Section 01 81 13.10 LEED FOR SCHOOLS v4 PROJECT SCORECARD, pertain to this specification section.
- B. Electrical Subcontractor shall provide all documentation indicating applicability of all products of this section to any potential LEED credits to the Project LEED Manager for submission to GBCI LEED Online. Refer to Section 018113 - SUSTAINABLE DESIGN REQUIREMENTS - LEED FOR SCHOOLS.
- C. The following sections contain additional LEED requirements for all subcontractors:
 1. Section 016000 – Product Requirements
 2. Section 017419 - Construction Waste Management and Disposal
- D. Submit required information using the LEED Data form for the following LEED items:
 1. IEQc4 - Low-Emitting Materials: Document that materials do not exceed VOC limits of either the Standard Practice For Testing of Volatile Organic Emissions from Various Sources using Small-Scale Environmental Chambers, including 2004 addenda prepared by the California Dept. of Health Services, or "Adhesives, Sealants and Sealant Primers must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168, July 1, 2005 and rule amendment date of January 7, 2005. Refer to Section 018113.
 - a. IEQc4.1 - Adhesives and Sealants: products applied on site within the building waterproofing barrier layer.
 - b. IEQc4.2 - Paints and Coatings: Field applied paints and coatings on components within the building waterproofing barrier layer, including primer and galvanizing touch up paint.

1.31 COMMISSIONING

- A. ~~Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 019113 – MEP Commissioning Requirements.~~
- B. ~~Complete installation and startup checks and functional tests according to Section 019113 – MEP Commissioning Requirements and manufacturers written instructions.~~
- C. ~~Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start up procedure.~~

- D. ~~Verify that equipment is installed and commissioned as per requirements of section 019113 and manufacturers written instructions/requirements.~~

A. GENERAL PROVISIONS

1. Commissioning Agent will be hired by the Electrical Subcontractor for Commissioning services outlined herein. Subcontractors responsible for items to be commissioned shall cooperate and coordinate with the Commissioning Agent and provide necessary information as outlined herein.
2. All of the Contract Documents, including Drawings, Invitation for Bids and Division 1 - General Requirements, apply to the Work of this Section.
3. Carefully examine all of the Contract Documents for requirements which affect the Work of this Section. The exact scope of Work of this Section cannot be determined without a thorough review of all specification Sections and other Contract Documents.
4. Commissioned systems shall be documented and functional performance tests verified with facility staff participating with on-the-job training, when available, during the functional performance testing.
5. Reference shall be made to the following sections:
 - a. Section 017700: Contract Closeout
 - b. Section 230548: Vibration Control and Seismic Restraint

B. SYSTEMS TO BE COMMISSIONED

1. Exterior lighting
2. Standby Electrical System.
3. Daylight Controls
4. Light sweep controls
5. Occupancy Sensors

C. COMMISSIONING TEAM

1. The Commissioning Team shall consist of representatives from the following parties involved in the design and construction of this facility:
 - a. Facility Manager/Owner Representative
 - b. Commissioning Firm
 - c. Electrical Design Team Representatives
 - d. Electrical Contractor Representatives
 - e. Testing Contractor

D. COMMISSIONING DOCUMENTATION

1. Commissioning Documentation shall include the following:
 - a. Commissioning meeting minutes shall be by the Commissioning Agent for documenting regularly scheduled meeting discussions, responsibilities and action agenda due dates.
 - b. Pending issues log for documenting issues identified and/or commissioning activities that are deferred and/or seasonal functional performance tests.
 - c. Maintain current shop drawing log for documenting equipment submittals to be commissioned and associated O&M requirements.

- d. Utilize static and operational performance test sheets for documentation of system(s) to be commissioned.
- e. Corrective action log for documenting performance test deficiencies found during the performance testing. Each corrective action shall require a re-test of that deficiency to demonstrate compliance.
- f. Equipment & System Training Log for documenting Contractor required training of Owner personnel.

E. COMMISSIONING GOALS

- 1. The goals of the commissioning process are as follows:
 - a. Certification that all noted systems meet the requirements set forth in the design documents for all systems and equipment noted.
 - b. To provide a comprehensive, Commissioning Plan
 - c. Provide a Commissioning Plan which defines the trade contractors' responsibilities as part of the commissioning process.
 - d. Demonstration of performance of systems commissioned.
 - e. Successful project closeout and warranty transition.

F. SCHEDULING OF ACCEPTANCE TESTING WORK

- 1. Static Review: Check procedures shall be conducted immediately after notification that the work of various systems and equipment is installed and the installing contractor has confirmed compliance with the contract documents.
- 2. Operational Performance Testing procedures shall be conducted immediately after notification that the work of the various systems and equipment is operational and that the installing contractor has completed his own tests to confirm compliance with the contract documents.

G. DOCUMENTATION

- 1. Prior to the conducting of static and operational testing procedures, the Commissioning Agent shall obtain the following:
 - a. Project Plans and Specifications including revisions made by addenda, approved alternates, Requests for Information (RFI) and change orders.
 - b. Approved submittals.

H. CONTRACTOR RESPONSIBILITIES

- 1. Electrical Contractor
 - a. The contractor shall be present as requested by the Commissioning Agent during the acceptance testing procedures of their respective systems and equipment.
- 2. General Contractor
 - a. The General Contractor shall verify completeness of the building envelope, which may effect proper operation and control of Electrical equipment and systems.

3. **Owner**

- a. The Owner shall assign maintenance personnel to participate in the commissioning process. The purpose shall be to become familiar with all tested systems as well as instruction on operation and maintenance.

I. **FINAL ACCEPTANCE**

1. When all noted systems are found to be operating satisfactorily in accordance with the plans and specifications, then the final commissioning report documenting satisfactory performance shall be prepared and submitted for review and approval.
2. After approval a copy of the commissioning plan and test results shall be included with each copy of the Operations and Maintenance Manuals.

J. **ACCEPTANCE PROCEDURES**

1. The agent-provided static and operational checklists shall be used to document the results of the testing process.
2. The performance testing process shall be accomplished for all equipment, subsystems, etc. listed in the approved commissioning plan. Complete a checklist for each piece of equipment and/or system noted to ensure documentation specific to each is complete.
3. Acceptance testing of all devices shall be performed by actual observations of the controlled devices such as photo sensors, occupancy sensors, switches, computer interface, or other remote or indirect method is not acceptable.
4. Functional performance testing shall progress from components to equipment to subsystems to complete systems, in order to identify and correct the root causes of problems before their effect on an entire system is observed. Submit all deficiencies to be corrected to the contractors for immediate correction.
5. At the end of the process, every system and all equipment, shall have been proven operational under all normal operational modes, including part and full load, and under abnormal or emergency conditions.
6. Testing shall be accomplished on each control device. All relays and adapters shall be checked for proper operation. All system interlocks, interconnections, and safety devices shall be checked for proper function.
7. Simulate temporary upsets of systems, such as distribution fault, control loss, setpoint change, and component failure, at different operating loads to determine system stability and recovery time.

K. **VERIFICATION AND DOCUMENTATION**

1. As each individual check or test is accomplished, the Commissioning Agent shall observe the physical responses of the system and compare them to the specified requirements to verify the test results. The actual physical responses of system components shall be observed. Reliance on control signals or other indirect indicators are not allowed. Observe the input and output signals for each control component to confirm correct actions and indication for each physical condition.
2. Verification of the testing shall be an integral part of commissioning testing.
3. The Commissioning Agent shall record the results of each individual check or test on pre-approved test and report form from the commissioning plan.
4. If any check or test cannot be accomplished for seasonal reasons, lack of occupancy, or for other reasons, this fact shall be noted along with an indication of when the test shall be scheduled.

5. If any check or test cannot be accomplished due to building structure or other building system deficiencies these deficiencies shall be resolved and corrected by the appropriate parties before completion of the commissioning process.
6. Every check or test for which acceptable performance was not achieved shall be repeated after the necessary corrective measures have been completed. This re-testing process shall be repeated until acceptable performance is achieved.

L. CORRECTIVE MEASURES

1. If acceptable performance cannot be achieved, then the design professional representative and the electrical contractor shall be notified.
2. If inadequate performance is due to equipment deficiencies, then the appropriate contractor shall work with the equipment manufacturer to resolve the problem.
3. If the inadequate performance is due to design deficiencies, then the design professional shall issue appropriate directions to implement the necessary corrective measures

M. INTERSYSTEM FUNCTIONAL PERFORMANCE TESTS

1. When all individual systems' functional performance has been proved, the interface or coordinated responses between systems shall be checked. The systems involved may be within the overall Electrical work, or they may involve other systems, such as HVAC and plumbing systems.
2. The approach to intersystem performance testing shall follow that previously described for systems.
3. Acceptance testing shall not be started on any system until it is documented to be complete by the contractor and/or his subcontractors. If all systems are not fully complete, but some are complete, it is permissible to acceptance test the completed systems first and continue with other systems after they have been completed.

N. Sample Functional Review checklist:

1. Exterior Lighting

Exterior Lighting Controls - Operational Performance Test

Project Name: _____		Date: _____		
Inspection-Verification Electrical	Electrical Connections Completed	☐	☐	☐
	Electrical contractor sign off by: _____			
Prerequisite	All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final setpoints, schedules, debugging and fine tuning of photo-cell parameters.	☐	☐	☐
	All A/E punchlist items for this equipment corrected.	☐	☐	☐
	Safeties and operating ranges reviewed.	☐	☐	☐
	Test requirements and sequences of operation attached.	☐	☐	☐
	Schedules and setpoints attached.	☐	☐	☐
	Have all energy savings control strategies, setpoints and schedules been incorporated that this equipment and control system are capable of?	☐	☐	☐
	If not, list recommendations below.			
	Review the EMS software control program(s) for this equipment. Parameters, setpoints and logic sequences appear to follow the specified written sequences.	☐	☐	☐
	Schedule of fixtures on each control type (Parking or Security) has been reviewed.	☐	☐	☐
	Record of All Values for Current Setpoints (SP), Control Parameters, Limits, Delays, Lockouts, Schedules, Etc. Changed to Accommodate Testing: ☐	☐	☐	☐
Parameter	Parking lot lights ON by photo cell	☐	☐	☐
	Parking lot lights OFF by photo-cell	☐	☐	☐
	Exterior security lights ON by photo cell	☐	☐	☐
	Exterior security lights OFF by photo-cell	☐	☐	☐
	Photo-cell BAS parameters	☐	☐	☐
Inspection-Verification Equipment Installation	Near dusk, observe exterior lights until they come ON.	☐	☐	☐
	All exterior lights come on at dusk, before dark, but not when still very light.	☐	☐	☐
	Change the Parking Lot light schedule OFF to be in 5 minutes.	☐	☐	☐
	Observe that the parking lot lights, designated by the approved schedule, shut OFF. Designated signage remains ON.	☐	☐	☐
	Before daylight in the morning, observe the security lights ON. Wait until dawn	☐	☐	☐
	When sufficiently light, Security Lights and signage lights shut OFF.	☐	☐	☐
	Return all changed control parameters and conditions to their pre-test values.	☐	☐	☐
	Record any permanently changed parameter values and submit to Owner.			
	Electrical contractor sign-off by: _____			
Equipment Manufacturer Verification	Manufacturer's start-up sheet completed	☐	☐	☐
	Warranty sheet completed	☐	☐	☐
	Training of owner complete	☐	☐	☐
	Manufacturer sign off by: _____			

2. Standby Electrical System

Standby Electrical System - Operational Performance Test

Project Name: _____

Date: _____

		PASS	FAIL	N/A
Inspection-Verification Electrical	Electrical Connections Completed	☐	☐	☐
	Electrical contractor sign off by: _____			
Prerequisite	Started up and startup reports and prefunctional checklists submitted	☐	☐	☐
	Emergency generator and ATS	☐	☐	☐
	UPS	☐	☐	☐
	All control system functions for this and all interlocking systems are programmed and operable per contract documents	☐	☐	☐
	All A/E punchlist items for this equipment corrected.	☐	☐	☐
	These functional test procedures reviewed and approved by installing contractor and vendors.	☐	☐	☐
	Safeties and operating ranges reviewed.	☐	☐	☐
	Test requirements and sequences of operation attached.	☐	☐	☐
	Verify that generator gages and meters for voltage, amperage and frequency are calibrated to hand-held or load profiler instrument readings.	☐	☐	☐
	Monitoring security company notified of test. Arrangements made to test UPS loads and load bank	☐	☐	☐
	Electrical contractor sign off by: _____			
Initial Procedures	Verify that power has been lost from each load served by emerg. power.	☐	☐	☐
Generator, ATS and Loads	Power Line Disturbance Monitor to monitor the transient responses. Compare to specifications.	☐	☐	☐
	Time delay from power failure to engine start signal should be within Actual _____ sec., Expected _____ sec.	☐	☐	☐
	Cranking time until prime-mover starts and runs should be within Actual _____ sec., Expected _____ sec.	☐	☐	☐
	Time until engine-generator is at proper voltage and frequency Actual _____ sec., Expected _____ sec.	☐	☐	☐
	Total time from power failure until ATS switch is on E-power Actual _____ sec., Expected _____ sec.	☐	☐	☐
	Delay to normal power Actual _____ min., Expected _____ min.	☐	☐	☐
	Neutral delay time Actual _____ min., Expected _____ min.	☐	☐	☐
	Cool down time Actual _____ min., Expected _____ min.	☐	☐	☐
	Electrical contractor sign off by: _____			
Full Load Test	Delay to normal power Actual _____ min., Expected _____ min.	☐	☐	☐
	Neutral delay time Actual _____ min., Expected _____ min.	☐	☐	☐
	Cool down time Actual _____ min., Expected _____ min.	☐	☐	☐
	Electrical contractor sign off by: _____			
Step Load Tests	Specified frequency regulation range = +/- _____ Hz	☐	☐	☐
	Specified voltage regulation range = +/- _____ V	☐	☐	☐
	Verify there are no significant variations in temperature between phases	☐	☐	☐
	Verify that generator starts and E-power sequence initiated	☐	☐	☐
	Verify alarms are generated and E-power system goes or remains off-line	☐	☐	☐
	Verify all alarms are properly annunciated in the remote panel	☐	☐	☐
	Verify alarm received by EMS and remote sites	☐	☐	☐
	ATS values			
	Hz Actual _____, Expected _____	☐	☐	☐
	Amps Actual _____, Expected _____	☐	☐	☐
	Volts Actual _____, Expected _____	☐	☐	☐

Standby Electrical System - Operational Performance Test

		PASS	FAIL	N/A
UPS	Observe the generator start and ATS switch to generator power	☐	☐	☐
	Verify UPS goes back to generator power per spec	☐	☐	☐
	Verify that specified voltage dynamic regulation is met: Actual _____, Expected _____	☐	☐	☐
	Steady-state voltage Actual _____, Expected _____	☐	☐	☐
	Frequency overshoot Actual _____, Expected _____	☐	☐	☐
	Verify that THD less than 5%	☐	☐	☐
	Verify that wave form deviation is minimal	☐	☐	☐
	Verify amperage of each phase off the UPS is balanced	☐	☐	☐
	Phase A = _____	☐	☐	☐
	Phase B = _____	☐	☐	☐
	Phase C = _____	☐	☐	☐
	Phase imbalance is within _____	☐	☐	☐
	Verify that UPS is tuned	☐	☐	☐
	Verify all alarms are properly annunciated	☐	☐	☐
	Verify that loaded UPS provides sufficient power	☐	☐	☐
	Verify that UPS is charging properly from the generator	☐	☐	☐
	Verify function of UPS bypasses	☐	☐	☐
	Check calibration of UPS digital readouts of frequency, current and volts	☐	☐	☐
	Hz Actual _____, Expected _____	☐	☐	☐
	Amps Actual _____, Expected _____	☐	☐	☐
	Volts Actual _____, Expected _____	☐	☐	☐
Building Test	Verify generator is running at less than 100% load, Actual _____	☐	☐	☐
	Verify that proper power is delivered to each device listed in emergency panel schedules and that equipment directly worded functions properly	☐	☐	☐
	Verify all emergency lighting is on as specified	☐	☐	☐
	All loads are properly served with power	☐	☐	☐
	Verify that specialty emergency lighting is on using emergency panel service	☐	☐	☐
	All loads are properly served with power	☐	☐	☐
	Verify proper power at each emergency power receptacle	☐	☐	☐
	Verify proper function of specialty load on emergency power	☐	☐	☐
	Security panel	☐	☐	☐
	Fire alarm panel	☐	☐	☐
	Telecom system	☐	☐	☐
	Elevator	☐	☐	☐
	UPS monitored alarms	☐	☐	☐
	Electrical failure	☐	☐	☐
	Detection of power being switched to UPS	☐	☐	☐
	Low battery	☐	☐	☐
	Space temperature above alarm setpoint	☐	☐	☐
Inspection-Verification Equipment Installation	Installation on housekeeping pad	☐	☐	☐
	Equipment per contract documents/details/shop drawing	☐	☐	☐
	Drain piping installation completed	☐	☐	☐
	Vent piping installation completed	☐	☐	☐
	Noise level and/or vibration acceptable	☐	☐	☐
	Equipment insulated	☐	☐	☐
	Equipment labeled	☐	☐	☐
	Equipment has been cleaned inside and out	☐	☐	☐
	Piping contractor sign-off by: _____	☐	☐	☐
	Insulation contractor sign off by: _____	☐	☐	☐
Inspection-Verification Equipment Manufacturer	Electrical contractor sign off by: _____	☐	☐	☐
	Manufacturer's start-up sheet completed	☐	☐	☐
	Warranty sheet completed	☐	☐	☐
	Manufacturer sign off by: _____	☐	☐	☐

3. Daylighting Controls

Daylighting Controls - Operational Performance Test

Project Name: _____		Date: _____		
Inspection-Verification Electrical	Electrical Connections Completed Electrical contractor sign off by: _____	☐ PASS	☐ FAIL	☐ N/A
Lighting Zone Schedule	Verify that lighting zoning is in accordance with submittals	☐	☐	☐
Daylighting Control System	Verify that the following are in accordance with submittals:			
	Luminaire control	☐	☐	☐
	Design illuminance setpoint	☐	☐	☐
	Work plane for application	☐	☐	☐
	Lighting control zone per each perimeter exposure on each floor	☐	☐	☐
	Controls were calibrated as part of system start-up	☐	☐	☐
	Calibration was done with finishings and furniture in place	☐	☐	☐
	Daylighting control type	☐	☐	☐
	Occupants have been explained the intent and operation of control:	☐	☐	☐
Nameplate Data	Verify that the following are in accordance with submittals:	☐	☐	☐
	Photosensor	☐	☐	☐
	Lighting controller	☐	☐	☐
	Controlled Ballasts	☐	☐	☐
Inspection-Verification Equipment Installation	Verify that lighting zone generally correlates with area of daylight availability	☐	☐	☐
	Verify that there is separate control of luminaires close to and far from the windows	☐	☐	☐
	Verify that photosensor is mounted in proper location	☐	☐	☐
	Verify that photosensor is protected from direct sunlight	☐	☐	☐
	If indirect lighting is used, verify that photosensor is mounted at lower plane of fixture, facing down	☐	☐	☐
	Verify that interior finishes and work space location are consistent with efficient use of daylighting	☐	☐	☐
	Verify that skylights and other toplighting glazing clean	☐	☐	☐
	Verify that all almps in lighting zone dim to approximately the same level	☐	☐	☐
Inspection-Verification Equipment Manufacturer	Manufacturer's start-up sheet completed	☐	☐	☐
	Warranty sheet completed	☐	☐	☐
	Manufacturer sign off by: _____			

4. Lighting Sweep Controls

Lighting Sweep Controls - Operational Performance Test

Project Name: _____		Date: _____		
		PASS	FAIL	N/A
Inspection-Verification Electrical	Electrical Connections Completed	☐	☐	☐
	Electrical contractor sign off by: _____			
Lighting Zone Schedule	Verify that the following are in accordance with submittals:			
	Interior corridor	☐	☐	☐
	Gymnasium	☐	☐	☐
	Auditorium	☐	☐	☐
	Cafeteria	☐	☐	☐
	Site Lighting	☐	☐	☐
	Administration Area	☐	☐	☐
	Control contractor sign off by: _____			
Inspection-Verification Equipment Installation	Verify that lighting scheduels are programmable with a micro-processor-based central processing unit	☐	☐	☐
	Verify that CPU allows separate weekday, weekend, & holiday sch.	☐	☐	☐
	Verify battery backup	☐	☐	☐
	Verify that zone is less than 2500ft sq. in area	☐	☐	☐
	Verify method of override	☐	☐	☐
	Verify override method is compatible with CPU	☐	☐	☐
	Verify override is located within general area of zone (s) controlled	☐	☐	☐
	Verify that the system provides warning to occupants prior to lights being swept off	☐	☐	☐
	Verify that schedule & override time period are reasonable for zone	☐	☐	☐
	Verify that occupants have been explained that intent & operation of the sweep system	☐	☐	☐
Performance Verification	Verify lights in zone are turned off at scheduled time	☐	☐	☐
	Verify lighting sweep is preceded by occupant warning (blinking of lights, etc.)	☐	☐	☐
	Verify override turns on zone lights only	☐	☐	☐
	Verify lights turned on by override are turned off after programmed override period	☐	☐	☐
	Verify if space has split wiring, inboard and outboard lights are properly sequenced	☐	☐	☐
	Verify if there is a keyed whole floor switch (for cleaning staff, etc.) this is also swept off	☐	☐	☐
Inspection-Verification Equipment Manufacturer	Manufacturer's start-up sheet completed	☐	☐	☐
	Warranty sheet completed	☐	☐	☐
	Owner's training complete	☐	☐	☐
	Manufacturer sign off by: _____			

5. Occupancy Sensor

Occupancy Sensor - Operational Performance Test

Project Name: _____

Date: _____

		PASS	FAIL	N/A
Inspection-Verification Electrical	Electrical Connections Completed	☐	☐	☐
	Electrical contractor sign off by: _____	☐	☐	☐
Inspection-Verification Equipment Installation	Verify sensor type	☐	☐	☐
	Verify wattage of controlled light fixture	☐	☐	☐
	Verify sensor wattage capacity is adequate for lights to be controlled	☐	☐	☐
	Verify unit mounted per manufacturer's requirements	☐	☐	☐
	Verify emergency lighting, uncontrolled by occ. sensor, in controlled space	☐	☐	☐
	Verify all occupant area in the controlled space is line-of-sight to sensor	☐	☐	☐
	Verify sensor not mounted in location that could be temporarily blocked from detection pattern (e.g. behind door)	☐	☐	☐
	Verify PIR sensors: mounted >4 feet from HVAC vents & heat sources	☐	☐	☐
	Verify PIR sensors: all occupant area in the controlled space is <20 feet from sensor, or per manufacturer's recommendation	☐	☐	☐
	Verify ultrasonic sensors: all occupant area in the controlled space in <30 feet from sensor, or per manufacturer's recommendation	☐	☐	☐
	Verify sensor not mounted such that it detects motion in space outside controlled space	☐	☐	☐
	Verify (if required) sensitivity range exceeds sensor range.	☐	☐	☐
	Verify that mask is adjusted to match controlled space	☐	☐	☐
	Verify time delay (time-to-off) setting (20 min. unless specified diff.)	☐	☐	☐
	Verify sensitivity settings for each area, entry, etc.	☐	☐	☐
	Electrical contractor sign off by: _____			
	Installation contractor sign off by: _____			
Performance Verification	Verify sensor type	☐	☐	☐
	Verify slight hand movement in center of occupied space turns on lights	☐	☐	☐
	Verify slight hand movement at periphery of occupied space turns on lights	☐	☐	☐
	Verify adjusted test time-to-off delay	☐	☐	☐
	Verify after occupied space is vacated, lights turn off after ___ mins	☐	☐	☐
	Verify that walking past door does not turn on lights	☐	☐	☐
Inspection-Verification Equipment Manufacturer	Manufacturer's start-up sheet completed	☐	☐	☐
	Warranty sheet completed	☐	☐	☐
	Owner's training complete	☐	☐	☐
	Manufacturer sign off by: _____			

PART 2 - PRODUCTS

2.1 GENERAL

- A. Product specifications are written in such a manner so as to specify what materials may be used in a particular location or application and therefore does not indicate what is not acceptable or suitable for a particular location or application. As an example: non-metallic sheathed cable is not specified; therefore, it is not acceptable.
- B. For purpose of establishing a standard of quality and not for purpose of limiting competition, the basis of this Specification is upon specified models and types of equipment and materials, as manufactured by specified manufacturers.
- C. In all cases, standard cataloged materials and systems have been selected. Materials such as lighting fixtures specially manufactured for this particular project and not part of a manufacturers' standard product line will not be acceptable. In the case of systems, the system components shall be from a single source regularly engaged in supplying such systems. A proposed system made up of a collection of various manufacturers' products will be unacceptable.
- D. Where Specifications list manufacturers' names and/or "as approved" or "Equal approved by Architect", other manufacturers' equipment will be considered if equipment meets Specification requirements and has all features of the specified items as are considered essential by Architect.
- E. All material shall be new and shall be UL listed.

2.2 RACEWAYS AND FITTINGS

- A. Raceways - General:
 - 1. No raceway shall be used smaller than $\frac{3}{4}$ in. diameter and shall have no more than four 90 deg. bends in any one run, and where necessary, pull boxes shall be provided. Only rigid metal conduit or intermediate metal conduit is allowed for slab work. Cable systems, if allowed to be used by other sections of this specification, shall not be used exposed or in slabs, whether listed by "UL" for such use or not.
 - 2. Rigid metal conduit conforming to, and installed in accordance with, Article 344 shall be heavy wall zinc coated steel conforming to American Standard Specification C80-1 and may be used for service work, exterior work, slab work, and below grade level slab, wet locations, and in mechanical rooms for drops down to equipment from elevations below eight feet and also where raceway may be subject to mechanical damage.
 - 3. Intermediate metal conduit conforming to, and installed in accordance with, Article 342, may be used for all applications where rigid metal conduit is allowed by these specifications.
 - 4. Electrical Metallic Tubing (EMT), conforming to, and installed in accordance with, Article 358 shall be zinc coated steel, conforming to industry standards, may be used in masonry block walls, stud partitions, above furred ceilings, where exposed but not subject to mechanical damage, and may be used for fire alarm work.
 - 5. Surface metal raceways conforming to, and installed in accordance with, Article 386 may be used only where raceways cannot be run concealed, and then, if only specifically approved.

6. Flexible metal conduit shall be used for final connections to recessed lighting fixtures from above ceiling junction boxes and for final flexible connections to motors and other rotating or vibrating equipment. Liquid tight flexible metal conduit shall be used for the above connections which are located in moist locations. All flexible connections shall include an insulated grounding conductor.
 7. Rigid non-metallic conduit may be used for underground electric and telephone services outside the foundation wall and also below slab and shall be polyvinyl chloride (PVC) schedule 40, 90 deg. C. Rigid metal conduits shall be used thru-foundation walls and thru-slab. Below slab conduits do not require concrete encasement.
 8. PVC Schedule 40 may be used for below slab circuits within building confines. Below slab rigid non-metallic conduits do not require concrete encasement. Rigid non-metallic conduits may be used for below slab feeders and branch circuits, but shall not be used in slabs, nor for elbows which penetrate slabs. Raceways and fittings shall be produced by same manufacturer.
 9. PVC schedule 40 may also be used for underground branch circuits outside the foundation wall.
 10. PVC schedule EB conduit will be used as indicated on Electrical Site Plan, and where encased in concrete.
 11. Acceptable manufacturers:
 - a. Pittsburgh Standard Conduit Company
 - b. Republic Steel and Tube
 - c. Youngstown Sheet and Tube Company
 - d. Carlon
 - e. Or equal
 12. Fittings:
 - a. Provide insulated bushings on all raceways 1 inch diameter or larger.
 - b. Manufacturer's standard fittings shall be used for raceway supports.
 - c. Expansion Fittings: Expansion fittings shall be used where structural and concrete expansion joints occur and shall include a ground strap. Bond separate buildings in accordance with code.
 - d. Couplings for rigid metal and intermediate metal conduit shall be threaded type.
 - e. Threadless fittings for EMT shall be watertight compression type or set-screw type (dry-locations). All fittings shall be concrete tight. No diecast fittings allowed except for raceways larger than 1 inch diameter.
 - f. Cable supports in vertical raceways shall be of the split wedge type. Armored cable supports for vertical runs to be of wire mesh basket design.
 - g. Wall entrance seals shall be equal to O.Z. Gedney type "WSK".
 - h. Couplings, elbows and other fittings used with rigid nonmetallic conduit shall be of the solvent cemented type to secure a waterproof installation.
 - 1) Acceptable manufacturers:
 - a) O.Z.
 - b) Crouse Hinds
 - c) Appleton
 - d) EFCOR
 - e) Steel City
 - f) Or equal
- B. Outlets, Pull and Junction Boxes:
1. Outlets:
 - a. Each outlet in wiring or raceway systems shall be provided with an outlet box to suit conditions encountered. Boxes installed in normally wet locations or surface mounted shall be of the cast-metal type having hubs. Concealed boxes shall be cadmium plated or zinc coated sheet metal type. Old work boxes with Madison clamps not allowed in new construction. Thru the wall boxes are not permitted.

- b. Each box shall have sufficient volume to accommodate number of conductors in accordance with requirements of Code. Boxes shall not be less than 1-1/2 in. deep unless shallower boxes are required by structural conditions and are specifically approved by Architect. Ceiling and bracket outlet boxes shall not be less than 4 in. octagonal except that smaller boxes may be used where required by particular fixture to be installed. Flush or recessed fixtures shall be provided with separate junction boxes when required by fixture terminal temperature requirements. Switch and receptacle boxes shall be 4 in. square or of comparable volume.
 - c. Far side box supports shall be Caddy J-1A.
 - d. Acceptable manufacturers:
 - 1) Appleton
 - 2) Crouse Hinds
 - 3) Steel City
 - 4) RACO
 - 5) Or equal
2. Pull and Junction Boxes: Where indicated on plans, and where necessary to terminate, tap off, or redirect multiple raceway runs or to facilitate conductor installation, furnish, and install appropriately designed boxes. Boxes shall be fabricated from code gauge steel assembled with corrosion resistant machine screws. Box size shall be sized per Code. Pencil fiberglass handholes are allowed as a substitute for Quazite handholes with H20 wheel load covers.
3. Boxes in moist or wet areas shall be galvanized type. Boxes larger than 4-11/16 inches square shall have hinged covers. Boxes larger than 12 inches in one dimension will be allowed to have screw fastened covers, if a hinged cover would not be capable of being opened a full 90 degrees due to installation location.
- a. Acceptable Manufacturers:
 - 1) Brasch
 - 2) Hoffman
 - 3) Keystone
 - 4) Lee Products Co.
 - 5) McKinstry Inc.
 - 6) Eldon Inc.
 - 7) Or equal

2.3 CONDUCTORS

- C. All conductors shall be a minimum size of #12 AWG except for control wiring and fire alarm wiring where #14 AWG may be used. For all exit sign circuits, normal/emergency and/or emergency only circuits, exterior lighting circuits, and also where distance from panelboard to first outlet exceeds 80 ft. at 120 volts and 150 ft. at 277 volts, #10 AWG shall be minimum size wire allowed. All feeder and branch circuit conductor shall be color coded as follows:

1.	208Y/120V	Phase A	Black
2.	208Y/120V	Phase B	Red
3.	208Y/120V	Phase C	Blue
4.	480Y/277V	Phase A	Brown
5.	480Y/277V	Phase B	Orange
6.	480Y/277V	Phase C	Yellow
7.	Grounded Conductor		
		120/208	White
		277/480	Grey
8.	Equipment Ground		
		120/208	Green
		277/480	Green with Yellow Trace
9.	Isolated Ground	120/208	Green with Orange Trace

- D. All conductors not installed in accordance with color scheme shall be replaced. All conductors larger than #6 AWG must be identified with colored tape.
- E. Comply with CMR 527, Massachusetts Electrical Code.
- F. Comply with Underwriter's Laboratories (UL) standards:
 - 1. UL 4: Armored Cable.
 - 2. UL 62: Flexible Cord and Fixture Wire.
 - 3. UL 83: Thermoplastic-Insulated Wires and Cables.
 - 4. UL 486A: Wire Connectors and Soldering Lugs for Use with Copper Conductors.
 - 5. UL1569: Metal -Clad Cables.
- G. Comply with NEMA WC-5: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- H. Connections throughout the entire job shall be made with solderless type devices.
 - 1. For #10 AWG and smaller: spring type.
 - 2. For #8 AWG and larger: circumferential compression type.
 - 3. Acceptable manufacturers:
 - a. 3M "Scotchlock"
 - b. IDEAL "Wingnut"
 - c. BURNDY
 - d. MAC
 - e. Or equal
 - 4. Any splices made up in ground mounted pull boxes shall be resin cast waterproof type or waterproof pressure type, as manufactured by King Technology, St. Louis, MO.
- I. Conductors shall be copper, soft drawn, and annealed of 98 percent conductivity. Conductors larger than #10 AWG shall be stranded; #10 AWG and smaller shall be solid. Conductors shall be insulated for 600 volts and be of following types:
 - 1. All conductors shall have heat/moisture resistant thermoplastic insulation type THHN/THWN (75 degrees C) except as follows:
 - a. In sizes #1 AWG and larger: Crosslinked polyethylene insulation type XHHW (75 degrees C – 90 degrees C) may be used.
 - b. Fire alarm system conductors shall be #14 AWG, type THHN, solid. Color coding of fire alarm conductors shall be in accordance with fire codes.
 - c. Fixture whips #16AWG type "SF".
- J. Stranded conductors for all wiring systems except fire alarm will be allowed if installed and terminated as specified under Execution Section.
- K. Mineral-Insulated Metal-Sheathed Fire-Resistive Cables (Type MI) - Cables shall consist of a factory assembly of one or more solid copper conductors insulated with highly-compressed magnesium oxide and enclosed in a seamless, liquid-and-gas-tight continuous copper sheath. Cables shall be rated for 600 volts and less. Cables shall comply with Article 332 of the National Electrical Code. Cables shall be classified by Underwriters Laboratories, Inc. as having a 2-hour fire resistive rating. Cable terminations shall be made with UL listed mineral-insulated cable fittings. Approved Manufacturer - Pyrotenax USA, Inc. or approved equal.
- L. Type MC Cable may be used for concealed branch circuits in hollow spaces where allowed by code if installed and terminated as specified under Execution Section. Armor shall be galvanized steel and shall be UL listed for 2 hour fire wall penetration. Aluminum armor is not acceptable.

- M. Type MC Cable may also be used for fire alarm where concealed and allowed by Code. Armor shall be red.
- N. Acceptable manufacturers:
 - 1. AFC Cable Systems
 - 2. American Wire & Cable
 - 3. Cerro
 - 4. Cornish
 - 5. Cresent
 - 6. General Cable
 - 7. Okonite
 - 8. Or equal
- O. Installation of conductors and cables
 - 1. Install all power and 120 volt control wire and cable in approved raceways. When low tension wiring is run exposed, install it in conduit. Plenum rated low tension cable may be used for installation above suspended ceilings where it is allowed by the Code and is allowed in the specification for the specific system.
 - a. Wire Size:
 - 1) Install minimum No. 12 AWG for power and lighting circuits.
 - 2) Install minimum No. 10 AWG for 120 volt 20 ampere branch circuits of 75 feet to 150 feet length, and minimum No. 8 AWG for the circuits of 150 feet to 250 feet unless otherwise shown on the drawings or required by the equipment shop drawings.
 - 3) Install minimum No. 10 AWG for 277 volt 20 ampere branch circuits of more than 150 feet unless otherwise shown on the drawings.
 - 2. Metal clad cable type MC may be used for branch circuit wiring above suspended ceilings and for device wiring in the metal stud partitions. MC cable shall not be used for a termination at the panels (homeruns) and where they run exposed. Any wiring associated with Smoke control systems can not be installed in MC cable as it does not meet 780 CMR Section 909.12.1.
 - 3. Bundle conductors #10 and smaller in branch circuit panelboards, signal cabinets, signal control boards in switchboards and motor control centers.
 - 4. Homerun Circuits:
 - a. Follow homerun circuit numbers shown on the drawings to connect circuits to the panelboards. Where homerun circuit numbers are not shown on the drawings, divide similar types of connected loads among phase busses so that currents in each phase are within 10% of each other during normal usage.
 - b. Wire multi-wire branch circuit homerun with two or three single phase and one common neutral conductor to a panel in a such manner that each phase circuit is fed from the adjacent circuit breakers. Do not combine circuits so that any homerun has more than three circuits (total of five wires) installed in one conduit, unless the circuit conductors are de-rated in strict accordance with the referenced Electrical Code.
 - c. Branch circuit wiring in the classrooms, laboratories and offices shall be provided with a dedicated neutral conductor for each phase conductor.
 - 5. Properly group feeders, branch circuit and auxiliary system wiring passing through pull boxes and/or being made up in panelboards; neatly bind each group of wires together with plastic cable ties, and trim loose ends of the ties.
 - 6. Peel branch circuits and auxiliary system wiring out of the wiring gutters at the terminal cabinet and panels at 90 degrees to circuit breakers and terminal lugs before making connections.
 - 7. Color code conductors No. 6 AWG and larger by applying colored plastic tape at ends and where connections and splices are made. Wrap tape around the conductor three complete turns.

8. Splices and Terminations:
 - a. Make splices and joints by means of UL-listed, solderless connectors rated 600 volt, of sizes and types required by manufacturer's recommendations, with temperature ratings equal to that of wire.
 - b. Attach copper wire to panelboards, switchboards, disconnect switches and other electrical equipment by means of bolt-on lugs with hex screws. Properly size lugs; do not cut strands from a conductor in order to fit conductor into a lug.
 - c. Connectors for cables 250 MCM and larger shall have two clamping elements and terminals for bus connections shall have two bolt holes.
9. Identification: Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems." Label feeder and branch circuits in pull and junction boxes, handholes and at cable terminations in the panelboards, motor control centers, and switchboards. Use non-ferrous tags or labels stamped or printed to correspond with markings on the drawings or marked so that feeder or cable may be identified readily. If suspended tags are provided, attach with nylon line or cable lacing.
10. Connect branch circuits to the breakers in multi-phase panelboards required to balance loads.
11. Provide handle ties for multiwire branch circuits as required in the NEC
12. Low Tension Cables: Provide separation from power wiring and lighting fixtures as follows:
 - a. Lighting fixtures - at least 6 inches.
 - b. Power branch circuit wiring with MC type cable - at least 12 inches.
 - c. Power branch circuit wiring in metal conduit - at least 6 inches.
13. When low-tension cables are not in conduit or trays, support cables from the deck and/or beams, spacing supports no farther apart than 6 ft.-0 in. on center. Provide hangers, clips or other approved method of grouping the cables and keeping them away from other systems. Take care to ensure that ties, clips and other support devices do not compress the cable or damage cable insulation; use J-hooks whenever possible.
14. Cable Supports:
 - a. Provide cable supports for vertical feeders required by the referenced Electrical Code.
 - b. Support vertical feeders at each floor level.
 - c. Support and secure metal-clad cable Type MC at intervals not exceeding 6 feet and within 12 inches from every outlet box, junction box or cabinet.
 - d. Support metal clad cable Type MC with cable supports equal to Caddy WMX-6, MX-3, and clamps equal to Caddy 449. Where cables are supported by the structure and only need securing in place, then cable ties will be acceptable.
15. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
16. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
17. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
18. For wiring in high temperature areas or high temperature equipment (i.e. boiler rooms, water heaters/boosters), furnish conductors for 90°C dry and wet rating.

2.4 ACCESS PANELS

- A. Coordinate and Furnish access panels for access to concealed junction boxes and to other concealed parts of system that require accessibility for operation and maintenance. In general, electrical work shall be laid out so access panels are not required.

- B. Access panels shall be located in a workmanlike manner in closets, storage rooms, and/or other non-public areas, positioned so that junction can be easily reached and size shall be sufficient for purpose (minimum size 12 in. x 12 in.). When access panels are required in corridors, lobbies, or other habitable areas, they shall be located as directed by the Architect. Submit layout and locations for approval.
- C. Access panels once coordinated with the architect and the G.C. shall be furnished by this trade contractor to the G.C. for installation. Coordinate all locations so that the finish trades can locate the rough openings appropriately.
- D. Furnish Access panels in compliance with Section 08 31 00.
- E. Furnish access panel shop drawings.

2.5 SLEEVES, INSERTS, AND OPENINGS

- A. Sleeves: Provide sleeves of proper sizes for all openings required in concrete floors and walls. Sleeves passing through floors shall be set with top of sleeve 1 in. above finished floor. Core drilling will also be acceptable if in accordance with any structural standards. Any unsleeved openings shall be waterproofed.
- B. Inserts: Provide inserts or other anchoring devices in concrete and masonry construction as required to support raceways and equipment.
- C. Openings: Where an opening is required in concrete slabs to allow passage of a multitude of raceways, give adequate notice to General Trades Contractor so he may box out opening in form work.
- D. Any openings through fire rated surfaces shall be closed off with fireproofing materials providing the same rating as the surface penetrated.

Manufacturers:

- 1. Specified Technologies Inc.
- 2. Thomas & Betts
- 3. International Protective Coatings Corp.
- 4. 3M Fire Protection Products
- 5. Or equal

2.6 FLOOR OUTLETS (FLUSH TYPE)

- A. Section includes flush floor boxes equal to Wiremold RFB Series. Provide appropriate floor box model that meets the intent of what is shown on the drawings.
- B. Quality Assurance
 - 1. Electrical Raceways and Components: Comply with requirements of applicable local codes, NEC, UL, and NEMA Standards pertaining to raceways and components. Listed and labeled in accordance with NFPA 70, Article 100.

C. Floor Boxes

1. RFB4 and RFB4-4DB Series Floor Boxes: Manufactured from stamped steel and approved for use on above grade floors. The box shall be 12-3/4" L x 10" W x 3-7/16" H [324mm x 254mm x 87mm]. Provide the box with four (4) independent wiring compartments that allow capacity for up to four (4) duplex receptacles, communication and/or audio/video services. The RFB4 Series Box shall permit tunneling from end power compartment to end power compartment. The RFB4-4DB Series Box shall permit tunneling from adjacent or opposite compartments. Two (2) of the four (4) compartments shall have a minimum wiring capacity of 16.4 cu in [269cu cm], one (1) compartment shall have a minimum capacity of 32.3 cu in [529cu cm], and one (1) compartment shall have a minimum capacity of 50 cu in [820cu cm]. Four (4) compartments shall have a minimum of two (2) inches of space behind the device plates. The box shall include the following number of conduit knockouts: one (1) 1/2-inch [12.7mm], three (3) 1-inch [25mm], six (6) 3/4-inch [19.1mm], and six (6) 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-7/8-inch [47.7mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics® workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
2. RFB4-CI-1 and RFB4-CI-NA Series Floor Boxes: Manufactured from cast-iron and approved for use on grade and above grade floors. The box shall be 14-1/2" L x 11-7/8" W x 3-7/16" H [368mm x 302mm x 87mm]. Provide the box with four (4) independent wiring compartments that allow capacity for up to four (4) duplex receptacles and/or communication services. The box shall permit tunneling from adjacent or opposite compartments. Two (2) of the four (4) compartments shall have a minimum wiring capacity of 27 cu in [443cu cm], and two (2) compartments shall have a minimum wiring capacity of 36 cu in [590cu cm]. Four (4) compartments shall have a minimum of two (2) inches of space behind the device plates. The box shall include the following number of conduit hubs: four (4) 1-inch [25mm] and four (4) 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-7/8-inch [48mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics® workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.

3. RFB4-SS Series Floor Boxes: Manufactured from stamped-steel and approved for use on above grade floors. The box shall be 13-5/8" L x 10" W x 2-7/16" H [346mm x 254mm x 62mm]. Provide the box with four (4) independent wiring compartments that allow capacity for up to four (4) duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments. Two (2) of the four (4) compartments shall have a minimum wiring capacity of 15.7 cu in [257cu cm] and two (2) compartments shall have a minimum wiring capacity of 31.2 cu in [511cu cm]. Four (4) compartments shall have a minimum of two (2) inches of space behind the device plates. The box shall contain the following number of conduit knockouts: two (2) 1/2-inch [12.7mm], six (6) 3/4-inch [19.1mm], and eight (8) 1-inch [25mm]. The box shall be fully adjustable, providing a maximum of 1-7/8-inch [48mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics® workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
4. RFB4E Series Floor Boxes: Manufactured from stamped steel and approved for use on above grade floors. The box shall be 13-1/8" L x 13-1/8" W x 4-1/16" H [333mm x 333mm x 103mm]. Provide the box with four (4) independent wiring compartments that allow capacity for up to four (4) duplex receptacles, communication and/or audio/video services. The box shall permit feed through removable barriers from adjacent compartments. Four (4) compartments shall have a minimum wiring capacity of 75 cu in [1230cu cm]. Four (4) compartments shall have a minimum of 3-1/2 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: six 3/4-inch [19.1mm], ten (10) 1-inch [25mm], and eight (8) 1-1/4-inch [32mm]. The box shall have two removable knockout plates that can be replaced with a 2-inch trade size conduit hub (2HUB). The box shall be fully adjustable, providing a maximum of 2-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
5. RFB4E-OG Series Floor Boxes: Manufactured from stamped steel and painted with a fusion-bonded epoxy designed for use on metal reinforcement bar and related accessories before encapsulation in concrete, and approved for use on grade and above grade floors. The box shall be 13-1/8" L x 13-1/8" W x 4-1/16" H [333mm x 333mm x 103mm]. Provide the box with four (4) independent wiring compartments that allow capacity for up to four (4) duplex receptacles, communication and/or audio/video services. The box shall permit feed through removable barriers from adjacent compartments. Four (4) compartments shall have a minimum wiring capacity of 75 cu in [1230cu cm]. Four (4) compartments shall have a minimum of 3-1/2 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: six 3/4-inch [19.1mm], ten (10) 1-inch [25mm], and eight (8) 1-1/4-inch [32mm]. The box shall have two removable knockout plates that can be replaced with a 2-inch trade size conduit hub (2HUB). The box shall be fully adjustable, providing a maximum of 2-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.

6. RFB6 Series Floor Boxes: Manufactured from stamped steel and approved for use on above grade floors. The box shall be 13-1/8" L x 12-1/2" W x 3-1/4" H [333mm x 317mm x 83mm]. Provide the box with six (6) independent wiring compartments that allow capacity for up to six (6) duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments. Two (2) of the six (6) compartments shall have a minimum wiring capacity of 23 cu in [376cu cm] and four (4) compartments shall have a minimum wiring capacity of 52cu in [850cu cm]. Four (4) of the six (6) compartments shall have a minimum of 3-1/4 inches of space behind the device plates and two (2) of the six (6) compartments shall have a minimum of 2-3/8 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: twelve 3/4-inch [19.1mm], four (4) 1-inch [25mm], and twelve 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-3/8-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
7. RFB6-OG Series Floor Boxes: Manufactured from stamped steel and painted with a fusion-bonded epoxy designed for use on metal reinforcement bar and related accessories before encapsulation in concrete, and approved for use on grade and above grade floors. The box shall be 13-1/8" L x 12-1/2" W x 3-1/4" H [333mm x 317mm x 83mm]. Provide the box with six (6) independent wiring compartments that allow capacity for up to six (6) duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments. Two (2) of the six (6) compartments shall have a minimum wiring capacity of 23 cu in [376cu cm] and four (4) compartments shall have a minimum wiring capacity of 52cu in [850cu cm]. Four (4) of the six (6) compartments shall have a minimum of 3-1/4 inches of space behind the device plates and two (2) of the six (6) compartments shall have a minimum of 2-3/8 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: twelve 3/4-inch [19.1mm], four (4) 1-inch [25mm], and twelve 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-3/8-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment.
The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
8. RFB6E Series Floor Boxes: Manufactured from stamped steel and approved for use on above grade floors. The box shall be 13-1/8" L x 12-1/2" W x 4" H [333mm x 317mm x 102mm]. Provide the box with six (6) independent wiring compartments that allow capacity for up to six (6) duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments through 1-1/4-inch grommet openings. Two (2) of the six (6) compartments shall have a minimum wiring capacity of 23 cu in [376cu cm] and four (4) compartments shall have a minimum wiring capacity of 52cu in [850cu cm]. Four (4) of the six (6) compartments shall have a minimum of 3-1/4 inches of space behind the device plates and two (2) of the six (6) compartments shall have a minimum of 2-3/8 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: twelve 3/4-inch [19.1mm], four (4) 1-inch [25mm], and twelve 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-3/8-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.

9. RFB6E-OG Series Floor Boxes: Manufactured from stamped steel and painted with a fusion-bonded epoxy designed for use on metal reinforcement bar and related accessories before encapsulation in concrete, and approved for use on grade and above grade floors. The box shall be 13-1/8" L x 12-1/2" W x 4" H [333mm x 317mm x 102mm]. Provide the box with six (6) independent wiring compartments that allow capacity for up to six (6) duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments. Two (2) of the six (6) compartments shall have a minimum wiring capacity of 23 cu in [376cu cm] and four (4) compartments shall have a minimum wiring capacity of 52cu in [850cu cm]. Four (4) of the six (6) compartments shall have a minimum of 3-1/4 inches of space behind the device plates, and two (2) of the six (6) compartments shall have a minimum of 2-3/8 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: twelve 3/4-inch [19.1mm], four (4) 1-inch [25mm], and twelve 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-3/8-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.

D. Activation Covers

1. FloorPort FPCT, FPBT, and FPFFT Series Covers: Manufactured of die-cast aluminum or die-cast zinc, and available in brushed aluminum finish and powder-coated paint finishes (black, gray, bronze, nickel and brass). Activation covers shall be available in flanged and flangeless versions. Covers shall be available with options for tile or carpet inserts, or flush covers. The cover's hinge shall allow for the cover to open 180 degrees. The furniture feed covers shall come equipped with one (1) 1-inch trade size screw plug opening and one (1) combination 1-1/4-inch and 2-inch trade size screw plug.
 - a. Flanged covers shall be 7-3/4" L x 6-9/16" W [197mm x 167mm].
 - b. Flangeless covers shall be 6-3/4" L x 5-9/16" W [171mm x 142mm].
2. 6CT, 6CTC, 6CFFTC, 8CTC, and 8CT Series Covers: Manufactured of die-cast aluminum alloy and available in powder-coated gray, black, brass, nickel or bronze finish. The covers shall be available in carpet and tile versions. Provide covers with two (2) gaskets (one (1) for carpet and one (1) for tile) to go under the trim flange to maintain scrub water tightness. The activation cover for the 8CTC and 8CT series shall be 9-1/4-inch [235mm] in diameter. The activation cover for the 6CT and 6CTC series shall be 7-1/4-inch [184mm] in diameter and the activation cover for the 6CFFTC series shall be 7-3/4-inch [197mm] in diameter. The carpet covers shall be surface mounted and the tile covers shall be flush with the finished floor covering. The covers shall have spring loaded slides to allow cables to egress out of the unit and maintain as small an egress opening as possible.
3. The covers shall have been evaluated by UL to meet the applicable U.S. and Canadian safety standards for scrub water exclusion when used on tile, terrazzo, wood, and carpet covered floors.

E. Communication Modules Mounting Accessories

1. The floor box manufacturer shall provide a complete line of faceplates and bezels to facilitate mounting of UTP, STP (150 ohm), fiber optic, coaxial, and communication devices. The box shall provide a series of device mounting plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, and other open system devices.

F. Installation

1. Strictly comply with manufacturer's installation instructions and recommendations and approved shop drawings. Coordinate installation with adjacent work to ensure proper clearances and to prevent electrical hazards.
2. Mechanical Security: Raceway systems shall be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, in accordance with manufacturer's installation sheets.
3. Accessories: Provide accessories as required for a complete installation, including insulated bushings and inserts where required by manufacturer.
4. Unused Openings: Close unused box openings using manufacturer's recommended accessories.
5. Provide a minimum concrete pour depth of 3-7/16-inch [87mm] plus 1/16-inch [1.6mm] above the top of the box for the RFB4, RFB4-4DB, RFB2, and the RFB2-OG Series Boxes; 2-7/16-inch [62mm] plus 1/16-inch [1.6mm] for the RFB4-SS and RFB2-SS Series Boxes; and 3-7/16-inch [87mm] plus 13/16-inch [21mm] above the top of the box for the RFB4-CI-1, RFB6, and RFB6-OG Series Boxes; and 4-1/16-inch [103mm] above the top of the RFB4E and RFB4E-OG Series Boxes; and 4-inch [102mm] above the top of the RFB6E and RFB6E-OG Series Boxes. Provide the box with four (4) locations to accommodate leveling for pre-concrete pour adjustment and include four (4) leveling screws for the pre-pour adjustment.

P. Poke-Through Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell.
 - b. Pass & Seymour.
 - c. Thomas & Betts Corporation.
 - d. Wiremold
 - e. Or equal
2. Poke-Thru Assembly
 - a. Floor Fitting
 - 1) The floor fitting shall consist of an insert and an activation cover. Floor fitting shall accommodate power and communications services in a single unit. Floor fitting shall have one ¾ in. trade size channel for power and one 2" trade size channel for communication cabling. Floor fitting shall consist of intumescent fire stop material to maintain the fire rating of the floor slab and UL Listed with a fire rating of 1, 1½, & 2 hours in an unprotected reinforced concrete floor or a 1 or 2 hour rating in floors employing steel floor units and concrete topping. The floor fitting shall be suitable in concrete floor thicknesses of 2.5 in. or greater. The insert shall have 12 installation barbs that will hold the poke-thru device in the floor slab without additional fasteners.
 - b. Insert Body
 - 1) The insert body shall allow the devices to be recessed 3.5-inches, or 2.25-inches with the use of 1 ¼ in. supplied stand-offs. There shall be complete separation of channels allowing for individual separation of power and communications services. There shall be one channel arranged such that communication cables can be conduit protected and connected with a 2-inch trade size openings to accept both rigid and flexible conduit connectors. The inserts shall consist of multiple compartments that allow for up to 2 duplex receptacles that can be wired in configurations including standard receptacles, isolated ground or up to 12 communication ports.

- c. Activation Cover/ Flange Assembly
 - 1) Activation covers and Flange shall be manufactured of die-cast aluminum alloy and be capable of being plated in brushed brass, satin nickel, and bronze finish, lacquer coated brushed aluminum or powder-coated in , black, finishes. Flange shall be suitable for either carpet, tile, terrazzo and wood covered floors. Flange shall include a gasket adhered to the top inside surface to maintain scrub water tightness with sub plates. Flange shall include a gasket for assembly against the floor to maintain scrub water tightness. Cover assembly shall provide a single hinged access doors that rotate 180 degrees flush with flange and incorporate foam gaskets to maintain scrub water tightness by preventing water, dirt, and debris from entering the power and communication compartment. Cover assembly shall feature cable access doors which secure to the underside of the closed cover that allow each cable access door to be opened and closed independently
- d. Communication Modules Mounting Accessories
 - 1) The poke-through manufacture shall have available modular inserts to facilitate mounting UTP (including Category 5, 5e, 6, 6a), STP, fiber optic, coaxial, and data/communications devices. The S1R6 series shall accommodate Extron MAAP or Extron AAP adapter plates. Where indicated provide connectivity outlets and modular inserts by Hubbell or approved equal.

Q. FURNITURE FEED POKE-THRU DEVICES

- 1. Poke-Through Assemblies:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Hubbell.
 - 2) Pass & Seymour.
 - 3) Thomas & Betts Corporation.
 - 4) Wiremold
 - 5) Or equal
- 2. Classification and Use: Furniture feed poke-thru devices shall have been examined and tested by Underwriters Laboratories Inc. to meet UL514A and/or UL514C and Canadian Standard C22.2, No. 18-98 and bear the U.S. and Canadian UL Listing Mark. Furniture poke-thru devices shall also have been tested by Underwriters Laboratories Inc. and Classified for fire resistance and bear the U.S. and Canadian UL Classification Mark. Poke-thru devices are approved for use in recessed and flush floor construction and meet and exceed the UL scrub water exclusion test.
 - a. Devices shall be classified for use in 1-, 1-1/2-, or 2-hour rated, unprotected reinforced concrete floors and 1-, 1-1/2-, or 2-hour rated floors employing unprotected steel floor units and concrete toppings (D900 Series designs), or concrete floors with suspended ceilings. Fire resistive designs with suspended ceilings shall have provisions for accessibility in the ceiling below the poke-thru fittings.
 - b. These devices are not suitable for wet or damp locations, or other areas subject to saturation with water or other liquids such as commercial kitchens.
 - c. Floor boxes shall be suitable for use in air handling spaces in accordance with Section 300-22(c) of the National Electrical Code.

3. MATERIALS

- a. RC7AFFTC Flush Furniture Feed Poke-Thru Assembly for power: Consists of an insert and activation cover. Overall poke-thru assembly length shall be 16-1/2 in. [419mm].
 - 1) Insert: Insert body shall have the necessary channels to provide complete separation of power and communication services. There shall be one 3/4-inch trade size channel for power and two 1/2-inch trade size channels for communication cabling. The channels shall be arranged such that communication cables can be conduit protected and connected to the insert body using a die-cast zinc conduit connector with two 1/2-inch trade size threaded openings to accept both rigid and flexible conduit connections.
 - a) The body will consist of an intumescent fire stop material to maintain the fire rating of the floor slab. The intumescent material will be held securely in place in the insert body and shall not have to be adjusted to maintain the fire rating of the unit and the floor slab. Insert shall have a spring-steel retaining ring that will hold the poke-thru device in the floor slab without additional fasteners. The poke-thru insert shall also consist of one 3/4-inch trade size conduit stub and one 1-1/2-inch trade size conduit stub that are connected to the insert body. There shall also be a 24.5 cu in [402ml] stamped steel junction box for wire splices and connections. The stamped steel junction box shall also contain the necessary means to electrically ground the poke-thru assembly.
 - 2) Activation Cover: The activation cover shall provide three conduit openings to feed modular furniture applications and provide a flush appearance. The activation cover trim flange shall be one-piece and be manufactured of forged aluminum alloy and be capable of being powder coated or plated. Coated finish is to be textured, two-stage epoxy paint in gray or black. Activation cover trim flange shall also be available in a solid brass forging and a die cast brushed aluminum finish. Aluminum and brass finish shall be a brushed finish with a lacquer sealant. The activation cover shall be seven inches [178mm] in diameter. A gasket is attached to the underside of the trim flange assembly to maintain scrub water tightness by preventing water, dirt, and dust from entering the power and communication compartments.
 - a) The activation cover insert shall provide one 3/4-inch NPSM threaded opening for power and two 1/2-inch NPSM threaded openings for communication to feed modular furniture workstations. Each activation cover shall also be supplied with one 3/4-inch trade size and two 1/2-inch trade size threaded conduit connectors and one (1/4-inch trade size and one 3/4-inch trade size and two 1/2-inch trade size conduit closure plugs.
- b. RC9AM2TC Furniture Feed Poke-Thru Assembly for data: Consists of an insert and activation cover. Overall poke-thru assembly length shall be 10 inches [254mm].
 - 1) Insert: There shall be one 2-inch trade size channel for all power or all communication cabling. The body will also consist of an intumescent fire stop material to maintain the fire rating of the floor slab. The intumescent material will be held securely in place in the insert body and shall not have to be adjusted to maintain the fire rating of the unit and the floor slab. Insert shall have a spring-steel retaining ring that will hold the poke-thru device in the floor slab without additional fasteners.

- 2) Activation Cover: The activation cover shall be manufactured of aluminum die-cast alloy and consist of a trim flange and a hexagonal service head. The activation cover shall be capable of being powder coated or plated. Finish shall be textured, two-stage epoxy paint available in a gray or black finish. A gasket is attached to the underside of the activation cover trim flange to maintain scrub water tightness. Trim flange shall have a combination 1-1/4 in. - 2 in. trade size conduit opening and closure plugs. The trim flange shall be seven inches [178mm] in diameter. All power connections must be made in a junction box below (not supplied).

R. Cleaning and Protection

1. Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer.
2. Protect boxes and fittings until acceptance.

2.7 WIRING DEVICES

A. Manufacturers:

1. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

- a. Cooper Wiring Devices.
- b. Hubbell.
- c. Leviton.
- d. Pass & Seymour.
- e. Or equal

B. Straight Blade Receptacles:

1. Duplex Receptacles: Comply with NEMA WD 1, NEMA WD 6 configuration NEMA5-20R, UL 498 and FS W-C-596. Specification grade industrial series, straight-blade, 2 pole 3 wire grounding type, back and side wired, nylon face, rated for 120 volts, 20 amperes. Hubbell No.5362 or equal. Hubbell No.5362WR or equal for weather-resistant listed receptacles. Receptacles that are controlled by an automatic control device shall be marked per NEC with the international power symbol. Provide as indicated on the drawings with one controlled face and split circuit hot tab equal to Hubbell BR20C1 series.
2. Ground fault interrupter (GFI) receptacles: Duplex receptacles conforming to UL 943, specification grade heavy duty, feed-through type, rated for 120 volt, 20 amperes, NEMA 5-20R, GFI Class "A" with a sensitivity to leakage 5 milliamps, weather-resistant and tamper-resistant listed. Hubbell No. GF20LA or equal.
3. Transient-Voltage Surge-Suppressor (TVSS) Receptacles: Duplex type, NEMA 5-20R configuration, with integral transient-voltage surge protection in a minimum of 3 modes: line-to-ground, line-to-neutral, and neutral-to-ground; listed as complying with UL 1449. Hubbell HBL5362SA or equal.
4. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Specification grade, straight-blade, 2 pole 3 wire grounding type, back and side wired. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498. Listed as tamper-resistant with "T" marking. Hubbell BR20TR or equal.
5. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498. Straight blade; equipment grounding contacts connected only to the green grounding screw terminal of the device, with inherent electrical isolation from mounting strap. Hubbell CR 5253IG or equal.

6. Duplex Receptacles with Integral USB jacks, 125 V, 20 A: Specification grade, straight-blade, 2 pole 3 wire grounding type, back and side wired. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498. "USB" marking indicates USB receptacle duplex grounding type NEMA 5-20R equal to Hubbell MX20X2 or equal
- C. All standard 15 and 20 ampere, 125 and 250 volt non-locking type receptacles located 5 ft. -6 in. or below within Auditorium, Gymnasium, Pre-schools and elementary school age classrooms, medical clinic areas, dental offices and any other areas that are listed in NEC 406.12 shall be tamper resistant type receptacles whether indicated or not by the "T" marking on the drawings.
- D. Exterior Outlets with Lockable Covers:
 1. Provide exterior outlets with lockable covers at all exterior outlet locations. Provide GFCI Circuit Breakers on all branch circuits. Provide in-use weatherproof locking covers with cord retention. Provide Taymac MX3200 for single gang vertical MX3300 for single gang horizontal and MX6200 for double duplex.
 - a. Equal manufacturers
 - 1) RACO
 - 2) Hubbell
 - 3) Or equal
- E. Hazardous (Classified) Location Receptacles:
 1. Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cooper Crouse-Hinds.
 - 2) Appleton Electric.
 - 3) Hubbell.
 - 4) KH Industries.
 - 5) Or equal
- F. Twist-Locking Receptacles:
 1. Single Convenience Receptacles, 125 V and 250 V, 20 A: Comply with NEMA WD 1, NEMA WD6 and UL 498. Hubbell HBL2310 (L5-20R), HBL2320 (L6-20R), or equal.
- G. Cord Reels
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell.
 - b. Cooper Crouse-Hinds.
 - c. Appleton Electric.
 - d. KH Industries.

2. Industrial grade retractable power cord reel with the following features:
 - a. Cast Aluminum construction, including mounting base
 - b. 12 position adjustable guide arm
 - c. Adjustable ratchet can be engaged (positive lock) or disengaged (constant tension) as needed
 - d. Adjustable ball stop
 - e. 6' Feeder Cord included
 - f. White powder-coat finish
 - g. Universal mounting overhead, wall or detached from bracket completely.
 - h. Adjustable cable stop.
 - i. Voltage 125 VAC
 - j. Slip Ring Rating 600V/30A
 - k. Payout End Blk Duplex/Duplex Outlet Box
 - l. Feeder End 5-20P
 - m. Max. Amperage 20 Amps
 - n. Gauge/Conductor 12/3
 - o. Cord Length 25 Feet
 - p. Mounting Bracket with 340 deg. pivot base.
 - q. Cord Type/Color SJO/White Cord Reel
 - r. Color White
 - s. Hubbell Model#HBLI25123GF220M1 or equal.

3. For WP Cord Reel provide as follows:
 - a. Hubbell Model#HBLW25123 or equal.
 - b. Hubbell Model#HBLPOB1 receptacle enclosure
 - c. Install two duplex receptacles in receptacle enclosure.
 - d. Provide GFCI type circuit breaker for all WP Cord Reels

H. Snap Switches:

1. Comply with NEMA WD 1 and UL 20.
 2. Switches, heavy duty, side wired, 120/277V, 20A:
 3. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way).
 - b. Hubbell; C1221 (single pole), C1222 (two pole), C1223 (three way).
 - c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way).
 - d. Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way).
- I. Securely fasten wiring devices in place, plumb, level, and true to finished lines and surfaces.
 - J. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
 - K. Provide gaskets on all wiring device plates where devices are on walls separating conditioned and non-conditioned spaces and exterior walls.
 - L. Composition material of wiring devices to be nylon with ivory finish. Outlets intended for computer use shall be grey finish, outlets on emergency shall be red finish.

M. Wall Plates:

1. Single and combination types to match corresponding wiring devices.
 - a. Plate-Securing Screws: Metal with head color to match plate finish.
 - b. Material for Finished Spaces: White- finish Type 302 stainless steel.
 - c. Material for Finished Spaces installed in concrete: Satin-finished Type 302 stainless steel.
 - d. Material for Unfinished Spaces: Galvanized steel.
 - e. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."
2. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum.

N. Finishes:

1. Color: Wiring device catalog numbers as specified do not designate device color.
 - a. Wiring Devices Connected to Normal Power System: Grey for computer circuits white for convenience receptacles other devices as selected by Architect, unless otherwise indicated or required by referenced Electrical Code or device listing.
 - b. Wiring Devices Connected to Emergency Power System: Red.
 - c. Isolated-Ground Receptacles: Orange.

2.8 LIGHTING FIXTURES

A. General

1. Submit the following in accordance with project submittal procedures:
 - a. Catalog Data: Submit catalog data describing luminaires, lamps, and ballasts. Include data substantiating that materials comply with specified requirements. Arrange data for luminaires in the order of fixture designation.
 - b. Performance Curves/Data:
 - 1) Submit certified photometric data for each type of luminaire.
 - 2) Submit supply-air, return-air, heat-removal, and sound performance data for air handling luminaires.
 - c. Drawings: Submit shop drawings for non-standard luminaires.
 - d. Calculations: Submit as requested to support equal product proposals.
 - e. Warranty: Submit warranties for luminaires and for electronic ballasts.
2. All lamps, ballasts, led sources, drivers, and controls shall meet the latest utility company incentive requirements. Refer to the latest program requirements documentation and coordinate with the utility company to ensure compliance.

B. Quality Assurance

1. Comply with the National Electrical Code (NEC) and the Massachusetts Building Code (MBC) for components and installation.

2. Provide luminaires listed and labeled by a nationally recognized testing laboratory (NRTL) for the application, installation condition, and the environments in which installed.
3. Use manufacturers that are experienced in manufacturing luminaires, lamps and ballasts similar to those indicated for this Project and have a record of successful in-service performance.
4. Coordinate luminaires, mounting hardware and trim with the ceiling system.

C. Lamps

1. Furnish lamps that comply with requirements specified below and the luminaire schedule on the Drawings.

D. LED Assemblies

1. LED luminaires shall conform to UL 1598 and to UL 8250 – Safety Standard for Light-Emitting Diode (LED) Light Sources for Use in Lighting Products.
2. Products shall be lead and mercury free.
3. Photometric characteristics shall be established using IESNA LM-79-08, IESNA Approved Method for the Electrical and Photometric Measurement of Solid-State Lighting Products.
4. Color characteristics of LED luminaires shall be as follows in accordance with ANSI C78.377 – Specifications for the Chromaticity of Solid State Lighting Products.
5. LED and driver cooling system shall be passive and shall resist the buildup of debris.
6. LED luminaire output after 50,000 hours of operation shall be not less than 70 percent of the initial lumen output when determined in accordance with IESNA LM-80-08 – IESNA approved Method for Measuring Lumen Maintenance of LED Lighting Sources.
7. LED source package electrical characteristics:
 - a. Supply voltage: 120 V, 208 V, 240 V, 277 V, or 480 V as indicated on the Drawings. Provide step-down transformers if required to match driver input voltage rating.
 - b. Total harmonic distortion (current): Not more than 10 percent
 - c. Power factor: Not less than 90 percent
 - d. RF interference: Meet FCC 47 CFR Part 15/18
 - e. Transient protection: IEEE C62.41 Class A.
8. All LED Assemblies shall be provided by Osram, Phillips, GE, or equal.

E. Extra Materials

1. Furnish the following extra materials matching products installed. Package with protective covering for storage and identify with labels describing contents.
 - a. Five percent of quantity of LED source packages of each type, but no fewer than two of each type.
 - b. One percent of quantity of louvers and lenses of each type, but not less than two of each type.
 - c. Five percent of quantity of LED drivers of each type, but not less than two of each type.
 - d. Ten percent of single faced exit signs, but no fewer than ten. Include 100' of type MC cable branch circuiting and installation labor.
 - e. Ten percent of double faced exit signs, but no fewer than five. Include 100' of type MC cable branch circuiting and installation labor.

F. Interior General:

1. Furnish interior luminaries that comply with requirements specified below, indicated on the Drawings to meet conditions of installation.
2. Metal parts shall be free from burrs and sharp corners and edges.
3. Metal components shall be formed and supported to prevent sagging and warping.
4. Steel parts shall be finished with manufacturer's standard finish applied over a corrosion-resistant primer. Finish shall be free from runs, streaks, stains, holidays or defects.
5. Doors and frames shall be smooth operating and free from light leakage under operating conditions. Relamping shall be possible without the use of tools. Doors, frames, lenses and diffusers shall be designed to prevent accidental falling during relamping and when secured in the operating position.
6. Luminaires shall have minimum reflecting surface reflectance as follows unless specified otherwise on the Drawings:
 - a. White Surfaces: 85 percent
 - b. Specular Surfaces: 83 percent
 - c. Diffusing Specular Surfaces: 75 percent
7. Lenses, diffusers, covers and globes shall be 100 percent virgin acrylic unless specified otherwise on the Drawings. Lenses shall have 0.125 inch minimum thickness. Lenses for troffers shall be injection molded.
8. Luminaires shall conform to UL 1598 - *Luminaires*. Provide product with damp location listing or wet location listing by installation location.

G. Interior Accessories

1. Provide stud supports, mounting brackets, frames, plaster rings and other accessories required for luminaire installation.
2. Furnish hangers as specified below by conditions of installation:
 - a. Stem hangers shall be made of 1/2-inch steel tubing with 45 degrees swivel ball hanger fitting and ceiling canopy. Finish the same as the luminaire.
 - b. Rod hangers shall be made of 1/4 inch threaded zinc-plated steel rod.
3. Use NRTL-listed T-bar safety clips for lay-in luminaires.

H. Interior Installation

1. Install interior lighting system in accordance with the NEC, manufacturer's installation instructions, approved shop drawings, and NECA National Electrical Installation Standards.
2. Have the manufacturer's installation instructions available at the Project site.
3. Mounting heights specified or indicated on the Drawings are to the bottom of the luminaire for ceiling-mounted fixtures and to the center of the luminaire for wall-mounted fixtures.
4. Where the ceiling forms the protective membrane of a fire resistive assembly, install protective coverings over luminaires in accordance with NRTL requirements.
5. Install slack safety wires as described below for luminaires in or on suspended ceilings.
 - a. Wire shall be minimum 12 gage galvanized soft annealed steel wire conforming to ASTM A641.
 - b. Attach wire to the building structure directly above the attachment point on the box or luminaire; make trapezes of framing channel material to span obstacles

- c. Secure wire(s) at each end with not less than three tight turns in 1-1/2 inch.
 - 6. Support pendant-mounted or cable-supported luminaires directly from the structure above using a 9 gage wire or an approved alternate support without using the ceiling suspension system for direct support.
 - a. Install seismic restraints for pendant-mounted and cable-supported luminaires.
 - b. Pendants, rods, cables, or chains 4 ft or longer shall be braced to prevent swaying using three cables at 120 degrees separation.
 - 7. Connect luminaires in suspended ceilings using 6 ft. lengths of flexible wiring method arranged accommodate not less than 4 inch of differential seismic movement in any direction.
- I. Interior Quality Control
- 1. Make electrical connections, clean interiors and exteriors of luminaires, install lamps, energize and test luminaires, inspect interior lighting system, and deliver spare parts in accordance with manufacturer's instructions and NECA National Electrical Installation Standards:
 - 2. Test electronic dimming ballasts for full range dimming capability.
 - a. Check for visually detectable flicker over the full dimming range.
 - 3. Prior to turnover to Owner, replace lamps that were installed and used during construction if more than 15 percent of their rated lamp life has been used.
- J. Exterior - General
- 1. Furnish exterior luminaires that comply with requirements specified in this Section and in the luminaire schedule on the Drawings.
 - 2. Luminaire photometric characteristics shall be based on IESNA approved methods for photometric measurements performed by a recognized photometric laboratory.
 - 3. Luminaire housing shall be primarily metal.
 - a. Metal parts shall be free from burrs and sharp corners and edges.
 - b. Sheet metal components shall be fabricated from corrosion-resistant aluminum, formed and supported to prevent sagging and warping.
 - c. Exposed fasteners shall be stainless steel.
 - 4. Doors and frames shall be smooth operating and free from light leakage under operating conditions.
 - a. Relamping shall be possible without the use of special tools.
 - b. Doors, frames, lenses and diffusers shall be designed to prevent accidental falling during relamping and when secured in the operating position.
 - c. Door shall be removable for cleaning or replacing lens.
 - 5. Luminaires shall have minimum reflecting surface reflectance as follows unless scheduled otherwise:
 - a. White surfaces: 85 percent
 - b. Specular surfaces: 83 percent
 - c. Diffusing specular surfaces: 75 percent

6. Provide lenses, diffusers, covers and globes as scheduled on the Drawings fabricated from materials that are UV stabilized to be resistant to yellowing and other changes due to aging or exposure to heat and ultraviolet radiation.
7. Doors shall have resilient gaskets that are heat-resistant and aging-resistant to seal and cushion lens and refractor.

K. Exterior Poles and Accessories

1. Furnish poles and accessories that comply with requirements specified in this Section and the luminaire schedule on the Drawings.
2. Pole, base, and anchorage shall carry the luminaires, supports, and appurtenances at the indicated height above grade without deflection or whipping.
3. Mountings, fastenings and other appurtenances shall be fabricated from corrosion-resistant materials that are compatible with poles and luminaires and will not cause galvanic action at contact points. Mountings shall correctly position luminaires to provide scheduled light distribution.
4. A reinforced access handhole shall be located in the wall of each metal pole.
5. A welded 1/2 inch grounding lug shall be accessible through the handhole of each metal pole. Grounding connection shall be designed to prevent electrolysis when used with copper ground wire.
6. Metal poles shall have anchor type bases and galvanized steel anchor bolts and leveling nuts.
7. Metal poles shall have a metal base cover that covers the entire base plate and anchorage.
8. Protect painted, anodized, or brushed pole finishes during shipment and installation. Minimum protection shall consist of spirally wrapping each pole shaft with protective paper secured with tape, and shipping small parts in boxes.
9. Aluminum poles shall be fabricated from corrosion resistant aluminum Alloy 6063-T6 or Alloy 6005-T5 for wrought alloys or Alloy 356-T4 for cast alloys.
 - a. Poles shall be square or round, tapered or straight as indicated on the Drawings.
 - b. Aluminum poles over 30 feet tall shall include factory-installed vibration dampers.
 - c. Poles shall be seamless extruded or spun seamless type with minimum 0.188 inch wall thickness.
 - d. Tops of shafts shall be fitted with a round or tapered cover.
 - e. Base shall be anchor bolt mounted, made of cast 356-T6 aluminum alloy in accordance with ASTM B 108/B 108M, Standard Specification for Aluminum-Alloy Permanent Mold Castings and shall be machined to receive the lower end of shaft. Joint between shaft and base shall be welded.
 - f. Hardware, except anchor bolts, shall be either 2024-T4 anodized aluminum alloy or stainless steel.
10. The poles EPA capacity shall meet the wind rating in the geographical area in which its installed. Refer to AASHTO wind map and provide appropriate wind rating with the paired light fixture. Wind rating shall be a minimum of 100MPH with 130MPH gust rating.
11. Anchor bolts shall be steel rod having minimum yield strength of 50,000 psi. The top 12 inch of the anchor bolt shall be galvanized in accordance with ASTM A153/A153M.
12. Manufacturers: Subject to compliance with requirements, provide products as scheduled or specified on the Drawings.
13. Fuses and Fuse holders
 - a. Furnish fuse overcurrent protection for each pole-mounted luminaire to isolate faulted ballasts from the lighting circuit.
 - b. Use 600 volt, Class CC, time-delay, current-limiting fuses.

- c. Select fuses rated between 200 percent and 300 percent of the luminaire ballast or driver maximum current.
 - d. Manufacturer: Bussman "LP-CC" or approved equal.
- 14. Furnish in-line fuse holders for installation in pole hand hole or transformer base.
 - a. Use non-breakaway type fuse holders unless breakaway poles are indicated on the Drawings.
 - b. Use breakaway type fuse holders where breakaway poles are indicated on the Drawings.
 - c. Load and line terminal sizes and types shall correspond to line and load conductor sizes and quantities.
 - d. Both breakaway and non-breakaway fuse holders shall have insulating boots.
 - e. Manufacturers: Ferraz Shawmut "FEC" for phase conductor(s), "FEBN" for neutral conductor, or approved equal.
- L. Exterior Installation
 - 1. Install products in accordance with manufacturer's instructions, NECA/IESNA 501, and approved shop drawings.
 - 2. Locations of luminaires and poles shown on the Drawings are diagrammatic. Coordinate luminaire locations with building finishes, building structure, paving and striping, utility piping, security fences, and existing trees. Obtain approval for location changes through LANL Subcontract Technical Representative (STR).
 - 3. Set poles and luminaires plumb, square, level and secure.
 - 4. Install surface mounted luminaires directly to an outlet box which is supported from structure.
 - 5. Install in-grade luminaires flush with surrounding surface. Coordinate pitch or grading of surface with Construction Manager to allow drainage away from fixture.
 - 6. Install lamps in luminaires in accordance with manufacturer's instructions.
 - 7. Pre-cast Concrete Foundations:
 - a. Concrete shall be a minimum of 5,000 psi after 28 days.
 - b. Electrical SubContractor shall coordinate conduit requirements, anchor bolt pattern, bolt projection, and approved light pole base including bolt covers with approved light pole prior to release of pre-cast base.
 - c. Base shape shall match pole shape and shall be a minimum of 18 in. or 2 in. larger than pole base bolt covers.
 - d. Comply with details on electrical drawings for dimensions, reveal above grade, and reinforcing.
 - e. Provide Shea concrete products or equal.
 - 8. Pole Erection
 - a. Do not install poles without luminaires.
 - b. Use fabric web slings to raise and set poles.
 - c. Use leveling nuts or shims to make poles plumb. When leveling nuts are used, set the lower nuts not more than 1 inch from the concrete foundation.
 - d. Tighten anchor bolt nuts and other pole hardware to torque recommended by manufacturer.
 - e. After pole is leveled, pack non-shrink grout between anchor base and concrete foundation to provide a full bearing surface. Use a short piece of 1/2-inch diameter pipe to make a drain hole through grout; arrange to drain condensation from interior of pole.

- f. Set embedded poles to depth indicated on the Drawings, but not less than 1/6 of pole length below finish grade.
- g. Auger holes large enough to permit the use of tampers the full depth of the hole.
- h. Backfill in 6 inch layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of the undisturbed earth.

2.9 ELECTRICAL POWER EQUIPMENT

A. Motor Controls - Manual and Magnetic:

- 1. Individually-mounted magnetic starters shall be NEMA rated across-the-line type with thermal overload on each phase, single-speed, two-speed, or reduced voltage start as indicated.
- 2. Motor Starters shall be furnished by Electrical Sub-Contractor unless part of package mechanical equipment such as rooftop units.
- 3. Starters shall be of maintained contact type, of size and type required for particular motor horsepower and voltage. Minimum size starter to be size 1 FVNR, unless noted otherwise.
 - a. Starters shall have OL reset button, green push-to-test type pilot light to indicate "ON", and "HAND-OFF-AUTO" switch in cover.
 - b. Starters to have 120 volt control transformers with fused output being provided for those units operating on 277/480 volt system.
 - c. Provide Class 20 fixed heater overloads with auto/manual reset.
 - d. Provide four (4) sets of auxiliary contacts of convertible type N.O. to N.C. for each starter.
 - e. Motor starters shall have NEMA I enclosures. Those in wet locations shall be NEMA 3R.
 - f. Manufacturers:
 - 1) Westinghouse
 - 2) Square D/Groupe Schneider
 - 3) Siemens
 - 4) Allen Bradley
 - 5) General Electric
 - 6) Or equal
- 4. Manual motor starters shall have pilot lights and shall be furnished with thermal overloads on each phase.

B. Motors: Each motor shall have disconnect switch and starter provided under this section.

- 1. Provide motor terminal boxes for each motor not furnished with same.

C. Disconnect Switches:

- 1. Disconnect (safety) switches shall conform to industrial standards of NEMA, be UL listed and shall be heavy duty type, quick-make, quick-break type with interlocking cover mechanism and provisions for padlocking switch handle in "OFF" position. Three pole toggle switches are not acceptable as substitute for disconnect switches.

2. Disconnect switches shall be of fused or unfused type as indicated with number of disconnecting poles indicated. The grounded conductor shall not be switched. Switches for use with current limiting fuses shall be rejection type and those used in conjunction with motors shall be horsepower rated. Provide oversize termination lugs if required by conductor size.
3. Enclosures shall be of proper NEMA type for intended location and shall be phosphate coated or equivalent code gauge galvanized sheet steel with ANSI #24 dark gray baked enamel finish.
4. Manufacturers:
 - a. Westinghouse
 - b. Square D/Groupe Schneider
 - c. Siemens
 - d. Allen Bradley
 - e. Or equal

D. Fuses:

1. Provide a complete set of fuses for each item of fusible type equipment.
2. Turn over to authorized representative of Owner upon completion a spare set of fuses of each different type and ampere rating installed. These spares shall be bound with twine and tagged.
3. Secondary system fuses, rated at 600 volts or less, shall be UL listed and constructed in conformance with the applicable standards set forth by NEMA and ANSI. All fuses of a particular class shall be of same manufacturer.
4. All fuses in distribution panelboards and switchboards shall be class "L" above 600 amperes and class "RK1" for 600 amperes and below.
5. Main, Feeder, and Branch Circuits:
 - a. Circuits 601 amperes and above shall be protected by (Bussmann type KRP-C LOW-PEAK) current limiting time delay fuses.
 - b. Circuits 0-600 amperes shall be protected by (Bussmann "LOW-PEAK" dual element), time delay current limiting fuses, LPN-RK (250 volts), LPS-RK (600 volts), UL class RK-1.
6. Manufacturers:
 - a. Bussmann, Division of McGraw
 - b. Gould/Shawmut
 - c. GEC-ALSTHOM
 - d. Or equal

2.10 ELECTRICAL SYSTEM CONTROLS AND INSTRUMENTS

- A. Provide a complete power system consisting of branch circuits, motor disconnect switches, pushbutton stations, motor starters, and other devices to connect up and leave in operating condition each piece of electrically operated equipment provided either under this section or other Divisions.
- B. All control wiring, not indicated in the electrical specifications or not shown on electrical drawings, will be provided by Temperature Control Subcontractor.

2.11 GROUNDING SYSTEM

- A. All equipment and systems shall be grounded. Refer especially to NEC Section 250 Requiring Connections to Building Steel, Foundation, Water Service, and Interior Piping. Provide transformer pad grounding in accordance with utility company standards.
- B. The grounded conductor shall be supplemented by an equipment grounding system.
- C. The equipment grounding system shall be installed so all conductive items in close proximity to electrical circuits operate continuously at ground potential and provide a low impedance path for ground fault currents.
- D. Grounding conductors shall be so installed as to permit shortest and most direct path to ground.
- E. Maximum measured resistance to ground of 5.0 ohms shall not be exceeded. Ground separately derived systems (dry type transformers) in accordance with Article 250-30 by grounding neutral to transformer ground lug and providing insulated grounding electrode conductor to nearest effectively grounded building steel or, if unavailable, to nearest available effectively grounded metal water pipe.
- F. Equipment grounding conductors and straps shall be sized in compliance with Code Table 250-122.
- G. Grounding conductors shall be insulated with green color. Grounding conductors for use on isolated ground receptacles shall be green with trace color to differentiate between normal ground conductors.
- H. Branch circuits shall consist of phase and grounded conductor installed in common metallic raceway. All receptacle circuits shall have dedicated neutrals. All circuits shall have a separate insulated grounding conductor installed. Any flexible cable system or non-metallic raceway system shall have an insulated grounding conductor. Any cable system for use on isolated ground circuits shall have both an isolated ground conductor as well as an equipment ground conductor, both of which shall be insulated.
- I. Each electrical expansion fitting shall be furnished with a bonding jumper. Provide grounding bushings and ground connections for all raceways terminating below equipment where there is no metal-to-metal continuity.
- J. Continuity between all metallic and nonmetallic raceway systems and equipment shall be maintained.
- K. Outdoor lighting fixtures shall be grounded and bonded in common with building system via a separate grounding conductor.
- L. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- M. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

- N. Ground Rods: Drive rods until tops at least 6 inches below finished floor or final grade, unless otherwise indicated. Interconnect ground rods with grounding electrode conductor below grade.
- O. Dry type transformer: Install an insulated grounding conductor from a transformer neutral to the building steel by means of copper wire, as scheduled on the drawings.
- P. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors in conduit, from a grounding bus of the building's main service equipment to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 - 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- Q. Refer to Technology Specifications for additional grounding requirements.
- R. Refer to Motorola R56 for communications systems grounding requirements.

2.12 MAIN BUILDING SWITCHBOARD

- A. Main building switchboard shall be constructed in accordance with UL 891 and ANSI standards and of the required number of vertical sections bolted together to form one metal enclosed rigid structure. The sides, top, and rear shall be covered with removable plates. Switchboard shall include all protective services and equipment as listed on drawings with necessary interconnections, instrumentation, and control wiring. Buses shall be copper. Provide oversize termination lugs for any terminations requiring same due to conductor sizing.
- B. Record drawings shall be furnished providing the following: Complete rating, short-circuit withstand ability of bus and of lowest rated device, overall outline dimensions, including space available for raceways, circuit schedule showing circuit number, device description, device fuse clip ampere rating, conductor ratings and one-line diagram with each circuit device numbered.
- C. Each section shall be 90 in. high, self-supported, and same depth as incoming line section, approximately 36 in. deep. Main protective device shall be individually mounted with front coverplate and bus connection straps. Where called for on schedule, "space" shall mean to include necessary bus, supports, and connections, leaving out only the breaker itself. Bus structure shall be arranged to permit future additions.
- D. Switchboard shall be arranged for operation as follows:
 - 1. Voltage - 480Y/277 volts
 - 2. Frequency - 60 cycles
 - 3. Service - 3 phase, 4 wire, ampere capacity as indicated on drawings.
 - 4. Neutral - full capacity
 - 5. Available short circuit current at line terminals - 65,000 RMS amperes symmetrical.
 - 6. Integrated equipment rating - 65,000 AIC
 - 7. Copper ground bus, full length
 - 8. UL service entrance label

- E. Provide electrical metering and voltage protection system equal to Square D Power Logic, Westinghouse IQ Data Plus or Siemens 4900 Series at main breaker. Coordinate Baud rate for meter with BMS system to ensure compatibility for communication.
- F. Main service entrance device shall be an insulated-case circuit breaker (ICCB): Rating as shown on drawings, 100 percent rated, sealed circuit breaker with interrupting capacity rating to meet available fault current.
 - 1. Fixed circuit-breaker mounting.
 - 2. Two-step, stored-energy closing.
 - 3. Microprocessor-based trip unit with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
 - 4. Instantaneous trip.
 - 5. Long- and short-time time pick-up and time delay adjustments.
 - 6. Ground-fault pickup level, time delay, and I2t response.
 - 7. Safety features: Phase loss protection.
 - 8. Provide maintenance mode arc flash reduction feature on main circuit breaker.
- G. Branch Devices shall be standard molded case circuit breakers, current limiting circuit breakers, or other devices as scheduled. Branch devices shall be mounted in panelboard type construction.
- H. Switchboard feeder protective devices shall be molded case circuit breakers. The circuit breakers 250 amperes and larger shall be with a solid-state trip, all other circuit breakers shall be of thermal-magnetic type. Breakers shall be built, tested, and labeled in accordance with UL 489.
- I. Include space and provisions for utility company metering. Refer to electric service section of this Division.
- J. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits.
 - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - 3. Electronic trip circuit breakers with field-replaceable rating plug and the following field-adjustable settings:
 - 4. Instantaneous trip.
 - 5. Long- and short-time pickup levels.
 - 6. Long- and short-time time adjustments.
 - 7. Ground-fault pickup level, time delay, and I2t response.
 - 8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - 9. Standard frame sizes, trip ratings, and number of poles.
 - 10. Lugs: Suitable for number, size, trip ratings, and conductor material.
 - 11. Application Listing: Type HACR for heating, air conditioning and refrigeration equipment power feeders.
 - 12. Shunt Trip: 120-V trip coil energized from separate circuit, where shown on the drawings.
- K. Acceptable Manufacturers: Square D is the Basis of Design.
 - 1. Square D/Groupe Schneider

2. Cutler-Hammer/Westinghouse
 3. Siemens
 4. Or equal
- L. Quick-Connect Generator Switchboard Sections
1. Summary
 - a. Scope: Provide design and engineering, labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, erection, and installation for Quick-Connect Generator switchboards as required for the complete performance of the work, and as shown on the Drawings and as herein specified.
 2. Standards: Comply with applicable requirements of the following standards:
 - a. NEMA PB 2.
 - b. NEC.
 - c. NFPA 70B.
 - d. NFPA 70E.
 - e. UL 98.
 - f. UL 489.
 - g. UL 891.
 - h. UL 943.
 - i. FS W-C-375.
 3. Basis of Design: Products specified shall be manufactured by Square D by Schneider Electric, or equal. Items specified are to establish a standard of quality for design, function, materials, and appearance. Equivalent products by other manufacturers are acceptable.
 4. Front Accessible, Quick-Connect Switchboard: Provide fixed, individually mounted main circuit breaker, incoming cable compartment, and outgoing load connection compartment.
 5. Nominal System Voltage: Nominal system voltage shall be 480Y/277 volts.
 6. Main Bus Continuous: Provide 2500 ampere rating.
 7. Short Circuit Current Rating: 65 kA or as indicated on the plans.
 8. Enclosure: Provide steel enclosure, in compliance with UL 891, Type 1.
 9. Enclosure Finish: Provide factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
 10. Buses and Connections: Three phase, four wire. Provide hard-drawn plated copper of 98 percent conductivity.
 - a. Ground Bus: Size per current NEC and UL 891 Tables 28.1 and 28.2, hard-drawn copper of 98 percent conductivity.
 - b. Bus Composition: Plated copper. Plating shall be applied continuously to bus work. The switchboard bussing shall be of sufficient cross-sectional area to meet UL 891 temperature rise requirements. The phase and neutral through-bus shall have an ampacity as shown on the Drawings. For four-wire systems, the neutral shall be of equivalent ampacity as the phase bus bar. Tapered bus is not permitted. Full provisions for the addition of future sections shall be provided. Bussing shall include, but shall not be limited to, necessary hardware to accommodate splicing for future additions.
 11. Generator Breaker compartment Breaker Type:
 - a. The generator circuit breaker compartment shall contain a UL Service Entrance (ULSE) approved, Square D brand [Powerpact R-Frame electronic trip circuit breaker] serving as the generator disconnect. The generator circuit breaker shall be key-interlocked with the main circuit breaker in the main switchboard line-up, as shown on the drawings.
 - b. The generator breaker compartment shall have an easy to follow "Sequence of Operations" instructions on an engraved nameplate, permanently attached to the front cover of the compartment

- c. The generator breaker shall have GFCI protection.
- 12. Incoming Quick Connect Compartment
 - a. The incoming quick connect compartment shall provide [both] lugs, suitable for connecting type W welding cable, [and Hubbell quick connect receptacles]. The quick connect compartment shall have removable covers to reduce the risk of damaging the temporary generator cables.
- 13. Outgoing Load Connection Compartment
 - a. The outgoing load connection compartment shall contain [through bus] [lugs] to connect to the main switchboard.
- 14. Multifunction Digital Metering Monitor: Where indicated, microprocessor-based unit suitable for three-wire or four-wire systems and with the following features:
 - a. Digital Display: Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - 1) Phase Currents, Each Phase: ± 1 percent.
 - 2) Phase-to-Phase Voltages, Three-Phase: ± 1 percent.
 - 3) Phase-to-Neutral Voltages, Three-Phase: ± 1 percent.
 - 4) Megawatts: ± 2 percent.
 - 5) Megavars: ± 2 percent.
 - 6) Power Factor: ± 2 percent.
 - 7) Frequency: ± 0.5 percent.
 - 8) Megawatt Demand: ± 2 percent; demand interval programmable from 5 to 60 minutes.
 - 9) Accumulated Energy, Megawatt Hours: ± 2 percent. Accumulated values unaffected by power outages up to 72 hours.
 - 10) Watt-Hour Meters: Flush or semiflush type, rated 5 amperes, 120 volts, three-phase, three-wire, with three elements, 15 minute-indicating-demand register, and provision for testing and adding pulse initiation.
 - 11) Recording Demand Meter: Usable as totalizing relay or as indicating and recording maximum demand meter with 15-minute interval. Meter shall count and control a succession of pulses entering two channels.
 - b. Mounting: Display and control unit flush or semi-flush mounted in instrument compartment or main device door.
- 15. General: Preparation and installation shall be in accordance with reviewed product data, final shop drawings, manufacturer's written recommendations, and as indicated on the Drawings.
 - a. Install switchboards and accessories according to NEMA PB 2.1 and NECA 400.
 - b. Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
 - c. Frame and mount the printed basic operating instructions for switchboards, including, but not limited to, control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
 - d. Install overcurrent protective devices, surge protective devices, and instrumentation.
 - e. Set field-adjustable switches and circuit breaker trip ranges.

2.13 PANELBOARDS

- A. Panelboards shall be dead-front, door in door safety type equipped with single or multi-pole circuit breakers suitable for 120/208 volt or 277/480 volt, 3 phase, 4 wire operation.

- B. Buses shall be copper. Panelboards shall have a circuit directory card mounted in a frame with plastic cover on inside of door. Panelboards to have a copper ground bus with terminals for each circuit. Panelboards serving isolated ground receptacles shall have a separate ground bus for terminations of the isolated grounds. The isolated ground bus shall be mounted to the panel tub via non-conducting means with a separate grounding conductor run to the normal panel ground bus. Provide oversize lugs for any termination requiring same due to oversize conductors. Provide 200% neutral buses on all 120/208 volt panelboards.
- C. Cabinets shall be minimum of 20 inch wide and be made of code gauge steel. Surface type shall be ordered without knockouts.
- D. Trims shall be made of code gauge steel, surface or flush as indicated. Panelboards shall be keyed alike. Trims shall be provided with full length piano hinge on one side, and secured to tub with sufficient quantity of latches opposite the hinge side to allow trim to fit flush with tub and when released, allow full access to wiring gutters. Inner door shall allow access to circuit breakers only.
- E. Panelboards shall be of the following types with minimum circuit breaker frame sizes listed below. Refer to schedules for larger circuit breaker frame sizes due to fault current availability. Square D is the Basis of Design.
1. 120/208 volt, three phase, four wire. Symmetrical interrupting capacity 10,000 AIC.
Style

Westinghouse type PRL-1	BAB Breakers (bolt-on)
Square D type NQOD	QOB Breakers (bolt-on)
Siemens type CDP-7	BQ Breakers (bolt-on)

Or equal
 2. 277/480 volt, three phase, four wire. Symmetrical interrupting capacity 42,000 AIC (series rated).
Style

Westinghouse type PRL-2	GHB Breakers (bolt-on)
Square D type NEHB	EHB Breakers (bolt-on)
Siemens type CDP-7	BQCH Breakers (bolt-on)

Or equal
 3. Distribution Panels:
 - a. Where scheduled as circuit breaker type, symmetrical interrupting capacity 65,000 AIC (series rated).
 - b. Westinghouse type PRL-3
 - c. Square D I-Line type
 - d. Siemens SPP
 - e. Or equal

	FD Breakers
	FA Breakers
	FXD6 Breakers

- F. Panelboards and distribution panels shall be of same manufacturer as switchboard. Refer to drawings where higher interrupting are required.
- G. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 150 A and larger.
 - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - 3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - 4. Instantaneous trip.
 - 5. Long- and short-time pickup levels.
 - 6. Long- and short-time time adjustments.
 - 7. Ground-fault pickup level, time delay, and I²t response.
 - 8. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (5-mA trip).
 - 9. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 - 10. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
- H. All power panels fed from K-13 transformers shall have surge protection. Coordination and Arc flash study shall be submitted with shop drawing submittal. All circuit breaker selection shall meet study recommendations and shall be provided as recommended by study.
- I. Electrical Sub-contractor shall provide infrared scanning of all panelboards after three months past substantial completion. Provide report indicating status of all terminations at respective panelboards per phase.

2.14 ELECTRIC SERVICE

- A. Coordinate and cooperate with Eversource, hereinafter called utility company, with respect to providing service and metering.
- B. Provide all primary system raceways, elbows, pull wires and all pad grounding. Utility company will provide pad mounted transformer and primary conductors including making up of all terminations and connections.
- C. Provide secondary service complete including all conductors, raceways, and connectors at transformer. Provide oversize lugs if required due to conductor sizing. Attachment of secondary conductors to the transformer terminals will be done by the electrical contractor.
- D. General Trades Contractor will do all excavation and back filling in accordance with utility company standards and will install the pre-cast transformer pad furnished by the E.C.
- E. All work to be done in accordance with utility company standards.
- F. Metering: All usage will be on one secondary meter. Utility Company will furnish current transformers and potential transformers to be installed in switchboard C.T. cabinet. Provide meter socket per utility company standards. Meter will be by the Utility Co. Metering will be cold Sequence per utility co. E.C. shall provide Main breaker ahead of C.T. cabinet.

2.15 DRY TYPE TRANSFORMERS

A. TRANSFORMER SPECIFICATION

1. Compatibility: This product must facilitate the ability of the electrical system to supply a sinusoidal voltage in order to improve the long-term compatibility of the electrical system with all types of linear and nonlinear connected loads today and in the future. All national and international standards on harmonics and power quality set limits on levels of voltage distortion to maintain compatibility.
2. Copper-wound, 3-phase, common core, ventilated, dry-type, isolation transformer built to NEMA ST20 and relevant NEMA, UL and IEEE standards; 200 percent rated neutral; 60Hz rated; Transformers 750 kVA and less, 600 volt primary and less, shall be U.L. and CSA Listed and bear the label. All terminals, including those for changing taps, must be readily accessible by removing a front cover plate. Windings shall be continuous with terminations brazed or welded. 10kV BIL.
3. Insulation System:
 - a. Shall be NOMEX-based with an Epoxy Co-polymer impregnant for lowest environmental impact, long term reliability and long life expectancy
 - b. Class: 220 degrees C
 - c. Impregnant Properties for low emissions during manufacturing, highest reliability and life expectancy
 - d. Epoxy co-polymer
 - e. VOC: less than 1.65 lbs/gal (low emissions during manufacturing)
 - f. Water absorption (24hrs @25C): less than 0.05 percent (superior insulation, longer life)
 - g. Chemical Resistance: Must have documented excellent performance rating by supplier
 - h. Dielectric Strength: minimum of 3200 volts/mil dry (for superior stress, overvoltage tolerance)
 - i. Dissipation Factor: max. 0.02 @25C to reduce aging of insulation, extending useful life
4. Operating Temperature Rise: 130 degree C in a 40 degree C maximum ambient
5. Noise levels:
 - a. Per NEMA ST-20
 - b. Production Test every unit. Data to be available upon request.
6. UL Listed and Labeled K-Rating: K-7 or higher
7. Maximum No Load Losses
 - a. Transformers are energized 24 hours a day for their entire life, potentially 40 years or more. These losses are incurred whether the transformer is loaded or not, and cost the user many times the purchase price of the transformer even at current energy rates.
 - b. No load losses shall not exceed: 15kVA: 60W, 30kVA: 99W, 45kVA: 130W, 75kVA: 180W, 112.5kVA: 260W, 150kVA: 330W, 225kVA: 450W, 300kVA: 560W, 500kVA: 850W

8. Efficiency at 35 percent loading
 - a. Data shows that transformers are typically very lightly loaded for extended periods of time, therefore to minimize operating cost under real world loading conditions, efficiency at 1/6 loading shall be maximized.
 - b. Efficiency at 35% load shall meet or exceed: 15kVA: 89 percent, 30kVA: 98.23 percent, 45kVA: 98.40 percent, 75kVA: 98.6 percent, 112.5kVA: 98.74 percent, 150kVA: 98.83 percent, 225kVA: 98.94 percent, 300kVA: 99.02 percent, 500kVA: 99.14 percent, 750kVA: 99.23 percent
9. Voltage Taps: For transformers 30kVA-300kVA, provide two 2-1/2 percent full capacity taps above and below nominal primary voltage. For transformers 15kVA and smaller as well as 500kVA and larger provide one 5 percent full capacity tap above and below nominal primary voltage.
10. Impedance: Between 3.5 percent and 5.8 percent unless otherwise noted.
11. Enclosure type: Ventilated NEMA 2, drip-proof
12. Maximum Footprint for 130 degree C rise model in a NEMA 1 enclosure:
 - a. 17 in. Wide x 17 in. Deep x 27 in. High for 15kVA.
 - b. 26 in. Wide x 18 in. Deep x 30 in. High for 30kVA, 45kVA
 - c. 33 in. Wide x 22 in. Deep x 40 in. High for 75kVA, 112.5kVA
 - d. 38 in. Wide x 28 in. Deep x 52 in. High for 150kVA
 - e. 38 in. Wide x 32 in. Deep x 52 in. High for 225kVA, 300kVA
 - f. 52 in. Wide x 38 in. Deep x 61 in. High for 500kVA
 - g. 63 in. Wide x 46 in. Deep x 67 in. High for 750kVA

B. TRANSFORMER FEATURES

1. Electrostatic Shield: Each winding shall be independently single shielded with a full-width copper electrostatic shield.
2. All transformers shall meet Department of Energy 2016 efficiency standards.

C. ACCEPTABLE MANUFACTURERS

1. Powersmiths International Corp., General Electric, Eaton, Square D, ACME, Jefferson Electric, Siemens, or equal.

2.16 STANDBY ELECTRICAL SYSTEM

- A. Provide one 350KW, 437.5 kVA, 277/480 Volt, 3 Phase, 4 Wire at .8 PF standby power rated diesel-fueled generator set, mounted in perfect alignment on an all welded, fabricated steel sub-base which shall allow for attachment of all necessary engine and generator accessories.

B. Summary

1. Work Included: Packaged diesel engine driven electric plant including engine generator set, cooling system, fuel system, combustion air intake and engine exhaust systems, starting system, and the following additional features:
 - a. Weatherproof and soundproof housing.
 - b. Automatic load transfer control to provide automatic starting and stopping of the plant and switching of the load within 10 seconds.
 - c. Automatic transfer switches

- d. Remote annunciator panel.
 - e. State code Fuel storage tank with interstitial space monitoring.
 - f. Integral Load bank
 - g. 10 ft. exhaust stack for generators rated 300KW and above.
 2. Provide control and alarm circuits wiring as shown on the manufacturer's diagrams and required for a complete installation.
 3. Provide labor, materials, tools, equipment, transportation, insurance, temporary protection, supervision and incidental items which are usually provided with this equipment, or which are essential for proper installation and operation, even though not these may not be specifically mentioned or indicated on the drawings.
- C. Manufacturers:
1. Kohler
 2. Caterpillar
 3. Onan/Cummings
 4. Or equal
- D. Engine
1. Water cooled with unit-mounted radiator. Provide starter and all field wiring required by manufacturer
 2. Dry-type replaceable element air cleaners.
 3. Full flow lube oil filters and bypass oil filter.
 4. Twelve (12) volt starting motor, 12 volt, 3 ampere battery charging alternator.
 5. Engine instrument panel to include ammeter, lube oil pressure gauge, lube oil temperature gauge, water temperature gauge, and hour meter.
 6. Engine-mounted safety control to provide alarm signals for engine shutdown in event of low oil pressure, high coolant temperature, overspeed, over crank, and pre-alarms for high water temperature and low oil pressure.
 7. Jacket water heater, 2000 watt, 120 or 208 volt, single phase or as recommended by generator manufacturer.
- E. Generator: 350KW, 437.5 kVA @ .8PF, 277/480 volt, 3 phase, 4 wire, 60 Hz, diesel fired 1800 RPM revolving field type main generator with brushless exciter and permanent magnet.
1. Voltage regulation + 1 percent from no load to full load.
- F. Cooling System: Unit mounted radiator with flange attached.
- G. Starting System: 12 volt heavy duty lead acid storage battery, connected for 12 volt DC output.
1. Battery rack, cables, and connectors shall be provided.
 2. Provide 10 amp battery charger fed from a 120 volt, single phase, 60 Hz service. Battery charger to include high and low battery voltage alarm relays for derangement panel. Battery charger shall meet NFPA 110 Standards.
 3. Exhaust System: Furnish one Maxim M-51 3 in. critical silencer, 3 in. side inlet, and one 3 in. end outlet complete with two (2) 3 in. companion flanges. Furnish one 3 in. x 18 in. flexible stainless steel exhaust connector, flanged on one end, threaded nipple on opposite end. Generator shall meet all applicable emissions regulations.
- H. Vibration Isolators: Set of four (4) Korfund rubber type vibration isolators for installation between steel base and concrete foundation.

- I. Exhaust System: Furnish one Maxim M-51 3" critical silencer, 3" side inlet, and one 3" end outlet complete with two (2) 3" companion flanges. Generator shall be Tier 3 compliant and meet all applicable emission standards.

Furnish one 3" x 18" flexible stainless steel exhaust connector, flanged on one end, threaded nipple on opposite end.

Furnish a stainless steel 10' stack exhaust extension supported from the generator housing with rain cap and all necessary components for a complete installation in accordance with Commonwealth of Massachusetts regulations. Stack shall be powder coated with black heat resistant paint.

J. Generator Control Panel:

1. To completely control operation of engine generator set. Panel to have automatic start control, AC volt meter, AC ammeter, pointer type frequency meter, volt meter, ammeter and selector switch. Alarm signals to indicate pre-low oil pressure, pre-high coolant temperature, and alarm signals to shut down engine in event of a low oil pressure, high coolant temperature, engine overspeed, or overcrank. Lights on face of panel to indicate failure. Provide dry contacts for remote disarrangement signal & louvers. Locate remote annunciator in administration area.
2. Terminal strip shall be included with alarms and prewarning devices prewired for remote annunciator specified herein. Provide wiring between generator and remote annunciator panel. Generator control switch shall be mounted on control panel face. A flashing light for selector switch "OFF" shall be included.
3. Provide molded case line circuit breakers mounted on generator in oversized terminal box. Provide oversized frame and LSIA type breaker in Life Safety branch, to ensure full selectivity coordination on the life safety system.
4. Generator Overcurrent Protection: The generator set shall be provided with a UL Listed/CSA Certified protective device that is coordinated with the alternator provided to prevent damage to the generator set on any possible overload or overcurrent condition external to the machine. The protective device shall be listed as a utility grade protective device under UL category NRGU. The control system shall be subject to UL follow-up service at the manufacturing location to verify that the protective system is fully operational as manufactured. Protector shall perform the following functions:
 - a. Initiates a generator kW overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
 - b. Under single phase or multiple phase fault conditions, or on overload conditions, indicates an alarm conditions when the current flow is in excess of 110% of rated current for more than 10 seconds.
 - c. Under single phase or multiple phase fault conditions, operates to switch off alternator excitation at the appropriate time to prevent damage to the alternator.
 - d. The operator panel shall indicate the nature of the fault condition as either a short circuit or an overload.
 - e. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot greater than 120% of nominal voltage.

K. Load Bank

1. Automatically controlled multiple stage resistor load bank in NEMA I enclosure intended for outdoor mounting adjacent to the generator in series with the engine radiator.

2. Characteristics: Unit shall be made up of (4) continuously rated 25% Steps, 3 phase resistance stages with voltage rating to match generator output, designed and connected so as to provide a load of up to 50% of generator rating.
 3. Construction: The load bank shall be completely self-contained, incorporating all of the following, integrally mounted in a single enclosure, except as otherwise noted:
 - a. Four (4) independent resistance stages made up of chromium alloy wire, each so
 - b. connected as to provide a 50 % at rated voltage. Resistors shall operate at a temperature not to exceed 1,100 deg F (600 deg C).
 - c. A 3-pole magnetic contactor and 3 current limiting fuses for each stage.
 - d. Fused control transformer with 120 volt output.
 - e. Integral manual override control to permit staged manual on-off control as desired.
 - f. Load bank shall be located in-line with, and downstream of the generator radiator.
 - g. Complete set of factory installed power and control wiring. Power wiring shall be rated for 150 deg C operation.
 - h. Pre-wired controls shall monitor normal power and disconnect the load bank upon power outage during load bank test.
 4. Construction: The load bank shall be completely self-contained, incorporating all of the following, integrally mounted in a single enclosure except as otherwise noted:
 - a. Load steps: Not less than four (4) independent resistance stages, made up of
 - b. chrome alloy wire, connected so as to provide load steps up to the total rating of the load bank. No stage shall exceed 50 KW.
 - c. Each resistance stage shall be independently protected by means of factory installed current limiting fuses and shall be provided with a magnetic contactor. Fuses and magnetic contactor shall be factory wired so as to provide a self-protected, individually controllable unit for each stage.
 - d. Main terminals arranged to accommodate a single power connection, sized for the full load rating of the load bank, complete with power circuit extensions to the protective devices for each branch circuit (i.e., stage).
 - e. Automatic protection against regenerative power from elevators. Include reverse
 - f. Both control panels include step-by-step manual control as well as status lights.
 5. Malfunction detection system shall incorporate sensors, alarms and wiring for intake and exhaust air over temperature and loss of cooling airflow; so arranged as to shut down load bank to avoid overheating.
 6. Complete set of factory installed power and control wiring. Cooling fan and control power shall be derived from a protected tap on the load side of the nearest transfer switch.
- L. Automatic Transfer Switches:
1. Provide Open transition automatic transfer switches as shown on drawings for operation on 277/480 volts, 3 phase, 4 wire operation. Units to be housed in a NEMA 1 enclosure and shall be 3 pole as indicated on drawings.
 2. The transfer switches shall be rated for 42,000 ARMS when rated over 400 amperes. Transfer switches shall be rated 42,000 ARMS when rated 400 amperes or less and fed from a current limiting breaker.
 3. Entire switch shall be listed under UL 1008.
 4. Manufacturers:
 - a. Russ Electric
 - b. ASCO
 - c. Kohler
 - d. Onan/Cummins

- e. Or equal
- 5. Unit shall be provided with standard accessories as follows.
 - a. Voltage and Frequency Sensing:
 - 1) Close differential voltage sensing on all phases of normal pickup adjustable 85-100 percent. Dropout 75-98 percent
 - 2) Voltage sensing of emergency source. Adjustable pickup 85-100 percent.
 - 3) Frequency sensing of emergency source. Adjustable pickup 90-100 percent.
 - b. Time Delays:
 - 1) Time delay to override momentary normal source outages. Adjustable 0.5 to 6 seconds.
 - 2) Retransfer to normal with 5 minute cooldown timer.
 - c. Engine Control:
 - 1) Contact to close when normal source fails.
 - 2) Contact to open when normal source fails.
 - 3) Test switch to simulate normal source failure.
 - d. Indicators: Pilot lights to indicate switch in normal position or emergency position.
 - e. Auxiliary Contacts: Two (2) to close on normal. Two (2) to close on emergency.
- 6. Required Accessories:
 - a. Plant exerciser.
 - b. In-phase monitor for Motor Load Transfer, ATS-OS and ATS-LS
 - c. Manual transfer to normal source.
 - d. Elevator control transfer module in ATS-OS. A load control circuit consists of two sets of single pole, double throw contacts that operate 3 seconds before transfer in either direction. Contacts rated 3 amperes, 208 volts AC or 10 amperes, 32 VDC, for signal to elevator of generator power available. Provide four #14AWG conductors in 3/4 in. conduit, interlock wiring to each elevator controller from each switch controlling elevator power.
- 7. Engine Start control and Monitoring
 - a. The Engine Start Control and Monitoring Modules shall be ASCO 5101 Engine Start Modules or equal. The solution must cover and provide complete compliance to the 2020 NEC 700.10 code.
 - b. The ATS shall provide continuous monitoring of the entire remote start circuit. Visual and audible annunciation of generator malfunction shall be initiated if the integrity of the start circuit is compromised.
 - c. There shall be minimum time delay (less than 5 seconds) in annunciation of any compromised condition such as an open or short circuit. A system which annunciates compromised conditions only after a generator start signal is initiated via a redundant path does not meet the intent of this specification.
 - d. The detection of a compromised start circuit shall initiate and latch the generator start circuit.

- e. Each Generator Engine Start Module shall be din-rail mounted and accept up to (8) ATS Engine Start. Each channel must have its own dedicated tri-colored status LED.
 - f. Each Engine Start channel must have its own dedicated switch with ability to enable or disable monitoring function.
 - g. Engine-start circuit shall be a single pair of typical hardwire used in legacy applications. Additional wiring and components beyond specified herein does not meet the intent of this specification.
 - 1) Coordinate placement of required components within the generator controls with the specified manufacturers.
- M. Remote Annunciator Panel: A flush mounted panel shall include a visual signal that battery charger is functioning properly and both audible and visual signals. Annunciator shall meet NFPA 110 Standards.
- 1. Audible signal shall have a silencing switch. A lamp test button shall be provided.
- N. Provide load bank test in the field by a factory certified representative for two hours at 25%, 50%, 75%, and 100% for 30 minutes at each stage and provide testing documentation. Also, provide a two hour building load test transferring the ATS switches to generator power. Provide an NFPA 110 test report for Engineer approval. The entire emergency system shall be field test operated for two (2) hours. Provide all fuel for testing. A normal power failure shall be simulated. The engine generator unit shall automatically start, come up to speed, and assume full emergency load. Entire building shall be in operation during test.
- O. Miscellaneous: Necessary lube oil and anti-freeze.
- P. Equipment Testing and Instruction Manual and Drawings:
- 1. Operating instructions and maintenance manuals shall contain the following information:
 - a. Operating Instructions
 - b. Replacement Parts
 - c. Wiring Diagram
 - d. Maintenance
 - 2. Custodians of the equipment shall be present during test. At that time they shall be instructed in operation and maintenance.
 - 3. Upon completion of tests, written reports containing results shall be submitted. Test reports shall contain readings taken at 30 minute intervals along with all other pertinent test information.
 - a. Ambient Temperature
 - b. Oil Pressure
 - c. Battery Charge Rate
 - d. AC Volts
 - e. AC Amperes All Phases
 - f. Frequency
 - g. Kilowatts
 - h. Power Factor
 - 4. Submit all required documentation for registration of generator with the DEP.
 - 5. Provide NFPA 110 equivalent testing and provide test report to engineer for approval.

Q. REMOTE ALARM ANNUNCIATOR PANEL

1. Provide a generator set remote alarm annunciator panel for installation at the location shown on the drawings.
2. Enclose the panel in NEMA 1 enclosure suitable for flush wall mounting and provide audible (A) and/or visual (V) signals for the following:

	Condition	Signal
1.	Generator set operating	V
2.	Failed to start	A/V
3.	Pre-low lube oil pressure	A/V
4.	Pre-high water temperature	A/V
5.	Low water temperature	A/V
6.	Engine overspeed	A/V
7.	Low battery voltage	V
8.	High battery voltage	V
9.	Low fuel supply	A/V
10.	Fuel leak detection	A/V

3. In the panel face, provide a separate lamp for each of the signals listed above, a lamp test pushbutton switch, and an audible alarm signal device with silence switch having ring back feature.
4. Provide a communication port to interface with the building management system for transmitting the generator set status and alarms data including alarm on a generator set failure to start automatic weekly exercise.
 - a. Supports industry-standard Modbus_RTU protocol.
 - b. Uses either an RS-232 or RS-485 Network port.
 - c. Communicates at baud rates up to 19200.
 - d. Allows selection of an access code for remote programming.
 - e. Remotely monitors system operation including run times, shutdowns, warnings, and input/output activity.
 - f. Allows selection of either metric (SI) or English (IP) units.
 - g. Provides more than 100 different Modbus_message codes for system monitoring, including System Ready and Generator Running.
 - h. Provides remote programming of most system parameters including time delays, trip points, voltage, frequency, and current.
 - i. Allows remote engine start/stop and controller reset.

R. Coordination of Trades:

1. The following equipment shall be furnished by Electrical Contractor but shall be installed under other sections.
 - a. Anchor bolts to be installed by General Trades Contractor based on approved shop drawings.

S. Generator Outdoor Housing

1. The engine generating set shall be factory installed in a weatherproof outdoor housing. The housing shall provide year round generating set protection against adverse weather and environmental conditions. The enclosure shall be sound attenuated and meet Federal Specifications.

2. The weatherproof shelter shall be constructed or welded and bolted of reinforced aluminum, 14 gauge walls and 14 gauge floor plate. All metal parts shall be prime coated and finished painted.
3. The shelter assembly shall have shuttered air openings on front and sides with mesh screens covering side shutters. The air shutters shall be opened by four 22 volt AC motors when the generating set operates. Motors shall be spring loaded to close shutters when set stops.
4. Hinged double doors on each side and one door in rear of the shelter shall allow easy access to engine generator and controls. All door handles shall be key lock design.
5. Vibration isolators of the open coil spring type, selected for 3 inch (76mm) static deflection, shall be furnished and installed. The number of isolators shall be as recommended by the generator set manufacturer, and complete details shall be included in the Submittals. Anchor bolts, nuts and sleeves shall be supplied with recommended Foundation Plan.
6. Provide an integral base mounted tank, double wall containment with alarms and capacity to run generator for 72 hours at 100% load. Include conduit entry provisions for tank. Tank shall be supplied in accordance with the state Fuel Storage Codes for above ground diesel fuel tanks. Provide 1,200 gallons of diesel fuel. Provide tank level gauge at annunciator.
7. The weatherproof housing shall allow installation of the silencer outside or inside the enclosure. Provide critical type silencer. Refer to riser for additional requirements regarding the 10' stack.
8. Provide sound deadening materials, baffles, hoods, etc. to reduce noise levels to 75DBA at 7 meters in any direction.
9. Provide weatherproof EPO with cover on the exterior of the generator enclosure that shuts down the primer mover per NEC.

2.17 GENERATOR TAP BOX

A. Scope:

1. Contractor shall furnish, deliver, install and test the generator tap boxes as specified herein and in accordance with the drawings.

B. Quality Assurance:

1. Generator tap boxes shall be UL listed and labeled under the UL 1008 standard with a minimum 42KA withstand rating at rated voltage. Withstand rating shall match the switchgear for the building.
2. Generator tap box manufacturer shall provide a complete factory assembled and tested generator tap box.
3. Generator tap box installation shall meet all applicable NEC standards.

C. Submittals:

1. Contractor shall submit manufacturer's drawings and data of generator tap boxes for Engineer's approval prior to start of fabrication. Drawings and data shall include, as a minimum, dimensioned general arrangement drawings, UL listing information including UL control or file number, component data, mounting provisions, conduit entry locations and installation instructions.

D. Warranty:

1. Generator tap boxes shall be covered by manufacturer's warranty for a minimum period of (1) one year after shipment from manufacturer.

E. General:

1. All equipment shall be new.
2. Generator tap box manufacturer must have produced and sold generator tap boxes as a standard product for a minimum of (2) years.
3. Contractor shall be responsible for the equipment until it has been installed and is finally inspected, tested and accepted in accordance with the requirements of this Specification.
4. Generator tap boxes shall be TempTap Inlet Boxes as manufactured by ESL Power Systems, Inc. or equal as approved by the Engineer.

F. Generator Tap Boxes:

1. Generator tap box shall consist of cam-style male connectors and grounding terminals, all housed within a padlockable enclosure.
2. Generator tap box enclosure shall be Type 3R, constructed of continuous seam-welded, powder coated galvanized steel. The main access shall be through a hinged door that extends the full height of the enclosure. Access for portable generator cables with female cam-style plugs shall be via cable entry openings in the bottom of the enclosure. A hinged flap door shall be provided to cover the cable openings when cables are not connected; the hinged flap door shall allow cable entry only after the main access door has been opened. Enclosure shall be powder coated after fabrication; color shall be light gray RAL 7038.
3. Cam-style male connectors (inlets) shall be UL Listed single-pole separable type and rated 400 amps at 600VAC. Cam-style male connectors shall be color coded. Cam-style male connectors shall be provided for each phase and for ground, and shall also be provided for neutral if required. The ground cam-style male connectors shall be bonded to the enclosure, and a ground lug shall be provided for connection of the facility ground conductor. None of the cam-style male connectors shall be accessible unless the main access door is open.

G. Installation:

1. Prior to installation of generator tap boxes, Contractor shall examine the areas and conditions under which the generator tap box is to be installed and notify the Engineer in writing if unsatisfactory conditions exist.
2. Generator tap box shall be installed as shown on the drawings and per the manufacturer's written instructions. In addition, the installation shall meet the requirements of local codes, the National Electrical Code and National Electrical Contractors Association's "Standard of Installation".
3. Conduit entry into the manual transfer switch shall be by Contractor; Contractor shall furnish and install listed watertight conduit hubs, as manufactured by MYERS or T&B, for each conduit entry on the generator tap box. The hub size shall match the conduit size for conductors and ground as shown on the drawings. Hubs shall be properly installed and tightened to maintain Type 3R integrity of the generator tap box.
4. Contractor shall terminate conductors and ground per the manufacturer's instructions. Use copper wire only for all conductors and grounds. All field wiring terminations in the generator tap box shall be torqued as required per the instructions on the generator tap box.

H. Field Testing:

1. Prior to energizing generator tap box, the Contractor shall perform the following checks and tests as a minimum:
 - a. Verify mounting and connections are complete and secure.
 - b. Verify internal components and wiring are secure.
 - c. Perform continuity check of all circuits.
 - d. Perform 1,000 VDC megger test on phase and ground cables.
 - e. Verify deadfront is secure.
 - f. Confirm operation of the generator tap box ground receptacle by attaching a plug to the generator tap box ground receptacle and then verify that the plug is grounded to the facility ground.

2.18 MANUAL TRANSFER SWITCH

A. Scope:

1. Electrical SubContractor shall furnish, deliver, install and test the manual transfer switches as specified herein and in accordance with the drawings.

B. Quality Assurance:

1. Manual transfer switch shall be UL listed and labeled under the UL 1008 standard.
2. Manual transfer switch manufacturer shall provide a complete factory assembled, wired and tested manual transfer switch.
3. Manual transfer switch shall be factory Hi-pot tested for a period of not less than 60 seconds.
4. Manual transfer switch installation shall meet all applicable NEC standards.

C. Submittals:

1. Electrical SubContractor shall submit manufacturer's drawings and data of manual transfer switches for Engineer's approval prior to start of fabrication. Drawings and data shall include, as a minimum, dimensioned general arrangement drawings and wiring diagrams, UL listing information including UL control or file number, component data, mounting provisions, conduit entry locations and installation instructions.
2. Upon installation of manual transfer switches Electrical SubContractor shall submit manufacturer's Operating & Maintenance Manual which shall include as a minimum:
 - a. Certified as-built General Arrangement drawings and Wiring Diagram.
 - b. Materials / Component List including part numbers.
 - c. Maintenance and service requirements.
 - d. Certificate of Compliance and hi-pot test data.

D. Warranty:

1. Manual transfer switches shall be covered by manufacturer's warranty for a minimum period of one year after shipment from manufacturer.

E. General:

1. All equipment shall be new.

2. Manual transfer switch manufacturer must have produced and sold manual transfer switches as a standard product for a minimum of three years.
3. Manual transfer switches shall be molded case circuit breaker type; knife switch or fused switches are not acceptable.
4. Electrical SubContractor shall be responsible for the equipment until it has been installed and is finally inspected, tested and accepted in accordance with the requirements of this Specification.
5. Manual transfer switches shall be StormSwitch, Model "SSDX-400A-H-400A-H-480-3-1-1-D-C" as manufactured by ESL Power Systems, Inc. or equal as approved by the Engineer.

F. Manual Transfer Switches:

1. Manual transfer switch shall consist of two mechanically-interlocked molded case circuit breakers, cam-style male connectors, power distribution block and grounding terminals, all housed within a padlockable enclosure.
2. Manual transfer switch enclosure shall be Type 3R, constructed of continuous seam-welded, powder coated galvalume steel. The main access shall be through an interlocked, hinged door that extends the full height of the enclosure. Access for portable generator cables with female cam-style plugs shall be via cable entry openings in the bottom of enclosure. A hinged flap door shall be provided to cover the cable openings when cables are not connected; the hinged flap door shall allow cable entry only after the main access door has been opened. Enclosure shall be powder coated after fabrication; color shall be light gray RAL 7038.
3. Cam-style male connectors (inlets) shall be UL Listed single-pole separable type and rated 400 amps at 600VAC. Cam-style male connectors shall be color coded. Cam-style male connectors shall be provided for each phase and for ground, and shall also be provided for neutral if required. Each of the phase cam-style male connectors within the enclosure shall be factory-wired to a molded case circuit breaker. The ground cam-style male connectors shall be bonded to the enclosure, and a ground lug shall be provided for connection of the facility ground conductor. The neutral cam-style male connectors, if required, shall be factory wired to a power distribution block. None of the cam-style male connectors shall be accessible unless both molded case circuit breakers are in the "OFF" position and the main access door is open.
4. A power distribution block shall be provided for load-side field wiring. The power distribution block shall be factory wired to the molded case circuit breakers.
5. Molded case circuit breakers shall be UL Listed and the short circuit interrupt rating shall be a minimum of 35kAIC at 480VAC. Trip rating of the molded case circuit breakers shall be as shown on the drawings. One molded case circuit breaker shall be fed from utility power; the other molded case circuit breaker shall be fed from the cam-style male connectors to supply power from a portable generator. Both molded case circuit breakers shall include UL Listed door-mounted operating mechanisms, preventing the opening of the main access door unless both breakers are in the "OFF" position. Both molded case circuit breakers shall be mounted behind a deadfront panel. The load-side of the molded case circuit breakers shall not be energizable unless the main access door is closed and one of the molded case circuit breakers is in the "ON" position. The (2) molded case circuit breakers shall be safety interlocked by mechanical means to ensure that only one breaker can be closed at any given time.
6. Manual transfer switch shall be suitable for use as service equipment in the USA.

G. Installation:

1. Prior to installation of manual transfer switches, Electrical SubContractor shall examine the areas and conditions under which the manual transfer switch is to be installed and notify the Engineer in writing if unsatisfactory conditions exist.

2. Manual transfer switch shall be installed as shown on the drawings and per the manufacturer's written instructions. In addition, the installation shall meet the requirements of local codes, the National Electrical Code and National Electrical Contractors Association's "Standard of Installation".
3. Conduit entry into the manual transfer switch shall be by Electrical SubContractor; Electrical SubContractor shall furnish and install listed watertight conduit hubs, as manufactured by MYERS or T&B, for each conduit entry on the manual transfer switch. The incoming hub size shall match the conduit size for feeders and ground as shown on the drawings. The outgoing hub size shall match the conduit size for loads and ground as shown on the drawings. Hubs shall be properly installed and tightened to maintain Type 3R integrity of the manual transfer switch enclosure.
4. Electrical SubContractor shall terminate feeder conductors, load conductors and ground per the manufacturer's instructions. Use copper wire only for all conductors and grounds. All field wiring terminations shall be torqued as required per the instructions on the manual transfer switch's power distribution block, circuit breaker & ground lug.

H. Field Testing:

1. Prior to energizing manual transfer switch, the Electrical SubContractor shall perform the following checks and tests as a minimum:
 - a. Verify mounting and connections are complete and secure.
 - b. Verify internal components and wiring are secure.
 - c. Perform continuity check of all circuits.
 - d. Perform 1,000 VDC megger test on feeder, load and ground cables.
 - e. Verify deadfront is secure.
 - f. With the manual transfer switch deadfront in place and the main access door closed and properly latched, actuate both Operator Mechanisms; verify only (1) breaker at a time can be turned to the "ON" position.
 - g. Confirm operation of the manual transfer switch ground receptacle by attaching a plug to the manual transfer switch ground receptacle and then verify that the plug is grounded to the facility ground.
 - h. Once utility power has been applied, confirm operation of manual transfer switch by following directions on main access door.

2.19 FIRE ALARM AND DETECTION SYSTEM

A. Description:

1. This section of the specification includes the furnishing, installation, connection and testing of the microprocessor controlled, intelligent reporting fire alarm network equipment required to form a complete, operative, coordinated system. It shall include, but not be limited to, alarm initiating devices, alarm notification appliances, Network Fire Alarm Control Panel (FACP), auxiliary control devices, annunciators, and wiring as shown on the drawings and specified herein.
2. The fire alarm system shall comply with requirements of latest NFPA Standard 72 for Protected Premises Signaling Systems except as modified and supplemented by this specification. The system shall be electrically supervised and monitor the integrity of all conductors.
3. The fire alarm manufacturer shall be of the highest caliber and insist on the highest quality. The system shall be manufactured by an ISO 9001 certified company and meet the requirements of BS EN9001: ANSI/ASQC Q9001-1994.
4. The FACP and peripheral devices shall be manufactured 100 percent by a single U.S. manufacturer (or division thereof).

5. The system and its components shall be Underwriters Laboratories, Inc. listed under the appropriate UL testing standard as listed herein for fire alarm applications and shall be in compliance with the UL listing.
6. The installing company shall employ NICET (minimum Level II Fire Alarm Telecommunications) technicians on site to guide the final check-out and to ensure the systems integrity.

B. Scope:

1. A new network intelligent reporting, microprocessor controlled fire detection and alarm system shall be installed in accordance with the specifications and drawings.
2. Basic Performance:
 - a. Alarm, trouble and supervisory signals from all intelligent reporting devices shall be encoded onto NFPA Style 7 (Class A) Signaling Line Circuits (SLC).
 - b. Initiation Device Circuits (IDC) shall be wired Class A (NFPA Style D).
 - c. Notification Appliance Circuits (NAC) shall be wired Class A (NFPA Style Z).
 - d. Digitized electronic signals shall employ check digits or multiple polling.
 - e. Power for initiating devices and notification appliances must be from the main fire alarm control panel.
 - f. A single ground or open on any system signaling line circuit, initiating device circuit, or notification appliance circuit shall not cause system malfunction, loss of operating power or the ability to report an alarm.
 - g. Alarm signals arriving at the main FACP shall not be lost following a power failure (or outage) until the alarm signal is processed and recorded.
3. Basic System Functional Operation:
4. When a fire alarm condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:
 - a. The FACP alarm LED on the FACP shall flash.
 - b. A local piezo-electric signal in the FACP control panel shall sound.
 - c. The 80-character LCD display on the local FACP node and on the intelligent network display shall indicate all information associated with the fire alarm condition, including the type of alarm point, and its location within the protected premises. This information shall also be displayed on the network reporting terminal.
 - d. Printing and history storage equipment shall log the information associated with the fire alarm control panel condition, along with the time and date of occurrence.
 - e. All system output programs assigned via control-by-event interlock programming to be activated by the particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated on either local outputs or points located on other network nodes.
5. Software Modifications:
 - a. Provide the services of a factory trained and authorized technician to perform all system software modifications, upgrades or changes. Response time of the technician to the site shall not exceed 4 hours.

- b. Provide all hardware, software, programming tools and documentation necessary to modify the fire alarm network on site. Modification includes addition and deletion of devices, circuits, zones and changes to system operation and custom label changes for devices or zones. The system structure and software shall place no limit on the type or extent of software modifications on-site. Modification of software shall not require power-down of the system or loss of system fire protection while modifications are being made.
6. Certifications:
- a. Together with the shop drawing submittal, submit a certification from the major equipment manufacturer indicating that the proposed supervisor of installation and the proposed performer of contract maintenance is an authorized representative of the major equipment manufacturer and trained on network applications. Include names and addresses in the certification.
 - b. Power supplies, relays, water flow switches and all accessories of the fire alarm system.
 - c. Each circuit in the fire alarm network shall be tested semiannually.
 - d. Each smoke detector shall be tested in accordance with the requirements of NFPA 72, Chapter 7.

C. Applicable Publications:

The publications listed below form a part of this specification. The publications are referenced in text by the basic designation only.

- 1. National Fire Protection Association (NFPA) - USA:
 - No. 72 National Fire Alarm Code
 - No. 70 National Electric Code
 - No. 101 Life Safety Code
- 2. Underwriters Laboratories Inc. (UL) - USA:
 - No. 50 Cabinets and Boxes
 - No. 268 Smoke Detectors for Fire Protective Signaling Systems
 - No. 864 Control Units for Fire Protective Signaling Systems
 - No. 268A Smoke Detectors for Duct Applications
 - No. 521 Heat Detectors for Fire Protective Signaling Systems
 - No. 228 Door Closers-Holders for Fire Protective Signaling Systems
 - No. 464 Audible Signaling Appliances
 - No. 38 Manually Actuated Signaling Boxes
 - No. 346 Waterflow Indicators for Fire Protective Signaling Systems

No. 1481	Power supplies for Fire Protective Signaling Systems
No. 1076	Control Units for Burglar Alarm Proprietary Protective Signaling Systems
No. 1971	Visual Notification Appliances

3. Local and State Building Codes.
4. All requirements of the Authority Having Jurisdiction (AHJ).

D. Approvals:

1. The system must have proper listing and/or approval from the following nationally recognized agencies:
UL Underwriters Laboratories Inc.
FM Factory Mutual
MEA Material Equipment Acceptance (NYC)
CSFM California State Fire Marshal
2. The fire alarm control panel shall meet the modular labeling requirements of Underwriters Laboratories, Inc. Each subassembly, including all printed circuits, shall include the appropriate UL modular label. Systems which do not include modular labels which may require return to the manufacturer for system upgrades, and are not acceptable.

E. Equipment and Material, General:

1. All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a protected premises protective signaling (fire alarm) system. The authorized representative of the manufacturer of the major equipment, such as control panels, shall be responsible for the satisfactory installation of the complete system.
2. All equipment and components shall be installed in strict compliance with each manufacturer's recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc. before beginning system installation. Refer to the riser/connection diagram for all specific system installation/termination/wiring data.
3. All equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place. (e.g., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.

F. Conduit and Wire:

1. Conduit:
 - a. Conduit shall be in accordance with the National Electrical Code (NEC), local and state requirements.
 - b. All wiring exposed shall be installed in conduit. All wiring exposed in finish spaces shall be in surface metal raceway. Conduit fill shall not exceed 40 percent of interior cross sectional area where three or more cables are contained within a single conduit.

- c. Cable must be separated from any open conductors of power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, per NEC Article 760-29.
 - d. Wiring for 24 volt control, alarm notification, emergency communication and similar power-limited auxiliary functions may be run in the same conduit as initiating and signaling line circuits. All circuits shall be provided with transient suppression devices and the system shall be designed to permit simultaneous operation of all circuits without interference or loss of signals.
 - e. Conduit shall not enter any FACP, or any other remotely mounted control panel equipment or backboxes, except where conduit entry is specified by the FACP manufacturer.
 - f. Conduit shall be 3/4 inch (19.1 mm) minimum.
2. Wire:
- a. All fire alarm system wiring must be new, unless specified herein.
 - b. Wiring shall be in accordance with local, state and national codes (e.g., NEC Article 760) and as recommended by the manufacturer of the fire alarm system. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 16 AWG (1.02 mm) for initiating device circuits and signaling line circuits, and 14 AWG (1.32 mm) for notification appliance circuits.
 - c. All wire and cable shall be listed and/or approved by a recognized testing agency for use with a protective signaling system.
 - d. Wiring used for the SLC multiplex communication loop shall be twisted and shielded unless specifically excepted by the fire alarm equipment manufacturer.
 - e. All field wiring shall be completely supervised.
 - f. MC cable with red armor may be used where concealed and allowed by code.
3. Terminal Boxes, Junction Boxes and Cabinets:
4. All boxes and cabinets shall be UL listed for the intended purpose.
5. Initiating circuits shall be arranged to serve like categories (manual, smoke, waterflow). Mixed category circuitry shall not be permitted except on signaling line circuits connected to intelligent reporting devices.
6. The FACP shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labeled at the main power distribution Panel as FIRE ALARM. Fire alarm control panel primary power wiring shall be 12 AWG. The FACP cabinet shall be grounded securely to either a cold water pipe or grounding rod. Provide lock-on device on breaker.

G. Fire Alarm Control Panel:

- 1. Fire alarm control panel shall be Notifier NFS3030, Edwards EST3, FCI-E3, or equal. The FACP shall contain a microprocessor based central processing unit (CPU). The FACP shall communicate with and control the following types of equipment used to make up the system: intelligent detectors, addressable modules, local and remote operator terminals, annunciators, and other system controlled devices.
- 2. Node Capacity and General Operation:
 - a. Each node shall provide, or be capable of, expansion to 198 intelligent addressable devices and 198 monitor/control modules for a total of 396 intelligent devices per system. FACP shall have 2 intelligent loops.
 - b. Each FACP node shall include a full featured operator interface control and annunciation panel which shall include a backlit Liquid Crystal Display (LCD), individual, color coded system status LEDs, and an alpha-numeric keypad for field programming and control of the node.

- c. All programming or editing of the existing programming the system shall be achieved without special equipment or interrupting the alarm monitoring functions of the fire alarm control panel.
 - d. Each FACP node shall provide the following features:
 - Block Acknowledge Printer Interface
 - Control-by-Time Non-Alarm Module Reporting
 - Day/Night Sensitivity Periodic Detector Test
 - Device Blink Control Remote Page
 - Drift Compensation Trouble Reminder
 - NFPA 72, Sensitivity Upload/Download to PC
 - Test computer
 - System Status Reports Verification Counters
 - Security Monitor Points Walk Test
 - Alarm Verification Maintenance Alert
3. Loop Interface Board (LIB):
- a. Loop interface boards shall be provided to monitor and control each of the Signaling Line Circuit (SLC) loops in the network node. The loop interface board shall contain its own microprocessor and shall be capable of operating in local mode in the case of a failure in the main CPU of the control panel. In local mode, the loop interface board shall detect alarms and activate output devices on its own SLC loop.
 - b. The LIB shall not require any jumper cuts or address switch settings to initialize SLC Loop operations.
 - c. The loop interface board shall provide power to, and communicate with, all of the intelligent detectors and addressable modules connected to its SLC Loop over a single pair of wires. This SLC Loop shall be capable of operation as NFPA Style 4, Style 6, or Style 7.
 - d. The LIB shall be able to drive two Style 4 SLC loops, each up to 10,000 feet in length, for an effective loop span of 20,000 feet.
 - e. The loop interface board shall receive analog information from all intelligent detectors and shall process this information to determine whether normal, alarm, or trouble conditions exist for that particular detector. The loop interface board software shall include software to automatically adjust and compensate for dust accumulation to maintain detector performance as it is affected by environmental factors. The analog information may also be used for automatic detector testing and for the automatic determination of detector maintenance requirements.
 - f. The LIB shall communicate with each intelligent addressable detector and addressable module on its SLC loop and verify proper device function and status. Communication with up to 198 intelligent devices shall be performed every 6 seconds or less.
4. Enclosures:
- a. Control panels shall be housed in UL listed cabinets suitable for surface or semi-flush mounting. Cabinets shall be corrosion protected, given a rust-resistant prime coat, and the manufacturer's standard finish.
 - b. The back box and door shall be constructed of .060 steel with provisions for electrical conduit connections into the sides and top.

- c. The door shall provide a key lock and include a transparent opening for viewing all indicators. For convenience, the door shall have the ability to be hinged on either the right or left-hand side.
 - d. The control unit shall be modular in structure for ease of installation, maintenance, and future expansion.
- 5. FACP nodes shall be designed so that it permits continued local operation of remote transponders under both normal and abnormal network communication loop conditions. This shall be obtained by having transponders operate as local control panels upon loss of network communication.
- 6. FACP nodes shall be modular in construction to allow ease of servicing. Each CPU and transponder shall be capable of being programmed on site without requiring the use of any external programming equipment. Systems which require use of external programmers or change of EPROM's are not acceptable.
- 7. The CPU and associated equipment are to be protected so that they will not be affected by voltage surges or line transients including RFI and EMI.
- 8. Each peripheral device connected to the FACP node CPU shall be continuously scanned for proper operation. Data transmissions between network nodes, FACP CPUs, transponders, and peripheral devices shall be reliable and error free. The transmission scheme used shall employ dual transmission or other equivalent error checking techniques. Failure of any transponder or peripheral device to respond to an interrogation shall be annunciated as a trouble condition.
- 9. FACP Power Supplies:
 - a. Main power supplies shall operate on 120 VAC, 60Hz, and shall provide all necessary power for the FACP.
 - b. Each main supply shall provide 3.0 amps of usable notification appliance power, using a switching 24 VDC regulator.
 - c. The main power supply shall be expandable for additional notification appliance power in 3.0 ampere steps. Provide dedicated power supplies for signal circuit.
 - d. Each main power supply shall provide a battery charger for 60 hours of standby using dual-rate charging techniques for fast battery recharge. It shall charge 55 Amp hour batteries with-in a 48 hour period.
 - e. The supply shall provide a very low frequency sweep earth detect circuit, capable of detecting earth faults on sensitive addressable modules.
 - f. It shall provide meters to indicate battery voltage and charging current.
 - g. The main power supply shall be power-limited per 1995 UL864 requirements.
- 10. System Circuit Supervision:
 - a. Each FACP node shall supervise all circuits to intelligent devices, transponders, annunciators and peripheral equipment and annunciate loss of communications with these devices. The FACP CPU shall continuously scan the above devices for proper system operation and upon loss of response from a device shall sound an audible trouble, indicate which device or devices are not responding and print the information on the printer.
 - b. Sprinkler system valves, standpipe control valves, PIV, and main gate valves shall be supervised for off-normal position.
- 11. Field Wiring Terminal Blocks:
 - a. For ease of service, all wiring terminal blocks shall be the plug-in type and have sufficient capacity for 18 to 12 AWG wire. Fixed terminal blocks are not acceptable.

12. Field Programming:

- a. The system shall be programmable, configurable and expandable in the field without the need for special tools or electronic equipment and shall not require field replacement of electronic integrated circuits.
- b. All local FACP node programming shall be accomplished through the FACP keyboard.
- c. All field-defined programs shall be stored in non-volatile memory.
- d. The programming function shall be enabled with a password that may be defined specifically for the system when it is installed. Two levels of password protection shall be provided in addition to a key-lock cabinet. One level is used for status level changes such as zone disable or manual on/off commands. A second (higher-level) is used for actual change of program information.

13. Specific System Operations:

- a. Smoke Detector Sensitivity Adjust: Means shall be provided for adjusting the sensitivity of any or all analog intelligent detectors in the FACP node from each system keypad or from the keyboard of the video terminal. Sensitivity range shall be within allowed UL limits.
- b. Alarm Verification: Each of the intelligent addressable detectors in the system may be independently selected and enabled for alarm verification. Each FACP shall keep a count of the number of times each detector has entered the verification cycle. These counters may be displayed and reset by the proper operator commands.
- c. System Point Operations:
 - 1) All devices in the FACP node may be enabled or disabled through the local keypad or video terminal.
 - 2) Any FACP node output point may be turned on or off from the local system keypad or the video terminal.
- d. Point Read: The FACP node shall be able to display the following point status diagnostic functions without the need for peripheral equipment. Each point will be annunciated for the parameters listed:
 - 1) Device Status
 - 2) Device Type
 - 3) Custom Device Label
 - 4) Software Zone Label
 - 5) Device Zone Assignments
 - 6) Detector Analog Value
 - 7) All Program Parameters
- e. System Status Reports: Upon command from a password-authorized operator of the system, a status report will be generated, and printed, listing all local FACP system status.
- f. System History Recording and Reporting: Each FACP node shall contain a history buffer that shall be capable of storing a minimum of 400 system events. Each local activation will be stored and time and date stamped with the actual time of the activation, until an operator requests that the contents be either displayed or printed. The contents of the history buffer may be manually reviewed, one event at a time, and the actual number of activations may also be displayed and or printed.
- g. The history buffer shall use non-volatile memory. Systems which use volatile memory for history storage are not acceptable.

- h. Automatic Detector Maintenance Alert: Each FACP node shall automatically interrogate each intelligent system detector and shall analyze the detector responses over a period of time.
- i. If any intelligent detector in the system responds with a reading that is below or above normal limits, then the system will enter the trouble mode, and the particular intelligent detector will be annunciated on the system display, network display and printed on the optional system printer. This feature shall in no way inhibit the receipt of alarm conditions in the system, nor shall it require any special hardware, special tools or computer expertise to perform.

H. Addressable Devices – General:

- 1. Addressable devices shall use simple to install and maintain decade (numbered 1 to 10) type address switches.
- 2. Addressable devices which use a binary address setting method, such as a Dip switch, are difficult to install and subject to installation error. This type of device is not an allowable substitute.
- 3. Detectors shall be intelligent (analog) and addressable, and shall connect with two wires to the FACP signaling line circuit.
- 4. Addressable smoke and thermal detectors shall provide dual alarm and power/polling LEDs. Both LEDs shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel, and both LEDs shall be placed into steady illumination by the control panel, indicating that an alarm condition has been detected. If required, the LED flash shall have the ability to be removed from the system program. An output connection shall also be provided in the base to connect an external remote alarm LED.
- 5. Smoke detector sensitivity shall be set in the fire alarm control panel and shall be adjustable in the field through the field programming of the system. Sensitivity may be automatically adjusted by the panel on a time-of-day basis.
- 6. Using software in the FACP, detectors shall automatically compensate for dust accumulation and other slow environmental changes that may affect their performance. The detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA Standard 72, Chapter 7.
- 7. The detectors shall be ceiling-mount and shall include a separate twist-lock base with tamper proof feature. Base shall include a sounder base with a built-in (local) sounder rated at 85 DBA minimum, a relay base and an isolator base designed for Class A applications.
- 8. The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel.
- 9. Detectors shall also store an internal identifying type code that the control panel shall use to identify the type of device (ION, PHOTO, THERMAL).
- 10. Detectors will operate in an analog fashion, where the detector simply measures its designed environment variable and transmits an analog value to the FACP based on real-time measured values. The FACP software, not the detector, shall make the alarm/normal decision, thereby allowing the sensitivity of each detector to be set in the FACP program and allowing the system operator to view the current analog value of each detector.
- 11. A magnetic test switch shall be provided to test each detector for 100 percent obscuration, reported to the FACP.

12. Addressable devices shall provide address-setting means using decimal switches and shall also store an internal identifying code that the control panel shall use to identify the type of device. LED(s) shall be provided that shall flash under normal conditions, indicating that the device is operational and is in regular communication with the control panel.
 13. A magnetic test switch shall be provided to test detectors and modules. Detectors shall report an indication of an analog value reaching 100 percent of the alarm threshold.
- I. Addressable Pull Box (manual station):
1. Addressable pull boxes shall, on command from the control panel, send data to the panel representing the state of the manual switch and the addressable communication module status. They shall use a key operated test-reset lock, and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a key.
 2. All operated stations shall have a positive, visual indication of operation and utilize a key type reset.
 3. Manual stations shall be constructed of Lexan with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters, 1.75 inches or larger.
 4. Stations shall be suitable for surface mounting or semiflush mounting as shown on the plans, and shall be installed not less than 42 inches, nor more than 48 inches above the finished floor.
 5. Manual pull stations shall be of the double action type.
- J. Intelligent Photoelectric Smoke Detector:
1. The detectors shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density.
- K. Intelligent Thermal Detectors:
1. Thermal detectors shall be intelligent addressable devices rated at 135 degrees Fahrenheit (58 degrees Celsius) and have a rate-of-rise element rated at 15 degrees F (9.4 degrees C) per minute. It shall connect via two wires to the fire alarm control panel signaling line circuit. Up to 99 intelligent heat detectors may connect to one SLC loop.
- L. Intelligent Duct Smoke Detector:
1. The in-duct smoke detector housing shall accommodate either an intelligent ionization detector or an intelligent photoelectric detector, of that provides continuous analog monitoring and alarm verification from the panel.
 2. When sufficient smoke is sensed, an alarm signal is initiated at the FACP, and appropriate action taken to change over air handling systems to help prevent the rapid distribution of toxic smoke and fire gases throughout the areas served by the duct system.
- M. Duct mounted carbon monoxide detector:
1. Manufactured by Air Products and Controls Model SL-701 or Equal

2. Product Specifications:

Voltages available:
APPROVALS

230VAC, 115VAC, 24VAC, 24VDC
Electrochemical Carbon Monoxide Sensor is a UL Recognized component in accordance with the requirements of UL2034. Also meets EN50291 requirements. SL-2000 Series Duct Smoke Detector Fire Alarm Certifications referenced side one:
UL & CUL Listed (UL268A, UROX, UROX7) File # S2829 CSFM Listed (3240-1004:105); MEA Accepted (73-92-E, VOL. 27)

SAMPLING TUBES Provide required length for duct coordinate with HVAC drawings

Sectional sampling tube
Metal sampling tube for 6" to 2.5' duct width
Metal sampling tube for 2.5' to 5.0' duct width
Metal sampling tube for 5.0' to 10.0' duct width

ACCESSORIES

MSR-50/CO remote accessory
TG-701 aerosol test gas
T-PB power supplies
WP-2000 weatherproof enclosure
(All available from Air Products and Controls Inc.)

POWER REQUIREMENTS

Input Power	Standby Current	Alarm Current
24VAC	55mA	190mA
24VDC	14mA	68mA
115VAC	22mA	32mA
230VAC	12mA	18mA

RELAY CONTACT RATING:

Alarm Contacts	Resistive load: 2 sets form "C" rated at 10 Amps @ 115VAC
Trouble Contacts	Resistive load: 1 set form "A" rated at 2 Amps Resistive load: 1 set form "C" rated at 10 Amps @ 115VAC

AIR VELOCITY

100 to 4,000 ft. /min.

AMBIENT TEMPERATURE

32°F to 158°F (0°C to 70°C)

HUMIDITY

10% to 85% RH Non-Condensing / Non-Freezing

WIRING

Solid or stranded: #12 to #22 AWG terminals

MATERIAL

Grey plastic back box, clear plastic cover (Makrolon 94V-0)

Do not expose to corrosive atmospheres.

DIMENSIONS

13 ½" L x 4 ½" W x 2 ¼" D

MAX. NET WT.:

2 ½ lbs.

HARDWARE

7" exhaust tube, FAST Tube starter sampling tube, sampling tube end cap, mounting template, and mounting hardware included.

N. Addressable Dry Contact Monitor Module:

1. Addressable monitor modules shall be provided to connect one supervised IDC zone of conventional alarm initiating devices (any N.O. dry contact device) to one of the fire alarm control panel SLC loops.
2. The monitor module shall mount in a 4-inch square, 2-1/8 inch deep electrical box.

3. The IDC zone may be wired for Style D or Style B operation. An LED shall be provided that shall flash under normal conditions, indicating that the monitor module is operational and in regular communication with the control panel.
4. For difficult to reach areas, the monitor module shall be available in a miniature package and shall be no larger than 2-3/4 inch x 1-1/4 inch x 1/2 inch. This version need not include Style D or an LED.

O. Two-Wire Detector Monitor Module:

1. Addressable monitor modules shall be provided to connect one supervised IDC zone of conventional 2-wire smoke detectors or alarm initiating devices (any N.O. dry contact device).
2. The two-wire monitor module shall mount in a 4-inch square, 2-1/8 inch deep electrical box or with an optional surface backbox.
3. The IDC zone may be wired for Class A or B (Style D or Style B) operation. An LED shall be provided that shall flash under normal conditions, indicating that the monitor module is operational and in regular communication with the control panel.

P. Addressable Control Module:

1. Addressable control modules shall be provided to supervise and control the operation of one conventional NACs of compatible, 24 VDC powered, polarized audio/visual notification appliances. For fan shutdown and other auxiliary control functions, the control module may be set to operate as a dry contract relay.
2. The control module shall mount in a standard 4-inch square, 2-1/8 inch deep electrical box, or to a surface mounted backbox.
3. The control module NAC may be wired for Style Z or Style Y (Class A/B) with up to 1 amp of inductive A/V signal, or 2 amps of resistive A/V signal operation, or as a dry contact (Form-C) relay. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to insure that 100 percent of all auxiliary relay or NACs may be energized at the same time on the same pair of wires.
4. Audio/visual power shall be provided by a separate supervised power loop from the main fire alarm control panel or from a supervised, UL listed remote power supply.
5. The control module shall be suitable for pilot duty applications and rated for a minimum of .6 amps at 30 VDC.

Q. Isolator Module:

1. Isolator modules shall be provided to automatically isolate wire-to-wire short circuits on an SLC loop. The isolator module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC Loop. At least one isolator module shall be provided for each floor or protected zone of the building.
2. If a wire-to-wire short occurs, the isolator module shall automatically open-circuit (disconnect) the SLC loop. When the short circuit condition is corrected, the isolator module shall automatically reconnect the isolated section.
3. The isolator module shall not require any address setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an isolator module after its normal operation.
4. The isolator module shall mount in a standard 4-inch deep electrical box or in a surface mounted backbox. It shall provide a single LED that shall flash to indicate that the isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

R. LCD Alphanumeric Display Annunciator:

1. The alphanumeric display annunciator shall be a supervised, backlit LCD display containing a minimum of eighty (80) characters for alarm annunciation in clear English text.
2. The LCD annunciator shall display all alarm and trouble conditions from either the network node or complete network, via the INA.
3. Up to 32 LCD annunciators may be connected to a specific (terminal mode) EIA 485 interface. LCD annunciators shall not reduce the annunciation capacity of the system. Each LCD annunciator shall include vital system wide functions such as, system acknowledge, silence and reset.
4. LCD display annunciators shall mimic the local control panel 80 character display or network annunciator and shall not require special programming.
5. The LCD annunciator shall have the same vital functions as the fire alarm control panel.

S. Batteries and External Charger:

1. Battery:
 - a. Batteries shall be 12 volt, Gell-Cell type.
 - b. The battery shall have sufficient capacity to power the fire alarm system for not less than 60 hours plus 15 minutes of alarm upon a normal AC power failure.
 - c. The batteries are to be completely maintenance free. No liquids are required. Fluid level checks for refilling, spills and leakage shall not be required.

T. Audio/Visual Unit (Xenon Strobe):

1. Combination horn strobe units - Provide Truealert Non-Addressable 75 Cd, Red Sync. Two Wire. Comprised of a 24 VDC Xenon Flash Tube entirely solid state. The unit shall require a sync. Control module. Provide True 75 Cd from all axis.
2. Combination horn strobe units - Provide Truealert Non-Addressable 110 Cd, Red Sync. Two-Wire. Comprised of a 24 VDC Xenon Flash Tube entirely solid state. The unit shall require a sync. Control module. Provide True 110 Cd from all axis.
3. Visual only – Provide Truealert Non-Addressable 15 Cd, Red Sync. Two-Wire comprised of a 24 VDC Xenon flash tube entirely solid state.

U. Magnetic Door Holders:

1. Provide Semi-Flush or Flush Wall Mounted, 24 V.D.C. with catch plate.

V. Provide clear plastic covers with local audible alarm for pull stations in cell block area, where indicated on drawings, and required by fire department.

W. Alarm Transmission:

1. FACP to include "UDACT" communicator with Contract ID to report by device.

X. Testing:

1. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components and the pretesting, testing, and adjustment of the system.

2. Service personnel shall be qualified and experienced in the inspection, testing, and maintenance of fire alarm systems. Examples of qualified personnel shall be permitted to include, but shall not be limited to, individuals with the following qualifications:
 - a. Factory trained and certified.
 - b. National Institute for Certification in Engineering Technologies (NICET) fire alarm certified.
 - c. International Municipal Signal Association (IMSA) fire alarm certified.
 - d. Trained and qualified personnel employed by an organization listed by a national testing laboratory for the servicing of fire alarm systems.
3. Pretesting: Determine, through pretesting, the conformance of the system to the requirements of the Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new and retest until satisfactory performance and conditions are achieved.
4. Final Test Notice: Provide a 10-day minimum notice in writing when the system is ready for final acceptance testing.
5. Minimum System Tests: Test the system according to the procedures outlined in NFPA 72.
6. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets the Specifications and complies with applicable standards.
7. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log.
8. Final Test, Certificate of Completion, and Certificate of Occupancy:
 - a. Test the entire system new 100 percent devices as required by the Authority Having Jurisdiction in order to obtain a certificate of occupancy.
9. Fire Alarm Testing and Maintenance Agreement
 - a. Provide a one-year inspection and testing agreement in accordance with local Fire Department requirements and NFPA 72 recommendations. The holder of the testing and maintenance contract shall be a properly licensed and NRTL certified provider of Fire Alarm services and acceptable to the Fire Department.
 - b. Fire alarm testing agreement shall provide for a minimum of four inspections per year. Upon completion of each test, list actual devices checked. Provide a report to the Owner.

Y. Training:

1. Provide two (2) 4-hour sessions of Owner training with Owner's Representative.

2.20 SURGE PROTECTION DEVICES

A. SCOPE

1. This section describes the materials and installation requirements for surge protective devices (SPD) for the protection of all main service and panelboards.

B. SUBMITTALS

1. Submit shop drawings and product information for approval and final documentation in the quantities listed according to the Conditions of the Contract. All transmittals shall be identified by customer name, customer location, and customer order number.
2. Submittals shall include UL 1449 3rd Edition Listing documentation verifiable by visiting www.UL.com, clicking "Certifications" link, searching using UL Category Code: VZCA and VZCA2:
 - a. Short Circuit Current Rating (SCCR)
 - b. Voltage Protection Ratings (VPRs) for all modes
 - c. Maximum Continuous Operating Voltage rating (MCOV)
 - d. I-nominal rating (I-n)
 - e. SPD shall be UL listed and labeled as Type 1 or Type 4 intended for Type 1 or Type 2 applications
3. Upon request, an unencapsulated but complete SPD formally known as TVSS shall be presented for visual inspection.
4. Minimum of ten (10) year warranty

C. RELATED STANDARDS

1. IEEE C62.41.1, IEEE Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits,
2. IEEE C62.41.2, IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits,
3. IEEE C62.45, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
4. National Electrical Code: Article 285
5. UL 1283 - Electromagnetic Interference Filters
6. UL 1449, Third Edition, effective September 29, 2009 – Surge Protective Devices

D. QUALITY ASSURANCE

1. Manufacturer Qualifications: Engage a firm with at least 5 years' experience in manufacturing transient voltage surge suppressors.
2. Manufacturer shall be ISO 9001 or 9002 certified.
3. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of ten (10) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
4. The SPD shall be compliant with the Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC.

E. DELIVERY, STORAGE AND HANDLING

1. Handle and store equipment in accordance with manufacturer's Installation and Maintenance Manuals. One (1) copy of this document to be provided with the equipment at time of shipment.

F. MANUFACTURERS

1. Provide an internally mounted Surge Protective Devices (SPD) formerly called Transient Voltage Suppressor (TVSS) by:
 - a. Siemens Industry.
 - b. Current Technology
 - c. LEA
 - d. Liebert
 - e. APT
 - f. Or equal

G. ELECTRICAL DISTRIBUTION EQUIPMENT

1. Service Entrance
 - a. SPD shall be UL 1449 labeled as Type 1 or Type 4 intended for Type 1 or Type 2 applications, verifiable at UL.com, without need for external or supplemental overcurrent controls. Every suppression component of every mode, including N-G, shall be protected by internal overcurrent and thermal overtemperature controls. SPDs relying upon external or supplementary installed safety disconnectors do not meet the intent of this specification.
 - b. SPD shall be factory installed integral to electrical distribution equipment.
 - c. SPD shall be UL labeled with 20kA I-nominal (I-n)
 - d. SPD shall be UL labeled with 200kA Short Circuit Current Rating (SCCR).
 - e. Standard 7 Mode Protection paths: SPD shall provide surge current paths for all modes of protection: L-N, L-G, L-L, and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.
 - f. True 10 Mode Protection paths: SPD shall provide "directly connected protection elements" between all possible modes of protection: L-N, L-G, L-L, and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.
 - g. SPD shall be connected external of the distribution equipment with an appropriately sized 200kA SCCR rated disconnect.
 - h. SPD shall meet or exceed the following criteria:
 - 1) Maximum 7-Mode surge current capability shall be 300kA per phase.
 - 2) Maximum 10-Mode surge current capability shall be 300kA per phase.
 - 3) UL 1449 - Third Edition Revision; effective September 29, 2009 Voltage Protection Ratings shall not exceed the following:

<u>VOLTAGE</u>	<u>L-N</u>	<u>L-G</u>	<u>N-G</u>	<u>L-L</u>	<u>MCOV</u>
208Y/120	800V	800V	800V	1200V	150V
 - i. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

<u>System Voltage</u>	<u>Allowable System Voltage Fluctuation (percent)</u>	<u>MCOV</u>
208Y/120	25 percent	150V
 - j. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of -50dB at 100 kHz.
 - k. Suppression components shall be heavy duty 'large block' MOVs, each exceeding 30mm diameter.

- l. SPD shall include a serviceable, replaceable module.
- m. SPD shall be equipped with the following diagnostics:
 - 1) Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
 - 2) Audible alarm with on/off silence function and diagnostic test function (excluding branch).
 - 3) Form C dry contacts
 - 4) Optional – Surge Counter
 - 5) No other test equipment shall be required for SPD monitoring or testing before or after installation.
- n. SPD shall have a response time no greater than 1/2 nanosecond.
- o. SPD shall have a 10 year warranty.

2. Distribution Panel

- a. SPD shall be UL 1449 labeled as Type 4 intended for Type 1 or Type 2 applications, verifiable at UL.com, without need for external or supplemental overcurrent controls. Every suppression component of every mode, including N-G, shall be protected by internal overcurrent and thermal overtemperature controls. SPDs relying upon external or supplementary installed safety disconnectors do not meet the intent of this specification.
- b. SPD shall be factory installed integral to electrical distribution equipment.
- c. SPD shall be UL labeled with 20kA I-nominal (I-n)
- d. SPD shall be UL labeled with 200kA Short Circuit Current Rating (SCCR).
- e. Standard 7 Mode Protection paths: SPD shall provide surge current paths for all modes of protection: L-N, L-G, L-L, and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.
- f. SPD shall be connected to the buss of the distribution equipment with an appropriately sized 200kA SCCR rated disconnect.
- g. SPD shall meet or exceed the following criteria:

- 1) Maximum 7-Mode surge current capability shall be 100kA per phase.
- 2) Maximum 10-Mode surge current capability shall be 150kA per phase.
- 3) UL 1449 - Third Edition Revision; effective September 29, 2009, Voltage Protection Ratings shall not exceed the following:

<u>VOLTAGE</u>	<u>L-N</u>	<u>L-G</u>	<u>N-G</u>	<u>L-L</u>	<u>MCOV</u>
208Y/120	800V	800V	800V	1200V	150V

- a) UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

<u>System Voltage</u>	<u>Allowable System Voltage Fluctuation (percent)</u>	<u>MCOV</u>
208Y/120	25 percent	150V

- h. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of - 50dB at 100 kHz.
- i. Suppression components shall be heavy duty 'large block' MOVs, each exceeding 30mm diameter.
- j. SPD shall include a serviceable, replaceable module.

- k. SPD shall be equipped with the following diagnostics:
- 1) Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
 - 2) Audible alarm with on/off silence function and diagnostic test function (excluding branch).
 - 3) Form C dry contacts
 - 4) Optional – Surge Counter
 - 5) No other test equipment shall be required for SPD monitoring or testing before or after installation.
- l. SPD shall have a response time no greater than 1/2 nanosecond.
- m. SPD shall have a 10 year warranty.]
- n. Branch Panels
- o. The panelboard shall be UL 67 Listed and the SPD shall be UL 1449 labeled as Type 1 or as Type 4 intended for Type 1 or Type 2 applications.
- p. The unit shall be top or bottom feed according to requirements. A circuit directory shall be located inside the door.
- q. SPD shall meet or exceed the following criteria:
- 1) Maximum 7-Mode surge current capability shall be 100kA per phase.
 - 2) Maximum 10-Mode surge current capability shall be 150kA per phase.
 - 3) UL 1449 - Third Edition Revision; effective September 29, 2009, Voltage Protection Ratings shall not exceed the following:
- | <u>VOLTAGE</u> | <u>L-N</u> | <u>L-G</u> | <u>N-G</u> | <u>L-L</u> | <u>MCOV</u> |
|----------------|------------|------------|------------|------------|-------------|
| 208Y/120 | 800V | 800V | 800V | 1200V | 150V |
- r. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):
- | <u>System Voltage</u> | <u>Allowable System Voltage Fluctuation
(percent)</u> | <u>MCOV</u> |
|-----------------------|---|-------------|
| 208Y/120 | 25 percent | 150V |
- s. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of - 50dB at 100 kHz.
- t. Suppression components shall be heavy duty 'large block' MOVs, each exceeding 30mm diameter.
- u. SPD shall include a serviceable, replaceable module.
- v. SPD shall be equipped with the following diagnostics:
- 1) Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
 - 2) Audible alarm with on/off silence function and diagnostic test function (excluding branch).
 - 3) Form C dry contacts
 - 4) Optional – Surge Counter
 - 5) No other test equipment shall be required for SPD monitoring or testing before or after installation.
- w. SPD shall have a response time no greater than 1/2 nanosecond.
- x. SPD shall have a 10 year warranty.
- y. The unit shall have removable interior.
- z. The main bus shall be [copper] [aluminum] and rated for the load current required.

- aa. The unit shall include a 200 percent rated neutral assembly with copper neutral bus.
- bb. The unit shall be provided with a safety ground bus.
- cc. The field connections to the panelboard shall be main lug or main breaker.
- dd. The unit shall be constructed with flush or surface mounted trim and shall be in a NEMA Type 1 enclosure.

H. INSTALLATION

- 1. Install per manufacturer's recommendations and contract documents.

I. ADJUSTMENTS AND CLEANING

- 1. Remove debris from installation site and wipe dust and dirt from all components.
- 2. Repaint marred and scratched surfaces with touch up paint to match original finish.

J. TESTING

- 1. Check tightness of all accessible mechanical and electrical connections to assure they are torqued to the minimum acceptable manufacture's recommendations.
- 2. Check all installed panels for proper grounding, fastening and alignment.

K. WARRANTY

- 1. Equipment manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than eighteen months from date of shipment.

2.21 AUTOMATED LIGHTING CONTROL SYSTEM

A. General: Summary

- 1. Section Includes:
 - a. Addressable Networked Light Management System.

B. References

- 1. National Fire Protection Association (NFPA)
- 2. cULus Listing/Certification
 - a. Certified as Energy Management Equipment (UL 916)
 - b. Certified as Emergency Lighting Equipment (UL 924)
 - c. Meet Heat and Smoke Release for Air-Handling Spaces (UL 2043)
- 3. Federal Communications Commission (FCC) / Industry Canada (IC)
- 4. California Energy Commission (CEC)
- 5. Local Building Codes

C. System Description

1. Lighting Control System includes computer-based software that provides control, configuration, monitoring and reports. System including but not limited to the following components:
 - a. Central Control Unit
 - b. System Server
 - c. 0-10V Dimming, Fixed Output Ballasts or 0-10V LED Drivers
 - d. System Field Devices (Input and Output Modules)
 - e. Lighting Control System Software
 - f. Lighting Controllers
 - g. Communication Wire
 - h. Occupancy sensors
 - i. Photo sensors
 - j. Wireless site lighting control modules (#WSLC), one per pole mounted fixture
 - k. Wireless Manager for site lighting
 - l. Wireless Control modules #WCM
 - m. Lighting control panels
 - n. Interface to audio visual equipment
 - o. Interface to BACnet
 - p. Interface to Tridium Niagara
 - q. Incandescent low-voltage dimming modules
 - r. Tunable white light programming
 - s. Coordination of final lighting programming
 - t. Owner training

D. Submittals

1. Bill of Materials: Complete list of all parts needed to fully install selected system components.
2. Product Data: For each type of product indicated.
3. Shop and Wiring Drawings: Submit shop drawings detailing control system, as supplied, including one-line diagrams, wire counts, coverage patterns, interconnection diagrams showing field-installed wiring and physical dimensions of each item.
4. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.
 - a. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
 - b. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.
5. Software Operational Documentation:
 - a. Software operating and upgrade manuals.
 - b. Program Software Backup: On compact disc or DVD, complete with data files.
 - c. Printout of software application and graphic screens, or upon request, a live demonstration of Control, Configure and Analyze functionality or a video demonstrating above stated system capabilities.
6. Installation Instructions: Manufacturer's installation instructions.

7. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.
8. Warranty: Copy of applicable warranty.

E. Quality Assurance

1. Installer Qualifications: Installer shall be one who is experienced in performing the work of this section, and who has specialized in installation of work similar to that required for this project.
2. Manufacturer Requirements: The manufacturer shall have a minimum of 10 years experience manufacturing networked lighting control systems and shall provide 24/7 telephone support by qualified technicians.
3. Contractor shall ensure that lighting system control devices and assemblies are fully compatible and can be integrated into a system that operates as described in the lighting control notes on drawings and as described within this specification. Any incompatibilities between devices, assemblies, and system controllers shall be resolved between the contractor and the system provider to ensure proper system operation and maintainability.
4. Performance Requirements: provide all system components that have been manufactured, assembled, and installed to maintain performance criteria stated by manufacturer without defects, damage, or failure.
5. Performance Testing Requirements
 - a. Manufacturer shall 100 percent test all equipment prior to shipment. Sample testing is not acceptable.
6. Code Requirements
 - a. System Control Unit and System Field Devices shall be cULus listed and certified.
 - b. All system components shall be FCC /IC compliant.
 - c. All system components shall be installed in compliance with National Electrical Codes and Canadian Electrical Code.
 - d. Building Codes: All units shall be installed in compliance with applicable, local building codes.
7. ISO Certification: System components shall be manufactured at ISO-9000 certified plants.

F. COORDINATION

1. Coordinate lighting control components to form an integrated interconnection of compatible components.
 - a. Match components and interconnections for optimum performance of lighting control functions.
 - b. Display graphics showing building areas controlled; include the status of lighting controls in each area.

G. Delivery, Storage & Handling

1. Ordering: Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
2. Delivery: Deliver materials in manufacturer's original, unopened, undamaged packaging with intact identification labels.

3. Storage and Protection: Store materials away from exposure to harmful weather conditions and at temperature and humidity conditions recommended by manufacturer.

H. Warranty

1. On-going system expansion, service and support shall be available from multiple factory certified vendors. Recommended service agreements shall be submitted at the time of bid complete with manufacturers suggested inventory and pricing for system parts and technical support labor.
2. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship within specified warranty period.
3. Manufacturer's Warranty: All equipment shall be warranted free of defects in materials and workmanship.
 - a. Warranty Period: All system hardware components shall have full warranty (non-prorated) for at least four years and all software components shall carry a warranty of 90 days from date of installation.
 - b. Owner Rights: Manufacturer's warranty is in addition to, not a limitation of, other rights the Owner may have under contract documents, or warranties of third party component manufacturers.

I. Basis of Design Products

1. Controls: ENCELIUM Energy Management System by OSRAM SYLVANIA
2. Sensors: ENCELIUM Sensors by OSRAM SYLVANIA & Hubbell Building Automation, Inc.

J. Acceptable Alternate Manufacturers

1. Controls: Lutron, N-light, Philips, or equal.
2. Sensors: Lutron, Sensor Switch, Watt Stopper, Leviton, Cooper or equal.

K. System Performance Requirements

1. This specification is intended to fully describe all of the design, engineering, programming, hardware, software, ancillary devices and associated technical services required to provide a building-wide networked lighting control system. This system is specified to perform scheduled and automated lighting control sequences.
2. The lighting control "system" shall include a fully distributed WAN/LAN network of global controller/routers, individually addressable System Field Devices, sensors, switches, relays and other ancillary devices required for a complete and operable system. The system WAN/LAN shall be commissioned by ENCELIUM personnel or other ENCELIUM certified commissioning contractors.
3. The basis of system design shall utilize non-propriety industry standard 0-10V dimming or fixed output ballasts and/or 0-10V LED drivers, occupancy sensors, and daylight sensors.
4. On-going system expansion, service and support shall be available from multiple factory certified vendors. Recommended service agreements may be submitted at the time of bid complete with manufacturers suggested inventory and pricing for system parts and technical support labor.

5. Lighting Control Software: The system shall offer two separate levels of lighting control: one personal lighting control for the average building occupant to control and adjust basic lighting functions in their workspace, and two central lighting control for the facility lighting administrator to perform energy management, configuration maintenance, monitoring operations, and providing support to building occupants.
 - a. Native central control software shall be utilized for energy reporting status and complete programming without the need for any third party hardware or software. Systems that require any third party linked software or graphics shall be unacceptable.
 - b. Software shall provide information on general system settings via mouse click on a floor plan. Left clicking over a device on the graphical software interface shall show a description of the selected device/function attribute.
6. Central Lighting Control:
 - a. Shall provide an Interactive, Web-based graphical user interface (GUI) showing floor plans and lighting layouts that are native to the lighting control software. The only means required to program and operate the lighting control system shall be programmed and operated from a user interface that is based on a plan view graphical screen on the user's computer or the lighting control system's main computer. Shall include the navigational features listed below to allow for user's orientation within the controlled space, geographic heading and/or landmarks:
 - 1) Interactive
 - 2) Vector based
 - 3) Zoom
 - 4) Rotate
 - 5) Pan
 - 6) Tilt
 - b. Shall allow building operator to navigate through an entire facility both in two-dimensional and three-dimensional multi-floor view, allowing for fast and easy navigation.
 - c. Three-dimensional view shall exclude walls and other structural features to avoid shadowing and cluttering of the plan view.
 - d. All programming, assignments of lighting loads to control strategies, lighting status and lighting energy reporting shall be native to the software and executed from this GUI. Editing shall be available from this GUI in a drag and drop format or from drop down menus without the need for any third party software. Systems that utilize or require third party linked graphics are unacceptable. The GUI shall continuously indicate the status of each connected device on the system and a warning indicator on the software if a device goes offline. Systems requiring spreadsheet editing for programming and that don't offer real time feedback are not acceptable.
 - e. Software settings and properties shall be selectable per individual device, room based, floor based or global building based.
 - 1) Lighting Control Software interface shall provide current status and enable configuration of all system zones including selected individual fixture availability, current light level, maximum light level, on/off status, occupancy status, and emergency mode (response to an emergency signal) status.

- f. Shall have the ability to display various lighting system parameters such as Lighting status (ON/OFF); Lighting levels, Load shedding status, or Lighting energy consumption, Occupancy status in a colorized gradient ("weather" map) type of graphical representation.
 - g. Energy Analysis data shall be exportable in a CSV or similar format.
 - h. Shall allow import of native AutoCAD files.
- 7. Reports: Reporting feature shall be native to the lighting control software and capable of reporting the following parameters for each device and zone individually without requiring any third party hardware and software:
 - a. Energy consumption broken down by energy management strategy.
 - b. Energy demand broken down by energy management strategy.
 - c. Occupancy data by zone.
 - d. Building wide occupancy status
 - e. Lighting energy consumption in a color gradient ("weather map" type) view
 - f. Energy performance reports shall be printable in a printer friendly format and downloadable for use in spreadsheet applications.
- 8. Personal Lighting Controls: The Personal Control Software interface shall provide current status and enable each user with the ability to dim and brighten lights, and turn them on and off by individual fixture or zone. The Software shall offer user configurable light scenes, which may be programmed and then selected via the Software. Personal lighting control shall be available in open/private office environments.
- 9. Daylight Harvesting (Light Regulation Averaging): In a photo sensor-equipped system, the Central Controller Unit shall rationalize changes to light levels when ambient (natural) light is available and shall maintain a steady light level when subjected to fluctuating ambient conditions where dimming ballasts and/or drivers exist. Areas equipped with fixed output ballasts and/or drivers shall energize when natural light falls below foot-candle levels specified. System shall utilize light level inputs from common and/or remote sensor locations to minimize the number of photo sensors required. The System shall operate with multiple users in harmony and not react adversely to manual override inputs.
- 10. Time Clock Scheduling: The system shall be programmable for scheduling lights on or off via the Lighting Control Software interface.
 - a. Support for BACnet Time Schedule Object: This allows the export of Lighting Control time schedules to BACnet devices and vice versa in the event of Lighting Control System's integration with BACnet.
 - b. Override: Manual adjustments via lighting controllers or personal control software shall temporarily override off status imposed by time clock schedule.
 - c. Response to Power Failure: In the event of a power failure, the time clock shall execute schedules that would still be in progress had they begun during the power outage.
 - d. Flick Warning: Prior to a scheduled lights-off event or expiry of a temporary override, the system shall provide two short light level drops as a warning to the affected occupants. Flick warning time shall have the ability to be programmed via software between one and five minutes.

11. Load Shed Mode: An automatic load shedding mode shall be available where, when activated through the system, the control unit will reduce its output to a programmable maximum electrical demand load. The system shall not shed more load than required and load shedding priority shall be centrally configurable by control zone or by common uses (i.e., all hallways can be treated as one load shed group), with subsequent load shed priority groupings being utilized until the required defined load has been shed, for either a defined period, or until the demand response input has been removed. Systems that simply select a "load shed scene" whereby there is no guarantee that the defined required load will actually be shed are not acceptable.
12. Emergency Mode: There shall be a mode, when activated through the system, that will immediately adjust lights to full light output and retain that level until the mode is deactivated in the event of an emergency. This setting shall override all other inputs. The system shall interface with the building of life safety transfer switch, fire alarm control panel, and security system control panel.
13. Addressing: All ballasts and/or drivers shall be centrally addressable, on a per fixture or multiple fixtures/zone basis, through the Central Control Software. The basis of design shall utilize industry standard 0-10V Dimming, Fixed Output Ballasts and/or 0-10V LED Drivers connected to an Output Module. To simplify ongoing maintenance, the system shall not require manual recording of addresses for the purpose of commissioning or reconfiguration.
14. Programmable Task Tuning: Maximum light level programmability shall be available by individual fixture.
15. Unoccupied State: The system shall provide two states when occupancy status is vacant as per an occupancy sensor: lights turn off or lights adjust to configurable (dimmed) light level.
16. Occupied State: The system shall be capable of creating "comfort" or "support" zones to ensure that occupants are not isolated by turning off lights in adjacent areas for occupant comfort and safety, such as a hallway path to exit the premises.
17. The Automated Lighting Control System (ALCS) BACnet Interface shall share the following information with the BACnet enabled Building Automation System and other systems listed below:

<u>Property</u>	<u>BACnet Type</u>	<u>Description</u>
Lighting Load	Analog Value*	Reports the total lighting load of the ALS, defined in Watts
Light Zone State	Binary Value*	State of the defined lighting zone - ON or OFF
Light Zone Dimming	Analog Value*	Light output level of the defined lighting zone, from 100 percent (maximum light output) to 0 percent (minimum light output)
Emergency System State	Binary Input	State of the emergency alarm system: alarm activated or alarm not activated
Fire Alarm State	Binary Input	State of the fire alarm system: alarm activated or alarm not activated

Security System State	Binary Input	State of security alarm system: alarm activated or alarm not activated
Occupancy State	Binary Output	State of the defined occupancy sensor – occupancy detected or not detected
Sheddable Load	Analog Output	Reports the total lighting load available for load reduction according to ALS, defined in Watts
Shed Status	Analog Output	Reports the total current load reduction achieved according to ALS defined prioritization, defined in Watts
Shed Request	Analog Input	Requested total amount of load reduction, defined in Watts or as a percentage of sheddable load
Sheddable Load (Group)	Analog Output	(As above, unprioritized for the selected group)
Shed Status (Group)	Analog Output	(As above, unprioritized for the selected group)
Shed Request (Group)	Analog Input	(As above, unprioritized for the selected group)

18. LAN Operations: System shall be capable of operating independent of building's existing network infrastructure if desired and shall not rely on tenant supplied PCs for operation. Network infrastructure shall only be utilized for Personal Control Software.
19. Firewall Security: Firewall technology shall be utilized to separate tenants from the lighting control network.
20. Lamp Burn In: The system software shall not permit dimming of new lamps prior to completion of lamp manufacturer 100 hour recommended accumulated operation at full brightness.
21. Re-configurability: The assignment of individual fixtures to zones shall be centrally configurable by Central Control Software such that physical rewiring will not be necessary when workspace reconfiguration or re-zoning is performed. Removal of covers, faceplates, and ceiling tiles. shall not be required.
22. Automatic Control Parameters: Occupancy sensor time delays shall be configurable through software. Light level sensor parameters shall be configurable through software.
23. Automatic Time Adjustment: System shall automatically adjust for leap year and daylight savings time and shall provide weekly routine and annual holiday scheduling.
24. Contact closure input: System shall be capable of receiving a momentary and sustained contact closure input from third party sources to control lighting zones.

25. The light management system shall interface digitally with the building automation system via BACnet/IP and Tridium Niagara AX interface. The lighting control system shall communicate the status of output devices (lighting loads) as well as input devices (dry contacts, switches, occupancy sensors, vacancy sensors, and photocells) over this connection allowing the building automation system to utilize lighting control system input devices such as occupancy sensors to determine if mechanical control zones are occupied for climate adjustments.
26. The system software shall provide a web based energy dashboard to show real time energy savings data and carbon footprint reductions.
27. Migration Plan to Control LED Fixtures
 - a. System shall be capable of migrating from the control of 0-10V Ballasts to 0-10V LED Drivers utilizing the same Output Modules without the need to change control hardware.

L. Lighting Controllers

1. Description: The system shall include separate lighting controllers for each of the listed functionalities and at minimum meet listed electromagnetic, mechanical, electrical and data specifications:
 - a. Software configurable lighting controller that provides on/off switching and dimming control for up to three lighting zones/scenes per controller or more with allowable multi-gang configurations. Status is indicated by an LED display to indicate function, scene or zone. Allows manual override of the time schedule.
 - b. Manual dimming and/or switching lighting controller that provides local on/off and dimming control over at least three lighting zones. Allows manual dimming of light levels and override of the time schedule.
 - c. Scenes in the central control software shall be synchronized with the buttons on the lighting controller.
 - d. Lighting controllers shall fit in a standard Decorator style wall plate and may be ganged together.
2. General
 - a. Addressing: All controllers shall be individually addressable & reconfigurable via Central Control Software.
 - b. Shall provide local on/off or dimming control over lighting zones
 - c. Shall utilizing a standard single-gang or multi-gang form factor
 - d. Shall have a terminal block that connects to lighting system with 18 AWG, polarity independent, CMP rated and low voltage wire
 - e. Shall be manufactured with push-in wire receptacles
 - f. LED's: All controllers shall feature LED's to indicate light on and light off status.
 - g. Color: All controllers shall meet NEMA WD1 color specifications.
 - h. Style: All controllers shall feature Decorator styling wall plates.
 - i. Lighting scenes reconfigure automatically based on scene changes from personal control software.
 - j. Industrial lighting controllers shall also be available for damp location applications.
 - k. Shall comply or exceed the following electromagnetic requirements:
 - 1) EN 61000-4-2
 - 2) EN 61000-4-4
 - 3) EN 61000-4-5
 - 4) FCC Part 15/ICES-003

3. Mechanical Specifications:
 - a. Dimensions: Shall meet NEMA WD-6 spec.
 - b. Maximum Operating Ambient Temperature: 60 deg C.
 - c. Mounts in standard size wall box suitable for multi gang installation or alternative of Low Voltage mounting bracket.
 - d. Suitable for use with Decorator style wall plates.
4. Electrical Specifications:
 - a. Class 2 Low Voltage device.
 - b. Power through interconnected 18 AWG cable with 2-pin header
5. Data Specifications:
 - a. Class 2 communication bus that uses prefabricated 18 AWG cable.

M. Wireless Site Lighting Control Module

1. The wireless site lighting control module shall extend the networked light management system's controls capability to a building's surroundings or site such as parking lots and short pathways, via a wireless mesh network based on Zigbee standards. The wireless site lighting control installs on top of a luminaire via an ANSI C136.41 compliance 7-pin twist-lock connector.
2. The wireless site lighting control shall be individually addressable via the wireless system management and can switch luminaires ON/OFF via an integrated high current relay, dim luminaires equipped with 0-10V dimming drivers or ballasts and has an input for an external occupancy sensor.
3. Specifications:
 - a. Power:
 - 1) Operating voltage 120V-347V
 - 2) Power consumption as no load: <1.0W
 - 3) Surge protection: 6kV, 6kA
 - b. Load Rating: 10A: Electronic driver/ballast, magnetic ballast, resistive load
 - c. Interface:
 - 1) Single dimming output that is 0-10V (IEC 60929 Annex E), DA-LI or DEXAL compatible.
 - 2) Sink/source 10 mA
 - 3) Sensor Input: Maximum 20 mA; minimum 18; nominal 19.5V
 - d. Software:
 - 1) Individual addressability
 - 2) Time schedule based control
 - 3) Daylight based control
 - 4) Astronomical schedule based control
 - 5) Occupancy based control

- e. Power Metering
 - 1) V, I, P Energy
 - a) Accuracy is <2% from 0.5A to 10A load
 - b) Accuracy is <5% below 0.5A
- f. Environmental
 - 1) Operational Temp: -40 deg. F to +150 deg. F (-40 deg. C to +65 deg. C)
 - 2) Relative humidity: 0% to 95%
 - 3) Ingress protection: IP66
- g. Communication
 - 1) Wireless protocol: ZigBee
 - 2) Radio Frequency: 2.4 GHz
 - 3) Transmit power: 20 dBm
 - 4) Up to 1,000 ft. Line of sight between modules
- h. Physical
 - 1) Base diameter: 3.31 in. (84 mm); height: 2.61 in. (66.4 mm)
 - 2) Weight: 0.44lbs (200g)
 - 3) Color: black
 - 4) Housing: UV stabilized PC
- i. Regulatory
 - 1) UL/916/773 cULus listed
 - 2) Meets ASHRAE Standard 90.1 and CEC Title 24 requirements
 - 3) FCC Part 15/ICES-003

N. Wireless Manager

- 1. The wireless manager shall collect, process and distribute lighting control information to control modules over a wireless mesh network. Each wireless manager typical can control up to 100 nodes.
- 2. The wireless manager is the central intelligence point in the system for the wireless devices. It collects signal information from control modules, it then determines appropriate brightness levels or ON/OFF status for each fixture and zone.
- 3. Specifications:
 - a. Wireless Range: 100 ft. line of sign, 50 ft through standard walls
 - b. Wireless manager Network Port – Ethernet 1-/100BaseTx Cat. 5 RJ45 port
 - c. Dual PoE ports for daisy chain of up to 3 wireless managers
 - d. Status LED on front of unit
 - e. Configuration stored in non-volatile flash memory
 - f. Weights: 115g (4.06oz) wireless manager 40g (1.41 oz) ceiling mounted kit
 - g. Operating temperature range: 32 deg. F to 104 deg. F (0 deg. C to 40 deg. C)
 - h. AES 128-bit encryption for wireless communication
 - i. Dimensions: 2.81 in. W x 4.631 in. H x 0.78 D (71.37mm W x 117.6mm H x 19.81mm D)
 - j. Includes Polaris 3D software

- k. cULus Listed
 - 1) Energy Management Equipment (UL 916)
 - l. Complies with the following electromagnetic requirements:
 - 1) EN 61000-4-2
 - 2) EN 61000-4-4
 - 3) EN 61000-4-5
 - m. FCC Part 15/ICES-003
- O. System Field Devices (Input and Output Modules)
- 1. General: Input Modules provide a common interface to low voltage occupancy sensors and photo sensors while Output Modules provide a common interface to 0-10V Dimming, Fixed Output Ballasts and/or 0-10V LED Drivers and analog dimming devices such as incandescent low-voltage dimming modules. These modules automatically self-address and detect the type of devices they are connected to (i.e., photo sensor, occupancy sensor, 0-10V ballast, 0-10V LED drivers or incandescent dimming module) and establish two-way communication between the system Control Unit (CU) and themselves. These individually addressable modules enable each lighting component to be independently controlled and configured to best meet the needs of the facility.
 - a. Addressing: System Field Devices shall be individually addressable via Central Control Software.
 - b. System shall automatically address individual nodes during system commissioning thus eliminating the need to pre-address devices or record serial numbers during installation.
 - c. Modules shall at minimum meet the listed general, mechanical and environmental specifications set at below.
 - 2. Provide Wireless site lighting control (WSLC) module for all site lighting unless specifically noted on the electrical site plan.
 - 3. Air Gap Off
 - a. Definition: Air Gap Off shall refer to the physical disconnection of AC power to the ballast or driver when "OFF" is selected either automatically or manually, thus ensuring maximum energy savings by eliminating off-state phantom power losses as well as ensuring that no potentially lethal high-voltage is present at the ballast or driver when the lights appear to be off (for life-safety reasons).
 - b. Provisions: Provide an air-gap off relay for each control zone in the system. Where each fixture is to be controlled (dimmed and/or switched) independently, provide one relay per fixture. Where multiple fixtures are to be controlled (dimmed and/or switched), provide one relay per control zone, sized to handle both the inrush current as well as the maximum connected load, at the specified voltage.
 - 4. General Specifications:
 - a. Shall supply 12VDC (up to 24VDC) to sensors.
 - b. Shall have 2 ports that accept 18 AWG, pre-fabricated, polarity independent quick connecting Class 2 communication bus that supplies 24 VDC.
 - c. Two models, one rated for regular indoor use and other for use in damp locations such as basements, cold storage areas. shall be available.

- d. Memory: Retains all system settings in non-volatile memory.
- 5. Mechanical Specifications:
 - a. Wiring: The System Field Device shall not require wiring connections to the System apart from pre-terminated, quick connecting 18 AWG, polarity independent quick connecting Class 2 communication bus.
- 6. Environmental Specifications:
 - a. Operating Temperature Range: -40 deg C to +55 deg C.
 - b. Humidity: 0 percent to 100 percent RH condensing rated for damp locations.
0 percent to 95 percent RH non-condensing rated for indoor locations.
- P. Energy Control Unit
 - 1. General: The Energy Control Unit (ECU) is a rack or wall mounted lighting control device that collects, processes and distributes lighting control information to System Field Devices and lighting controllers over a Class 2 communication bus. Each ECU has multiple Class 2 communication channels and can control a large quantity of nodes (sensors, lighting controllers, 0-10V Dimming, Fixed Output Ballasts and 0-10V LED Drivers.) per channel, per the manufacturers recommended maximum. The ECU is the central intelligence point for the area that it controls, collecting signal information from sensors, lighting controllers and personal control software and determining appropriate brightness levels or on/off status for each fixture or zone. Each ECU has an Ethernet connection for communication with a facility's or tenant's Local Area Network (LAN) to enable desktop personal control.
 - a. Shall interconnect with other ECUs and System Server Unit (SSU) using standard Ethernet connection that employs TCP/IP protocol.
 - b. Control units shall at minimum meet the mechanical, electrical, data, electromagnetic and environmental specifications listed below.
 - 2. Mechanical Specifications:
 - a. Shall mount in a standard 1 inch rack (1U width), or alternatively where no rack is shown, via an individual wall mount.
 - 3. Electrical Specifications:
 - a. Power Supply: 120V/60Hz/200W. Provide dedicated 120V receptacle fed from a dedicated normal power circuit; do not connect to a UPS or normal/emergency power source.
 - 4. Data Specifications:
 - a. Shall have 8 ports that accept 18 AWG, pre-fabricated, polarity independent quick connecting Class 2 communication bus that supplies 24 VDC
 - b. Each ECU channel shall support up to 100 nodes or 800 nodes in total.
 - c. Each ECU shall have two Ethernet 10/100Base - Tx Cat 5 RJ45 ports that employs TCP/IP protocol:
 - 1) Lighting Control Network
 - 2) Tenant LAN Access Point

- d. Shall have a status LED on front of unit.
 - e. Shall have configuration stored in non-volatile flash memory.
5. Shall comply or exceed the following electromagnetic requirements:
- a. EN 61000-4-2
 - b. EN 61000-4-4
 - c. EN 61000-4-5
 - d. FCC Part 15/ICES-003
6. Environmental Specifications:
- a. Operating Temperature Range: -20 deg C to +40 deg C.
 - b. Humidity: 0 percent to 95 percent RH non-condensing.

Q. System Server Unit

1. General: System Server Unit (SSU) shall host the lighting control system database for all the lighting control devices. Server shall have the ability to:
- a. Remotely access a system in order to change system settings or configuration;
 - b. Analyze system performance or energy data or generate system report;
 - c. Record energy consumption with average sampling every 5 minutes for unlimited duration;
 - d. Host the web interface required for the web enabled Personal Control Software or web based Central Control Software;
 - e. Optionally can reside on a client server (virtual server) thus eliminating the need for dedicated physical hardware if desired;
 - f. Interconnect with ECUs over standard Ethernet connection that employs TCP/IP protocol;
2. Hardware based servers shall at minimum meet the specifications listed below:
- a. Specifications:
 - 1) Mechanical Specifications:
 - a) Shall mount in a standard 19 inch rack (1U width), or alternatively where no rack is shown, via an individual wall mount.
 - b. Electrical Specifications:
 - 1) Power Supply: 120V/60Hz/200W. Provide dedicated 120V receptacle fed from a dedicated normal power circuit.
 - c. Regulatory:
 - 1) FCC (US only) Class A.
 - 2) DOC (Canada) Class A.
 - 3) UL 60950.
 - 4) CAN/CSA-C22.2 No. 60950.

R. Communication Wire

1. Wiring: 18 AWG, pre-fabricated, polarity independent quick connecting wiring. The system shall have the capability to use both Class 1 and Class 2 wiring. The maximum connected length of wiring shall be 2500 ft. per channel.
2. Field Bus: Integrates peripheral devices such as 0-10V ballasts and/or 0-10V LED drivers, occupancy sensors, photo sensors, relay-based controls, power packs and low voltage wall controls into a complete, networked programmable lighting control system. Provides power to photo sensors, PIR occupancy sensors and dual-technology occupancy sensors. Devices may be connected randomly on the network and special termination of each network channel is not required.
3. Field bus shall at minimum meet the specifications listed below:
 - a. Specifications:
 - 1) Class 2 communication bus.
 - 2) Prefabricated one ft., five ft., ten ft., 15 ft., 20 ft., 25 ft. and 50 ft. lengths.
 - 3) Daisy chain topology
 - 4) Prefabricated with 2-wire connectors.
 - 5) Flame rated jacket for plenum use NFPA 262 (UL: FT6, CSA: CMP).
 - 6) Power Supply: 12 VDC (up to 24 VDC) to sensors.

S. Conductors and Cables

1. Class 2 Control Cable: Multi-conductor cable with stranded-copper conductors not smaller than No. 18 AWG.

T. Lighting Control Panels

1. General
 - a. Addressing: All lighting control panels shall be individually addressable via Central Control Software.
 - b. Communication: All lighting control panels shall communicate via the same prefabricated, quick connecting low voltage wiring as all other devices.
 - c. Wiring: Relay control panels shall be interconnected on the same field bus as all other system components.

U. Lighting Control System Software

1. Personal Control Software: Enables individuals in a building to control lighting levels in their workspace from their own desktop PC. User can control the light level of each fixture in their workspace or can control all of the fixtures together as a group. Preset lighting scenes may be stored, recalled and modified. This software shall have the capability of acting as a "virtual occupancy sensor" for the system by detecting keyboard or mouse activity on each PC for incremental occupancy status data.
 - a. Technical Information:
 - 1) TCP/IP network traffic < 2kb/s.

2. Web based Personal Control Software: This feature allows individuals to control lighting levels in their workspace without the requirement for installation of software on client PCs. Individuals can access the interface through the web browser and perform individual fixture dimming control, on/off switching, modify and save preset lighting scenes.
3. Technical Information: Adobe Flash ® based user interface.
 - a. System Requirements:
 - 1) Internet web browser with Flash® Player 8 or later.
 - 2) Internet/Intranet connection.
 - 3) SSU enabled and configured to host dynamic website.
 - 4) Network connection with access to a network-enabled CU.
4. Web based Central Control Software: Central control software application is used to commission, configure and manage the system. Every system parameter in a building (or campus of buildings) is configured for each individual user or space and baseline settings are established for each of the following (depending on the basis of design) system features:
 - a. Daylight harvesting.
 - b. Occupancy control.
 - c. Smart time scheduling.
 - d. Task tuning.
 - e. Personal control.
 - f. Load shedding.
 - 1) Software utilizes a web based interface that permits a user to easily navigate between zones, floors or different buildings and allows a user to zoom in or zoom out of specific areas of a building. Both 3-dimensional and 2-dimensional multi-floor views shall be available. System features such as creation of zone hierarchies, overlapping and support zone definitions, user access rights, timeout settings for occupancy sensors, calibration of light levels for daylight harvesting and the configuration of multiple time schedule profiles shall be available. A web based Graphical User Interface (GUI) application integral to the system will be used to develop a dynamic, real-time, point-and-click graphic of each floor plan with representation of all light fixtures, lighting controllers, sensors, and switches. A central system server will be provided to support system data base and enterprise control management.
5. System Requirements:
 - a. Software must be able to run on a Windows Operating systems (Windows XP or newer) and also on Apple Mac Intel PCs (Mac OS 10.4 or newer).
 - b. Must support all common browsers, i.e.,
 - 1) Internet Explorer 6.0 or later
 - 2) Mozilla Firefox 3.0 or later
 - 3) Safari
 - 4) Google Chrome
 - c. Network connection with access to network-enabled CUs.

- d. Color gradient ("weather map" type) data view (see below for an example) shall be available to display the following criteria:
 - 1) Current energy consumption
 - 2) Current energy savings
 - 3) Current fixture brightness
 - 4) Current fixture status
 - 5) Current occupancy data
 - 6) Current load shedding status
 - 7) Other custom modes that may be specified elsewhere

V. Photo Sensor:

Photo sensors shall at minimum meet the specifications listed below:

1. General Specifications:

- a. Shall be Class 2, low voltage.
- b. Ambient light sensor designed to interface directly with the analog input of the Lighting Control System.
- c. Sensor shall supply an analog signal to the ALCS proportional to the light measured.
- d. Sensor output shall provide for zero or offset based signal.
- e. Sensor shall be capable of a fully adjustable response in the range between 0 and 10,000 foot candles with a +/- 1 percent accuracy at 70 deg F.
- f. Input: 10VDC.
- g. Minimum Output: 0 VDC.
- h. Maximum Output: 10 VDC.
- i. Sensor housing shall be flame retardant and meet UL 94 HB standards.
- j. Operating Temp: -10 deg C to 60 deg C.
- k. The sensitivity adjustments shall be at sensor body, and outside of the sensor's viewing angle.
- l. The sensor housing shall be flame retardant and meet UL 94HB standards

2. Interior:

- a. Indoor sensors shall have a Fresnel lens, with a 60 degree cone of response. The indoor sensor range shall be between 0 and 750 FC.

3. Exterior:

- a. Outdoor models shall have a hood over the aperture to shield the sensor from direct sunlight. The outdoor sensor circuitry shall be completely encased in an optically clear epoxy resin. Outdoor sensors shall mount to a standard threaded 1/2 in. conduit or fit a 1/2 in. knockout. The Outdoor sensor range shall be between 0 and 750 FC.

4. Atrium:

- a. The Atrium sensors shall have a translucent dome with a 180 degree field of view. Atrium sensor shall mount to a standard treaded 1/2 in. conduit or fit a 1/2 in. knockout. Atrium sensor range shall be from 2 to 2,500 FC.

5. Skylight:

- a. The Skylight sensors shall have a translucent dome with a 180 degree field of view. Skylight sensor shall mount to a standard treaded 1/2 in. conduit or fit a 1/2 in. Skylight sensor range shall be between 10 and 7,500 FC.

W. Occupancy Sensors

1. Environmental:

Operating Temperature Range: 0°C to 40°C

- a. Relative Humidity: 0 percent to 95 percent non-condensing
- b. Ceiling Mount Occupancy/Vacancy Sensors
 - 1) Sensing mechanism:
 - 2) Dual technology (ultrasonic / passive infrared):
 - 3) Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
 - 4) Utilize an operating frequency of 32kHz or 40kHz that shall be crystal controlled to operate within plus or minus 0.005 percent tolerance.
 - 5) Electrical: Rating: 12 VDC input voltage, up to 40 mA current draw.
 - 6) Sensors shall turn off or reduce lighting automatically after reasonable time delay when a room or area is vacated by the last person to occupy the space
 - 7) Sensor shall accommodate all conditions of space utilization and all irregular work hours and habits.
 - 8) Sensors shall be UL listed.
 - 9) Sensors shall be fully adaptive and adjust their sensitivity and timing to ensure optimal lighting control for any use of the space
 - 10) Sensors shall have field adjustable controls for time delay and sensitivity to override any adaptive features. Sensor timeouts shall be configurable by System software.
 - 11) Power failure memory:
 - 12) Controls incorporate non-volatile memory. Should power be interrupted and subsequently restored, settings and learned parameters saved in protected memory shall not be lost.
 - 13) Provide all necessary mounting hardware and instructions.
 - 14) Sensors shall be Class 2 devices.
 - 15) Indicate viewing directions on mounting bracket for all Ceiling mount sensors.
 - 16) Provide customizable mask to block off unwanted viewing areas for all ceiling mounted sensors using infrared technology. Field prepare proper maskings for each space to eliminate unnecessary sensing beyond the space in which the sensor is located.
 - 17) Provide an internal additional isolated relay with Normally Open, Normally Closed and Common outputs for use with HVAC control, Data Logging and other control options.

X. Examination

- 1. Site Verification: Verify that wiring conditions, which have been previously installed under other sections or at a previous time, are acceptable for product installation in accordance with manufacturer's instructions.

2. Inspection: Inspect all material included in this contract prior to installation. Manufacturer shall be notified of unacceptable material prior to installation.

Y. Installation

1. The Electrical Sub-contractor, as part of the work of this section, shall coordinate, receive, mount, connect, and place into operation all equipment. The Electrical Sub-contractor shall furnish all conduit, wire, connectors, hardware, and other incidental items necessary for properly functioning lighting control as described herein and shown on the plans (including but not limited to System Field Devices, 0-10V dimming ballasts, fixed output ballasts, 0-10V LED drivers and communication wire). The Electrical Sub-contractor shall maintain performance criteria stated by manufacturer without defects, damage, or failure.
2. Power: The contractor shall test that all branch load circuits are operational before connecting loads to sensor system load terminals, and then de-energize all circuits before installation.
3. Related Product Installation: Refer to other sections listed in Related Sections for related products' installation.

Z. Sensor Installation

1. Adjust sensitivity to cover area installed
2. Set time delay on occupancy sensors that are connected to the lighting control system to the minimum. Time delays shall be controlled via Central Control Software.
3. Sensor shall be powered through Input Module. No external power packs shall be used for powering sensors.
4. Install occupancy sensors on vibration free stable surface.
5. Install atrium and skylight light sensor facing toward window or skylight.
6. Install interior light sensor in ceiling facing the floor.

AA. Wiring Installation

1. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 3/4 inch.
2. Wiring within Enclosures: Comply with NEC & CEC. Separate power-limited and non power-limited conductors according to conductor manufacturer's written instructions.
3. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
4. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

BB. Software Installation

1. Install and program software with initial settings of adjustable values. Make backup copies of software and user-supplied values. Provide current site licenses for software.

CC. Field Quality Control

1. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

2. Perform the following field tests and inspections with the assistance of a factory-authorized service representative:
 - a. Operational Test: After installing lighting controllers and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Lighting control devices will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

DD. Coordination with the owner

1. Owner meeting: The manufacturer shall supply factory trained representatives for a minimum of 16 hours (2) 8 hour sessions with the owner to review and complete the system programming data sheet and controlability of the system. The Sequences as designed and shown on the contract documents shall be outlined and explained to the owner and any input/changes from the owner shall be incorporated as long as overrides of energy code mandated controls are not suggested.

EE. Commissioning Requirements

1. Commissioning: The manufacturer shall supply factory trained representatives for a minimum of 24 hours to commission the lighting control system. Manufacturer shall start up all lighting control equipment and verify that it meets the requirements of this specification.
2. Training: As part of the standard commissioning process, the manufacturer shall train the owner's representatives in the operation of the system to a maximum of 4 hours per building. Manufacturer shall also provide owner's representatives with system operating manuals together with a system training video. Specific training on the operation of the tunable white lighting shall be provided. In addition to the 4 hours an additional 4 hours of training shall be provided for spaces utilizing tunable white light.
3. Technical Support: The manufacturer shall supply 24/7 technical telephone support to the client. If the manufacturer does not provide 24/7 support, they must provide a list of contacts (names and cell phone numbers) in the event of a system failure during non-business hours.
4. Replacement components: The manufacturer shall be able to ship replacement parts within 24 hours for any component that fails during the warranty period.
5. Extended Service Coverage: Maintenance agreements shall be available from the manufacturer to provide service for the system both during and after the warranty period.
6. Requests for commissioning shall be at least two weeks prior to date desired for commissioning.
7. Electrical Sub-contractor shall perform functional testing under the guidance of commissioning agent and in accordance with factory specified guidelines.
8. Factory appointed personnel shall provide commissioning services for the lighting control system.
 - a. Verify proper communication over control wires.
 - b. Map addresses of occupancy sensors (via Input Modules), light level sensors (via Input Modules), lighting controllers to control units and system server.
 - c. Map all system data to appropriate BACnet points and assist BMS sub-sub-contractor in programming all points into the BMS system and verifying their proper functionality.
 - d. Verify communication to control units and system server.

- e. Configure occupancy sensors, light level sensors, lighting controllers and other contacts to suit design specifications.
- f. Configure and program lighting control sequences as described on contract documents.
- g. Demonstrate to Owner and Engineer proper operation of all areas the system is installed.

FF. Testing

- 1. Upon completion of all line, load and interconnection wiring, and after all fixtures are installed and lamped, a qualified factory representative shall completely configure and test the system.
- 2. At the time of checkout and testing, the owner's representative shall be thoroughly instructed in the proper operation of the system.

GG. Demonstration

- 1. Engage a factory-authorized service representative to train Owner's maintenance personnel and building supervisors to adjust, operate, utilize, troubleshoot, conduct software installation, and maintain lighting controls and software training for PC-based control systems. Provide up to eight hours of on-site training with audio and video recorded. Provide a hard copy of manuals, instructional videos, and recorded training session(s) on CD or DVD.
- 2. Submit shop drawings indicating outline dimensions, connection and support points, weight, specified ratings and materials.
- 3. Submit product data indicating standard model design tests and options.
- 4. Submit manufacturer's installation instructions.

HH. OPERATION AND MAINTENANCE DATA

- 1. Submit operation and maintenance data under.
- 2. Include procedures for cleaning unit, and replacing components.

II. QUALITY ASSURANCE

- 1. Manufacturer: Company specializing in distribution transformers with Five years Documented experience.

2.22 LADDER TRAY/WIREWAYS

- A. Provide ladder tray where indicated on drawings. Ladder tray shall be as manufactured by b-line, "ladder type", or equal. Provide all hangers required.
- B. Wireway:
 - 1. This specification covers NEMA type 1 wireway used to house and protect communication cable. The wireway system shall consist of wireway and appropriate fittings to complete the installation per the electrical drawings.
 - 2. Metal wireway (NEMA type 1) is to be utilized in dry interior locations only as covered in article 362 part a of the national electrical code, as adopted by the national fire protection association and as approved by the American National Standards Institute. The wiremold c" or "sp" series is listed by underwriters' laboratories under file no. E137690 guide zoyx.

3. The wireway system specified herein shall be the "c" or "sp" system as manufactured by the wiremold company. Systems of other manufacturers may be considered equal if, in the opinion, and the written approval of the engineer, they meet all the performance standards specified herein.
4. The wireway and all system components must be UL Listed in full compliance with their standard ul870, "electrical wireways, auxiliary gutters and associated fittings". It shall be manufactured from 16-gauge cold rolled steel, finished in ASA 61 gray powder coat paint. All sizes larger than 6 in. x 6 in. shall be manufactured from 14-gauge cold rolled steel, finished in ASA 61 gray powder coat paint. A factory installed divider shall be available to separate power and low voltage wiring housed in the same wireway sections.
5. A full complement of fittings for the raceway shall be available including, but not limited to, 45 deg. and 90 deg. flat, vertical inside and outside elbows, tee and cross fittings, couplings for joining sections of wireway, reducers, hangers, end blanks, a field installed divider and all other components necessary to make the system workable. The fittings shall have an ASA 61 gray powder coat paint finish to match the wireway.
6. Prior to and during installation, refer to system layout drawing containing all elements of the system. Installer shall comply with detailed manufacturer's instruction sheets which accompany system components as well as complete system instruction sheets, whichever is applicable.
7. All wireway systems shall be mechanically continuous and connected to all electrical boxes and cabinets, in accordance with manufacturer's installation sheets.
8. All connections shall be checked to make sure they are correctly tightened and to insure that all wireway shall be electrically continuous and bonded in accordance with the national electric code for proper grounding.
9. All wireway systems shall be installed complete. Work shall include fastening all wireway and appropriate fittings to install a complete wireway system as indicated on the electrical and/or communication drawings and in the applicable specifications

2.23 UNINTERRUPTIBLE POWER SUPPLY (30 KW/37.5 kVA UPS)

A. General

1. This specification describes a continuous duty, three-phase, solid-state, static Uninterruptible Power System (UPS) hereafter referred to as the UPS. The UPS shall contain a full rated input rectifier / boost converter (hereafter referred to as Input Converter), output inverter, and 10 percent battery charging circuit. The system shall also contain a continuous duty bypass static switch, internal mechanical bypass, removable hot swap battery plant, and LCD interface display. Maintenance bypass and extended battery is required to meet this specification shall be contained in matching enclosures with all interconnecting cabling included. All programming and miscellaneous components for a fully operational system as described in this specification shall be provided as part of the UPS.

B. Standards

1. The UPS shall meet the requirements of the following standards:
 - a. IEEE 587-1980/ANSI C62.41 1980 Standards for Surge Withstand Ability.
 - b. FCC rules and regulations of Part 15, Subpart J, Class A.
 - c. UL listed under 1778, Standards for Uninterruptible Power Supply Equipment.
 - d. UL Canada (cUL).
 - e. NEMA PE 1 (National Electrical Manufacturers Association) - Uninterruptible Power Systems.
 - f. NEMA 250 (National Electrical Manufacturers Association) – Enclosures for Electrical Equipment (1000 Volts Maximum).

- g. IEEE 519-1992 Standard Practices and Requirements for Harmonic Control in Electrical Power Systems
- h. NFPA 70 – National Electrical Code.
- i. ISO 9001.
- j. ISO 14001
- k. Occupational Safety & Health Administration (OSHA).

C. Submittals

Submittals shall contain the following documentation:

- 1. Installation Drawings: Indicate electrical characteristics and connection requirements. Provide cabinet dimensions; battery type, size, dimensions, and weight; detailed equipment outlines, weight, and dimensions; location of conduit entry and exit; single-line diagram, control, and external wiring requirements; heat rejection, full and part load efficiencies and air flow requirements.
- 2. Product Data: Provide catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements.

D. Warranty

- 1. UPS Module: The UPS shall be covered by a full parts and labor warranty from the manufacturer for a period of twelve (12) months from date of acceptance by customer.
- 2. Battery: The battery manufacturer's warranty shall be passed through to the final customer and shall have a minimum period of one year.

E. Maintenance, Accessibility and Self Diagnostics

- 1. All UPS subassemblies, as well as the battery, shall be accessible from the front. UPS design shall provide maximum reliability and minimum MTTR (mean time to repair). To that end, the UPS shall be equipped with a self-test function to verify correct system operation. The self-test function shall identify the subassembly-requiring repair in the event of a fault. The electronic UPS control and monitoring assembly shall therefore be fully microprocessor based, thus doing away with all potentiometer settings. This shall allow:
 - a. Auto-compensation of component drift;
 - b. Self-adjustment of replaced subassemblies;
 - c. Extensive acquisition of information vital for computer-aided diagnostics (local or remote);
 - d. A socket for connection to a computer-aided diagnostics system.
- 2. The UPS shall be repairable by replacing standard subassemblies requiring no adjustments or settings. Communication with a remote maintenance system shall be possible.

F. System Description and Operation

- 1. Approved Manufacturer(s): The specified equipment shall be manufactured by Eaton, Liebert, Mitsubishi, APC/Sneider, or equal.
- 2. UPS Design Requirements
 - a. Output Power Continuous Rating: The continuous output power rating of the UPS shall be shall be 24KW, 30 kVA at a 0.8 lagging power factor.

- b. Input Voltage: 120/208 VAC – 25 percent / +15 percent, 3 phase, 4 wire plus ground.
 - c. Output voltage: 120/208 VAC 3 phase, 4 wire plus ground.
 - d. Battery Autonomy: The UPS have battery strings such that it shall be capable of operating at full load for (60 minutes) at 0.8 PF output at a temperature of 25°C on battery power.
 - e. Battery Type: Hot swappable valve regulated sealed lead acid (VRLA).
 - f. AC Input Characteristics.
 - 1) Input Frequency: 60 Hz (- 25 percent to + 15 percent)
 - 2) Maximum Input Current at Low Line Voltage: 51 A with 125 percent continuous overload.
 - 3) Input Power Factor: > .98 lagging for loads greater than 50 percent and > .95 for loads greater than 15 percent.
 - 4) Harmonic Distortion of Input Current Wave Form: less than 5 percent at full load.
 - g. Power walk-in: Linear 0 to 100 percent over a 15-second period.
 - h. Magnetizing Inrush Current: Less than nominal input current for less than one cycle.
3. AC Output Characteristics.
- a. Voltage Regulation: + 1.0 percent for balanced load; + 1.75 for 50 percent unbalanced load; + 2.5 percent for 100 percent unbalanced load
 - b. Frequency: 60 Hz +1 percent (or selectable up to 4 percent). 60 Hz + 0.1 percent when free running.
 - c. Voltage Distortion: Maximum 2 percent total (THD) and 1 percent any single harmonic on 100 percent linear loads.
 - d. Voltage Transient (Step Load) Response:
 - 1) + 3 percent for 50 percent step load change
 - 2) + 5 percent for 100 percent step load change
 - 3) + 1 percent for loss or return of AC input power or manual transfer at full load.
 - e. Voltage Recovery Time: Return to within 1 percent of nominal value within 50 milliseconds.
 - f. Phase Angle Displacement: 120 deg. + 1 deg. degrees for balanced load; 120 deg. + .3 deg. degrees for 100 percent unbalanced load
 - g. Non-Linear Load Capability: Output voltage total harmonic distortion shall be less than 3 percent when connected to a 100 percent non-linear load with a crest factor not to exceed 3.0.
 - h. Slew Rate: 1 Hz/second maximum (or selectable up to 2.0 Hz/sec).
 - i. Power Factor: 0.8 at the rated volt-amperes (VA)
 - j. Inverter Overload Capability:
 - 1) 120 percent of rated load for 1 minute
 - 2) 145 percent of rated load for 30 seconds
 - 3) Bypass Overload Capability: > 800 percent for 500 milliseconds, 125 percent continuous.
 - 4) Overall AC to AC efficiency with fully charged battery 93.0 percent at full load and 93.4 percent at 50 percent load.
4. DC Bus.
- a. Normal DC voltage 192VDC.

- b. Maximum DC current at cutoff voltage will be 43.3 A.
 - c. End of discharge 152VDC
5. Modes of Operation.
- The UPS module shall be designed to operate as a double conversion, on-line reverse transfer system in the following modes.
- a. Normal: The input converter and output inverter shall operate in an on-line manner to continuously regulate power to the critical load. The input and output converters shall be capable of full battery recharge while simultaneously providing regulated power to the load for all line and load conditions within the range of the UPS specifications.
 - b. Battery: Upon failure of the AC input source, the critical load shall continue being supplied by the output inverter, which shall derive its power from the battery system. There shall be no interruption in power to the critical load during both transfers to battery operation and retransfers from battery to normal operation.
 - c. Recharge: Upon restoration of the AC input source, the input converter and output inverter shall simultaneously recharge the battery and provide regulated power to the critical load.
 - d. Static Bypass: The static bypass shall be used to provide transfer of critical load from the Inverter output to the bypass source. This transfer, along with its retransfer, shall take place with no power interruption to the critical load. In the event of an emergency, this transfer shall be an automatic function.
 - e. Internal Mechanical Bypass: As a standard feature, the UPS shall be equipped with an internal, make before break, bypass switch. This switch shall mechanically bypass the UPS for times where maintenance is required.
6. Component Description.
- a. Rectifier / Battery Charger: The input power converters of the system shall constantly control the power imported from the mains input of the system, to provide the necessary UPS power for precise regulation of the DC bus voltage, battery charging, and Main Inverter regulated output power.:
 - 1) Soft-Start Operation: As a standard feature, the UPS shall contain soft-start functionality, capable of limiting the input current from 0-100 percent of the nominal input over a default 15 second period, when returning to the AC utility source from battery operation. The change in current over the change in time shall take place in a linear manner throughout the entire operation. ($di/dt = \text{constant}$)
 - 2) Input Current Total Harmonic Distortion: The input current THDI shall be held to 5 percent or less at full system, while providing conditioned power to the critical load bus, and charging the batteries under steady-state operating conditions. This shall be true while supporting loads of both a linear or non-linear type. This shall be accomplished with no additional filters, magnetic devices, or other components.
 - 3) The input converter shall control and limit the input current draw from utility to 150 percent of the UPS output. During conditions where input current limit is active, the UPS shall be able to support 100 percent load, charge batteries at 10 percent of the UPS output rating, and provide voltage regulation with mains deviation of up to +/-15 percent of the nominal input voltage.
 - 4) Modular Assembly: The rectifier/battery charger assembly shall be constructed of modular design to facilitate rapid maintenance.

- 5) Charging Levels: The battery charging shall keep the DC bus float voltage of +/- 220v, +/-1 percent
 - 6) Battery Charge Current Limit: The UPS shall be capable of limiting the energy sourced from the mains for purposes of battery charging. As a default setting, the battery charge energy will be set to 100 percent of its nominal value. When signaled by a dry contact, (such as from an emergency generator) the UPS shall be capable of limiting the battery charge energy taken from the mains. This shall take place in user selectable increments of 75 percent, 50 percent, 25 percent, 10 percent and 0 percent of the nominal charge power. The selection shall be made from the UPS front panel display/control unit.
 - 7) Temperature Compensated Charging: The battery charger shall be equipped with a temperature probe to enable temperature compensated charging and adjust the battery float voltage to compensate for the ambient temperature using a negative temperature coefficient of 3 mV per cell per degree Celsius at a nominal temperature of 25°C.
 - 8) Capacity: The rectifier/battery charger shall have sufficient capacity to support a fully loaded inverter and fully recharge the battery to 95 percent of its full capacity within 6-8 hours.
- b. Inverter: The UPS output shall be derived from a Pulse Width Modulated (PWM) IGBT inverter design. The inverter shall be capable of providing the specified precise output power characteristics (specified in section 2.2.C) while operating over the battery voltage range. The inverter assembly shall be constructed as a modular assembly to facilitate rapid maintenance.
 - c. Static Bypass: As part of the UPS, a system static bypass switch shall be provided. The system static bypass shall provide no break transfer of the critical load from the Inverter output to the static bypass input source during times where maintenance is required, or the inverter cannot support the critical bus. Such times may be due to prolonged or severe overloads, or UPS failure.
7. Uninterrupted Transfer: The static bypass transfer switch shall automatically cause the bypass source to assume the critical load without interruption after the logic senses one of the following conditions:
 - a. Inverter overload exceeds unit's rating.
 - b. Battery protection period expired and bypass current is available.
 - c. Inverter failure.
 8. Interrupted Transfer: If the bypass source is beyond the conditions stated below, the UPS will make an interrupted transfer (not less than 500 msec. in duration).
 - a. Bypass voltage greater than + 10 percent, -10 percent from the UPS rated output voltage.
 - b. Bypass frequency greater than + 2 Hz from the UPS rated output frequency.
 9. Automatic Uninterrupted Forward Transfer: The static bypass transfer switch shall automatically forward transfer power from the bypass to the rectifier / inverter, without interruption, after the UPS inverter is turned "ON", after an instantaneous overload-induced reverse transfer has occurred and the load current returns the UPSs nominal rating or less.
 10. Manual Transfer: A manual static transfer shall be initiated from the UPS Control Panel by turning the UPS inverter off.

11. Overload Ratings: The static bypass transfer switch shall have the following overload characteristics after which time a thermal protection device will engage to protect the static bypass.
 - a. 800 percent of UPS output rating for 0.5 seconds (one cycle).
 - b. 150 percent for 30 seconds.
 - c. 125 percent of UPS output rating continuous.
 - d. Microprocessor Controlled Logic.
 - 1) The full UPS operation shall be provided through the use of microprocessor controlled logic. All operation and parameters are firmware controlled, thus eliminating the need for manual adjustments or potentiometers. The logic shall include a self-test and diagnostic circuitry such that a fault can be isolated down to the printed circuit assembly or plug-in power assembly level. Every printed circuit assembly or plug-in power assembly shall be monitored. Diagnostics shall be performed via a PC through the local diagnostics port on the UPS.

G. System Controls and Indicators

1. Display Unit: A microprocessor controlled display unit shall be located on the front of the system. The display shall consist of an alphanumeric display with backlight, an alarm LED, and a keypad consisting of pushbutton switches. The following metered data, shall be available on the alphanumeric display:
 - a. Measurements, status indications and events.
 - b. Event log with time stamping.
 - c. Access to all measurements.
2. System Parameters Monitored (data displayed): The visual display will display the following system parameters based on true RMS metering:
3. Measurements:
 - a. Year, Month, Day, Hour, Minute, Second of occurring events.
 - b. Source Input Voltage
 - c. Input Frequency
 - d. Output AC voltage
 - e. Output AC current
4. Status indications and events:
 - a. Static bypass switch on
 - b. EPO Active
 - c. Mechanical bypass activated
 - d. External bypass switch (Q3) activated
 - e. Battery discharged
 - f. Return from low battery
 - g. Low battery
 - h. Load not powered from UPS
 - i. UPS in bypass
 - j. Runtime calibration aborted
 - k. Runtime calibration started
 - l. Runtime calibration complete
 - m. Battery self-test aborted

- n. Battery self-test started
 - o. Battery self-test completed
 - p. Number of battery modules decreased
 - q. Number of battery modules increased
 - r. Fan fault
 - s. SBS fault
 - t. System not in sync.
 - u. Bypass not available, frequency/voltage out of range
 - v. Mains voltage/frequency out of range
 - w. Site wiring fault
 - x. Low battery voltage shut down
 - y. Defective battery detected
 - z. Runtime is below alarm threshold
 - aa. Load is above alarm threshold
 - bb. Battery over-voltage warning
 - cc. Battery over-temperature warning
 - dd. Emergency power supply fault
 - ee. Output overloaded
- 1) Time-stamped historical events: This function shall time-stamp and store all important status changes, anomalies and faults and make this information available for automatic or user-requested consultation; it shall interpret the events and indicate remedial measures if applicable.
5. Push Button User Controls
- a. Up Arrow
 - b. Down Arrow
 - c. Help Key
 - d. Escape Key
 - e. Enter Key
6. Emergency Power Off (EPO): The UPS shall be equipped with a local emergency power off button and dry contact input that can be used to command UPS shut down remotely. Activation of this command shall lead to the following actions:
- a. Inverter shutdown
 - b. Opening of the static bypass switch and the battery circuit breaker
 - c. Opening of an isolated dry contact on the programmable relay board
7. RJ-45 Interface port for remote communications with a network via web browser or SNMP, or APC InfraStruXure Manager. Provide Communication card and software licenses to perform Advanced power actions including but not limited to Load shedding, shutdown of targeted virtual machines, migrate virtual machines to targeted hosts, Automatic VM group assignment, Shutdown VMware vApp, Automate VMware SRM Recovery plan, Fully virtualized cluster shutdown, and VMware vSAN shutdown.
8. Dry Contacts: The UPS shall be provided standard with a programmable input/output relay board. This board shall have 8 dry contacts, i.e. 6 for input signals and 2 for output signals. Contacts shall be programmed as:
- a. Low battery
 - b. Load on battery power
 - c. Load on automatic bypass
 - d. Load on UPS

- e. Common Fault
- f. UPS Off

- 1) The contacts will be programmable normally open or normally off and will change state to indicate the operating status. The contacts will be rated at 2.0 A (250 VDC / 30 VDC).

H. Mechanical Design and Ventilation

- 1. Enclosure: The UPS shall be housed in a freestanding enclosure with dead front construction. The mechanical structure of the UPS shall be sufficiently strong and rigid to withstand handling and installation operations without risk. Access to UPS subassemblies shall be through the front or top. The sheet-metal elements in the structure shall be protected against corrosion by a suitable treatment, such as zinc electroplating, bichromating, epoxy paint or an equivalent.
- 2. Cable Access: The standard UPS shall accommodate top or bottom entry cables.
- 3. Cabinet Weights and Dimensions: The width of the UPS System is 32.8 (in Inches) and has an approximate weight of 1050 lbs.
- 4. Ventilation and Heat Rejection: The UPS shall be designed for forced air-cooling. Air inlets shall be provided from the front bottom of the UPS enclosure. Air exhaust shall be from the top rear portion of the unit. Full load heat rejection is 4777 BTU /hour.

I. Battery

- 1. The UPS battery shall be of modular construction made up of user replaceable, hot swappable, fused, battery modules. Each battery module shall be monitored to determine the highest battery unit temperature for use by the UPS battery diagnostic, and temperature compensated charger circuitry.
- 2. The battery jars housed within each removable battery module shall be of the Valve Regulated Lead Acid (VRLA) type.
- 3. The UPS shall incorporate a battery management system to continuously monitor the health of each removable battery module. This system shall notify the user in the event that a failed or weak battery module is found.

J. Accessories

- 1. External Control and Communications Devices
The following control and communications devices shall be provided in the UPS module.
- 2. Network Adaptor:
The Ethernet Web/SNMP Adaptor shall allow one or more network management systems (NMS) to monitor and manage the UPS in TCP/IP network environments. The management information base (MIB) shall be provided in DOS and UNIX "tar" formats. The SNMP interface adaptor shall be connected to the UPS via the RS232 serial port on the standard communication interface board.
The UPS, in conjunction with a network interface card, shall be capable of gracefully shutting down one or more operating systems during when the UPS is on reserve mode. The UPS shall also be capable of using an RS232 port to communicate by means of serial communications to gracefully shut down one or more operating systems during an on battery situation.

3. Remote UPS Monitoring

a. The following three methods of remote UPS monitoring shall be available:

- 1) Web Monitoring: Remote monitoring shall be available via a web browser such as Internet Explorer.
- 2) RS232 Monitoring: Remote UPS monitoring shall be possible via either RS232 or contact closure signals from the UPS.
- 3) Simple Network Management Protocol (SNMP): Remote UPS Monitoring shall be possible through a standard MIB II compliant platform.

K. Connect UPS monitoring system to Owner's communications room computer system. Provide all wiring in conduit. Coordinate with Owner for tie-in point.

L. Factory Assisted Start-Up

1. Factory trained service personnel shall perform the following inspections, test procedures, and on-site training:

a. Visual Inspection:

- 1) Inspect equipment for signs of damage.
- 2) Verify installation per manufacturer's instructions.
- 3) Inspect cabinets for foreign objects.
- 4) Inspect Battery Units.
- 5) Inspect Power Module(s).

b. Mechanical Inspection:

- 1) Check all UPS and external maintenance bypass cabinet internal power wiring connections.
- 2) Check all UPS and external maintenance bypass cabinet terminal screws, nuts, and/or spade lugs for tightness.

c. Electrical Inspection:

- 1) Verify correct input and bypass voltage.
- 2) Verify correct phase rotation of all mains connections.
- 3) Verify correct UPS control wiring and terminations.
- 4) Verify voltage of all battery modules.
- 5) Verify neutral and ground conductors are properly landed.

d. Site Testing:

- 1) Ensure proper system start-up.
- 2) Verify proper firmware control functions.
- 3) Verify proper firmware bypass operation.
- 4) Verify proper maintenance bypass switch operation.
- 5) Verify system set points.
- 6) Verify proper inverter operation and regulation circuits.
- 7) Simulate utility power failure.
- 8) Verify proper charger operation.
- 9) Document, sign, and date all test results.

- e. On-Site Operational Training: During the factory assisted start-up, operational training for site personnel shall include key pad operation, LED indicators, start-up and shutdown procedures, maintenance bypass and AC disconnect operation and alarm information.

M. Field Quality Control & Service Organization

1. Field Service Engineer Qualifications

- a. The manufacturer must employ a 7 X 24 nationwide field service organization with rapid access to all regions of the nation. The responding service professionals must be factory-trained engineers with an accredited and proven competence to service three phase UPS systems.

2. Spare Parts

- a. Field Engineers must have immediate access to recommended spare parts with additional parts storage located in regional depots. Additional spare parts shall be accessible on a 7 x 24 basis from the national depot and must be expedited on a next available flight basis or via direct courier (whichever mode is quickest).

3. Maintenance Training

- a. The manufacturer shall make available to the customer various levels of training ranging from basic UPS operation to UPS maintenance.

4. Maintenance & Service Contracts

- a. The manufacturer shall offer additional preventative maintenance and service contracts covering both the UPS system and the battery bank. Accredited professional service engineers, employed exclusively in the field of critical power systems service shall perform all maintenance and service. The manufacturer shall also offer extended warranty contracts.

2.24 SEALS

A. Water Tight Seals

- 1. Conduits entering from the exterior or below grade shall have water tight fittings on the outside and on the inside of the conduit.
 - a. Fittings on the outside of the conduit shall be O-Z Gedney type FSK or equal. Provide type WSK if penetration is within two feet of the high water table. Provide grounding attachment.
 - b. Fittings on the inside of the conduit shall be O-Z Gedney type CSBI or equal. Provide type CSBG if penetration is within two feet of the high water table. Provide a blank fitting to seal spare or empty conduits.
 - c. O-Z Gedney type CSM or equal fitting may be used when sealing within a sleeve or cored hole.
- 2. Submit on seals to be used.

B. Environmental Seals

1. Provide seals on raceways exposed to widely different temperatures, as in refrigerating or cold storage areas. Install seal to prevent circulation of air from warmer to colder sections through the raceway.

C. Hazardous Area Seals

1. Provide explosion proof seals as required by the Electric Code.
 - a. Explosion-proof exhaust fans.

D. Smoke and Fire Stopping Seals

1. Provide a seal around raceways or cables penetrating full height walls (slab to slab), floors or ventilation or air handling ducts so that the spread of fire or products of combustion shall not be substantially increased.
2. Penetrations through fire-resistant-rated walls, partitions, floors or ceilings shall be firestopped using approved methods and NRTL listed products to maintain the fire resistance rating.
3. Fire stopping in sleeves or in areas that may require the addition or modification of installed cables or raceways shall be a soft, pliable, non-hardening fire stop putty. Putty shall be water resistant and intumescent. Provide for all sleeves and raceways.
4. Firestopping in locations not likely to require frequent modification shall be NRTL listed putty, caulk or mortar to meet the required fire resistant rating.
5. Box penetrations into a fire rated wall or shaft shall have a fire stopping pad installed on the back of the box.
6. Firestopping of cable trays or busways through walls shall be within a non-hardening putty or with seal bags.
7. Firestopping materials shall be NRTL listed to UL 1479 (ASTM E814). Installation methods shall conform to a UL firestopping system. Submit specifications and installation drawings for the type of material to be used. Firestopping materials shall be as manufactured by 3M, International Protective Coatings Corp., RayChem or approved equal.

2.25 LIGHTNING PROTECTION SYSTEM

A. General:

1. Provide all labor, material, equipment, and services required for the complete lightning protection system in accordance with NFPA 780, UL96A and applicable contract drawings for the Building. System shall receive UL Master Label. This section is responsible for providing a design for an approved "UL Master Label System" in accordance with the drawings and specifications.

B. The following items of work are specifically included in, but not necessarily limited to the work of this section without limiting the generality implied by the Specifications.

1. Air terminals.
2. Copper cable roof conductors.
3. Down conductor.
4. Ground grid installation.

- C. Manufacturer shall provide seven complete sets of shop drawings for review, showing location of air terminals, conductors, installation procedures and details, and detailed manufacturer's data sheets on all components, accessories, and miscellaneous equipment to be used in this installation.
- D. Description of System:
 - 1. The contractor shall provide a complete installation of equipment to comprise a system for protection against damage by lightning.
 - 2. The system, including air terminals, conductors, and complementary parts, shall be installed so that completed work is unobtrusive and does not detract from the building appearance.
 - 3. The work shall comply with all applicable federal, state, municipal laws, ordinances, and regulations.
- E. Standards of Quality:
 - 1. All materials shall be the product of a manufacturer regularly engaged in the production of lightning protection equipment.
 - 2. All material shall be manufactured by Thompson Lightning Protection, Harger, East Coast Lightning Equipment, Heary Bros. or equal.
- F. Service, Testing and Guarantee:
 - 1. Installation of equipment shall be done under direct supervision of the equipment manufacturer's factory representative. A master labeled system is to be provided.
 - 2. The completed lightning protection systems shall be fully tested in the presence of the Architect to demonstrate continuity of all conductors. A written test report shall be submitted.
 - 3. The ground grid resistance shall be measured and a written statement submitted to the architect. Grid resistance shall be 5 ohms or less.
- G. Products:
 - 1. Air Terminals:
 - a. Complete assembly consisting of chrome plated air terminal with attachment mechanisms.
 - 2. Conductors:
 - a. Copper conductors shall be 28 strands of #13 gauge, net weight 420 pounds per 1000 ft., minimum.
 - 3. Ground Rods:
 - a. Ground rods shall be copperweld, $\frac{3}{4}$ in. minimum diameter, 10 feet minimum length.
 - 4. Connectors, Fitting, Fasteners and Hardware:
 - a. Provide all connectors, fittings, fasteners, hardware, clamps, guards, lugs, etc., as required to connect, interconnect and install all parts of the system.
 - b. All shall be fabricated from copper metal and be approved for use intended.

- c. All connections between dissimilar metals shall have connectors approved for this type of application.

H. Installation:

1. Installation shall be accomplished in a professional manner by qualified personnel regularly engaged in and experienced in this type of work.
2. All work installed within the building shall be concealed.
3. All work installed in accessible locations shall be properly guarded and protected.
4. All material shall be installed in a manner to prevent electrolytic action under the presence of moisture.
5. All roof, wall or other building penetrations shall be made in a manner to prevent the ingress of water or moisture. Roof penetrations shall be furnished and installed by Roofing Contractor.
6. PVC sleeves shall be provided where conductors pass through all floors.
7. Installation shall be accomplished in a manner to eliminate possibility of displacement and subsequent maintenance.
8. All connections shall be mechanically and electrically sound and all bonding surfaces shall be cleaned and brightened just prior to attachment.
9. All excavating, backfilling and tamping earthwork as required by General Trades Contractor.
10. Install down conductors concealed within wall.
11. Cables on flat roof areas may be run exposed. Adhesive type fasteners shall be spaced at 3 ft. – 0 in. maximum. Adhesive used shall be compatible with roofing materials. Coordinate with approved shop drawings.
12. Ground rods shall be driven to full depth in soil undisturbed by building excavation and are not to be driven into excavation backfill area.
13. Provide connection between grid and water service.
14. Provide grid resistance of 5 ohms maximum.
15. Top of ground rods shall be installed at least 2 ft. – 0 in. below finished grade.

I. Master Label:

1. Submit factory certified tests.
2. Submit guarantee for installation and range of lightning protection.

2.26 UNDERGROUND DUCTBANKS

- A. General: Furnish and install the ductbanks as herein specified and as shown on drawings.

B. Division of Work:

1. The Construction Manager shall be responsible for the work and material required for the following:
 - a. Excavation
 - b. Backfill
 - c. Installation of handholes/manholes
 - d. Brick or concrete collars to bring handhole frames and covers up to grade. Installation of frames and collars which are to be furnished by the Electrical Subcontractor.
 - e. Concrete Encasement

2. All other material, equipment, and labor required for the complete ductbank shall be furnished and installed by the Electrical Subcontractor under this Section, including the following:
 - a. Service raceways.
 - b. Grounding material.
 - c. Ductbank warning tape.
 - d. Furnishing pre-cast handholes/manholes.
 - e. Conduit spacers.

C. Materials:

1. Conduit: UL listed, schedule 40 PVC in accordance with NEMA standard TC-2. Schedule EB PVC is acceptable where encased in concrete.
See BASIC MATERIALS SECTION.
2. Conduit Supports (duct system): Shall be molded plastic with interlocking lugs and skeletonized structure, minimum separation 3 in.
3. Tags: Non-ferrous metal or fibre, 1/4 in. high letters.
4. Warning tape shall be yellow polyethylene 4 mil thick, 6 in. wide terratape, similar to REEF Industries, Houston, Texas and shall be installed above all ductbanks both high and low tension.
5. Installation of Underground nonmetallic raceways shall be in accordance with NEMA Standards Publication TCB-2-2017.

D. Duct System:

1. The duct system shall consist of Schedule 40 PVC conduit except where otherwise specified. The size and number of conduits shall be as indicated on the drawings. Provide a pull wire in each conduit.
2. The entire length between handholes and end of ductbank shall be excavated and graded before any conduit is laid.
3. The ductbank shall be set on undisturbed earth.
4. The conduit shall be installed so that top is a minimum of 36 in. below finished grade unless otherwise indicated, and shall be laid to a minimum grade of 4 in. for each 100 feet of length. Duct system shall drain to manholes/handholes.
5. Changes in direction shall be made by long sweep bends, minimum radius 25 feet except that at the end of a run, within ten feet of termination. Manufactured ends may be used having a minimum radius of 36 inches.
6. Conduit base and intermediate spacers shall be installed a maximum of 5 feet on centers. Spacers shall not be placed one above the other, but shall be staggered a minimum of 6 in..
7. All conduit joints shall be made watertight by means of a sealing compound before the coupling is installed. Joints in conduit shall be staggered, minimum space between joints in adjacent conduit shall be 6 inches.
8. When the required number of conduits have been installed, securely tie the assembly together at distances not exceeding 7 ft. Tie shall consist of three turns of No. 18 iron wire. Separate ties required for low tension and high tension conduit runs.
9. Duct envelope shall be vibrated to eliminate voids.
10. Ductbanks shall not be covered until the conduit installation has been observed by the utility company and Architect.
11. Warning tape shall be installed during backfilling and shall be placed approximately 12 in. above the conduits.

12. After the installation is completed, each conduit shall be cleaned and identified. A standard flexible mandrel and a stiff bristle brush shall be pulled through each conduit. The mandrel shall not be less than 12 in. long and the diameter approximately $\frac{1}{4}$ in. less than the conduit.

2.27 VARIABLE FREQUENCY DRIVES (VFD'S)

- A. The variable frequency drives (VFD's) shall be solid state, with a Pulse Width Modulated (PWM) output waveform (VVI, six-step, and current source drives are not acceptable). The VFD package as specified herein shall be enclosed in a NEMA 1 enclosure, completely assembled and tested by the manufacturer. The VFD shall employ a full wave rectifier (to prevent input line notching), DC Line Reactor, capacitors, and Insulated Gate Bipolar Transistors (IGBT's) as the output switching device (SCR's, GTO's and Darlington transistors are not acceptable). The drive efficiency shall be 97 percent or better at full speed and full load. Fundamental power factor shall be 0.98 at all speeds and loads.
- B. Specifications at 480 volts:
 1. Input VAC +/-10 percent (capable of operation to 550 VAC), 3 phase, 48-63Hz. Output 0 - Input Voltage, 3 phase, 0 to 500 Hz for drives up to 75 HP; 0 to 120 Hz for drives over 75 HP. Operation above 60 Hz. shall require programming changes to prevent inadvertent high speed operation. Environmental operating conditions: 0 to 40 C @ 3 klz switching frequency, 0 to 3300 feet above sea level, less than 95 percent humidity, non-condensing. Units shall be UL, CUL and CA approved.
- C. All VFD's shall have the following standard features:
 1. All VFD's shall have the same customer interface, including digital display, keypad and customer connections; regardless of horsepower rating. The keypad is to be used for local control, for stepping through the displays and menus.
 2. The VFD shall give the user the option of either (1) displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last reference revised, or (4) cause a Warning to be issued, if the input reference (4-20mA or 2-10V) is lost; as selected by the user. The VFD shall provide a programmable relay output for customer use to indicate the loss of reference condition.
 3. The VFD's shall utilize plain English digital display (code numbers and letters are not acceptable). The digital display shall be a 40-character (2 line X 20 characters/line) LCD display. The LCD shall be backlit to provide easy viewing in any angle. All set-up parameters, indications, faults, warnings and other information must be displayed in words to allow the user to understand what is being displayed without the use of a manual or cross-reference table.
 4. The VFD's shall utilize pre-programmed application macro's specifically designed to facilitate start-up. The Application Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time.
 5. The VFD shall have the ability to automatically restart after an overcurrent, overvoltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between reset attempts shall be programmable. If the time between reset attempts is greater than zero, the time remaining until reset occurs shall count down on the display to warn an operator that a restart will occur.
 6. The VFD shall be capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).

7. The VFD shall be equipped with an automatic extended power loss ride-through circuit which will utilize the inertia of the load to keep the drive powered. Minimum power loss ride-through shall be one-cycle, based on full load and not inertia. Removing power from the motor is not an acceptable method of increasing power loss ride-through.
8. The customer terminal strip shall be isolated from the line ground.
9. Prewired 3-position Hand-Off-Auto switch and speed potentiometer. When in "Hand", the VFD will be started, and the speed will be controlled from the speed potentiometer. When in "Off", the VFD will be stopped. When in "Auto", the VFD will start via an external contact closure, and its speed will be controlled via an external speed reference.
10. The drive shall employ three current limit circuits to provide trip free operation.
11. The Slow Current Regulation limit circuit shall be adjustable to 125 percent (minimum) of the VFD's variable torque current rating. This adjustment shall be made via the keypad, and shall be displayed in actual amps, and not as percent of full load. The Rapid Current Regulation limit shall be adjustable to 170 percent (minimum) of the VFD's variable torque current rating. The Current Switch-off limit shall be fixed at 255 percent (minimum, instantaneous) of the VFD's variable torque current rating. The overload rating of the drive shall be 110 percent of its variable torque current rating for 1 minute every 10 minutes, and 140 percent of its variable torque current rating for 2 seconds every 15 seconds, input line fuses standard in the drive enclosure. VFD shall have a DC Line Reactor to reduce the harmonics to the power line and to increase the fundamental power factor.
12. The VFD shall be optimized for a 4 kHz carrier frequency to reduce motor noise and provide high system efficiency. The carrier frequency shall be adjustable by the start-up engineer in ACH 501 units. The VFD shall have a manual speed potentiometer in addition to using the keypad as a means of controlling speed manually.

D. All VFD's to have the following adjustments:

1. Five programmable critical frequency lockout ranges to prevent the VFD from continuously operating at an unstable speed.
2. PI Setpoint controller shall be standard in the drive, allowing a pressure or flow signal to be connected to the VFD, using the microprocessor in the VFD for the closed loop control.
3. Two programmable analog inputs shall accept a current or voltage signal for speed reference, or for reference and actual (feedback) signals for PI controller. Analog inputs shall include a filter; programmable from 0.01 to 10 seconds to remove any oscillation in the input signal. The minimum and maximum values (gain and offset) shall be adjustable within the range of 0-20 MA and 0-10 Volts. Additionally, the reference must be able to be scaled so that maximum reference can represent a frequency less than 60 Hz, without lowering the drive maximum frequency below 60 Hz.
4. Six programmable digital inputs for maximum flexibility in interfacing with external devices. One digital input is to be utilized as a customer safety connection point for fire, freeze, and smoke interlocks (Enable). Upon remote, customer reset (reclosure of interlock), drive is to resume normal operation.

E. The following operating information displays shall be standard on the VFD digital display. The display shall be in complete English words (alpha-numeric codes are not acceptable):

Output Frequency

Motor Speed (RPM, percent or Engineering units)

Motor Current

Calculated Motor Torque

Calculated Motor Power

DC Bus Voltage

Output Voltage

Heatsink Temperature

Analog Input Values

Keypad Reference Values

Elapsed Time Meter

kWh meter

F. Speed Command Input shall be via:

1. Keypad.
2. Two Analog inputs, each capable of accepting a 0-20mA, 4-20mA, 0-10V, 2-10V signal. Input shall be isolated from ground, and programmable via the keypad for different uses.
3. Floating point input shall accept a three-wire input from a Dwyer photohelic (or equivalent type) instrument.

G. Accessories to be furnished and mounted by the drive manufacturer.

1. Customer Interlock Terminal Strip-provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external interlocks and start/stop contacts shall remain fully functional whether the drive is in hand, Auto or Bypass.
2. All wires to be individually numbered at both ends for ease of troubleshooting.
3. Door interlocked thermal magnetic circuit breaker which will disconnect all input power from the drive and all internally mounted options. The disconnect handle shall be thru-the-door type, and be padlockable in the "Off" position.
4. Manual transfer to line power via contactors. Include motor thermal overload and fuse or circuit breaker protection while in bypass operation. A three position selector switch to control the bypass contactor and the drive output contactor is to be mounted on the enclosure door. When in the "Normal" mode, the bypass contactor is open and the drive output contactor is closed. In the "Test" position both contactors are open, and in the "Bypass" position, the drive output contactor is open, and the bypass contactor is closed. The drive output contactor shall also open when a stop command is given, isolating the motor from the drive. Start/stop signals and safety interlocks will work in drive and bypass modes.
5. Pilot lights or LED's shall be provided for indication of "Normal" operation, "Bypass" operation, and "External Fault". All pilot lights shall be push-to-test type.
6. Service contactor (drive input contactor) which provides the ability to service the drive (electrically isolate the drive while in bypass operation without having to remove power from the motor). The service contactor shall open when the drive is switched to bypass, and also be controlled by a switch which is mounted inside the drive enclosure so that its access is limited to service personnel only.
7. A class 20 bimetallic thermal motor overload relay shall be provided to protect the motor in bypass.

H. Compliance to IEEE - 519

1. The VFD manufacturer shall provide calculations specified to this installation showing that the Total harmonic Distortion for the VFD's, reflected into the electrical distribution system is limited to the level defined by IEEE - 519 (latest edition) for general systems. Harmonic analysis shall be included with VFD submittal for approval by the engineer.
2. The VFD manufacturer shall conduct on site harmonic measurements before and after startup of the VFD's. Results of the measurements, showing harmonic contribution of the VFD's, shall be provided to the engineer one month after start up.
3. Three phase A. C. input, 3 percent line reactors (externally mounted ahead of diode bridge) shall be provided as a minimum, with all VFD's. The line reactors are to provide attenuation of line side voltage transients, thus preventing overload trips or other unnecessary V.F.D. shutdown, and provide a reduction in harmonic distortion.
4. Line reactors shall have the following requirements:
 - a. Two or three percent line impedance.
 - b. 150 percent continuous current rating for one minute.
 - c. Saturation rating no less than 2.5 times the continuous current rating.
 - d. U.L. recognized.

I. General: Install variable frequency drives where indicated, in accordance with manufacturer's published installation instructions, complying with recognized practices to ensure that variable frequency drives comply with requirements and serve intended purposes.

J. Access: Provide access space around control panels for service as indicated, but in no case less than that recommended by manufacturer.

K. Support: Install drive control panels on walls where indicated on drawings. Provide necessary Unistrut and structural steel to provide adequate support as required by manufacturer.

L. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

M. Start-Up

1. Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer.

N. Adjusting and Cleaning:

1. Alignment: Check compatibility of control panel to motor and where necessary, adjust frequency and provide necessary filters to assure noise free operation of motors. Verify response from control panel to motor to assure turn down ratio specified and that static pressure signals are being received and that drives are controlling as specified and within recommended tolerances by manufacturer. Provide start-up report prepared by manufacturers representative to assure operation is as specified.
2. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

O. Acceptable Manufacturers:

1. ABB
2. Allen – Bradley
3. Siemens
4. Square D
5. Or equal

2.28 EMERGENCY RESPONDER RADIO SIGNAL AMPLIFICATION SYSTEM (BDA SYSTEM)

A. General

1. Provide an in-building radio signal amplification system to provide complete coverage in the building for the public safety agencies as required by the local fire department and other agencies and authorities having jurisdiction. System users shall receive and transmit radio broadcasts from their portable radio units within the building. This shall be accomplished utilizing the following components:
 - a. Bi-Directional Amplifiers (Signal Boosters)
 - b. Plenum rated Coaxial Cable
 - c. Antennas
 - d. Cable taps
 - e. Connectors
 - f. Power dividers
 - g. Other components and interconnecting circuitry as required
2. ~~The system shall comply with the requirements of the Massachusetts State Building Code (780 CMR), 8th Edition as amended on April 11, 2014 and NFPA 72, 2010 edition, as referenced.~~ **The system shall comply with the requirements of the Massachusetts State Building Code (780 CMR), 9th Edition as amended and NFPA-72, 2013 edition, as referenced.**
3. The entire system shall meet with approval of the Fire Department, the Building Department and all other agencies and authorities having jurisdiction (AHJ).
4. The work in this section shall include the responsibility for all fillings with the AHJ, as required. This responsibility shall include furnishing of floor plans, descriptive notes and/or specifications, wiring diagrams, certifications, shop drawings and amendment forms.
5. Early completion of the in-building radio communication enhancement system will be required as to permit a Certificate of Occupancy to be obtained in a timely manner
6. Any permits necessary for the installation of the work shall be obtained prior to the commencement of the work. All permit costs and inspection fees shall be included as the part of the required work.

B. Design requirements

1. In-building radio signal amplification systems for emergency responders are an integral component of the life safety equipment of a building or structure. The primary function is to provide reliable emergency responder communications at the required signal strength within the specified areas.
2. Critical Areas such as emergency command center, fire pump room, exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations and similar critical areas shall be provided with 100% floor area radio coverage.
3. General building areas shall be provided with 95% radio coverage, or as specified by AHJ.

4. The In-building radio signal amplification systems must provide the following signal strengths:
 - a. Downlink - Minimum signal strength of -95 dBm throughout the coverage area.
 - b. Uplink - Minimum signal strength of -95 dBm received at the AHJ Radio System.
5. The system shall be complete with all components and wiring required for compliance with all applicable codes and regulations, and for its operations described hereinafter.
6. EC shall sub-contract an approved manufacturer or a qualified and approved radio systems vendor to supply, test and determine locations of components which are required for proper operation as well as to supply, deploy, test and certify the performance of the complete system. Vendor qualifications and must also be acceptable to the AHJ.
7. All installation and testing personnel shall be certified and authorized by the signal booster manufacturer in the installation and operation of their equipment. Personnel qualifications must also be acceptable to the AHJ.
8. The system design is based on the RSI branded line of Public Safety NFPA-72 and FCC compliant Signal Boosters as manufactured by Radio Solutions, Inc. to establish standards of quality for materials and performance. The naming of a specific manufacturer or a catalog number does not waive any requirement or performance of individual components described in the specifications.
9. Assembly and installation of all components of the Emergency Responder Radio Communication Enhancement System shall comply with all applicable sections of the National Electrical Code.
10. Survivability from attack by fire shall meet NFPA 72, National Fire Alarm and Signaling Code, 2010 edition
11. The system must comply with all applicable sections of the FCC rules. Signal booster shall have FCC certification prior to installation.
12. Antenna isolation shall be maintained between the donor antenna and all inside antennas to a minimum of 20dB under all operating and environmental conditions.

C. Technical Specifications and Performance Requirements

1. The system specified is based upon RSI branded line of Public Safety NFPA-72 compliant signal boosters, manufactured and integrated by Radio Solutions, Inc. Provide RSI or equal.
2. The signal booster shall be either a Class B or a Class A Public Safety type as designated by the FCC and as required by the AHJ.
3. The secondary power supplies, battery chargers and system monitoring shall be fully compliant with NFPA-72, 2010 edition. The signal booster shall have both the primary and the secondary power supplies fully enclosed in a sealed, non-vented NEMA-4 enclosure.
4. All signal boosters and other active system components must have FCC certification prior to installation. The equipment FCC ID must be shown on the product brochures and technical submittals. The ID must also be displayed on the product as required by the FCC.
5. Equipment installation must be done in accordance with the OEM (original equipment manufacturer) specifications. External filters, attachments or other non-approved aftermarket modifications of the original equipment shall not be accepted.
6. The signal booster shall be set and tuned by the equipment manufacturer to pass all frequencies specified by the local fire department.

7. To reduce the possibility of unwanted interference affecting the operation of the system, signal boosters shall be of a band-selective or channel-selective type with a maximum 200KHz (Fc +/- 100KHz) 3dB channel bandwidth. Wide-band, non-selective signal boosters shall not be accepted unless it is required to cover multiple consecutive channels within the same band, or if specified by the AHJ.
8. Signal Boosters shall have oscillation prevention circuitry to protect the public safety radio system in case of signal booster malfunction.
9. Signal Boosters shall have a minimum of 80dB gain. The gain shall be adjustable in a minimum of 25dB range. System gain shall be set and documented at the time of the final system test.
10. Maximum Propagation delay of the signal booster system shall be 14µs (microseconds) or as specified by AHJ.
11. The signal booster shall include built-in automatic alarming of malfunctions of the signal booster and battery system as per NFPA 72, 2010 Edition, Sections 24.5.2.6.1, and 24.5.2.6.2. Aftermarket equipment add-ons and modifications to comply with this specification will not be accepted.
12. A dedicated monitoring panel shall be provided within the emergency command center or other location as designated by AHJ to annunciate the status of all signal booster locations. The monitoring panel shall provide visual and labeled indication of the following for each signal booster:
 - a. Normal AC power
 - b. Signal booster trouble
 - c. Loss of normal AC power
 - d. Failure of battery charger
 - e. Low battery capacity
13. The system installation vendor shall verify the system monitoring requirements with the AHJ prior to system installation. System monitoring shall be fully compliant with the AHJ requirements.
14. All signal booster components shall be contained in a NEMA4 rated waterproof cabinet. Signal booster and battery backup enclosures shall be painted red with signage in bright yellow or as required by AHJ.

D. Installation Requirements

1. Assembly and installation of all components of the Emergency Responder Communication Enhancement System shall comply with all applicable sections of the National Electrical Code, NFPA-70 and the National Fire Alarm and Signaling Code, NFPA-72, current enforceable editions.
2. At least 2 independent and reliable power supplies shall be provided as specified in sections 3 and 4 below.
3. The primary power source shall be supplied from a dedicated twenty (20) ampere branch circuit and comply with NFPA-70 National Electrical Code, and NFPA 72, National Fire Alarm and Signaling Code, 2010 edition
4. The emergency responder radio coverage enhancement system shall be equipped with a secondary source of power. The secondary source of power shall be a battery system with a dedicated battery charger powered by a separate, dedicated twenty (20) ampere branch circuit. The secondary power supply shall supply power automatically when the primary power source is lost. The secondary source of power shall be capable of powering the emergency responder radio coverage enhancement system for a minimum period of 24 hours. The battery system shall automatically charge in the presence of external power input. Battery charger and all other electronic components must be fully enclosed in a non-vented NEMA-4 rated enclosure. Batteries shall be enclosed in a separate, vented NEMA rated enclosure.

5. The signal booster shall be designed to allow continued operation in adverse environmental conditions, such as high temperatures in the event heat from a nearby fire, water spray, voltage fluctuations or other abnormal conditions that may occur during an emergency. Circuits that intentionally disable the signal booster in such situations (i.e. under/over voltage, over/under current, over/under temperature, etc.) are not acceptable, unless required for FCC regulatory or safety compliance. It is the purpose of this specification to assure the maximum possible level of communications to public safety personnel depending upon the signal booster, even to the extent of damaging the signal booster, as long as some communications benefit can be provided during the emergency.
6. External UPS (Uninterruptable Power Supplies) are not acceptable
7. The power supply system design shall be such that neither the failure of the normal power source, the transfer to an emergency source, nor the re-transfer to the normal source shall cause an interruption or change in system status.
8. The amplifier shall be housed in a 2-hour fire rated room or other suitable space as approved by the Engineer or Architect, or where specifically shown on the drawing.
9. Radiating cable, if used, shall be run without conduit. All other cable can be run in conduit if required for mechanical protection of the cable, or where specified by the electrical engineer.
10. RF Coaxial Cable shall be a fire-resistant, low-smoke type, U.L. classified as plenum. The classification shall be clearly marked on the outer surface of the cable regular intervals.

E. Acceptance and Test Procedures

1. Acceptance testing for an in-building radio system is required upon completion of installation.
2. The coverage testing shall be done in accordance with NFPA 72, National Fire Alarm and Signaling Code, 2010 edition, and as required by the local AHJ
All tests shall be conducted, documented, and signed by a person in possession of a current FCC General Radio Operator License.
3. All test records along with system diagrams, equipment specifications, user manuals, RF link budget calculations, battery backup calculation and other design data shall be submitted upon completion of the project.

2.29 LEVEL 2 AC DUAL ELECTRIC VEHICLE CHARGING EQUIPMENT (EVSE)

- A. Scope: Furnish and install Level 2 AC Dual Electric Vehicle Charging equipment as specified herein and as shown on the contract drawings.
- B. References: The electric vehicle supply equipment (EVSE) and all components shall be designed, manufactured and tested in accordance with the latest version of the following standards (unless otherwise noted):
 1. SAE J1772, Electric Vehicle Conductive Charge Coupler
 2. SAE J2836 , Use Cases for Communication Between Plug-in Vehicles and the Utility Grid
 3. SAE J2847, Communication between Plug-in Vehicles and the Utility Grid
 4. SAE J2931, Digital Communications for Plug-in Electric Vehicles
 5. National Electric Code Article 625, Electric Vehicle Charging System
 6. UL 2231, Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits
 7. UL 2594, Electric Vehicle Supply Equipment
 8. UL 1998, Software in Programmable Components
 9. CSA C22.2 No. 107.1, General Use Power Supplies

10. FCC Part 15, Class B

C. Submittals – for Review/Approval

1. The following information shall be submitted to the Engineer:
 - a. Product data sheets
 - b. Installation Manuals

D. Submittals – for construction

1. The following information shall be submitted for record purposes:
 - a. Final as-built drawings
 - b. Wiring diagrams
 - c. Installation information including equipment anchorage provisions

E. Qualifications

1. The manufacturer shall have been self-manufacturing EVSE or similar transportation electrification equipment for a minimum of three years. The manufacturer shall also have been in manufacturing for a minimum of five (5) years.

F. Delivery, Storage and Handling

1. EVSE being stored prior to installation shall be stored so as to maintain the equipment in a clean and dry condition as required by the manufacturer's instructions, in accordance with manufacturer's instructions (1) copy of these instructions shall be included with the equipment at time of shipment.

G. Operation and Maintenance Manuals

1. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly.

H. Warranty

1. The manufacturer warrants equipment to be free from defects in materials and workmanship for 1 year from date of substantial completion.

I. Manufacturers

1. Chargepoint
2. Siemens
3. General Electric
4. Or equal

The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Basis of Design is Chargepoint CT4021.

J. Construction

1. Provide a third party recognized AC, Level 2 charging station, quantities and current ratings as shown on drawings.

2. Physical Specifications
 - a. Enclosure Construction and Finish
 - 1) Enclosure shall be manufactured from aluminum or other corrosion resistant material
 - 2) Enclosure shall consist of a coat of thermosetting, polyester powder paint applied electrostatically with a metallic finish.
 - b. Enclosure Mounting
 - 1) Pedestal Mount dual SAE J1772 connectors
 - c. Cable Length
 - 1) 25 feet
 - d. Connector and Cable Management
 - 1) The EVSE shall incorporate a cord management system or method to minimize the potential for cable entanglement, user injury or connector damage from lying on the ground and comply with NEC articles 625 as it applies to cord management systems.
 - 2) The EVSE shall include a dock for inserting the SAE J1772 connector when not in use.
 - 3) The EVSE connector and cable assembly shall be field replaceable.
 - e. The EVSE shall include a removable device panel to allow for field retrofits and replacement of optional equipment.
3. Environmental
 - a. Operating Temperature
 - 1) -22 F (-30 C) to 104 F (40 C)
 - b. Surge Withstand
 - 1) 6kV at 3000A
 - c. Humidity
 - 1) 90% relative humidity, non-condensing
 - 2) Corrosion Resistance
 - 3) The enclosure coating shall have a corrosion resistance of 600 hours to 5% salt spray.
 - d. The printed circuit boards (PCB's) integral to the EVSE shall be conformal coated.
4. User Interface
 - a. The station's display shall be simple, with universal symbols accompanying text to allow easy understanding and use of the EVSE.
 - b. The EVSE shall include the following status indicators:
 - 1) Power
 - 2) Charging
 - 3) Charging Complete
 - 4) Remotely Controlled
 - 5) Temporary Fault
 - 6) Service
 - c. The EVSE shall include the following:
 - 1) Reset Pushbutton

5. Protection
 - a. The EVSE shall provide integral overcurrent protection at 5% over the nameplate rating.
 - b. The EVSE shall provide integral ground fault interruption of 20mA per UL 2231.
 - c. The EVSE shall incorporate an automatic ground fault detection feature at the beginning of each plug session.
 - d. The EVSE shall incorporate a manual ground fault test feature.
 - 1) The EVSE shall include a DIP switch enabled Automatic Reset feature to allow the station to reset after a temporary fault without user interaction.
 - e. The EVSE shall include a DIP switch enabled Soft Start feature to allow for the ramp up of current to the Available Line Current or Nameplate Current Rating of EVSE.
 - f. The EVSE shall include a Cold-Load Pickup feature to allow for randomized restart on power failure and/or delay before charging resumes after a power failure.
6. Input / Output
 - a. The EVSE shall include a normally closed (NC) dry contact permissive run input.
7. Communications and Data Collection
 - a. The EVSE shall be open architecture with native Modbus RTU and RS-232 Serial communications.
 - b. The EVSE shall allow for curtailment of the maximum current output through Modbus communications.
 - c. The EVSE shall be capable of Master / End Device configurations through a Modbus RTU daisy chain topology.
8. Required Accessories
 - a. Systems Integration Enabled
 - 1) Communications for Open Charge Point Protocol networking
 - 2) Authentication and Payment Authorization
 - a) Swipe Credit Card Reader for time based payments
 - 3) Local area network 2.4Ghz Wi-Fi(802.11b/g/n)
 - 4) Wide area network 3G GSM, 3G CDMA
- K. Factory Testing
 1. Each EVSE shall undergo factory testing of all operational and protective features prior to shipment.
- L. Installation
 1. The Electrical SubContractor shall install all equipment per the manufacturer's recommendations and contract drawings.
 2. All necessary hardware to secure the assembly in place shall be provided by the Electrical SubContractor.
- M. Training
 1. Provide four hours of owner training with manufacturer's representative present.
- N. Service plan
 1. Provide a 5 year service plan for each station.

2.30 ELECTRICITY METERING

A. COORDINATION

1. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. WARRANTY

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

C. PRODUCTS

1. MULTIPLE CHECK METERING SYSTEM

- a. Provide a system of check meters consisting of Multiple Meter Unit Cabinets equal to E-MON D-MON MMU Series. Multiple Meter Cabinets shall consist of 8, 16 and 24 meters as indicated on Plans. Each meter shall meet the following criteria:
 - 1) Meter shall be fully electronic with 4-line by 20-character backlit LCD display showing kwh, kW demand (with peak date and time), power factor per phase, real-time load in kW, Amps per phase and Volts per phase.
 - 2) Meter shall utilize 0-2 volt AC output current sensors to allow paralleling and/or mounting up to 500 feet from the meter. Sensor shall be of split-core configuration to allow installation without disconnecting cabling. Sensors shall be available from 100 amp to 1200 amp. Sensors shall be optionally available to solid-core configuration (100 & 200 amp.)
 - 3) Meter shall be field programmable for meter date/time and ID code for communication options.
 - 4) Meter shall provide installation diagnostics on display.
 - 5) Meter shall be enclosed in MMU NEMA 1 enclosure (standard) with padlocking hasp & mounting flanges for indoor/outdoor installation (stand alone) with one 1 1/16 in. KO on bottom of enclosure.
 - 6) Meter shall be UL/CUL Listed to latest applicable standards for safety.
 - 7) Meter shall meet or exceed NSI C12.20 accuracy standards.
 - 8) Meter shall provide non-volatile memory to maintain reading during power outages.
 - 9) Meter shall store interval data or kWh and kVARh for up to 72 days in first-in first-out format. (Standard firmware).
 - 10) Meter shall be capable of daisy-chain or star connection using RS-485 communications in combinations of Class 3200s, 3400s, 5000s, IDR-8s, IDR-16s not to exceed 52 devices. Cabling shall be available terminal block (3-conductor), 18-22AWG, up to 4,000 cable feet total. Class 1000 meters may be used for single phase loads.
 - 11) Meter shall be provided with the following communication protocols:
 - a) Requires third-party EMS/BMS system supplied by others.
 1. BACnet MS/TP (Replace EZ7 in model with BAC when ordering)
 2. Modbus RTU Communications (Replace EZ7 in model with RTU when ordering)
2. Multiple Meter Unit Cabinets shall be prewired complete with voltage feeds. Clearly label all meter with load served.
3. Acceptable Manufacturers:
 - a. E-Mon D-Mon

- b. National Meter Industries
 - c. Square D
 - d. Or Equal
4. Provide 4 hours of owner training.

PART 3 - EXECUTION

3.1 WORK COORDINATION AND JOB OPERATIONS

- A. Equipment shall not be installed in congested and possible problem areas without first coordinating installation of same with other trades. Relocate electrical equipment installed in congested or problem areas should it interfere with the proper installation of equipment to be installed by other trades.
- B. Particular attention shall be directed to coordination of lighting fixtures and other electrically operated equipment requiring access which is to be installed in ceiling areas. Coordinate with other trades, the elevations of equipment in hung ceiling areas to insure adequate space for installation of recessed fixtures before said equipment is installed. Conflicts in mounting heights and clearances above hung ceilings for installation of recessed lighting fixtures or other electrically operated equipment requiring access shall be brought to the attention of Architect for a decision prior to equipment installation.
- C. Furnish to General Trades Contractor and other subcontractors information relative to portions of electrical installation that will affect other trades sufficiently in advance so that they may plan their work and installation.
- D. Obtain from other trades information relative to electrical work which he, the Electrical Subcontractor, is to execute in conjunction with installation of other trades' equipment.
- E. Lighting fixtures in mechanical spaces or utility/ storage rooms shall only be installed after all mechanical equipment is in place.

3.2 PLANS AND SPECIFICATIONS

- A. Plans:
 - 1. Drawings showing layout of electrical systems indicate approximate location of raceways, outlets, and apparatus. Runs of feeders and branch circuits are schematic and are not intended to show exact routing. Final determination as to routing shall be governed by structural conditions and as indicated on the approved coordination drawings.
- B. Specifications:
 - 1. Specifications supplement drawings and provide specifics pertaining to methods and material to be used.

3.3 IDENTIFICATION

A. Equipment shall be marked for ease of identification as follows:

1. Provide screw-on nameplates on switchboards, panelboards, F.A. terminal cabinets, starters, and disconnect switches. Nameplates to be of black phenolic with white engraving. For starters and disconnect switches lettering shall be minimum of ¼ in. high. Nameplates on panelboards shall have the following information.
 - a. Line 1 - Panel designation in ½ in. high letters.
 - b. Line 2 - Utilization voltage in 3/8 in. high letters.
 - c. Line 3 - Distribution source "Fed from ¼ in. high letters.
2. Neatly typed directory cards listing circuit designations shall be fastened inside the cover of panelboards. Spare circuits shall be penciled.
3. Provide Signage on all rooms that contain Fire alarm control equipment within it. Where a Fire alarm control panel is located within a separate room provide permanent signage that reads " FIRE ALARM CONTROL PANEL INSIDE" with minimum 7 in. high by 10 in. width with 2-inch high block letters a 0.5 in. letter stroke - white letters on a contrasting red background. The sign shall be permanently attached, at normal eye level to the door leading to the fire alarm control panel(s).
4. Color coding schedules. If there is more than a single system voltage, different voltages shall have separate color codes, as previously specified. A copy of the color code schedule shall be affixed to each secondary switchboard and distribution panel and shall be of the phenolic nameplate type as previously specified. A typewritten color code schedule shall also be affixed, under plastic, inside each panelboard door.
5. Outlet boxes both concealed and exposed shall be identified as to panel origination and circuit number by means of fibre pen on the inside of coverplate.
6. Special system outlet boxes concealed above hung ceilings shall be identified as to system by spray painting during roughing. The following systems shall be identified.
 - a. Fire Alarm - red.
 - b. Normal/Emergency - yellow.
 - c. Security - blue.
 - d. Sound - green.
7. Wiring device plates on devices connected to normal-emergency circuits shall be red in color.
8. All conductors in boxes larger than standard outlet boxes, in all wireways, and trench headers. shall be grouped logically and be identified.
9. Grounding conductors and neutrals shall be labeled in panels, and wireways. as to circuits associated with.
10. Emergency system wiring shall comply with 700.10(A).
11. Power and raceway identification:
 - a. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
 - b. Colors for Raceways Carrying Circuits at 600 V or Less:
 - c. Black letters on an orange field.
 - d. Legend: Indicate voltage and system or service type (Power, Lighting, Emergency, Control).
 - e. Colors for Raceways Carrying Circuits at More Than 600 V:
 - f. Black letters on an orange field.

- g. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- high letters.
 - h. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
 - i. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch- wide black stripes on 10-inch centers diagonally over orange background that extends full length of raceway. Stop stripes at legends.
 - j. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
 - k. Write-On Tags: Polyester tag, with corrosion-resistant grommet and cable tie for attachment to conductor or cable. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
12. Armored metal clad cable identification:
- a. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
 - b. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.
13. Power and Control Cable identification:
- a. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
 - b. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
 - c. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
 - d. Write-On Tags: Polyester tag, with corrosion-resistant grommet and cable tie for attachment to conductor or cable. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - e. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
14. Conductor Identification materials:
- a. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
 - b. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
 - c. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
 - d. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
 - e. Write-On Tags: Polyester tag, with corrosion-resistant grommet and cable tie for attachment to conductor or cable. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

15. Underground warning tape:

- a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines but not less than 4 mils thick and 6 inches wide.
- b. Printing on tape shall be permanent and shall not be damaged by direct-burial service.
- c. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
- d. Color and Printing:
 - 1) Comply with ANSI Z535.1 through ANSI Z535.5.
 - 2) Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
 - 3) Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

16. Warning labels and signs:

- a. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
- b. Baked-Enamel Warning Signs:
- c. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. Nominal size, 7 by 10 inches.
- d. Metal-Backed, Butyrate Warning Signs:
- e. Weather-resistant signs, non-fading, preprinted, cellulose-acetate butyrate signs with galvanized-steel backing; and with colors, legend, and size required for application. Nominal size 10 by 14 inches.
- f. Safety signs shall warn of potential electrical hazard and shall include, but are not limited to, the following legends:
- g. Multiple power source warning.
- h. Workspace clearance warning.
- i. Potential electric arc flash hazard.

17. Equipment identification labels:

- a. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.
- b. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.
- c. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

18. Cable ties:

- a. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.
- b. Minimum Width: 3/16 inch.
- c. Color: Black except where used for color-coding.

- d. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.
 - e. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking. UL 94 Flame Rated.
- 19. Verify identity of each item before installing identification products. Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as approved in submittals and required by code.
 - 20. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
 - 21. Apply identification devices to surfaces that require finish after completing finish work.
 - 22. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
 - 23. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
 - 24. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
 - 25. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
 - 26. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
 - 27. Outdoors: UV-stabilized nylon.
 - 28. In Spaces Handling Environmental Air: Plenum rated.
 - 29. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
 - 30. Renovation Projects: For alterations and additions to existing facilities, use existing identification system. Where systems have not been standardized, use the identifying and marking system specified in this standard.
 - 31. Distribution Equipment: Identify major components of the distribution system (such as circuit breakers, switches, transformers, switchboards, panelboards, motor control centers) with nameplates. Nameplates on disconnect switches and control stations shall identify the equipment served.
 - 32. Identification Schedule:
 - a. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for service, feeder, and branch circuits more than 30A and 120V to ground: Identify with self-adhesive vinyl label applied at 10-foot maximum intervals.
 - b. Power-Circuit Conductor Identification, 600 V or Less: Identify conductors in the panels, pull and junction boxes, manholes, handholes.
 - 1) Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors for ungrounded service, feeder and branch-circuit conductors as specified in Division 26 Section "Low-Voltage Power Conductors".
 - a) Factory applied continuous color coding for conductors No.8 AWG and smaller.
 - b) Field-applied, color coding conductor tape: For conductors No.6 AWG and larger. Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made.

- 2) Lighting and Receptacle Outlet Boxes: Identify with the panel and circuit number.
- c. Power-Circuit Conductor Identification, above 600 V: For conductors in the vaults, pull and junction boxes, manholes and handholes, use write-on tags.
- d. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- e. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
- f. Terminal Blocks: Attach numbered nameplates to terminal blocks which require identification numbers; use the designations shown on the wiring diagrams. Install nameplate at the top of vertically mounted terminal blocks and at the end of horizontally mounted terminal blocks. Indicate the individual terminal point designation shown on the wiring diagrams.
- g. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
- h. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in the finished spaces.
- i. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Apply warning, caution, and instruction signs where required by the referenced Electrical code, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install self-adhesive warning labels or baked-enamel warning signs with approved legend where instructions or explanations are needed for system or equipment operation. Install metal-backed, butyrate warning signs for outdoor items.
- j. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch high letters for emergency instructions at equipment used for power transfer, load shedding and other emergency operations.
- k. Safety sign for the switchboards and panelboards: Provide a sign to warn qualified persons of potential electric arc flash hazard.
- l. All electrical distribution equipment and mechanical/plumbing/fire protection equipment fed from the electrical distribution system shall contain in addition to the identification requirements listed in this section shall be labelled where they are fed from. For example Distribution panel 4DP1A is fed from MSB-1A, its label shall be "4DP1A fed from MSB-1A" submit full labeling scheme for review and approval.
- m. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to the disconnect switches and protection equipment, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
- 1) Labeling Instructions:
 - a) Indoor Equipment: Self-adhesive, laminated acrylic or melamine label.
 - b) Outdoor Equipment: Engraved, laminated acrylic.
 - c) Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

- 2) Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be engraved laminated acrylic. Panelboard directories shall identify the load name and location (i.e. AHU-1, Room #, FCU-1, Room #).

3.4 PROTECTION AND CLEANUP

A. Protection:

1. Materials and equipment shall be suitably stored and protected from weather.
2. During progress of work, pipe and equipment openings shall be temporarily closed so as to prevent obstruction and damage.
3. Be responsible for maintenance and protection of material and equipment until final acceptance.

B. Cleanup:

1. Keep job site free from accumulation of waste material and rubbish. Remove all rubbish, construction equipment, and surplus materials from site and leave premises in a clean condition.
2. At completion, equipment with factory finished surfaces shall be cleaned and damaged spots touched up with the same type paint applied at factory.
3. Particular attention is called to Section 110-12(c) of the NEC, which requires that internal parts of electrical equipment not be contaminated by construction operations.

3.5 PORTABLE OR DETACHABLE PARTS

- A. Retain possession of and be responsible for spare parts, portable and detachable parts, and other removable portions of installation including fuses, keys, locks, blocking clips, inserts, lamps, instructions, drawings, and other devices or materials that are relative to and necessary for proper operation and maintenance of the system until final acceptance, at which time such parts shall be installed or turned over to the Owner, as the case may be.

3.6 SAFETY PRECAUTIONS

- A. Provide proper guards, signage, and other necessary construction required for prevention of accidents and to insure safety of life and property. Remove any temporary safety precautions at completion.

3.7 MOUNTING HEIGHTS

- A. All electrical equipment shall be mounted at the following heights unless noted or detailed otherwise on drawings. Notes on architectural drawings shall supersede those noted below or detailed on the electrical drawings. If mounting height of an electrical component is questionable, obtain clarification from Architect before installation.

1. Duplex convenience outlets, microphone outlets, and telephone outlets - 18 inches.
2. Light switches, pushbutton stations, HOA switches, and all other toggle or control switches for the operation of heating, ventilating, and air conditioning, plumbing, and general service - 48 inches.
3. Clock outlets - 84 inches.
4. Fire alarm pull stations - 48 inches.
5. Fire alarm audio visual signals - 80 inches or 6 inches below ceiling, whichever is lower.
6. Panelboards for lighting, power, telephone, and other auxiliary systems - 78 in. to top.

7. Equipment located in lobbies shall be located as detailed on architectural drawings or as directed by Architect.
8. All receptacles, light switches, fire alarm signals, and clocks sharing a common location shall be symmetrically arranged.
9. Exterior and interior wall brackets shall be as detailed on architectural drawings or as directed by Architect.

- B. Mounting heights given are from finished floor to centerline. In the case of a raised floor, surface of raised floor is the finished floor.

3.8 WORKMANSHIP AND INSTALLATION METHODS

- A. Work shall be installed in first-class manner consistent with best current trade practices. Equipment shall be securely installed plumb and/or level. Flush-mounted outlet boxes shall have front edge flush with finished wall surface. No electrical equipment shall be supported by work of other trades. Cable systems shall be supported and not draped over ducts and piping or laid on ceiling suspension members. Lighting fixtures shall be installed to agree with Architects reflected ceiling plans.

- B. Supports:

1. Support work in accordance with best industry practice and by use of standard fittings.
2. In general, walls and partitions will not be suitable for supporting weight of panelboards, dry type transformers and the like. Provide supporting frames or racks extending from floor slab to structure above.
3. Provide supporting frames or racks for equipment, intended for vertical surface mounting in free standing position where no walls exist.
4. Supporting frames or racks shall be of standard angle, standard channel or specialty support system steel members, rigidly bolted or welded together and adequately braced to form a substantial structure. Racks shall be of ample size to assure a workmanlike arrangement of equipment.
5. Provide 3/4 in. thick painted plywood mounting surfaces in all electric and telephone areas and for all equipment on free standing racks. All plywood shall be fire retardant and painted both sides and edges with 2 coats of white paint.
6. No work for exposed installations in damp locations shall be mounted directly on any building surface. In such locations, flat bar members or spacers shall be used to create a minimum of 1/4 in. air space between building surfaces and work.
7. Nothing (including outlet, pull and junction boxes and fittings) shall depend on electric raceways or cables for support. All outlet, pull, and junction boxes shall be independently supported.
8. Nothing shall rest on, or depend for support on, suspended ceiling or its mounting members.
9. Support surface or pendant mounted lighting fixtures:
 - a. From outlet box by means of an interposed metal strap, where weight is less than five pounds.
 - b. From outlet box by means of a hickey or other direct threaded connection, where weight is from five to fifty pounds.
 - c. Directly from structural slab, deck or framing member, where weight exceeds fifty pounds.
 - d. Pendant lighting fixtures shall be supported by threaded rods in non-public areas and by manufacturers standard tube hangers with swivel aligner and canopy in public areas. Provide non-standard pendant lengths where required to mount fixtures at elevations either called for on drawings or as shown in architectural elevations.

10. Support recessed lighting fixtures directly from structural slabs, decks or framing members, by means of jack chain or air craft cable, one at each end of fixture at opposite corners.
11. Where support members must of necessity penetrate air ducts, provide airtight sealing provisions which allow for a relative movement between the support members and the duct walls.
12. Provide channel sills or skids for leveling and support of all floor mounted electrical equipment.
13. Where permitted loading is exceeded by direct application of electrical equipment to a slab or deck, provide proper dunnage to distribute the weight in a safe manner.
14. Support metallic raceways by either running within steel frame or hung from the building frame. Anything hung from building frame shall be attached with metallic fasteners.

C. Fastenings:

1. Fasten electric work to building structure in accordance with the best industry practice.
2. Where weight applied to attachment points is 100 pounds or less, fasten to building elements of:
 - a. Wood -- with wood screws.
 - b. Concrete and solid masonry -- with bolts and expansion shields.
 - c. Hollow construction -- with toggle bolts.
 - d. Solid metal -- with machine screws in tapped holes or with welded studs.
3. Where weight applied to attachment points exceeds 100 pounds, fasten as follows:
 - a. At field poured concrete slabs, provide inserts with 18 in. minimum length slip-through steel rods, set transverse to reinforcing steel.
 - b. Where building is steel framed, utilize suitable auxiliary channel or angle iron bridging between structural steel elements to establish fastening points. Bridging members shall be suitably welded or clamped to building steel. Provide threaded rods or bolts to attach to bridging members.
4. Floor mounted equipment shall not be held in place solely by its own dead weight. Provide floor anchor fastenings. Floor mounted equipment over 72 inches in height shall also be braced to nearest wall or overhead structural elements.
5. For items which are shown as being mounted at locations where fastenings to the building construction element above is not possible, provide suitable auxiliary channel or angle iron bridging to building structural elements.
6. Fastenings for metallic raceways using the fastening as support shall be of the metallic type. Fastenings to hold raceways or cables in place may be via traps.

D. General Raceway Installation:

1. Install the various types of raceways in permitted locations as previously specified. All raceways shall be run concealed. Consult Architect for instruction for raceways which must be exposed in public spaces.
2. Raceways for normal emergency or emergency only wiring cannot contain other conductors.
3. Raceways shall be properly aligned, grouped, and supported in accordance with code. Exposed raceways shall be installed at right angles to or parallel with structural members. Concealed raceways may take most direct route between outlets.
4. Raceways run on trapeze hangers shall be secured to the trapeze.

5. Raceways shall be continuous and shall enter and be secured to all boxes in such a manner that each system shall be electrically continuous from service to all outlets. Provide grounding bushings and bonding jumpers where raceways attach to painted enclosures or terminate below equipment.
6. Where raceways enter boxes, cabinets, tap boxes, other than those having threaded hubs, a standard locknut shall be used on the outside and locknut and bushing on the inside.
7. Where raceways terminate below equipment and there is no direct metal to metal continuity, provide grounding bushings on raceways and interconnect with equipment grounding conductor.
8. All empty raceways shall be provided with a pull wire.
9. All raceway sleeves, stub-ups, or stub-outs, where not connected to a box or cabinet, shall be terminated with a bushing.
10. All raceway joints shall be made up tight and no running threads will be permitted.
11. Where raceways are cut, the inside edge shall be reamed smooth to prevent injury to conductors.
12. All vertical raceways passing through floor slabs shall be supported.
13. Raceways shall not be installed in concrete slabs above grade or below waterproofed slabs.
14. Electric raceways and/or sleeves passing through floors or walls shall be of such size and in such location as not to impair strength of construction. Where raceways alter structural strength or the installation is questionable, the structural engineer shall be contacted for approval.
15. Raceways shall not run directly above or below heat producing apparatus such as boilers, nor shall raceways run parallel within 6 inches of heated pipes. Raceways crossing heated pipes shall maintain at least a 1 inch space from them.
16. Raceways shall be installed in such a manner as to prevent collection of trapped condensates, and all runs shall be arranged to drain.
17. Raceways passing between refrigerated and non-refrigerated spaces and those penetrating enclosures with air movement shall be provided with seals.
18. Raceways feeding fire and jockey pumps shall be rigid metal conduit either run below slab or inside 2 hour rated enclosure. Final connections to motors shall be liquidtight flexible conduit.
19. Where two alternate wiring methods interconnect such as EMT to flexible metal conduit, an outlet box shall be provided.
20. All empty raceways entering building and all sleeves or core drilled openings through floors shall be sealed.
21. Each exterior raceway or assembly in a ductbank shall be provided with continuous warning tape installed 12 inches above raceway or ductbank.
22. Underground rigid non-metallic raceways where allowed and run as a ductbank encased in concrete shall be installed with plastic spacers to ensure a separation of 3 inches between raceways. Top of ductbanks shall be 30 inches below grade, unless otherwise detailed.
23. Elbows and extensions of rigid non-metallic raceway systems which penetrate slabs shall be rigid or intermediate metal conduit.
24. Raceways used for transformer connections shall be flexible type and shall contain a grounding conductor.
25. Raceways entering building through foundation wall into a basement area shall be provided with wall entrance seals or with other acceptable waterproofing method.

26. Underground non-metallic raceways shall be fully surrounded by a selected backfill to prevent more than the desired deflection and, in power raceways is needed to provide room for heat dissipation and good compaction of backfill. Separation Between Direct-Buried, Non-encased Ducts: 3 inches minimum for like services, and 12 inches minimum between power and signal ducts, unless shown otherwise on the drawings. Raceways formation for non-encased ducts shall be built up layer by layer. After each layer is placed, the selected backfill shall be placed over it to the specified depth. This fill should be spread evenly and compacted to provide continuous support for the next tier of raceways. Any temporary spacers used should be removed from each layer of raceway as soon as backfill is completed in that layer. A maximum of 9 conduits shall be grouped in the same trench unless otherwise noted on the drawings.
27. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
28. Run conduit concealed in finished areas above suspended ceilings, in wall spaces. Exposed conduit runs in finished areas require Architect's approval. Properly group conduit runs. Install conduit parallel to walls, structure and ceilings, and support with proper hangers and clamps. Running conduits at the bottom of structural members in exposed conditions is not allowed. Check door swings before installing back boxes for switches and receptacles.
29. Where conduit passes through a building expansion joint, use weatherproof, telescopic type expansion fittings which permit at least 4 inches of movement.
30. Form bends in conduit by means of a conduit bending machine or by an approved hickey. To fasten conduit to outlet boxes, cabinets, use locknuts and insulated throat bushings of compatible material.
31. Cut conduit ends square, thread conduit, and ream to remove burrs and sharp edges. Field threads shall be of the same type and have the same effective length as factory cut threads. Turns, wherever required in exposed conduit runs, shall be made by the use of factory-made bends, or field-made bends that meet the requirements of this Section and Electric Code. In the event of a multiplicity of conduits making the same turn, a steel junction box with a removable steel cover may be used. Offsets and bends for changes in elevation of exposed conduit runs shall be made at walls or beams and not in open spaces between walls or beams. Rout conduits required to avoid interfere with the operation or maintenance of equipment.
32. Plug or cap conduit ends as soon as conduit is installed, to prevent entrance of moisture or other debris during construction. Do not pull wire into any conduit until the conduit system is complete.
33. Drawings, in relation to the routing of conduits, are diagrammatic. Except where additional conduits may be required to avoid derating of branch circuits, elsewhere within this Section, the number and size of conduits and wire shall be furnished and installed as indicated by the drawings. Coordinate routing of conduits in the field with the building structure. Run conduit in straight lines parallel and perpendicular to walls, beams, and columns and with right angle bends and threaded conduit fittings. Maintain 12 inches clearance between conduit and surface with temperatures exceeding 104 degrees F.
34. Conduits passing through floors, walls and beams shall be of such size, number, and in such locations so as not to impair the strength of the construction.
35. Rout raceways in ceiling spaces in an orderly and organized manner, and to eliminate or minimize the number of junction boxes required. Support and secure conduits by means of rods, clamps and other conduit support devices approved by the Architect. Do not use wire to support conduits.
36. Where rigid metal conduit is threaded in the field, use a standard conduit cutting die providing 3/4 inch taper per foot.

37. Conduit and EMT runs shall be mechanically and electrically continuous from service entrance to outlets. Secure conduit to cabinet, junction box, pull box or outlet box with locknut outside and bushing inside, or with liquid-tight, threaded, self-locking, cold-weld wedge adapter. Locknuts and bushings or self-locking adapters will not be required where conduits are screwed into tapped connections. Before installing conduits, protect vertical conduit runs that terminate in bottoms of wall boxes or cabinets from entrance of foreign material.
38. Size rigid steel conduit, EMT and flexible metallic conduit required by the referenced Electrical Code, except as otherwise specified or shown on the drawings. Check raceway sizes to determine that equipment grounding conductor fits in same raceway with phase and neutral conductors to meet Massachusetts Electrical Code percentage of fill requirements.
39. Where conduit is secured rigidly on opposite sides of building expansion joints, and where runs of exposed conduit are long and subject to stress, provide expansion fittings capable of safely deflecting and expanding to twice the distance of structural movement. Provide separate external copper bonding jumper secured with grounding straps on each end of fitting.
40. Install a pull or junction box every 100 feet of straight conduit run, and wherever there is an equivalent of four 90 degree elbows or a total of 360 degree bend. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
41. Install sealing fittings at following points, and elsewhere as shown:
 - a. Where conduits enter or leave hazardous areas equipped with explosion proof lighting fixtures, switches, receptacles, and other electrical devices.
 - b. Where conduits pass from warm to cold locations.
42. Pull cords: In each empty raceway, provide nylon fishing line having tensile strength not less than 200 lbs, or provide No. 14 AWG steel wire. Label each end of each line or wire with a securely attached tag which indicates the location of the other end.
43. Liquid-tight type flexible conduits installed in the air-handling plenum space shall be with a plenum-rated outer jacket.
44. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

E. General Outlet Box Installation:

1. Boxes shall be set flush with finish surface and provided with proper type extension rings or plaster covers. Thru the wall boxes are not permitted. Check device or fixture to be mounted to box to ensure box orientation is proper.
2. In addition to boxes shown, install additional boxes where needed to prevent damage to cables and wires during pulling-in operation.
3. Plug unused openings on all remove knockouts.
4. Where required for horizontal and vertical alignment of boxes in stud partitions, bar hangers spanning two studs shall be used. Device boxes for insertion type receptacles shall be provided with far side box supports where there are less than two entering nonflexible raceways, and where bar hangers are not provided.
5. Boxes flush mounted in fire rated partitions and on opposite sides of the partition shall be separated by a distance of 24 inches in accordance with UL listing for the box.
6. Locations of outlets indicated on drawings are approximate. For items exposed to view, refer to architectural drawings and coordinate locations with masonry joints, panel joints, ceiling grids, and structural members.
7. In case of conflict with standard mounting heights and device alignment, consult Architect prior to roughing.

8. Check all door swings on architectural drawings to ensure lighting switches are installed on strike side of door.
9. The right to make any reasonable change in location of outlets prior to roughing is reserved by Architect. "Reasonable change" shall be interpreted as movement within 10 feet of location shown.
10. Obtain dimensioned plan from Architect for floor outlets.
11. Outlet boxes for use where surface metal raceways are allowed shall be of a type specifically designed to be used with such surface metal raceway systems.

F. Conductor Installation:

1. No conductors shall be pulled into individual raceways until such raceway system is complete and free of debris. No harmful lubricants shall be used to ease pulling.
2. All conductors shall be wired so that grounded conductor is unbroken; switches in all cases being connected in ungrounded conductor.
3. Connections throughout the entire job shall be made with solderless type devices of approved design satisfactory to Inspector of Wires.
4. All taps and splices shall be insulated equal to that of conductor insulation.
5. All conductors of each feeder in pull boxes and wireways shall be grouped, tied together, supported, and identified.
6. All conductors in panelboards and other wiring enclosures shall be neatly formed and grouped.
7. All conductors of emergency only and/or normal/emergency shall be run in separate raceway systems to final outlet box.
8. Provide support for conductors in vertical raceways in accordance with Article 300-19.
9. Strip insulation from conductors with approved tools and only of sufficient length for proper termination. Cutting of conductor stranding is unacceptable.
10. Taps from paralleled conductors shall be of a type which tap each conductor, such as ILSCO "PTA" series.
11. Grounding conductors are to be identified as to associated power circuits.

G. Type MC Cable Installation:

1. Where cable is permitted under the products section, the installation of same shall be done in accordance with code and the following:
 - a. Cable shall be supported in accordance with code. Tie wire is not an acceptable means of support. Horizontally run cable supports such as Caddy WMX-6, and clamps on vertical runs such as Caddy CJ6 shall be used. Where cables are supported by the structure and only need securing in place, then ty-raps will also be acceptable. Ty-raps are not acceptable as a means of support. All fittings, hangers, and clamps for support and termination of cables shall be of types specifically designed for use with cable, i.e., romex connectors not acceptable.
 - b. Armor of cable shall be removed with rotary cutter device equal to roto-split by Seatek Co., not with hacksaw.
 - c. Use split "insuliner" sleeves at terminations.
 - d. Any cable system used in conjunction with isolated ground circuits shall have both an isolated ground conductor and an equipment ground conductor.

H. Stranded Conductor Installation:

1. If Contractor selects stranded conductors for #10 AWG and smaller, terminate such conductors as follows:
 - a. No stranded conductor may be terminated under a screwhead. Provide insulated terminal lugs for all screw connections equal to Thomas & Betts "STA-KON" type RC with forked tongue and turned up toes. Installation of lugs shall be done with compression tool such as T&B WT-145C which prevents opening of tool until full compression action is completed.
 - b. Backwired wiring devices shall be of clamp type; screw tightened. Force fit connections not allowed.
2. Stranded conductors will not be allowed for fire alarm work.

I. Accessibility:

1. Electrical equipment requiring service or manual operation shall be accessible.
2. Work switches for equipment within accessible hung ceiling spaces, such as fan powered terminal boxes, shall be located at terminal box, and so located so as to be accessible.

J. Vibration Elimination: All equipment connections to rotating equipment or equipment capable of vibration shall be made up by flexible raceways.

K. Wiring Device Gaskets: Provide wiring device gaskets at coverplates where device is mounted in wall separating conditioned and non-conditioned spaces.

3.9 FEEDER CIRCUITS

- A. Provide feeders as called for on the drawings.
- B. Feeders shall be defined as any circuit originating from the distribution panels.
- C. All feeder conductors shall be continuous from origin to panel or equipment termination without splicing.
- D. All feeders shall be conductors pulled into raceways. Cable systems are not allowed for feeders unless specifically indicated.

3.10 BRANCH CIRCUITS

- A. Provide all branch circuit wiring and outlets for a complete and operating system. The system shall consist of insulated conductors connected to the panelboards and run in raceways or as cable systems if permitted under products section, as required to the final outlet and shall include outlet boxes, supports, fittings, receptacles, plates, fuses, etc.

- B. Physical arrangement of branch circuit wiring shall correspond to circuit numbering on drawings. Combining of circuits and raceways will be allowed up to a 3 phase, 4 wire circuit in a single raceway, unless shared neutrals are not allowed by other sections of this Division, or are indicated as separate neutrals on the drawings. Any combination of homeruns such as this, however, shall be indicated on record drawings. When a common grounded conductor is used for more than one circuit, the arrangement shall be such that a receptacle, fixture, or other device may be removed or disconnected without disconnecting the grounded conductor for other circuits. Ground fault circuit breakers and isolated ground outlets shall be wired with separate neutrals and separate grounding conductors per circuit. A consistent phase orientation shall be adhered to throughout project at terminations.
- C. Circuits feeding three phase equipment shall not be combined into common raceways, unless specifically indicated.
- D. All wiring in panelboards and cabinets shall be neatly formed and grouped.

3.11 FIREPROOFING AND WATERPROOFING

- A. General: Install firestop systems at all new and existing fire-rated construction where penetrated by the Work of this Section.
- B. Refer to Section 078400 - Firestopping, for all installation requirements for maintaining integrity of fire-rated construction at penetrations.

3.12 CUTTING AND PATCHING

- A. Openings through new wall surfaces will be provided by General Conditions if Electrical contractor gives suitable notice as erection of surface proceeds. If suitable notice is not given, Electrical contractor shall then be responsible for cost of corrective work required.
- B. Patching will be provided by the trade responsible for the surface to be patched.

3.13 ELEVATOR COORDINATION

- A. Elevator Electrical Work:
 - 1. Several items pertaining to elevator electrical system shall be provided by Electrical Subcontractor as follows:
 - a. Power source to elevator machine room including fused disconnect switch and wiring between disconnect switch and controller for each elevator.
 - b. Power source to elevator machine room including fused disconnect switch (120 volt) for elevator signal system and cab light for each cab.
 - c. Light, switch, and GFCI receptacle in each pit.
 - d. Light, switch, and GFCI receptacle in machine room.
 - e. Junction box in machine room with five control modules from fire alarm system for elevator recall to prevent cab opening on a fire floor.
 - f. Junction box in machine room for cab telephone with one 1 in. conduit with (2) CAT 6 telephone cables to main telephone demarcation backboard.
 - g. Power to automatic damper in hoistway penthouse louver.
 - h. Power wiring to elevator sump pump.

3.14 MECHANICAL SYSTEM COORDINATION

- A. The Mechanical System contractor will be providing various items of mechanical services equipment and control apparatus. In general, Electrical contractor shall connect up power wiring to this equipment.
- B. The Mechanical and Electrical contractor shall closely coordinate their respective portions of work.
- C. If, due to local regulations, electric heating equipment furnished by the mechanical systems subcontractor is required to be installed by licensed electricians in order to allow connection by Electrical contractor's licensed electricians, it will then be Mechanical contractor's responsibility to engage and pay for services of such licensed electricians.
- D. Power wiring to be provided by Electrical contractor is the line voltage power supply wiring. Control wiring is responsibility of Mechanical System contractor unless specifically indicated on electrical drawings, or in this Division of the specifications. Temperature Control contractor shall refer to electrical drawings for location of all magnetic starters.
- E. 120-volt control wiring source to temperature control panel is the responsibility of Electrical contractor.

3.15 DISTRIBUTION EQUIPMENT TESTING

- A. All panelboards, individual motor starters, main distribution panel, motor controls, feeder conductors, and emergency systems shall be tested in accordance with the following. In general, all tests shall be done in accordance with the 2017 Acceptance Testing Specifications of the International Electrical Testing Association.
- B. The Testing Subcontractor may be an independent contractor or a manufacturer of the equipment, which is to be tested.
- C. Test report forms, delineating tests to be made, and method of recording same shall be submitted prior to commencing work. Test reports when submitted shall include interpretation of results and recommendation for any corrective work required.
- D. Main Distribution Panel:
 - 1. Visual Inspection:
 - a. Check for foreign material within bus enclosure.
 - b. Check for missing hardware.
 - c. Inspect entire assemblies for transit damage or factory defects.
 - d. Check for all bus dimensions and bracing per specifications.
 - e. Check ratings of current transformers and potential transformers.
 - f. Check ratings of all protective relays per drawings.
 - 2. Physical Inspection:
 - a. Torque all bus hardware to proper tension.
 - b. Circuit breaker interlocks all work properly.
 - c. All doors and hinged panels open and close properly.
 - d. Relay blocking removed from all control and protective relays.
 - e. All circuit breakers operate, close and trip mechanically.

- f. Torque all feeder conductors to terminal manufacturers' recommendations.
- 3. Electrical Testing:
 - a. Breakers operated electrically trip and close from local and remote positions.
 - b. All circuit breakers calibrated to manufacturer's respective time current curves as specified.
 - 1) Long time pick-up amps.
 - 2) Long time delay tripping at 300 percent of current setting.
 - 3) Resets okay at 80 percent of pick-up value.
 - 4) Short time pick-up current.
 - 5) Short time delay trip time at 105 percent of setting.
 - 6) Instantaneous minimum pick-up current.
 - c. All protective relays calibrated to manufacturer's characteristic time curves for pick-up, drop-out, instantaneous and time delay.
 - d. All instruments calibrated for accuracy.
 - e. Protective relay schemes to be electrically tested by primary injection of current through current transformers and the tripping of associated circuit breakers.
 - f. Insulation resistance tests made on all circuit breakers, line to load breaker open, line to ground breaker closed, 3 poses tested individually. Switchgear bus to be tested phase to phase and phase to ground with Megohmmeter type instrument. Relays also to be insulation resistance tested.
- E. Magnetic Starters:
 - 1. Visual inspection to determine:
 - a. Shipping damage.
 - b. Proper bussing and contactor sizes.
 - c. Correct overload relay heater ratings. Any incorrectly sized overloads shall be replaced by the contractor who originally provided same.
 - 2. Electrical Testing:
 - a. Electrical operation of control relays, timing relay, and contactor coils.
 - b. Insulation resistance test on all current carrying bus to ground and between phases.
 - c. Calibration check of overload heater to ascertain tripping point and time delay at 300 percent of heater rating.
- F. Conductors:
 - 1. All secondary service conductors and all feeder conductors from switchboards and distribution panels shall be tested.
 - 2. Visual and mechanical inspection
 - a. Conductors to be inspected for physical damage and proper connection and sizing in accordance with single line diagram.
 - b. Conductor connections shall be torque tested to manufacturer's recommended values.

3. Electrical Tests:

- a. Perform insulation resistance test on each conductor with respect to ground and adjacent conductor.
- b. Perform continuity test to insure proper conductor connection.

G. Emergency Systems:

1. Engine Generator - Prior to the emergency generator test specified under the emergency generator specification, the testing contractor shall perform the following:

a. Visual and Mechanical Inspection:

- 1) Inspect for physical damage.
- 2) Compare nameplate rating and connection with specifications and single line diagram.
- 3) Inspect for proper anchorage and grounding. Verify engine cooling and fuel system integrity.

b. Electrical and Mechanical Tests:

- 1) Perform a dielectric absorption test on generator winding with respect to ground. Determine polarization index.
- 2) Perform phase rotation test to determine compatibility with load requirements.
- 3) Test protective relay devices in accordance with applicable sections of these specifications.
- 4) Perform dc over potential test between winding and ground.

2. Automatic Transfer Switches:

a. Visual and Mechanical Inspection:

- 1) Inspect for physical damage.
- 2) Verify that the short circuit withstand rating exceeds the available short circuit duty.
- 3) Compare equipment nameplate information and connections with single line diagram and report any discrepancies.
- 4) Check switch to ensure positive interlock between normal and alternate sources. (Mechanical and Electrical).
- 5) Check tightness of all control and power connections.
- 6) Perform manual transfer operation.
- 7) Ensure manual transfer warnings are attached and visible to operator.

b. Electrical Tests:

- 1) Perform insulation resistance tests phase-to-phase and phase-to-ground with switch in both source positions.
- 2) Measure contact resistance in normal and alternate source position.
- 3) Set and calibrate in accordance with the project electrical engineer's specifications.
 - a) Voltage and frequency sensing relays.
 - b) All time delay relays.

- c) Engine start and shutdown relay.
- 4) Perform automatic transfer by tests.
 - a) Simulating loss of normal power.
 - b) Return to normal power.
 - c) Simulating loss of emergency power on return to normal.
 - d) Simulate all forms of single phase conditions.
- 5) Monitor and verify correct operation and timing.
 - a) Normal voltage sensing relays.
 - b) Engine start sequence.
 - c) Time delay upon transfer.
 - d) Alternate voltage sensing relays.
 - e) Automatic transfer operation.
 - f) Interlocks and limit switch function.
 - g) Timing delay and retransfer upon normal power restoration.
 - h) Engine cool down and shutdown feature.

3.16 FAULT CURRENT, ARC FLASH AND COORDINATION STUDY

A. Trade Contract:

- 1. Work of this Section is part of the Electrical trade contract. Refer to Section 26 00 00 for additional information about this work.

B. Related Documents:

- 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

C. Scope:

- 1. The Electrical SubContractor shall furnish short-circuit and protective device coordination studies as prepared by the manufacturer of the switchgear provided for the project. Mechanical equipment shall be included in the study in accordance with NEC 440.4(B) and require documentation per 440.10(B).
- 2. The Electrical SubContractor shall furnish an Arc Flash Hazard Analysis Study per the requirements set forth in the current version of NFPA 70E -Standard for Electrical Safety in the Workplace. The arc flash hazard analysis shall be performed according to the IEEE Standard 1584 – 2002, the IEEE Guide for Performing Arc-Flash Calculations.
- 3. The scope of the studies shall include new distribution equipment supplied by switchgear manufacturer furnishing the electrical distribution equipment for this project.

D. References:

- 1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
 - b. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
 - c. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis

- d. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
 - e. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
 - f. IEEE 1584 -Guide for Performing Arc-Flash Hazard Calculations
2. American National Standards Institute (ANSI):
- a. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
 - b. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
 - c. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 - d. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single- Pole Air Switches, Fuse Disconnecting Switches and Accessories.
3. The National Fire Protection Association (NFPA)
- a. NFPA 70 -National Electrical Code, latest edition
 - b. NFPA 70E – Standard for Electrical Safety in the Workplace
- E. Submittals For Review/Approval:
- 1. The studies shall be submitted to the design engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the study may cause delays in equipment shipments, approval from the Engineer may be obtained for a preliminary submittal of data to ensure that the selection of device ratings and characteristics will be satisfactory to properly select the distribution equipment. The formal study will be provided to verify preliminary findings.
- F. Submittals For Construction:
- 1. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. A minimum of five (5) bound copies of the complete final report shall be submitted. For large system studies,
 - 2. requiring more than five copies of the report will be provided without the section containing the computer printout of the short- circuit input and output data. Electronic PDF copies of the report shall be provided upon request.
 - 3. The report shall include the following sections:
 - a. Executive Summary including Introduction, Scope of Work and Results/Recommendations.
 - b. Short-Circuit Methodology Analysis Results and Recommendations
 - c. Short-Circuit Device Evaluation Table
 - d. Protective Device Coordination Methodology Analysis Results and Recommendations
 - e. Protective Device Settings Table
 - f. Time-Current Coordination Graphs and Recommendations

- g. Arc Flash Hazard Methodology Analysis Results and Recommendations including the details of the incident energy and flash protection boundary calculations, along with Arc Flash boundary distances, working distances, Incident Energy levels and Personal Protection Equipment levels.
- h. Arc Flash Labeling section showing types of labels to be provided. Section will contain descriptive information as well as typical label images.
- i. One-line system diagram that shall be computer generated and will clearly identify individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location, device numbers used in the time-current coordination analysis, and other information pertinent to the computer analysis.

G. Qualifications:

- 1. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the responsible charge and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies.
- 2. The Registered Professional Electrical Engineer shall be an employee of the equipment manufacturer.
- 3. The approved engineering firm shall demonstrate experience with Arc Flash Hazard Analysis by submitting names of at least ten actual arc flash hazard analyses it has performed in the past year.

H. Computer Analysis Software:

- 1. The studies shall be performed using SKM Systems Analysis Power*Tools for Windows (PTW) software program.

I. Studies:

- 1. The Electrical SubContractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E -Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D. This study shall also include short-circuit and protective device coordination studies.

J. Data:

- 1. Electrical SubContractor shall furnish all data as required for the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash hazard analysis studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Electrical SubContractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.
- 2. Source combination may include present and future motors and generators.
- 3. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner, or General Contractor.
- 4. If applicable, include fault contribution of existing motors in the study. The Electrical SubContractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

K. Short-Circuit Analysis:

- 1. Transformer design impedances shall be used when test impedances are not available.

2. Provide the following:
 - a. Calculation methods and assumptions
 - b. Selected base per unit quantities
 - c. One-line diagram of the system being evaluated that clearly identifies individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location and other information pertinent to the computer analysis
 - d. The study shall include input circuit data including electric utility system characteristics, source impedance data, conductor lengths, number of conductors per phase, conductor impedance values, insulation types, transformer impedances and X/R ratios, motor contributions, and other circuit information as related to the short-circuit calculations.
 - e. Tabulations of calculated quantities including short-circuit currents, X/R ratios, equipment short-circuit interrupting or withstand current ratings and notes regarding adequacy or inadequacy of the equipment rating.
 - f. Results, conclusions, and recommendations. A comprehensive discussion section evaluating the adequacy or inadequacy of the equipment must be provided and include recommendations as appropriate for improvements to the system.
3. For solidly-grounded systems, provide a bolted line-to-ground fault current study for applicable buses as determined by the engineer performing the study.
4. Protective Device Evaluation:
 - a. Evaluate equipment and protective devices and compare to short circuit ratings
 - b. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short- circuit stresses
 - c. Switchgear Manufacturer shall notify Owner in writing, of any circuit protective devices improperly rated for the calculated available fault current.
- L. Protective Device Time-Current Coordination Analysis:
 1. Protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs.
 2. Include on each TCC graph, a complete title with descriptive device names.
 3. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
 4. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
 5. Plot the following characteristics on the TCC graphs, where applicable:
 - a. Electric utility's overcurrent protective device
 - b. Medium voltage equipment overcurrent relays
 - c. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
 - d. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
 - e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves
 - f. Medium voltage conductor damage curves
 - g. Ground fault protective devices, as applicable
 - h. Pertinent motor starting characteristics and motor damage points, where applicable
 - i. Pertinent generator short-circuit decrement curve and generator damage point

- j. The largest feeder circuit breaker in each motor control center and applicable panelboard.
- 6. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.
 - a. Provide the following:
 - 1) A One-line diagram shall be provided which clearly identifies individual equipment buses, bus numbers, device identification numbers and the maximum available short-circuit current at each bus when known.
 - 2) A sufficient number of log-log plots shall be provided to indicate the degree of system protection and coordination by displaying the time-current characteristics of series connected overcurrent devices and other pertinent system parameters.
 - 3) Computer printouts shall accompany the log-log plots and will contain descriptions for each of the devices shown, settings of the adjustable devices, and device identification numbers to aid in locating the devices on the log-log plots and the system one-line diagram.
 - 4) The study shall include a separate, tabular printout containing the recommended settings of all
 - 5) adjustable overcurrent protective devices, the equipment designation where the device is located, and the device number corresponding to the device on the system one-line diagram
 - 6) A discussion section which evaluates the degree of system protection and service continuity with overcurrent devices, along with recommendations as required for addressing system protection or device coordination deficiencies.
 - 7) Switchgear Manufacturer shall notify Owner in writing of any significant deficiencies in protection and/or coordination. Provide recommendations for improvements.

M. Arc Flash Hazard Analysis:

- 1. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2009, Annex D. The arc flash hazard analysis shall be performed in conjunction with the short-circuit analysis (Section 2.03) and the protective device time-current coordination analysis (Section 2.04).
- 2. The flash protection boundary and the incident energy shall be calculated at significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.
- 3. Circuits 240V or less fed by single transformer rated less than 125 kVA may be omitted from the computer model and will be assumed to have a hazard risk category 0 per NFPA 70E.
- 4. Working distances shall be based on IEEE 1584. The calculated arc flash protection boundary shall be determined using those working distances.
- 5. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations

6. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location in a single table. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum. Conversely, the maximum calculation will assume a maximum contribution from the utility. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable as well as any stand-by generator applications.
The Arc-Flash Hazard Analysis shall be performed utilizing mutually agreed upon facility operational conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.
7. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors should be decremented as follows:
 - a. Fault contribution from induction motors should not be considered beyond 5 cycles.
For each piece of ANSI rated equipment with an enclosed main device, two calculations shall be made. A calculation shall be made for the main cubicle, sides, or rear; and shall be based on a device located upstream of the equipment to clear the arcing fault. A second calculation shall be made for the front cubicles and shall be based on the equipment's main device to clear the arcing fault. For all other non-ANSI rated equipment, only one calculation shall be required and it shall be based on a device located upstream of the equipment to clear the arcing fault.
8. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.
9. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.
10. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. A maximum clearing time of 2 seconds will be used based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.
11. Provide the following:
 - a. Results of the Arc-Flash Hazard Analysis shall be submitted in tabular form, and shall include device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, working distances, personal-protective equipment classes and AFIE (Arc Flash Incident Energy) levels.
 - b. The Arc-Flash Hazard Analysis shall report incident energy values based on recommended device settings for equipment within the scope of the study.
 - c. The Arc-Flash Hazard Analysis may include recommendations to reduce AFIE levels and enhance worker safety.

N. Field Adjustment:

1. Electrical SubContractor shall adjust relay and protective device settings according to the recommended settings table provided by the coordination study.

2. Electrical SubContractor shall make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.
3. Switchgear manufacturer shall notify the design engineer in writing of any required major equipment modifications.

O. Arc Flash Labels:

1. Electrical SubContractor shall provide a 4.0 in. x 4.0 in. Brady thermal transfer type label of high adhesion polyester for each work location analyzed.
 2. The labels shall be designed according to the following standards:
 - a. UL969 – Standard for Marking and Labeling Systems
 - b. ANSI Z535.4 – Product Safety Signs and Labels
 - c. NFPA 70 (National Electric Code) – Article 110.16
 3. The label shall include the following information:
 - a. System Voltage
 - b. Flash protection boundary
 - c. Personal Protective Equipment category
 - d. Arc Flash Incident energy value (cal/cm²)
 - e. Limited, restricted, and prohibited Approach Boundaries
 - f. Study report number and issue date
 4. Labels shall be printed by a thermal transfer type printer, with no field markings.
 5. Arc flash labels shall be provided for equipment as identified in the study and the respective equipment access areas per the following:
 - a. Floor Standing Equipment - Labels shall be provided on the front of each individual section. Equipment requiring rear and/or side access shall have labels provided on each individual section access area. Equipment line-ups containing sections with multiple incident energy and flash protection boundaries shall be labeled as identified in the Arc Flash Analysis table.
 - b. Wall Mounted Equipment – Labels shall be provided on the front cover or a nearby adjacent surface, depending upon equipment configuration.
- P. General Use Safety labels shall be installed on equipment in coordination with the Arc Flash labels. The General Use Safety labels shall warn of general electrical hazards associated with shock, arc flash, and explosions, and instruct workers to turn off power prior to work.

3.17 WASTE MANAGEMENT

- A. Separate and recycle materials and material packaging in accordance with Waste Management Plan and to the maximum extent economically feasible and place in designated areas for recycling.
- B. Set aside and protect materials suitable for reuse and/or remanufacturing.
- C. Separate and fold up metal banding; flatten and place along with other metal scrap for recycling in designated area.
- D. Coordinate with Section 017419 – CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

3.18 TRAINING

- S. All training shall be scheduled with the user. Training shall be videotaped and a DVD delivered to the Owner. Refer to each specific system for amount of training required.

3.19 SPARE PARTS/ATTIC STOCK:

- T. REQUIREMENTS:
1. Provide attic stock of the following quantities and parts for each piece of equipment as follows:

Equipment/Unit	Parts Description	Quantity
LED Lights	LED Drivers	2 of each type
	Single faced exit signs	3
	Double faced exit signs	3
Fire Alarm	Smoke detectors of each type (Duct, ceiling, fire detectors)	3
	Detector	3
	Pull stations	3
	Spare printer ribbon	1
	Extra set of keys and tools for access to locked and tamperproof components	3

3.20 STORAGE AND INSTALLATION OF EQUIPMENT

- A. The electrical subcontractor shall store and install electrical equipment and wiring listed for dry locations only after the building is watertight.

END OF SECTION

SECTION 270000

COMMUNICATIONS
(Filed Sub-Sub Bid Required)

PART 1 - GENERAL	1
1.1 FILING OF FILED SUB-SUB BIDS	1
1.2 RELATED DOCUMENTS	1
1.3 GENERAL REQUIREMENTS	1
1.4 QUALITY ASSURANCE	2
1.5 COOPERATION AND COORDINATION WITH OTHER TRADES	2
1.6 SUBMITTALS	3
1.7 TELEPHONE/DATA SYSTEM	4
1.8 DEFINITIONS	6
1.9 SYSTEM DESCRIPTION	7
1.10 PROTECTION OF WORK AND PROPERTY	7
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END OF INDEX

SECTION 270000

COMMUNICATIONS
(Filed Sub-Sub Bid Required)

PART 1 - GENERAL

1.1 FILING OF FILED SUB-SUB BIDS

- A. Filed Sub-Sub-Bid Requiring a Paragraph "E" Listing on the FORM FOR SUB-BID required per M.G.L. Chapter 149 Section 44A to 44L, as amended to date. The Electrical Subcontractor will be responsible for all related building preparation and coordination, see specification for additional Paragraph "E" Listing requirements of the Listed Systems Contractor, and coordination of responsibilities.
- B. Section 27 00 00 COMMUNICATIONS shall be a Filed Sub-Sub Bid of Section ~~26-00-01~~ **26 00 10**, requiring a Paragraph "E" Listing on the FORM FOR SUB-BID.
- C. Work to be done in this SECTION is included in the Contract Documents as listed in the List of Drawings.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 GENERAL REQUIREMENTS

- A. The Conditions of the Contract and General Requirements of the Project Manual apply to this Subcontractor, material suppliers, and all other persons furnishing labor and materials under this Section. The General Conditions, and applicable parts of Division 01 are included as part of this Section.
- B. Examine all Project Specifications and Drawings for requirements which affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.
- D. The following definitions apply to the Drawings and Specifications:
 - 1. Furnish: The term "furnish" is used to mean "supply and deliver to the Project Site, ready for unloading, unpacking, assembly, installation, and similar operations".
 - 2. Install: The term "install" is used to describe operations at the Project Site including actual "unloading, unpacking, assembly, erection, piecing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations".
 - 3. Provide: The term "provide" is used to mean "furnish and install, complete and ready for the intended use".
 - 4. Installer: An "installer" is the Contractor or an entity engaged by the Contractor, either as an employee, Subcontractor, or Sub-Subcontractor for performance of a particular construction activity, including installation, erection, application, and similar operations. Installers are required to be experienced in the operations they are engaged to perform.

- E. When open-flame or spark producing tools such as blow torches, welding equipment, and the like are required in the process of executing the work, the General Contractor shall be notified not less than twenty four (24) hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant non-working fire watch where work is being performed until it is completed.

1.4 QUALITY ASSURANCE

- A. Sustainable Goals: The Architect has designed the project to meet the Owner's sustainable goals. Products and systems have been specified which meet certain third-party evaluations or have particular VOC and source requirements. Evaluation of products proposed for substitution will be evaluated based on the Owner's sustainable goals and other criteria included in Division 01. The Contractor is encouraged to use sustainable construction practices, means and methods. Unless specifically stated in a specification section, no sustainable design documentation is required of the Contractor.

1.5 COOPERATION AND COORDINATION WITH OTHER TRADES

- A. The work shall be so performed that the progress of the entire building construction, including all other trades, shall not be delayed and not interfered with. Materials and apparatus shall be installed as fast as conditions of the building will permit and must be installed promptly when and as directed.
- B. This Section shall be furnish/installed as follows by a single firm/company that is a qualified systems contractor. The Electrical Subcontractor shall be responsible for properly preparing the project for installation by systems contractor, as specified.
 - 1. Electrical Subcontractor responsibilities shall include: The Electrical Subcontractor shall be responsible for furnishing and installing all related building preparation including, but not limited to: outlet boxes with plaster rings, floor boxes, poke through devices, pathways, power, cableways, cable tray, cable protection, wiremold, surface raceways, cable supports, J hooks, conduits with bushings, conduit stubs with bushings, sleeves with bushings (all conduits, stubs, sleeves, etc. shall be brought to an accessible ceiling or accessible area below floor), pull strings, bonding, grounding, core drilling, cutting, patching, environmental seals, seismic supports, supplementary steel and channels, etc., for a completely operational system, as specified. The Electrical Subcontractor shall also accept delivery and properly store & secure all equipment and materials required by the systems contractor. The Electrical Subcontractor shall install all specialized backboxes and any exterior antennas furnished by Systems Contractor.
 - a. The Electrical Subcontractor shall provide cable tray over each rack and cabinet as required to facilitate a neat and orderly installation of cables and to secure the top of the racks to the structure. Cables shall drop straight down to equipment racks. Cable trays shall be secured at both ends to the structure and connected together as required for a complete contiguous installation. Utilize proper supports to support the cable tray to the building structure as well as the equipment rack and cabinet. Submit mounting supports for approval before installation.
 - b. Communication cables installed outside DCOA areas that serve the DCOA shall be installed in accordance with NEC 708.14.
 - c. This entire Section: The Electrical Subcontractor shall read this section in its entirety and shall provide all requirements of the Electrical Subcontractor as detailed in this Section.

2. Systems Contractor responsibilities for this section shall be: Systems contractor shall be responsible for providing, installing, programming, troubleshooting, training and warranty service of all cabling, terminal equipment, headend equipment specified in this section for a completely operational system.
 - a. Keep fully informed as to the shape, size and position of all openings required for all apparatus and give information in advance to build openings into the work. The electrical subcontractor shall furnish and set in place all sleeves, pockets, supports and incidentals.
 - b. All distribution systems which require pitch or slope such as plumbing drains, steam and condensate piping shall have the right of way over those which do not. Confer with other trades as to the location of pipes, ducts, lights and apparatus and install work to avoid interferences.
 - c. Coordinate exact locations and roughing in dimensions of all work before installation and make all final connections as required. Any changes required to avoid interferences or to provide adequate clearances for Code and maintenance requirements shall be made at no additional costs.
 - d. Structural elements of the project shall not be relocated, altered or changed to accommodate the work without written authorization from the Architect.
 - e. Work that is installed before coordination with other trades or that causes interference with the work of other trades shall be changed to correct condition.
 - f. Obtain a complete set of Project Drawings and Specifications for coordination and to determine the full scope of work.
 - g. Attend project coordination meetings to coordinate work of this Section, work of other trades and project and phasing requirements.

1.6 SUBMITTALS

- A. Product Data for all materials specified and shown on drawings to be installed.
- B. Equipment List: Provide a detailed Equipment List showing quantities by manufacturer and model number of all major items of equipment and installation material to be used in the system as specified herein.
- C. Submit supporting hardware for this system as part of the work for approval prior to installation.
- D. Product Data: Include complete sets of indexed cut sheets, in quantity as dictated by the project, of all major pieces of equipment and materials being supplied. Arrange these sheets in the order the equipment appears in the Specification. Clearly highlight information showing compliance with this and/or all applicable Specifications. In the event that the manufacturer or representatives' cut sheet contains more than one item, clearly indicate which items of the cut sheet are intended for installation.
- E. Shop Drawings: Submit a set of complete Shop Drawings, by system, showing equipment to be installed. Include system configuration block diagrams of all equipment, indicating equipment type and model numbers. Show each and every component, system and subsystem, as well as all proposed connections between system components, and proposed layouts of equipment racks for the entire system.
 1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 2. Cabling administration drawings and printouts.
 3. Wiring diagrams to show typical wiring schematics including the cross-connects.

4. Cross-connects. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
5. Cross-connects and patch panels. Detail mounting assemblies and show elevations and physical relationship between the installed components.
6. Cable tray layout showing cable tray route to scale with relationship between the tray and adjacent structural, electrical and mechanical elements.

F. Quality Assurance Submittals:

1. Provide manufacturer's certification that Installer is qualified to install systems specified. Include a written statement signed by the Installer attesting that they have been in business for at least five years in the installation and servicing of systems specified. Include the names of at least five clients for whom similar Work as specified has been performed in the past three years; list the individual responsible for the day-to-day operation of the system along with their current telephone number and address.
2. Provide names, qualifications, and certifications of installation personnel including Communication Systems Installer's site Supervisor/Foreman who shall be in charge of, and responsible for, all activities at the job site for the duration of the Project. The job Supervisor/Foreman shall not be changed during the project without notification and approval from the Owner.
3. Complete warranty information including sample Registration Certificate.
4. Technical Diagrams and Drawings:
 - a. Simplified single line block diagrams showing the interconnection of all equipment and functional relationships. Show all equipment, patch panels, cables and jacks, whether connected or not. The intent of these diagrams is to provide sufficient clear and complete information that a technician of average skill may efficiently troubleshoot and service the system, even if unfamiliar with the installation.
 - b. Provide "As Built" architectural quality plan Drawings at 1/8 in. = 1 ft.-0 in. scale. Provide an electronic copy of the "As Built" drawings on CD(s).
 - c. All technical diagrams and drawings shall be mounted on the wall behind a clear plastic cover for protection. There shall be one set of the above drawings and diagrams provided for the MDF Room.

1.7 TELEPHONE/DATA SYSTEM

A. General:

1. All telecommunication and data system interconnecting wiring, terminal blocks, connections, terminations, shall be furnished and installed by a licensed and certified installer.
2. The Electrical Subcontractor (E.C.) shall furnish and install all raceways, and outlet boxes as indicated on the drawings, including pull wires for all empty raceways and all access panels. General contractor will furnish and install all backboards (3/4 in. thick by 78 in. high) which shall be mounted at the MDF room.
3. General Requirements:
 - a. Applicable Standards:
 - 1) Materials and equipment shall be installed in accordance with the most current versions of the National Electrical Code, local codes, safety codes, ANSI, ASTM, EIA, TIA, BISCO, IEEE, UL, NFPA.

- a) The following industry standards are the basis for the structured cabling system described in this document.

ANSI/TIA/EIA TIA/EIA-568-B	Commercial Building Telecommunications Cabling Standard
TIA/EIA-568-B.1	General Requirements
TIA/EIA-568-B.2	Balanced Twisted Pair Cabling Components Standard
TIA/EIA-568-B.3	Optical Fiber Cabling Components Standard
TIA/EIA - 942	Telecommunications Infrastructure for Data Centers
TIA/EIA-569-A	Commercial Building Standard for Telecommunications Pathway and Spaces
TIA/EIA-606-A	Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
J-STD-607-A	Commercial Building Grounding/Bonding Requirements NFPA
NFPA 70	National Electric Code (NEC) ISO/IEC
ISO 11801	Generic Cabling for Customer Premises
EIA/TIA-TSB 67.	Telecommunications Systems Bulletin, Additional Transmission Specifications for Unshielded Twisted-Pair Cabling Systems"
EIA/TIA-455-61.	"FOTP-61, Measurement of Fiber or Cable Attenuation Using An OTDR".
IEEE 802.3	"Carrier Sense Multiple Access With Collision Detection".
ATM	Forum Standard for 155 Mb/s ATM over Category 6 (AF-PHY-0015.000, 9/94)
BISCI:	Telecommunications Distribution Methods and LAN Design Manual
IEEE-802:	Standards for Local Area Networking
UL	Performance Levels Certification Program
ANSI-IEEE-C2:	National Electrical Safety Code (NESC)
ANSI/NFPA-101:	Life Safety Code
Massachusetts Electric Code	CMR527

- b. Exposed wiring is not acceptable in any occupied space.
- c. Contractor is responsible for strict adherence to Massachusetts electrical codes, and all other applicable codes.
- d. The contractor is responsible for obtaining municipal permits and inspections as mandated by law.
- e. All exposed cabling shall be run in raceway or conduit.
- f. All penetrations in station raceway shall have rubber or equivalent grommets to prevent cable cuts on rough edges.
- g. Raceway shall be of sufficient size to accommodate all wiring. Fill density not to exceed 40 percent, unless otherwise noted. It is the responsibility of the bidder to determine the size needed based upon the floor plans provided. A minimum size of 1 in. conduit shall be adhered to, U.N.O or approval by the engineer.
- h. All raceways shall be attached to the building structure using screws and anchors.
- i. The I.T. subcontractor is responsible for all aspects of MDF construction. Refer to drawings for configuration of each MDF.

- j. All cabling at the MDF shall be neatly bundled and dressed to the termination blocks. All appropriate cable management materials (slotted duct, D rings, etc.) should be utilized for this purpose.
 - k. All labeling of cables shall be 6 in. back from the termination with machine generated labels, hand written labels are not permitted.
 - l. All cable pulls in conduit, raceway, innerduct, etc. shall have pull string left in place for future use.
 - m. Color code identification of cables must be maintained throughout all splices.
 - n. All station cabling shall be clearly and legibly labeled at both the faceplate end and the MDF termination blocks. In addition to labeling both the inside of the faceplates and MDF termination blocks, the cable jacket shall be labeled six inches back from the terminations on both ends. Labeling shall be machine generated.
 - o. Labeling of the outside of the jack with identification numbers shall be made using a Panduit LS8 handheld label machine or equal. Samples shall be provided to Engineer for approval prior to installation; the labeling scheme shall be submitted for review and approval, coordinate with the IT Department prior to submitting.
 - p. In order to qualify for installation of the data communications system, Contractor must possess the required license classification, a performance history, experience in the installation and termination of optical fiber cable systems, and proof of time in business. Contractor must be trained and certified for the communications cable and hardware which it installs, and must furnish proof of certification.
 - q. License Classification: Contractor must possess a valid state Contractor's License.
- B. Unless otherwise indicated, the following work is not included as part of the systems integrator's responsibilities in this SECTION, except for coordination, and is to be performed by others as indicated:
- 1. Raceway shall be provided by the electrical contractor.
 - 2. Empty conduits to accessible point above ceiling or below floor shall be provided by the electrical contractor.
 - 3. Floor boxes and poke through devices shall be provided by the electrical contractor.
 - 4. Standard device boxes with plaster rings for data and Integrated Instructional Technology Network System shall be provided by the electrical contractor.
 - 5. Speaker/paging system backboxes shall be installed by the electrical contractor and provided by this systems integrator.
 - 6. Structural blocking to support wall and ceiling mounted televisions/monitors shall be provided by the General Contractor.
 - 7. Interface with public utilities telephone service shall be arranged by the owner, and coordinated with this systems integrator.
 - 8. Telephone equipment and handsets will be provided under a separate contract.

1.8 DEFINITIONS

- A. Main Cross Connect (MC): The MC is the location, within a building or complex of buildings, where the entire telecommunications system originates. It may include: the physical location, enclosure, wire and cable management hardware, termination hardware, distribution hardware, and patching and equipment racks.
- B. Horizontal Cross Connect (HC): The HC is the location in a building where a transition between the backbone or vertical riser system and the horizontal distribution system occurs.
- C. Designated Critical Operations Areas (DCOA) areas within a facility or site designated as requiring critical operations power.

- D. Telecommunications main ground bar (TMGB)

1.9 SYSTEM DESCRIPTION

- A. The data communications system shall consist of four components, active switch equipment, an optical fiber backbone, a copper twisted-pair backbone, and twisted pair copper work station cabling.
- B. The audio-visual systems shall consist of wiring, jacks, amplification equipment, control equipment, and head end video equipment.
- C. The work under this Section includes providing of all material, labor, equipment and supplies and the performance of all operations to provide a complete working Integrated Instructional Technology Network System as required by the Drawings and details and as specified herein. Where the Drawings, Specifications, Codes, Regulations, Laws, or the requirements of the local Authority conflict, provide the higher quality and higher quantity indicated or required and follow the strictest requirement. In general, the work includes, but is not limited to, the following:
 - 1. Cabling for Sound per manufacturers requirements.
 - 2. Equipment Racks and Cabinets.
 - 3. Relay Brackets.
 - 4. Terminations.
 - 5. Protection of all work.
 - 6. Record Drawings and Documentation.
 - 7. Staging.
 - 8. Telephone and data cabling.
 - 9. Data network racks and patch panels
 - 10. Operation and Maintenance Instructions and Manuals for the Section's work.
 - 11. Nameplates, Labels and Tags.
 - 12. Testing and certification.
 - 13. Coordination with manufacturers, other trades and Owner.
 - 14. CATV wiring, amps and splitters.
 - 15. Provide and maintain in safe adequate condition all staging and scaffolding required for the proper execution of the work of this Section.
 - 16. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.10 PROTECTION OF WORK AND PROPERTY

- A. Be responsible for the care and protection of all work included under this Section until it has been tested and accepted.
- B. Protect all equipment and materials from damage from all causes including theft. All materials and equipment damaged or stolen shall be replaced with equal material or equipment at the option of the Architect and Owner.
- C. Materials and equipment stored for this project shall be protected and maintained according to the manufacturer's recommendations and requirements and according to the applicable requirements of NFPA 70B.
- D. Protect all equipment, outlets and openings with temporary plugs, caps and covers. Protect work and materials of other trades from damage that might be caused by work or workmen and make good any damage caused.

- E. Use caution to avoid damage to existing work, and to prevent harm to personnel working in all areas.
- F. Observe all safety precautions and requirements for the construction.
- G. When open-flame or spark producing tools such as blower torches, welding equipment, etc., are required in the process of executing the work, the General Contractor shall be notified not less than twenty four hours in advance of the time that the work is to begin and the location where the work is to be performed. Provide, where necessary, fire protective covering and maintain a constant non-working fire watch where work is being performed and until it is completed.
- H. The General Contractor and the Installer are responsible for initiating, maintaining, and supervising all safety precautions and requirements during construction.

1.11 SEQUENCING AND SCHEDULING

- A. Coordinate the work of this Section with the respective trades responsible for installing interface work, and ensure that the work performed hereunder is acceptable to such trades for the installation of their work.
- B. Continuity of all services shall be maintained in all areas which will be occupied or temporarily relocated during the construction period. If an interruption of service becomes necessary, such shall be scheduled in advance, made only upon consent of the Owner and at a time outside normal working hours as the Owner shall designate.
- C. Refer to the overall scheduling of the work of the project. Schedule work, process Submittal and order materials and equipment to conform to this schedule and install work to not delay nor interfere with the progress of the project.
- D. Inform Architect immediately of any delays or potential delays. Furnish manufacturer's letter to verify order date, equipment delays, expected shipment date, order number, and potential remedies to speed up delivery. Any costs to speed up delivery shall be implemented at no cost to the project if the equipment or material was not ordered as soon as possible after Contract award or within the time frames indicated with the Submittal.
- E. Include premium time required to comply with the project scheduling and phasing.
- F. Be aware of, and plan for, project scheduling and phasing. Provide for complete continuous operation of all systems. Coordinate scheduling and phasing with the Architect, Owner, other Trades, and the General Contractor.

1.12 WARRANTY

- A. Voice and Data Cabling Warranty: The products that shall best support the needs of the project, and provide the highest level of system performance over the life of the facility, shall be a voice and data cabling system that is made up of system components designed, manufactured and installed as a total system solution. This requirement also applies to data patch cords specified in this Section; e.g. Ortronics patch cords shall be used with Ortronics jacks and patch panels.

- B. Provide a Manufacturer's Extended Product Warranty that covers product defects for all passive components of the Voice and Data Cabling System. Passive components are defined as those exhibiting no gain or contributing no energy to the Data Cabling System and include but are not limited to cabling, connectors, outlets, patch panels, patch cords, racks as outlined in PART 2 of this Specification.
1. The following shall be covered by the Manufacturer's Extended Product Warranty:
 - a. All passive components that comprise the Voice and Data Cabling System will be free from manufacturing defects in material of workmanship under normal and proper use.
 - b. All passive components that comprise the Voice and Data Cabling System shall exceed the specifications of ANSI/TIA/EIA 568B series, and exceed ISO/IEC 11801 standards, including all subsequent changes to these standards that are in effect at the time of bidding, and shall meet or exceed the performance specifications as outlined in PART 2 of this Specification.
 - c. The installation shall exceed the insertion and return loss, attenuation and near end crosstalk (NEXT) requirements of ANSI/TIA/EIA 568B series and the ISO/IEC 11801 standards for cabling links/channel configurations specified in these standards including all subsequent changes to these standards that are in effect at the time of bidding.
 - d. Each Voice and Data Channel shall be capable of delivering data at 1.2 Gbps between active network electronics. A Data Channel is comprised of all passive components including cabling, connectors, patch panel port, and patch cords, with up to a total of 4 connections between Owner's network electronics (not in the contract).
 2. Upon successful completion of the Voice and Data Cabling System installation by the Communication Systems Installer, and subsequent inspection by an authorized representative of the Manufacturer of the passive components, the Owner shall be provided with Registration Certificate, from the Manufacturer, registering the Installation.
 3. Duration of Warranty: The warranty shall run for 20 years from the Date of Substantial Completion of the Project, unless the Registration Certificate is issued by the Manufacturer at a later date, in which case the warranty shall run for 20 years from the date that the Registration Certificate is issued.
 4. The Extended Product Warranty is applicable to the Voice and Data Cabling System passive components at the original site of installation. Under the Extended Product Warranty, the Manufacturer of the passive components shall either repair or replace the defective product(s) at the Manufacturers cost. This includes the replacement or repair cost of defective materials and the cost of labor to repair or replace any and all defective products.
 5. The Communication Systems Installer shall provide a Manufacturer's warranty that the Voice and Data Cabling System shall be free from defects which prevent operation of the specific applications for which the original Voice and Data Cabling System was designed to support, including but not limited to: 10Base-T; 100Base-T; 52/155 Mbps ATM; 622Mbps 64-CAP ATM; 1000Base-T Gigabit Ethernet.

1.13 MAINTENANCE

- A. Provide installers maintenance contract quote, upon request, for a period equal to warranty.

- B. Upon receipt of notice from the Owner of failure of any part of the systems during the warranty period, the affected parts shall be replaced. Any equipment requiring excessive service consisting of more than two unscheduled service calls, shall be considered defective and shall be replaced.
- C. Response times to warranty issues shall differ according to the level of the problem.
 - 1. A problem is considered to be corrected when the system and its components operate according to specified requirements.
 - 2. Warranty work shall be performed according to the procedures of the Owner, its staff and tenants and their normal operations.

1.14 SEISMIC REQUIREMENTS

- A. Equipment and work shall meet the restraint requirements per the Massachusetts Building Code.

1.15 FUNCTION AND OPERATION

- A. The intended function of the data communications cable system is to transmit data signals from a central location to several individual data outlet locations. Upon completion of the work outlined in this specification, the system shall be capable of transmitting data signals at a rate of 1000 Mbps.
- B. The multimode optical fiber cable system shall be capable of transmitting signals with a minimum bandwidth of 500 MHz at both 850 or 1300 nm. The cumulative signal loss, through connectors, jumpers, couplers, and fiber cable, shall be less than 10 dB. The singlemode optical fiber cable system shall be capable of transmitting signals with a bandwidth of up to 500 MHz at both 1300 and 1550 nm. The cumulative signal loss, through connectors, jumpers, couplers, and fiber cable, shall be less than 10 dB.
- C. Work station cable, from the HC to the work area, shall be installed in accordance with EIA/TIA-568-A specified installation practices, EIA/TIA TSB 67 recommended installation practices, manufacturer specified installation practices, and shall be capable of transmitting a signal at 1000 Mbps with acceptable attenuation and cross-talk measurements. The entire work station cable system, including wiring blocks, cable, and telecommunications outlets shall be tested for Category 6 compliance.

1.16 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Connecting Blocks: One of each type.
 - 2. UTP 4-pair Station Cable: 1,000 feet.
 - 3. UTP Backbone Cable: 300 feet.
 - 4. Patch-Panel Units: One of each type.
 - 5. Device Plate: 10 of each type.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Throughout Part 2, material quantities are given. These quantities are given for reference purposes only. It is the responsibility of the Contractor to provide appropriate quantities of materials to provide a complete, functional system.
- B. Equipment shall be installed in accordance with Technology drawings. General installation provisions are as follows:
 - 1. Equipment Racks: Equipment racks shall be assembled and mounted in locations shown in the Drawings and as described herein. Each rack shall be assembled in accordance with the manufacturer's instructions and recommendations. Each rack shall be mounted such that the side rails are plumb. Each rack shall be affixed to the building structure at each of the mounting holes provided. Attachment shall be by 1/2 in X 1-1/4 in. lag bolts. A 3/8" pilot hole shall be drilled for each lag bolt. Each bolt shall be tightened to the extent that it holds the mounting hardware firmly, but not so tight as to distort the hardware or strip the threads. Equipment racks are to be co-located with the quadplex power outlets to allow for easy connection of racked equipment to the power system.
 - 2. Wiring Blocks and Wire Management Components: Where required, wiring blocks and wire management components shall be mounted to the plywood backboard. Wiring blocks and wire management shall be mounted in accordance with the attached drawings. Each device shall be mounted such that its horizontal dimension is level. In cases where more than one device is mounted, they shall be aligned vertically. Each device shall be affixed to the plywood backboard by means of screws suitable for fastening to plywood. A minimum of four of the mounting holes provided shall be utilized for fastening. Screws shall be tightened to the extent that they hold the device snug to the backboard, but not so tight as to distort or damage the device. Wiring blocks shall be terminated in accordance with the manufacturer's instructions and recommendations. Installation of accessories shall also be conducted in accordance with the manufacturer's instructions and recommendations.

2.2 COMMUNICATION EQUIPMENT ROOM FITTINGS

- A. SUMMARY
 - Section Includes:
 - 1. Telecommunications mounting elements.
 - 2. Pathways
 - 3. Telecommunications equipment racks and cabinets
 - 4. Grounding.
- B. COORDINATION: Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.
 - 1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
 - 2. Record agreements reached in meetings and distribute them to other participants.
 - 3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.

4. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.
5. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

C. PATHWAYS

1. General Requirements: Comply with TIA/EIA-569-A.
2. Cable Support: NRTL labeled. Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.
 - a. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.
 - b. Support brackets with cable tie slots for fastening cable ties to brackets.
 - c. Lacing bars, spools, J-hooks, and D-rings.
 - d. Straps and other devices.

D. EQUIPMENT FRAMES (RACKS)

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. APC
 - b. Cooper B-Line, Inc.
 - c. Hubbell Premise Wiring.
 - d. Panduit
 - e. Or equal
2. Floor-Mounted Racks: Modular-type, four-post quick rail, aluminum construction.
 - a. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip.
 - b. Baked-polyester powder coat finish.
 - c. Refer to drawings for rack configurations.
3. Cable Management for Equipment Frames:
 - a. Metal, with integral wire retaining fingers.
 - b. Baked-polyester powder coat finish.
 - c. Vertical cable management panels shall have front and rear channels, with covers.
 - d. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.
4. Power Strips: Comply with UL 1363.
 - a. Rack mounting.
 - b. Receptacles: Six 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles for each power strip. Provide two in each rack. Power strip shall connect with a twist lock to match receptacle on cable tray.
 - c. LED indicator lights for power and protection status.
 - d. LED indicator lights for reverse polarity and open outlet ground.

- e. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
- f. Cord connected with 15-foot line cord.
- g. Rocker-type on-off switch, illuminated when in on position.
- h. Peak Single-Impulse Surge Current Rating: 33 kA per phase.
- i. Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all 3 modes shall be not more than 330 V.

E. GROUNDING

- 1. Comply with requirements in 26 00 10 Section "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.
- 2. Telecommunications Main Bus Bar:
 - a. Connectors: Mechanical type, cast silicon bronze, solderless exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
 - b. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide with 9/32-inch holes spaced 1-1/8 inches apart.
 - c. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.
 - d. Comply with ANSI-J-STD-607-A.
- 3. Bond all racks and cable tray to TMGB.

F. LABELING

- 1. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.3 FIBER OPTIC CABLE:

- A. Fiber: The following cable specifications shall also be met by the cable manufacturer for fiber optic cable:
 - 1. Multimode Optical Fiber Cabling: Multimode optical fiber cables shall meet all of the requirements delineated within the specifications of ANSI/TIA/EIA-568-B1, B2, B3 and ISO/IEC 11801, 50/125 fiber shall be as noted in Table 1 and 2. Fiber shall be laser optimized type OM3.

Table 1 Minimum Performance Parameters for LightSystem™ Cables Containing 50/125 Multimode Fiber						
Fiber	Maximum Attenuation (dB/km)		Minimum Bandwidth (MHz-km)		Guaranteed Transmission Distance (m)	
	@ 850 nm	@ 1300 nm	@ 850 nm	@ 1300 nm	@ 850 nm	@ 1300 nm
50/125	3.5	1.0	200	500	275	550

TABLE 2 Minimum Performance Parameters for LightSystem Plus™ Cables Containing 50/125 or 50/125 Multimode Fiber						
Fiber	Maximum Attenuation (dB/km)		Minimum Bandwidth (MHz-km)		Guaranteed Transmission Distance (m)	
	@ 850 nm	@ 1300 nm	@ 850 nm	@ 1300 nm	@ 850 nm	@ 1300 nm
50/125	3.5	1.0	220	1000	300	550

2. Singlemode Optical Fiber Cable: Singlemode mode LightSystem™ fiber cables shall meet all of the requirements delineated within the specifications as listed in Section 1 except that the attenuation and zero dispersion limits shall be as noted in Table 3 and 4.

TABLE 3 Minimum Performance Parameters for LightSystem™ Cables Containing Singlemode Fiber					
Fiber	Cable Type	Maximum Attenuation (dB/km)		Zero Dispersion	
		@ 1310 nm	@ 1550 nm	Wavelength (nm)	Slope (nm ² -km)
Singlemode	Inside Plant	1.0	1.0	1300-1324	< 0.093
	Outside Plant	0.5	0.5		

TABLE 4 Minimum Performance Parameters for LightSystem Plus™ Cables Containing Singlemode Fiber					
Fiber	Cable Type	Maximum Attenuation (dB/km)		Zero Dispersion	
		@ 1310 nm	@ 1550 nm	Wavelength (nm)	Slope (nm ² -km)
Singlemode	Inside Plant	0.5	0.5	1300-1320	< 0.092
	Outside Plant	0.4	0.3		

3. Attenuation: The LightSystem™ cable as noted in Tables 1 and 3 and LightSystem Plus™ as noted in Tables 2 and 4 cable shall perform in accordance with the attenuation limits when tested per ANSI/EIA/TIA-455-46, -53, -61 or -78 (as applicable).
4. Bandwidth: LightSystem™ as noted in Table 1 cable and LightSystem Plus™ cable as noted in Table 2 shall perform in accordance with the bandwidth limits when tested per ANSI/EIA/TIA-455-51 or ISO/IEC 793-1-C2A
5. Transmission distance: The protocol pertinent to the transmission distance noted in Table 1 for LightSystem™ and Table 2 for LightSystem Plus™ cable is Gigabit Ethernet per IEEE 802.3z.
6. Zero Dispersion Wavelength and Slope: LightSystem™ cable shall perform as noted in Table 3 and LightSystem Plus™ cable as noted in Table 4 in accordance with the Zero Dispersion wavelength and slope limits when tested per ANSI/EIA/TIA-455-168, -169, or -175 (as applicable).
7. Fiber 50/125 μm Multimode Optical fiber cables shall be manufactured by one of the following:
- Belden
 - Berk-Tek
 - Commscope
 - General Cable
 - Mohawk
 - Or equal
 - Be a minimum of twelve strands of 50/125 μm multimode optical fiber for horizontal cabling.
 - Be appropriate for the environment in which it is installed.
8. Fiber equipment cords shall:
- Be available in standard lengths of 1, 3, and 5 meters, custom lengths shall also be available, and shall meet or exceed standards as defined in ANSI/TIA/EIA-568-A and ISO/IEC 11801.

- b. Utilize duplex fiber cable that is 50/125 micron multimode, OFNR riser grade, and meets the requirements of UL 1666.
 - c. Utilize cable where the attenuation shall not exceed 3.5 dB/km @ 850 nm wavelength or 1.0 dB/km @ 1300 nm.
 - d. Have a cable jacket color for 50/125 in gray.
 - e. The connectors shall be SC or ST in accordance with TIA/EIA-568-A and must include a ceramic ferrule.
 - f. Have ST connectors with a metal coupling nut.
 - g. Have a minimum return loss of 20 dB (25 dB typical) at both 850 nm & 1300 nm.
 - h. Be made by an ISO 9001 and 14001 Certified Manufacturer.
 - i. Be UL 1666 approved.
 - j. Siemon Company FJ Series Fiber Jumpers Recommended Category 6:
- 9. Coordinate fiber patch cords with Owner prior to release. Provide SC to LC, ST to LC, or any combination of the two. Provide one per fiber port.
 - 10. Warning Tags: At each location where the fiber cable is exposed to human intrusion, it shall be marked with warning tags. These tags shall be yellow or orange in color, and shall contain the warning: "CAUTION FIBER OPTIC CABLE". The text shall be permanent, black, block characters, and at least 3/16 in. high. A warning tag shall be permanently affixed to each exposed cable or bundle of cables, at intervals of not more than five feet. Any section of exposed cable which is less than five feet in length shall have at least one warning tag affixed to it.
 - 11. T-Bar Suspended Ceilings: Copper station cabling may be run outside of conduits and above T-Bar suspended ceilings when available, at the option of the installer. Cables installed in this fashion are to be run horizontally in bundles and tied down neatly, well clear of any light fixtures or other electrical appliances that may affect data transmissions.
- B. Optical fiber Interconnect Equipment: Interconnect equipment may be mounted either on the plywood backboard or in the equipment racks, depending on the particular application. When mounted on the backboard, the horizontal dimension shall be level. A minimum of four of the mounting holes provided shall be utilized for fastening. Screws shall be tightened to the extent that they hold the device snug to the backboard, but not so tight as to distort or damage the device. Interconnect equipment mounted in racks shall be affixed to the rack by at least four screws. The screws shall be of the correct size and thread configuration for the holes in the rack. They shall be tightened to the extent that they hold the equipment firmly to the rack, without distorting the equipment or stripping the threads. All optical fiber interconnect devices shall be assembled and installed in accordance with the manufacturer's instructions and recommendations. All large openings into wall mounted cabinets shall be covered by a grommet.

2.4 UTP CABLE (BACKBONE)

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. General Cable
 - 2. CommScope
 - 3. Mohawk; a division of Belden CDT.
 - 4. Or equal
- B. Description: Multi-pair Backbone Cable: Category 5e, 100-ohm, 25-pair UTP binder groups covered with a gray thermoplastic jacket.
- 1. Comply with ICEA S-90-661 for mechanical properties.
 - 2. Comply with TIA/EIA-568-B.1 for performance specifications.
 - 3. Comply with TIA/EIA-568-B.2, Category 5e.

4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
 - a. Communications: Type CMP, complying with NFPA 262.
- C. Multi-pair backbone cables: Provide copper backbone cable that meets or exceeds the following specifications:
 1. Electrical Specifications:

Maximum DC Resistance	28.6 Ω /1,000 ft (9.4 Ω /100m)
Maximum DC Resistance Unbalanced	5 percent
Maximum Capacitance Unbalanced (pair to ground)	1,000 pF/1000 ft. (328 pF/m)
Mutual Capacitance @ 1kHz	18 nF/1000 ft (5.9 nF/100 m), max.
 2. Attenuation (dB/100 m [328 ft.]):

Frequency	Attenuation (Max.)
1.00 MHz	2.3 dB
4.00 MHz	4.9 dB
10.00 MHz	8.5 dB
16.00 MHz	12 dB
 3. Worst Pair Near-End Crosstalk (NEXT) dB/100 m [328 ft]:

Frequency	Pair-To-Pair NEXT (Max.)
1.0 MHz	13.8 dB
4.0 MHz	11.2 dB
10.0 MHz	10.2 dB
16.0 MHz	9.2 dB

2.5 FIBER INNERDUCT

- A. DESCRIPTION: From the MDF to each IDF, segments of optical fiber innerduct shall be installed.
 1. Quantities Required: Innerduct runs do not have to be continuous throughout, breaks are expected at the pull boxes. Contractor is responsible for determination of actual lengths of innerduct required. Enough innerduct shall be provided and installed to extend from the fiber service loop in the MDF to the fiber service loop in each IDF. If the route passes through a pull box, the segments of innerduct shall extend twelve inches into the pull box. If the route passes through an enroute HC, each segment of innerduct shall extend at least twelve inches beyond the end of the service conduit.
- B. INSTALLATION: Fiber innerduct shall be installed in accordance with manufacturer's instructions and industry standards. Within the equipment rooms, the innerduct shall extend from the end of conduit to four feet above the floor and shall be affixed to the backboard by means of clamps designed for that purpose. Care shall be taken to avoid kinking the innerduct or applying excessive tension during the installation process.

2.6 FIBER DISTRIBUTION

- A. DESCRIPTION: From the MDF to each IDF a continuous segment of fiber cable shall be provided.
 - 1. Product: 12 strands multi-mode 50/125 UM OM3 laser optimized and 6 strands single-mode 8.3/125 UM.
 - 2. Quantities Required: The contractor is responsible for determination of actual segment lengths. Actual quantities will be determined by the routing established by the electrical engineer.
 - 3. Required Accessories and Quantities:
 - a. Kit of Parts: Sufficient quantities to block and buffer both ends of each cable segment.
 - b. Sealant: Sealant sufficient quantities to block each end of each cable segment.
- B. INSTALLATION: Installation shall be conducted following guidelines established by the product manufacturer and industry standards.
 - 1. Fiber Optic Cable: During installation of the optical fiber cable segments into the conduit system, special care shall be taken to avoid damage to the cable. While under pulling tension, the cable shall not be bent into a curve with a radius of less than 20 times the cable diameter. Pulling tension shall not exceed manufacturer's recommended maximum tensile load. Contractor shall utilize a winch with tension control or a "break-away" link designed to break away at or below the recommended maximum tension.
- C. The optical fiber cable shall be routed through the existing conduit and onto the appropriate HC backboard. Routing on the backboard shall be straight and plumb. A minimum ten foot service loop shall be provided at each terminal location. Refer to Drawings for cable configuration.

2.7 WORK STATION CABLE

- A. DESCRIPTION: From each MDF, 4-pair enhanced Category 6 cables shall be routed to each work station (data outlets).
 - 1. Product:
 - a. Copper 4-pair UTP:
 - 1) UTP cables shall:
 - a) Be manufactured by one of the following:
 - b) Hitachi Cable Manchester
 - c) Berk-Tek
 - d) Commscope
 - e) General Cable
 - f) Mohawk
 - g) Or equal
 - h) Be 100 Ω 4-pair, category 6 cable.
 - a. Shall be rated for the environment in which it is installed.

2. Required Accessories and Quantities (Hard Wall Locations):
 - a. Work Station: Panduit CFPLS** stainless steel Single Gang, Single Port Face plate. Using Panduit CMB**-X blank modules to fill unused ports. Refer to drawings for two, three, and four gang configurations. Modules shall be CJ688TP** – color to be selected by engineer.
3. Work Area Equipment Cords: The Work Area Equipment Cords shall meet or exceed the following criteria:
 - a. Modular Equipment Cords: Category 6
4. CAT6A cables shall be small diameter cable. The nominal cable outside diameter shall be no greater than 0.27 in. and distance limitations shall be no less than 295 ft.
5. Category 6, modular equipment cords shall:
 - a. Be round, and consist of eight insulated 24 AWG, stranded copper conductors, arranged in four color-coded twisted-pairs within a flame-retardant jacket.
 - b. Be equipped with modular 8-position (RJ45 style) plugs on both ends, wired straight-through with standards compliant wiring.
6. Use modular plugs which exceed FCC CFR 47 part 68 subpart F and IEC 60603-7 specifications, and have 50 microns minimum of gold plating over nickel contacts.
7. Be resistant to corrosion from humidity, extreme temperatures, and airborne contaminants.
8. Utilize cable that exhibit power sum NEXT performance.
 - a. Be available in several colors with color strain relief boots featuring a snagless design.
 - b. Provide (2) foot patch cord per data jack shown on drawings. Coordinate with owner exact sizes required in the closet side.
 - c. Be made by an ISO 9001 and 14001 Certified Manufacturer.
 - d. Electrical Specifications:
 - e. DC resistance per lead: $9.38 \Omega / 100 \text{ m}$ maximum.
 - f. Input impedance without averaging: $100 \Omega + 15 \text{ percent}$ from 1 to 100 MHz.
 - g. 100% transmission tested with laboratory grade network analyzers for proper performance up to 1000 MHz. Vendor shall guarantee cords are compatible with category 6 links.
9. UL VERIFIED (or equivalent) for TIA/EIA proposed category 6 electrical performance.
10. UL LISTED 1863.
11. All information outlets for 100Ω 22-26 AWG copper cable shall:
 - a. Be available in blue, black, white, gray, ivory and light ivory.
 - b. Accommodate a minimum of two 8-position / 8-conductor modular jacks.
 - c. Utilize compliant pin technology 110 style insulation displacement connectors which allows the use of a 4-pair impact tool.
 - d. Allow for a minimum of 200 re-terminations without signal degradation below standards compliance limit.
 - e. Be constructed of high impact, flame-retardant thermoplastic.
 - f. Be available in a screened version for 100Ω SFTP cable.
 - g. Be made by an ISO 9001 and 14001 Certified Manufacturer.
 - h. Electrical Specifications:

- i. ANSI/TIA/EIA-568-B1, B2, B3 and ISO/IEC 11801 proposed category 6 compliant.
- j. The following requirements shall also be met (NEXT Loss and FEXT tested in both Differential and Common Mode):

Parameters	Performance	Performance @ 100 MHz *
NEXT Loss	+ 3.0 dB	43.0 dB
FEXT	+ 3.0 dB	43.0 dB **
Insertion Loss (Attenuation)	+ 40 percent	.24 dB
Return Loss	+ 6 dB	20 dB
LCL	40 dB (1-100 MHz)	**

- B. INSTALLATION: Installation shall be conducted in accordance with guidelines established the manufacturer and industry standards. Wall Plates shall be mounted such that their vertical dimension is plumb. Each wall plate shall be labeled with its respective work station number. Each modular mounting frame shall be labeled with its respective work station number.
- C. Technical Requirements: Horizontal cabling: the horizontal subsystem is the portion of the telecommunications cabling system that extends from the work area telecommunications outlet/connector to the horizontal cross-connect in the Telecommunications room/closet. It consists of the telecommunications outlet/connector, the horizontal cables, optional consolidation point, and that portion of the cross-connect in the telecommunications room/closet serving the horizontal cable.

- 1. Cable Types: All UTP and fiber optic cables shall conform to the following standards:

- a. ANSI/TIA-568C.0 Generic Telecommunications Cabling for Customer Premises
- b. ANSI/TIA-568C.1 Commercial Building Telecommunications Cabling
- c. ANSI/TIA-568C.2 Balance Twisted Pair Telecommunications Cabling
- d. ANSI/TIA-568C.3 Optical Fiber Cabling and Components Standard
- e. Including all applicable addenda) and ISO/IEC 11801 (International) Generic Cabling for Customer Premises standard (latest amendment and including all applicable addenda).

f.	Input	Bonded-Pair	Non-bonded Pair
	Impedance		
	100 +	12 1-20 MHz	-----
	100 +	15 20-250 MHz	1-100 MHz
	100 +	20 250-350 MHz	-----
	100 +	22 350-625 MHz	100-200 MHz
	100 +	32 -----	200-625 MHz

- g. Copper: The following cable specifications shall also be met by the cable manufacturer for 4-pair UTP, premium category 6 cables:

- 1) Attenuation: Qualified Cables shall exhibit worst case attenuation less than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable attenuation performance for selected frequency points of interest is also provided.

Attenuation Limits Table			
		System 6SM	
Frequency Range		1-350 MHz	
Worst Case		$\leq 1.82\sqrt{f} + .017 \cdot f + \frac{0.20}{\sqrt{f}}$	
Frequency Points of Interest	MHz		
	100	19.8 dB	
	200	29 dB	
	300	35.3 dB	

h. Near End Crosstalk (NEXT) Loss:

- 1) Qualified Cables shall exhibit worst case NEXT Loss greater than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable NEXT Loss performance for selected frequency points of interest is also provided.

NEXT Loss Limits Table			
		System 6SM	
Frequency Range		1-350 MHz	
Worst Case Cable NEXT Loss		$\geq 76 - 15\log(\frac{f}{0.772})$	
Frequency Points of Interest	MHz		
	100	44.3 dB	
	200	39.8 dB	
	300	37.1 dB	

i. Power Sum Near-End Crosstalk (PSNEXT) Loss:

- 1) Qualified Cables shall exhibit worst case PSNEXT Loss greater than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable PSNEXT Loss performance for selected frequency points of interest is also provided.

PSNEXT Loss Limits Table				
			System 6SM	
Frequency Range			1-350 MHz	
Worst Case PSNEXT Loss			$\geq 74 - 15\log\left(\frac{f}{0.772}\right)$	
Frequency Points of Interest	MHz			
	100		42.3 dB	
	200		37.8 dB	
	300		35.1 dB	

j. Equal Level Far-End Crosstalk (ELFEXT):

- 1) Qualified Cables shall exhibit worst case ELFEXT greater than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable ELFEXT performance for selected frequency points of interest is also provided.

ELFEXT Limits Table				
			System 6SM	
Frequency Range			1-350 MHz	
Worst Case ELFEXT			$\geq 70 - 20\log\left(\frac{f}{0.772}\right)$	
Frequency Points of Interest	MHz			
	100		27.8 dB	
	200		22.7 dB	
	300		18.2 dB	

k. Power Sum Equal Level Far-End Crosstalk (PSELFEXT):

- 1) Qualified Cables shall exhibit worst case PSELFEXT Loss greater than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable PSELFEXT performance for selected frequency points of interest is also provided.

PSELFEXT Loss Limits Table				
			System 6SM	
Frequency Range			1-350 MHz	
Worst Case PSELFEXT			$\geq 67 - 20\log(\frac{f}{0.772})$	
Frequency Points of Interest	MHz			
	100		24.8 dB	
	200		18.7 dB	
	300		15.2 dB	

I. Return Loss:

- 1) Qualified Cables shall exhibit worst case Return Loss greater than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable Return Loss performance for selected frequency points of interest is also provided.

Return Loss Limits Table						
			System 6SM			
Frequency Range			1-350 MHz			
Worst Case Return Loss			Frequency (MHz)	Return Loss (dB)		
			$\leq f < 10$	$21 + 4 \cdot \log(f)$ dB		
			$10 \leq f < 20$	25 dB		
			$20 \leq f \leq 300$	$25 - 7 \cdot \log(f/20)$		
Frequency Points of Interest	MHz					
	100	-	20.1 dB			
	200		18 dB			
	300		16.8 dB			

m. Propagation Delay (ANSI/TIA/EIA-568-A-1):

- 1) Qualified Cables shall exhibit worst case Propagation Delay less than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable Propagation Delay performance for selected frequency points of interest is also provided.

Propagation Delay Limits Table				
			System 6SM	
Frequency Range			1-350 MHz	
Worst Case Propagation Delay			$< 476 + \frac{36}{\sqrt{f_{MHz}}}$	
Frequency Points of Interest	MHz			
	100		480 ns	
	200		479 ns	
	300		478 ns	

n. Delay Skew (ANSI/TIA/EIA-568-A-1):

- 1) Qualified Cables shall exhibit worst case Delay Skew less than the values specified in the chart below per 100 m from 1 MHz to the highest referenced frequency value.

Delay Skew Limits Table				
			System 6SM	
Frequency Range			1-350 MHz	
Worst Case Delay Skew	MHz			
	100		25 ns	
	200		25 ns	
	300		25 ns	

o. Longitudinal Conversion Loss (LCL):

- 1) For all categories of 100 Ω unshielded and screened cables, the worst case calculated LCL for any pair in a 100 m cable shall not be less than 35 dB, from 1 MHz to the highest referenced frequency for each performance category. LCL measurements shall be performed in accordance with ITU-T Recommendation O.9 (November, 1988) or equivalent. Calculated LCL performance shall be determined by subtracting the test balun loss correction factor (as specified by the balun manufacturer) from the measured value at all frequencies.

LCL Limits Table				
			System 6SM	
Frequency Range			1-350 MHz	
Worst Case Delay Skew	MHz			
	100		35 dB	
	200		35 dB*	
	300		35 dB	

p. Longitudinal Transfer Conversion Loss (LCTL):

- 1) For all categories of 100 Ω unshielded and screened cables, the worst case calculated LCTL for any pair in a 100 m cable shall not be less than 35 dB, from 1 MHz to the highest referenced frequency for each performance category. LCTL measurements shall be performed in accordance with ITU-T Recommendation O.9 (November, 1988) or equivalent. Calculated LCL performance shall be determined by subtracting the test balun loss correction factor (as specified by the balun manufacturer) from the measured value at all frequencies.

LCTL Limits Table				
			System 6SM	
Frequency Range			1-350 MHz	
Worst Case Delay Skew	MHz			
	100		35 dB	
	200		35 dB*	
	300		35 dB*	

q. Attenuation to Crosstalk Ratio (ACR):

- 1) Using “pair-to-pair NEXT Loss”, all Qualified Cables shall exhibit worst case ACR performance for the specified frequency range shown in the following table.

ACR Limits Table				
			System 6SM	
Frequency Range			1-350 MHz	
Worst Case ACR	MHz			
	1-80		24.1 dB	
	80-100		24.1 dB	
	1-100		24.1 dB	
	100-300		.5 dB	

PSACR Limits Table				
			System 6SM	
Frequency Range			1-350 MHz	
Worst Case PSACR	MHz			
	1-80		22.1 dB	
	80-100		22.1 dB	
	1-100		22.1 dB	
	100-300		-1.5 dB	

r. Transfer Impedance:

- 1) Surface+ Transfer Impedance is specified for ScTP cables and is determined by the formula below in mΩ/m where f = frequency. All qualified ScTP cables shall have a margin greater than or equal to the values specified in the following table.

$$T_{cable} = 37 + 4f + 4\sqrt{f} + 5\sqrt[3]{f}$$

Transfer Impedance Limits Table			
Margin 1-100 MHz		System 6SM	
Transfer Impedance		10 %	

2.8 MAIN DISTRIBUTION FACILITY (MDF)

A. DESCRIPTION: The equipment shall be installed in accordance with Drawings.

1. Products and Quantities:

- a. Equipment Rack: - As specified.
- b. Fiber Interconnect: Panduit FRME24 rack mount fiber optic enclosure or equal. Supply and install as many as necessary to service all fiber strands entering the MDF.
- c. Modular Patch Panels: Panduit angled patch panel or equal: 48-port patch panel wired Category 6 Patch Panel. One port for each workstation served from the MDF with a minimum of 12 spare ports are required. Provide CAT6A angled patch panel for wireless CAT6A ports. If the number of workstation cables, plus required spare count 12 is greater than 48, then a second 48-port patch panel is required. Supply and install as many patch panels in the MDF as necessary to service all workstation cables plus the required spare count. Provide separate CAT 6A patch panels as required for CAT 6A cables serving wireless access point outlets.
- d. Patch Cables: Panduit UTPSPXX-** or equal where XX is the length in feet and ** is the color. The length shall vary between 3' and 15' and shall be determined by the owner. Colors shall also be determined by the owner. A minimum of five different color patch cables shall be carried for different systems.

2. Required Accessories and Quantities:

- a. Adapter Panels: Panduit FAP6WEIDSC – 6 Port Duplex Multimode SC Adapter Panels.
- b. Fiber Jumpers: Panduit F6D3-3M3Y, 3 meter, Duplex, 50 micron OM3, SC to LC Fiber and ST to LC Fiber Jumper or equal.
- c. Cable Management: Panduit WMPH2E Front/Rear cable manager or Panduit WMPLS Low Profile Cable Manager or equal.
- d. Cable Management Rings and Strain Relief: Panduit WMBV1 21 in. x 5 in. Vertical Manager Ring, Panduit WMBV2 2 in. x 5 in. Vertical Manager Ring and/or Panduit WMSRC1 or WMSRC2 strain relief clips. Provide and install sufficient quantities to conform to attached Drawings.

B. INSTALLATION: Installation shall be conducted in accordance with manufacturer's recommendations, industry standards, and this specification. Installation includes complete assembly and mounting of the fiber interconnect equipment, dressing the fiber and copper cables, complete assembly and mounting of the equipment rack, and mounting of the wiring blocks. Equipment shall be mounted in accordance with attached Drawings.

2.9 INTERMEDIATE DISTRIBUTION FACILITIES

- A. DESCRIPTION: The equipment shall be installed in accordance with Drawings.
1. Products and Quantities:
 - a. Equipment Rack: - As specified.
 - b. Fiber Interconnect: Panduit FRME24 rack mount fiber optic enclosure or equal. Supply and install as many as necessary to service all fiber strands entering the IDF.
 - c. Modular Patch Panels: Panduit CPPLA48WBLY or equal: 48-port patch panel wired Category 6A Patch Panel. One port for each workstation served from the IDF with a minimum of 12 spare ports are required. If the number of workstation cables, plus required spare count 12 is greater than 48, then a second 48-port patch panel is required. Supply and install as many patch panels in the IDF as necessary to service all workstation cables plus the required spare count.
 - d. Patch Cables: Panduit UTPSPXX-** or equal where XX is the length in feet and ** is the color. The length shall vary between 3 ft. and 15 ft. and shall be determined by the owner. Colors shall also be determined by the owner. A minimum of five different color patch cables shall be carried for different systems.
 2. Required Accessories and Quantities:
 - a. Adapter Panels: Panduit FAP6WEIDSC – 6 Port Duplex Multimode SC Adapter Panels.
 - b. Fiber Jumpers: Panduit F6D3-3M3Y, 3 meter, Duplex, 50 micron OM3, SC to LC Fiber and ST to LC Fiber Jumper or equal.
 - c. Cable Management: Panduit WMPH2E Front/Rear cable manager or Panduit WMPLS Low Profile Cable Manager or equal.
 - d. Cable Management Rings and Strain Relief: Panduit WMBV1 21 in. x5 in. Vertical Manager Ring, Panduit WMBV2 2 in. x5 in. Vertical Manager Ring and/or Panduit WMSRC1 or WMSRC2 strain relief clips. Provide and install sufficient quantities to conform to the attached Drawings.
- B. INSTALLATION: Installation shall be conducted in accordance with manufacturer's recommendations, industry standards, and this specification. Installation includes complete assembly and mounting of the fiber interconnect equipment, dressing the fiber and copper cables, complete assembly and mounting of the equipment rack, and mounting of the wiring blocks. Equipment shall be mounted in accordance with Drawings.

2.10 TESTING AND DOCUMENTATION

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
1. Visually inspect UTP jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
 2. Visually confirm Category 6 and 6A marking of outlets, cover plates, outlet/connectors, and patch panels.
 3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

4. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - a. Provide test instruments that meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
5. Multi-pair Voice Riser Tests:
 - a. Test each pair of multi-pair voice riser cables for proper polarity; no reversals; no transpositions; continuity; no shorts; no AC voltages; no DC voltages; no opens; and proper numbering at each termination.
 - b. Bring cables and/or pairs not meeting the requirements of the standard into full compliance, at no additional cost to the Owner.
 - c. Document cable testing in accordance with Submittals Article. Provide a table of test results in a 3-ring binder submitted with the as-built Drawings.
6. Category 6 Data, and Voice UTP Cable Testing:
 - a. Test voice and data jack in each Outlet for Category 6 ANSI/TIA/EIA 568B series compliance, using a Certified Level III testing instrument. Tests shall verify both the integrity of all conductors and correctness of the termination sequence. Tests shall also include length, mutual capacitance, characteristic impedance, attenuation and near-end and far-end crosstalk. Testing shall be performed between modular jacks at the Outlets and the modular jacks at the patch panel field.
 - b. The Communication Systems Installer shall bring cables and/or pairs not meeting the requirements of the standard into full compliance, at no additional cost to the Owner.
 - c. Document cable testing in accordance with Submittals Article. Provide a table of test results in a 3-ring binder submitted with the as-built Drawings.
- D. Final Verification Tests: Perform verification tests for UTP systems after the complete communications cabling and workstation outlet/connectors are installed.

Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
- E. Document data for each measurement. Print data for submittals in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- F. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
- G. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- H. Prepare test and inspection reports.

2.11 CABLE TELEVISION SYSTEM

- A. Furnish and install cable and all outlets. Cabling shall be provided as indicated on the drawings.
- B. Television outlet locations shall have wall boxes mounted both at 18 in. above finished floor unless otherwise indicated. The boxes shall be 4 in. square with double gang plaster ring, and cover for cable outlet and duplex receptacle where shown on Plan. At other locations, provide single gang plaster ring and cover.
- C. Provide one RG-6 quad shielded cable per CATV outlet run above ceiling to MDF room.

2.12 TWO WAY CALL BOXES SYSTEM

A. Summary:

- 1. Section Includes: Area of Refuge Base Stations, call boxes and signage.
 - a. The Area of Refuge Base Station is to be located at a central control point on the first floor or as determined by local Authority having jurisdiction. Rath Call Boxes are to be located on all floors above and below the first floor.
 - b. The Area of Refuge Base Station must be capable of handling a minimum of 5 Rath Call Boxes. Visual indicators on the base station allow Rescue personnel to know which Area of Rescue Call Box needs assistance. The Base Station must allow Rescue personnel to speak to all Call Boxes or individual Call Boxes.
 - c. The Emergency communication hardware shall comply with the Americans with Disabilities Act (ADA). The phone shall have the ability to be programmed with up to 5 emergency phone numbers. Upon activation of the emergency push button, a call will be automatically placed to the Base Station. If no one answers at the Base Station, the Call Box must dial a secondary location outside the building to activate two way off-site person to person voice communications.

B. Manufacturers:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Rath Area of Refuge
 - b. Aiphone
 - c. Housing Devices, Inc.
 - d. Or Equal.

C. Functional Description of System

1. Construction

- a. The Area of Refuge Base Station (models 2500) must have a stainless steel or powder coated steel housing, red coil cord emergency Handset, be 120vac powered, and maintain back-up power for 4 hours.
- b. The Area of Refuge Call Boxes (models 2100) must be in full compliance with Americans with Disabilities ACT (ADA). Call Boxes require a hands-free speakerphone with an LED to indicate status of call.
- d. The Area of Refuge Call Boxes must allow the programming in of a specific location message of the Call Box. This allows Rescue personnel to know the location of the activated Call Box.

- e. The Area of Refuge Call Boxes are to be located no higher than 48" above ground level to ensure conformance with the ADA requirements.
 - f. The Area of Refuge Call Boxes must have a Braille faceplate located no higher
 - g. than 48" for front reach and 54" for side reach above ground level to ensure
 - h. conformance with the ADA requirements.
 - i. The Area of Refuge Base Station must provide an audible and visual indicator that
 - j. a Call Box has been activated.
 - k. The area of Refuge 24vac Power Supply model 2500-PWR24 must be capable of
 - l. supplying power to a minimum of 40 Call Boxes. (does not power Base Station)
2. Mounting
- a. The Area of Refuge Base Station is to be mounted on a wall surface or flush mounted.
 - b. Areas of Refuge Call Boxes are to be wall surface or flush mounted.
3. Electrical
- a. The Base Station is to be powered by 120vac. Call Boxes are to be powered by Rath 24vac Power Supply model 2500-PWR24.
 - b. Call Boxes must have a battery back-up capable of providing up to 4 hours of electrical back-up in case of building power failure.
 - c. Base Station must have a battery back-up capable of providing up to 4 hours of electrical back-up in case of building power failure.
 - d. System shall be in compliance with all state and local Electrical Codes.
4. Communications
- a. The Call Boxes shall have an ADA compliant and vandal resistant speakerphone.
 - b. The Call Boxes shall be Hands-Free and be a push-button-once to talk system.
 - c. Once the button has been pushed, the Call Box will call the Base Station. If no answer at the Base Station, it will automatically call preprogrammed emergency numbers. The Call Box must be capable of being programmed with up to 5 emergency numbers.
 - d. Call Box shall have Location Message capability. Call Box must have a minimum 18 second recordable message capability, programmable to play 1 or 2 times. Call Box shall notify called party of the location of the call upon being received at the emergency dispatch center.
 - e. Call Box shall be capable of allowing the called party to replay the Location Message if necessary to ensure an understanding of the caller location.
 - f. If system is not attended to 24 hours a day, the Call Box must dial a secondary location outside the building to activate two way off-site person to person voice communications.
 - g. Once call has been made (button pushed), the call can only be terminated by the called party.
 - h. Call Box must have a red LED that will light up upon push of the button. The light shall be a solid color when the Call Box is activated, and will flash when call has been answered.
 - i. The Call Box must be capable of being programmed and reprogrammed on-site and remotely.
5. Standard Call Box features:
- a. Five number programming.
 - b. Operating Temperature of between -40°F to +150°F (-40° to + 65° C)

- c. Programmable passwords.
- d. On-Site or Remote Programmable.

6. Monitoring

- a. Off-Site monitoring of the system shall be provided as requested by the Owner.
- b. Must be a UL Listed monitoring service provider
- c. Minimum 3 year agreement for monitoring of the system.
- d. Call Boxes shall dial the monitoring service.

7. Graphics

- a. Area of Refuge Base Station must include wording identifying the location of each
- b. Call Box and light an LED when a particular Call Box has been activated.
- c. Call Box wording must include "Help Phone", "International Phone symbol" and raised Braille lettering.

D. Startup Service:

- 1. Engage a factory-authorized service representative to perform startup service.
 - a. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
 - b. Complete installation and startup checks according to manufacturer's written instructions.

E. Adjusting:

- 1. On-Site Assistance: Engage a factory-authorized service representative to provide onsite assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.
- 2. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

F. Warranty:

- 1. The base station and call boxes shall be warranted for a period of one year.

G. Demonstration:

- 1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the system.

2.13 PUBLIC PAGING SYSTEM

- A. Provide public paging system as described herein and as shown on the Drawings. All wiring for audio systems shall be color grey. Paging system shall be T.O.A. or equal.
- B. Provide in accordance with the manufacturer's instructions all wiring and equipment required for the erection of a complete system.

- C. The system shall consist of a complete paging system with all features as herein specified and shown on drawings. The system shall contain the following components.
 - 1. The amplifier shall deliver an audio output of a minimum of 150 watts RMS per channel with a total harmonic distortion of .05% at 1 kHz rated power. Output regulation shall be .5 dB (direct) 1.0 dB (Transformer).
 - 2. The amplifier shall provide complete input and mixing facilities for 4 low-impedance microphone inputs, and auxiliary input. Each microphone input shall also include an overload circuit which permits microphone signals of up to 1 volt to be reproduced without any discernible increase in distortion.
 - 3. Provisions shall be included for the telecommunications system or fire alarm control panel to take precedence over all other inputs for emergency announcement.
 - 4. The amplifier shall include all circuitry and controls necessary to provide complete system equalization for optimum sound reproduction and maximum gain before feedback. The equalizer filters shall be of the 1 octave bandpass type having an individual range of 12 dB. A total of 9 individual filters shall be provided. Filter controls shall be slide type.
 - 5. The amplifier shall have auxiliary program inputs, to allow user of input sources such as a mixer, tuner, Zetron input, telephone, radio. Signal level at this input is controlled by the program level control and is fed to the master output. This auxiliary input shall also mute upon emergency messages.
- D. The paging system shall have a telephone interface module to transmit emergency messages from a telephone handset throughout the entire facility.
- E. Loudspeakers (Sallyport) (Evidence Garage):
 - 1. Sound reinforcement loudspeaker shall be a self-contained, broad dispersion. The frequency range shall be 50 Hz to 22,000 Hz. The speaker shall have a sensitivity of 89.5 dB SPL, 100 dB at 1 meter, or more, and shall have a continuous power handling capacity of 125 watts rms. Provide equipment soundtube RS800i or equal.
 - 2. Each unit shall be provided with a hanging kit for every speaker. Provide equipment by Pro Acoustics, Inc. or approved equal.
 - 3. Each unit shall be provided with a 125 watt line matching transformer designed for use with the specified speaker. Provide equipment by QSC or approved equal.
- F. The main sound reinforcement ceiling loudspeakers speakers, as shown on plans, shall be Lowell 8C5W-T251 8"Speaker Assembly. The assembly shall be a 8" Dual cone speaker with 25/70 volt line matching transformer and 5oz. ceramic magnet assembled to a Lowell WB-B Baffle or approved equal. Power rating shall be 15 watt RMS; voice coil shall have an impedance of 8 ohms and measure 1" in diameter. The circular baffle shall be 12 3/4" in diameter and 3/8" deep. It shall be constructed of 22 gauge cold rolled steel, with white baked on epoxy finish.

2.14 MISCELLANEOUS CABLING SYSTEM

- A. Provide and terminate all speaker, microphone, antenna, cabling per manufacturer's recommendations for a completely operational system as specified.

- B. Sound/Speaker cabling shall be home run and looped directly to applicable headend termination board, as specified. All cable runs shall be free from in-line splices. Insulate all cable shields (at field device end) from field grounds by cutting and taping shields.
 - 1. Office speakers, conference room speakers, work room speakers, exterior speakers and others areas that have only one (1) public address speaker shall each be individually home run, without splices, back to their respective sound system headend. Provide 22 AWG solid shielded speaker cables.
 - 2. Hallways and other areas that have multiple speakers, may have a maximum of eight (8) speakers per speaker loop home run, without splices, back to their respective sound headend. Provide 18 AWG stranded speaker cables.
 - 3. Loud Speakers areas that have multiple speakers, may have a maximum of four (4) speakers per speaker loop home run, without splices, back to their respective sound headend. Provide 18 AWG stranded speaker cables.

2.15 ELEVATOR TELEPHONE LINE FAULT MONITOR

- A. Provide Line Fault Monitor designed for connection across incoming telephone lines on systems using telephone dialers (e.g., 612) or digital communicators (e.g., 678, 678UL-B, 793 or 794) or control/communicators. It will cause a signal to be generated if the telephone line between dialer or communicator and the central station is cut or shorted, or if incoming service is otherwise interrupted. The signal can be in the form of sounding the on-premises protective system's alarm bell (when the system is ON), or the lighting of a trouble indication lamp on an optional accessory tester (such as the 664 for non-UL Listed applications).
- B. Monitor shall be mounted within a Listed control unit or other enclosure connect to intrusion alarm system on dedicated zone.

PART 3 - EXECUTION

3.1 GENERAL

- A. Do not install equipment and materials which have not been reviewed by the Architect. Equipment and materials which are installed without the Architect's review or without complying to comments issued with the review shall be removed from the project when so instructed by the Architect. No payment will be made for unapproved or removal if it is ordered removed. The Installer shall be responsible for any ancillary costs incurred because of its removal and the installation of the correct equipment and materials.
- B. Obtain detailed information on installation requirements from the manufacturers of all equipment to be furnished, installed or provided. At the start of construction, check all Contract Documents, including all Drawings and all Sections of the specifications for equipment requiring electrical connections and service and verify electrical characteristics of equipment prior to roughing.
- C. Equipment and systems shall not be installed without first coordinating the location and installation of equipment and systems with the General Contractor and all other Trades.
- D. Any and all material installed or work performed in violation of above requirements shall be re-adjusted and corrected by the Installer without charge.

- E. Refer to all Drawings associated with the project, prior to the installation or roughing-in of the electrical outlets, conduit and equipment, to determine the exact location of all outlets.
- F. After installation, equipment shall be protected to prevent damage during the construction period. Openings in conduits and boxes shall be closed to prevent the entrance of foreign materials.
- G. Home runs indicated are not to be combined or reduced without written consent from the Architect.
- H. All connections to equipment shall be made as required, and in accordance with the approved submittal and setting drawings.
- I. Delivery, Storage and Handling:
 - 1. Deliver, store, protect and handle products in accordance with recommended practices listed in Manufacturer's Installation and Maintenance Manuals.
 - 2. Deliver equipment in individual shipping splits for ease of handling, mount on shipping skids and wrap for protection.
 - 3. Inspect and report concealed damage to carrier within specified time.
 - 4. Store in a clean, dry space. Maintain factory protection or cover with heavy canvas or plastic to keep out dirt, water, construction debris, and traffic. Heat enclosures to prevent condensation. Meet the requirements and recommendations of NFPA 70B and the Manufacturer. Location shall be protected to prevent moisture from entering enclosures and material.
 - 5. Handle in accordance with NEMA and the Manufacturer's recommendations and instructions to avoid damaging equipment, installed devices and finish.
 - 6. The equipment shall be kept upright at all times. When equipment has to be tilted for ease of passage through restricted areas during transportation, the Manufacturer shall be required to brace the equipment suitably to insure that the tilting does not impair the functional integrity of the equipment.
- J. Site Observation:
 - 1. Site observation visits will be performed randomly during the project by the Architect. Reports will be generated noting observations. Deficiencies noted on the site visit reports shall be corrected. All work shall comply with the Contract Documents, applicable Codes, regulations and local Authorities whether or not a particular deficiency has been noted in a site visit report.
 - 2. Be responsible to notify the Architect ten working days prior to closing in work behind walls, raised access floors, ceilings, etc., so that installed work can be observed prior to being concealed.
 - 3. Areas shall stay accessible until deficiencies are corrected and accepted. Notify the Architect when all deficiencies are corrected. Return reports with items indicated as corrected prior to re-observation by the Architect.
- K. Project Open House:
 - 1. If the Owner elects to have an open house at the end of the project, provide assistance to the Owner. Cooperate and provide manpower to operate and demonstrate systems during the open house as requested by the Owner.

3.2 EQUIPMENT RACKS, CABINETS AND BRACKETS

- A. Securely mount equipment racks, cabinets and wall mounted relay brackets to the building structure. Proper supports such as 3/8 in. lag screws and expansion anchors shall be used. Proper quantity of supports shall be utilized. Drywall screws and other types of supports not specifically approved to support equipment are specifically prohibited. Submit mounting supports for approval before installation.
- B. Position racks, cabinets, and wall mounted relay brackets in order to have minimum 3 foot clearance for easy access. Equipment racks, cabinets and relay brackets mounted on or against walls shall have 3 foot clearance in front of deepest component. Free standing equipment racks and cabinets shall have 3 foot clearance in front and rear of deepest components. Provide 3 foot clearance between free standing equipment racks or cabinets and any other obstruction to allow access from front to rear of rack or cabinet for maintenance.
- C. The Electrical Contractor shall provide cable tray over each rack and cabinet as required to facilitate a neat and orderly installation of cables and to secure the top of the racks to the structure. Cables shall drop straight down to equipment racks. Cable trays shall be secured at both ends to the structure and connected together as required for a complete contiguous installation. Utilize proper supports to support the cable tray to the building structure as well as the equipment rack and cabinet. Submit mounting supports for approval before installation.
- D. Cable Management: All cables shall enter the wiring closet to within the equipment racks and/or brackets. Secure the bundle(s) to the rack strain relief and wire management behind the patch panels and cross connect block panels. Install horizontal and side-mounted vertical cable management panels and brackets for routing and management of patch cables. Maintain EIA/TIA and BICSI standards on bundling, supporting and bend radii.
- E. Once the cabling system has been installed and terminated, install all active components and surge protected power strips into the racks, cabinets and wall mounted relay brackets.
- F. Surge Protected Outlet Strips: Mount UPS and surge protected outlet strips per Manufacturer's directions. Refer to details on the Drawings for mounting location.

3.3 TERMINATIONS

- A. All copper conductors of every cable shall be completely terminated at both ends.

3.4 CABLE PATHWAYS

- A. Install cables in pathways provided by the Electrical Subcontractor or required under execution part of this Section.
- B. Provide all equipment and cabling for a complete installed operating system. In general, pathways, outlet boxes and grounding are provided by the Electrical Subcontractor.
- C. All pathways provided under this Section shall comply with fill capacities as per Code, EIA/TIA 569 and BICSI.
- D. Cable bending radius shall not be less than minimum required by EIA/TIA and BICSI.
- E. Cabling installed concealed shall be supported from the building structure (e.g. cable trays, J-Hooks, etc.).

- F. Cables shall be installed no closer than 12 inches (305mm) to electrical equipment and wiring. When cables are required to cross power wiring, they shall only do so perpendicular to the power wiring. Telecommunications cabling and power wiring shall only cross each other the minimal number of times as required due to building design limitations.
- G. Clearances: Clearances between cabling and other building systems as required by EIA/TIA 569 and BICSI shall be maintained throughout the building.
- H. All cables shall be installed in a neat and workman-like manner. Cables shall be installed parallel and perpendicular to building elements.
- I. Provide expansion fittings and adequate cable slack at all building expansion joints.
- J. Fire/smoke seal all conduits, raceways, sleeves, slots, etc. where cables pass from one location to another.

3.5 SEALING OF PENETRATIONS AND OPENINGS

A. Environmental Seals

- 1. Provide seals on raceways exposed to widely different temperatures, as in refrigerated or cold storage areas. Install seal to prevent circulation of air from warmer to colder sections through the raceway.
- 2. Provide seals under device plates for outlets on walls between conditioned and non-conditioned spaces.
- 3. Provide outlet plate gasket seals at all work area outlets on interior and exterior walls.

3.6 SEISMIC SUPPORTS, SUPPLEMENTARY STEEL AND CHANNELS

- A. Provide all supports, supplementary steel and channels required for the proper Seismic installation, mounting and support of all work installed under this Section.
- B. All supports, supplementary steel and channels shall be furnished, installed and secured with all fittings, support rods and appurtenances required for a complete support or mounting system.
- C. Supplementary steel and channels shall be firmly connected to the building construction in a manner approved by the Architect prior to the installation of same. Submit to the Architect, via the General Contractor, the locations proposed for using supplementary steel and channels for the support of equipment, fixtures and raceways. The submittal shall indicate the mounting methods, size and details of the supports, channels and steel; it shall indicate also that weight which the supports, channels and supplementary steel is to carry.
- D. The type and size of the supporting channels and supplementary steel shall be of sufficient strength and size for seismic restraint and to allow only a minimum deflection in conformance with the channel and supplementary steel manufacturer's requirements for loading.
- E. All supplementary steel and channels shall be installed in a neat and workmanlike manner parallel to the walls, floor and ceiling construction. All turns shall be made with 90 degrees and 45 degrees fittings, as required to suit the construction and installation conditions.
- F. All supplementary steel, channels, supports, and fittings, shall be Underwriters' Laboratories, Incorporated, approved, be galvanized steel and be manufactured by Steel City, Unistrut, Power-Strut, T. J. Cope, Chalfant or approved equal.

- G. Provide supports to meet the required Seismic rating as indicated under "Part One" of this Specification.
- H. Provide beam clamps with set screws (C-clamp type).
- I. Work under this Section shall be held in place by Seismic rated methods.
- J. Supporting from the roof decking will not be acceptable.
- K. Provide expansion anchors on masonry units or brick work. Power actuated supports will not be accepted.
- L. Provide stainless steel or corrosion resistant supports in corrosive areas on wet or damp areas.
- M. Support work from the building structure, independent of suspended ceilings, roof deck or other trades work. Where duct work, pipes, pipe racks, type of building construction materials or structural framing members provide obstruction or difficult support means, hanger rods shall be used in association with horizontal sections of steel support channels, in an approved manner.
- N. All work shall be installed in a rigid and satisfactory manner and shall be supported by bar hangers in frame construction or shall be fastened directly with wood screws on wood, bolts with expansion shields on concrete or brick toggle bolts on hollow masonry units, and machine screws or welded threaded studs on metal. Threaded studs of the proper type and holding capacity driven in by a power charge and provided with lock washers and nuts are acceptable for mounting of equipment on solid concrete walls or slabs.
- O. Obtain written permission from the General Contractor allowing use of power activated charges. Use only properly trained and licensed operators.
- P. Do not use power charge driven supports for any work that is to be hung from a horizontal surface without written permission from the Architect.
- Q. Preset inserts of the proper type and holding capacity shall be used in overhead slab construction wherever possible.
- R. Provide lateral supports for work to prevent excessive movement during a seismic event using rods, braces or galvanized or stainless steel cables.
- S. Pendants, supports or hanging rods longer than 12 inches (300mm) shall be laterally braced.
- T. Where installed in damp, wet and areas requiring wash down, all surface mounted panels, boxes, junction boxes, conduit, etc., shall be supported by spacers to provide a clearance between wall and equipment.

3.7 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 26 00 10 "Identification for Electrical Systems."
 - 1. Confirm labeling scheme with the Owner prior to final labeling.
 - 2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

- B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.
- C. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.
- E. Cable and Wire Identification:
 - 1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
 - 4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
 - b. Label each unit and field within distribution racks and frames.
 - 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- F. Provide preprinted or computer-printed type labels with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA 606-A, for the following:
 - 1. Cable Labels: Use flexible vinyl or polyester that flexes as cables are bent.

3.8 CABLE SUPPORTS

- A. Provide strain relief hardware for backbone cables at each floor level as they pass from one floor to the next.
- B. Provide hook and loop (Velcro) cable wraps at all panels, equipment racks and cabinets. Cable ties are specifically prohibited.

- C. Cable ties for horizontal cables shall be secured with minimum required compression in order to secure the cables properly without impeding the signal transmission rating (geometry) of the cable. Hook and loop (Velcro) cable wraps may be used in lieu of cable ties for copper cables only. Cable-ties are specifically prohibited for fiber optic cables.
- D. When pathways are not provided or specified, provide J-Hook supports from the building structure as required for cable runs to the cable drop location. Maximum distance between supports shall be five feet (1 500mm) depending on the structural elements of the building. Maximum number of cables per support shall be thirty. Provide additional supports as required when cable quantities exceed thirty and to maintain required bending radius of cables. Cables installed exposed or in areas subject to abuse (below 10 feet (3m) above finished floor) or in accessible areas shall be installed in conduit.
- E. All cables shall be supported directly from building structure. Under no circumstance shall cable be installed using cross bracing, plumbing/sprinkler pipes, ceiling systems or any other system that is not a specifically approved method to independently support cables. Cables shall not be allowed to rest on ceiling tiles, duct work, piping, etc. Supports shall be provided as required in order for cables to avoid contact with any other building system. Bundle cables in groups by Room.

3.9 CABLE PROTECTION

- A. Provide bushings in all metal studs and the like where cables will pass through. Bushings shall be of two piece construction with one piece inserted through the opening and the second piece locking it into place. Single piece bushings with locking tabs or friction fit are specifically prohibited.
- B. Cables to be installed in existing enclosed open bays or furred spaces where conduit stubs are not provided shall be protected from chafing or any damage. The Installer shall verify that the warranty shall not be violated before installing any cabling in these locations.
- C. Provide cutting, coring, sleeves and bushings and seal as required at all penetrations.
- D. Fiber optic backbone cables shall be installed in inner duct.
- E. Cables damaged during installation shall not be repaired. They shall be completely replaced with new cable.

3.10 INSTALLATION

- A. All cabling shall be installed in conduit where indicated on plans, or shall be installed open using other methods, approved by architect, such as J-Hooks.
 - 1. Install wiring, per manufacturers recommendations. Use UL listed plenum cable in environmental air spaces including plenum ceilings.
- B. All wiring shall be new and concealed in pipe where exposed.
- C. All conduits and raceways shall have pull strings remaining after cable is pulled.
- D. Impedance and Level Matching:
 - 1. Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

E. Control Circuit Wiring:

1. Install control circuits in accordance with NFPA 70 and as indicated. Provide number of conductors as recommended by system manufacturer to provide control functions indicated or specified.
2. Make installation in strict accordance with approved manufacturer's drawings and instructions.
3. The Installer shall provide necessary transient protection on the AC power feed, all station lines leaving or entering the building, and all central office trunks. All protection shall be as recommended by the equipment supplier and referenced to earth ground.

F. Weatherproofing:

1. Provide weatherproof enclosures for items to be mounted outdoors or exposed to weather.

G. Typical Layouts and requirements of the specified systems:

1. Typical layout:

- a. Equipment racks and cabinets
- b. Backbone cabling
- c. Headend equipment

2. Typical layout of telecommunications equipment racks and cabinets.

a. Each equipment rack and cabinet shall contain the following equipment:

- 1) Fiber optic patch panel
- 2) Fiber optic cable management
- 3) Surge protector power strip
- 4) Patch panels - Horizontal distribution
- 5) Horizontal distribution cable management
- 6) Vertical cable management
- 7) Patch cords

- b. Provide space for the installation of network electronics equipment in the equipment racks.
- c. Furnish and install horizontal cable management between each patch panel (fiber optics, Hub distribution, Horizontal distribution, and telephone distribution).
- d. Furnish and install horizontal distribution patch panels in each wire center with sufficient ports to terminate all modular jacks shown on the drawings plus twenty percent spares. The exact number of modular jacks and horizontal distribution patch panels shall be obtained from the drawings.
- e. Furnish and install all equipment racks and cabinets required to support the aforementioned equipment.
- f. Grounding bars shall be installed under SECTION 26 00 10. Furnish and install the required grounding to ensure that all of the aforementioned equipment is grounded and bonded.

3. Headend

- a. Final terminations from IDC cross connect block panels to telephone equipment and PBX by -Telephone Company and Equipment Installer. Coordinate with Telephone Company and Equipment Installer for final terminations.
- b. Final terminations from the IDC cross connect block panels to the headend equipment shall be provided by the headend equipment installer.
- c. Coordinate with the headend equipment installer and the electrical contractor for:
 - 1) The installation of all the IDC cross connect block panels at the headend equipment. Installation shall be neat in appearance.
 - 2) The final terminations at the headend.

3.11 TRAINING

A. As a minimum, training sessions shall consist of the following:

1. General project information and review shall be by the General Foreman or Superintendent of the Trade.
2. Specific system training shall be by a Factory Trained Representative.
3. Provide a complete review of the project and systems including, but not limited to, the following:
 - a. In a classroom environment review each Record Drawing (use of typical is acceptable).
 - b. Note equipment layouts, locations and control points.
 - c. Review each system.
 - d. Review system design operation and philosophy.
 - e. Review alarms and necessary responses.
 - f. Review standard troubleshooting techniques for each system.
 - g. Review areas served by equipment.
 - h. Identify color codes used.
 - i. Review features and special functions.
 - j. Review maintenance requirements.
 - k. Review operation and maintenance manuals.
 - l. Respond to questions (record questions and answers).
4. After classroom training, walk the entire project, review each equipment room and typical locations. Explain equipment and proper operation.

B. During the instruction period the Owner and Maintenance Manual shall be used and explained.

C. The Owner and Maintenance Manual material shall be bound in 3-ring binders and indexed. On the edge of the binder provide a clear see-through plastic holder with a typed card indicating the Project name, the Architect's name, the installer's name and the Volume number (e.g., Vol. No. 1 of 2).

D. Provide name, address and telephone number of the manufacturer's representative and Service Company for all items supplied so that the source of replacement parts and service can be readily obtained.

1. Include copies of manufacturers and installer's warranties and maintenance contracts and performance bonds properly executed and signed by an authorized representative.

2. Include copies of all test reports and certifications.

E. Providers of the Broadband Video Distribution System shall provide training as part of their package. This comprehensive training plan shall address the following areas:

1. Training, providers of the Broadband Video Distribution System shall provide (4) hours of training as part of their package, this comprehensive training plan shall address the following areas:
 - a. System Orientation for all involved staff members.
 - b. Small group hands-on training sessions for all media center staff focusing on system-wide hardware and troubleshooting.
 - c. Small group hands-on software training sessions for all media center staff.

3.12 ACCEPTANCE DEMONSTRATIONS

- A. Systems installed under this Section shall be demonstrated to the Owner and Architect. Demonstrations are in addition to necessary testing and training sessions. Notify all parties at least 7 days prior to the scheduled demonstration. Schedule demonstrations, in cooperation with and at times convenient to all parties, so as to not disturb ongoing activities.
- B. Systems shall be tested prior to the demonstrations and each system shall be fully operational and tested prior to arranging the Acceptance Demonstration. Final payments will be withheld until a satisfactory demonstration is provided for all systems indicated or requested.
- C. If the demonstration is not totally complete, performing all functions, features and connections or interfaces with other systems, or if there is a failure during the demonstration, additional demonstrations shall be arranged. Provide and pay for all costs, labor and expenses incurred for all attendees for each additional demonstration required for acceptance and demonstration of complete system operation.
- D. Demonstrations shall be scheduled in ample time to complete all activities prior to final acceptance and Owner occupancy. Demonstrations shall take place at least 30 days prior to the scheduled project completion date and 30 days prior to owner's use and occupancy.
- E. As a minimum, provide demonstrations for systems indicated under "Work Included" under Part One of the Specifications. Provide demonstrations of additional systems as requested by the Owner, or Architect.

3.13 PROJECT OWNER COORDINATION

- A. Prior to Substantial Completion of the project and in ample time to address and resolve any coordination issues, request and arrange meetings between the Owner, Owner's Vendors and Consultants, Architect and General Contractor to discuss the Scope of Work for each system being provided and the interface required for a fully functional and operational system upon project completion. Initial meetings shall be scheduled three months prior to the scheduled Substantial Completion date or as soon as Submittals are submitted and reviewed for projects with shorter schedules.
- B. At these meetings the required interface with the Owner shall be reviewed, requests for information required to complete programming or for coordination shall be presented and system operation and philosophy shall be discussed.

- C. Additional meetings shall be held as requested by any party so that all issues are resolved and with the goal and intent being that all systems are fully operational and functional upon project Substantial Completion and that the responsibility for all components required is clearly established.

3.14 CLEANING UP

- A. Upon completion of all work, and testing, thoroughly inspect all exposed portions of the installation and completely remove all exposed labels, markings, and foreign material.
- B. The interior of all boxes and cabinets shall be left clean; exposed surfaces shall be cleaned and plated surfaces polished.
- C. Repair damage to finish surfaces resulting from work under this Section.
- D. Remove material and equipment from areas of work and storage areas.
- E. All equipment shall be clean from dirt, dust, and fingerprints prior to final acceptance.
- F. Touch up all damaged pre-finished equipment using materials and methods recommended by the Manufacturer.

3.15 PROJECT CLOSEOUT

- A. Provide close out submittals as required herein and in SECTION 01 78 00 - CLOSEOUT SUBMITTALS including the following close out submittals.
 - 1. Operation and Maintenance Manuals
 - 2. Record Drawings.
 - 3. Test Reports.
 - 4. Extra Materials.
- B. Obtain written receipts of acceptance close out submittals submitted. Receipts shall specifically detail what is being delivered (description, quantity and specification section) and shall be dated and signed by firm delivering materials and by the Owner's Representative.
- C. Telecommunications:
 - 1. Provide fifteen (15 percent) spare patch cables and line cord for each cable length provided.
 - 2. Provide record drawings indicating actual cable routing and cable terminations and all required identifiers. Provide copy mounted in each telecommunications closet and the main cross connect.
 - 3. All sketches, drawings, and charts herein are for the purpose of providing for specifications in a simplified format. Errors and omissions in such does not relive the Contractor of the responsibility for providing a fully complete, secure and properly operating integrated instructional technology network system suitable for the intended use. Bidders must obtain a complete set of Project Drawings and Specifications to determine the full scope of work. In case of conflict the Project Drawings and Specifications shall prevail.
- D. Construction Waste Management

- E. Comply with Division 01 requirements for construction waste management and recycling.

END OF SECTION

SECTION 280000

INTEGRATED ELECTRONIC SECURITY SYSTEM
(Filed Sub-Sub Bid Required)

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END OF INDEX

SECTION 280000

INTEGRATED ELECTRONIC SECURITY SYSTEM
(Filed Sub-Sub Bid Required)

PART 1 - GENERAL

1.1 FILING OF FILED SUB-SUB BIDS

- A. Filed Sub-Sub-Bid Requiring a Paragraph "E" Listing on the FORM FOR SUB-BID required per M.G.L. Chapter 149 Section 44A to 44L, as amended to date. The Electrical Subcontractor will be responsible for all related building preparation and coordination, see specification for additional Paragraph "E" Listing requirements of the Listed Systems Contractor, and coordination of responsibilities.
- B. Section 28 00 00 INTEGRATED ELECTRONIC SECURITY SYSTEM shall be a Filed Sub-Sub Bid of Section ~~26 00 01~~ **26 00 10**.
- C. , requiring a Paragraph "E" Listing on the FORM FOR SUB-BID.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 GENERAL REQUIREMENTS

- A. The Conditions of the Contract and General Requirements of the Project Manual apply to this Subcontractor, material suppliers, and all other persons furnishing labor and materials under this Section. The General Conditions, and applicable parts of Division 01 are included as part of this Section.
- B. Examine all Project Specifications and Drawings for requirements, which affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.
- D. The following definitions apply to the Drawings and Specifications:
 - 1. Furnish: The term "furnish" is used to mean, "supply and deliver to the Project Site, ready for unloading, unpacking, assembly, installation, and similar operations".
 - 2. Install: The term "install" is used to describe operations at the Project Site including actual "unloading, unpacking, assembly, erection, piecing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations".
 - 3. Provide: The term "provide" is used to mean, "furnish and install, complete and ready for the intended use".
 - 4. Installer: An "installer" is the Contractor furnishing and installing the IESS in its entirety. Installers are required to be experienced in the operations they are engaged to perform.

- E. When open-flame or spark producing tools such as blow torches, welding equipment, and the like are required in the process of executing the work, the General Contractor shall be notified not less than twenty four (24) hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant non-working fire watch where work is being performed until it is completed.

1.4 OVERVIEW

- A. The IP Integrated Security System consists of the following subsystems. All systems referenced below shall be connected to a stand alone, dedicated security network as provided by the System Integrator.
 - 1. Electronic Access Control
 - 2. Control Center Network Video Management and Storage System
 - 3. Interview Room Recording System and Recording Management
 - 4. Two Way Critical Communication and Intercom System
 - 5. Servers and Workstations
 - 6. Network Electronics (PoE)
 - 7. LPR (License Plate Recognition) based access control system with LPR camera.
- B. Integration between the IP Video, IP Audio/Communications and IP Access Control System (ACS) is defined as follows:
 - 1. Each duress button shall be individually annunciated on the Unified Security Platform GUI.
 - 2. Each cell speaker and intercom station shall annunciate and communicate with each GUI workstation in dispatch and as connected to the Unified Security system.
 - 3. The ACS shall support integration with the IP Video Surveillance System. Integration with the IP video surveillance system shall permit the user to view live and recorded video from one GUI and one single window. The same GUI shall be utilized for both the access control solution and the specified video surveillance solution. Switching from one application or GUI to another shall not be acceptable as well as utilizing two applications simultaneously to achieve the functionality specified is not allowed. The cell audio threshold alarms and two way communications shall be integrated with the IP video and be controlled through a GUI.
- C. The Security Integrator shall coordinate with the owner prior to installation, CCTV camera area of coverage, field of view and aiming.
- D. Service and Preventative Maintenance Program
 - 1. Includes manufactured approved software maintenance agreement (SMA) for the duration of the warranty period.
 - 2. Includes all service and warranty support on entire IESS.
 - 3. Includes quarterly preventative maintenance on entire IESS. See specification for details.
 - 4. Includes a minimum of (1) IESS software upgrade during the warranty period to the latest version of software.
 - 5. All labor must be performed by manufactured certified technicians.

1.5 QUALIFICATIONS

- A. It is the intent of this specification to have a single qualified Systems Integrator provide the Division 280000 scope in its entirety, which will include, but not be limited to; all material, cable, cabling, installation, programming, configuration, testing and warranty. Boxes, conduit and 120-volt provisions are installed by the Electrical Contractor.

- B. The Systems Integrator will be the firm whom is listed as the sub-contractor on the Electrical bid form.
- C. The firm listed as the Systems Integrator on the Electrical bid form is responsible for the warranty on the entire IESS, including but not limited to; all equipment, cable, cabling, and installation.
- D. The Systems Integrator shall have experience in the IESS and provide documentation on manufacture letterhead that they are a certified dealer of the IESS platform for a minimum of (5) years.
- E. The Systems Integrator must be certified from the manufacture and will be required to provide documentation which demonstrates they themselves have been a dealer of the IESS for a minimum of (5) years. Provide certification with submittal.
- F. To ensure the proper and accurate installation and management of the IESS, the Project Manager of the firm performing the installation of the IESS must be certified by the manufacture. Provide certification with submittal.
- G. The Systems Integrator must have a minimum of (5) five manufacture trained technicians on staff. Provide technician certificates with the submittal.
- H. The Systems Integrator shall hold and maintain a valid S-License from the State of Massachusetts Department of Public Safety. Individuals employed by S-License holder must obtain a Certificate of Clearance prior to engaging in any work on the Project.
- I. The Systems Integrator shall be DCAM certified in Electronic Security Systems.
- J. The Systems Integrator shall have a local office with service depot no more than (100) miles from the project site. The local office shall have manufacture trained engineers and technicians who are qualified to provide instructions, routine and emergency maintenance and repairs on all portions of systems. Service staff shall be available for emergency service on a 24-hour basis.
- K. The Systems Integrator shall be experienced in the operations they are engaged to performed.

1.6 SUBMITTALS

- A. General: Submit the following according to the Conditions of Contract and Division 01 Specification Sections:
 - 1. Product data sheets for system components highlighted to indicate the specific products, features, or functions required to meet this specification. Alternate or as-equal products submitted under this contract must provide a detailed line-by-line comparison of how the submitted product meets, exceeds or does not comply with this specification.
 - 2. Wiring diagrams from manufacturer.
 - 3. Shop drawing showing system details including location of all devices and circuiting. Provide point to point diagrams with all accessory equipment shown.
 - 4. System operation description including method of operation.
 - 5. Operation and maintenance data for inclusion in Operating and Maintenance Manual. Include data for each type product, including all features and operation sequences, both automatic and manual. Provide the names, addresses and telephone numbers of service organizations.

PART 2 - PRODUCTS

2.1 SYSTEM CABLING

- A. Provide and terminate all cabling per manufacturers recommendations for a completely operational system as specified.
- B. CCTV System Cabling, provide & terminate all cabling as required for a completely operational CCTV System as required by equipment manufacturer.
 - 1. CCTV Camera Cabling:
 - a. CAT 6 cabling shall be provided for each CCTV camera location.
 - b. Provide CAT 6 patch cabling as required between patch panels and POE switches at each IDF/MDF location and at camera locations.
 - c. Power cabling for exterior devices shall be 12 gauge 2 conductor, provide applicable gauge per applicable distances.
 - d. Data/Control cabling (for PTZ pan/tilt/zoom cameras) shall be 2-pair 22 gauge with an overall shield to applicable PTZ locations as specified, Belden #9841.
 - e. Provide all line cords as required, field measured for proper length.
 - f. Provide any additional cabling as required per manufacturer's specifications.
 - 2. Telephone Line interface; provide and terminate a Cat 6 cable between security system headend and the MDF/Demarc.
- C. Cabling for Access Control System, provide & terminate all cabling as required for a completely operational Access Control System as required by equipment manufacturer.
 - 1. EL = Door Lock Device; provide & terminate cabling between EL and associated Power Supply and between Power Supply and associated ACC. Electrical Sub-contractor shall confirm power supply location with installer. Electrical Sub-contractor shall provide 120VAC outlet and power supply backbox at power supply location. EL furnished and installed by door hardware, associated EL Power Supply furnished by door hardware provider, installed and wired by systems integrator. EL may be an Electronic Door Strike, Magnetic Door Lock, etc., see Architect for details.
 - 2. CR = Door Reader Device; provide CR, provide and terminate cabling to associated ACC. The cable requirements of the card reader shall be a minimum five (5) conductor, 22 AWG, stranded cable with overall shield (for a Wiegand protocol interface). A six (6) conductor cable is required when controlling the red and green LED individually. A seven (7) conductor cable is required when both the red and green LED's are controlled by the Host. A 22 AWG twisted pair, shielded, stranded cable is required for use of the tamper switch. The card reader shall be provided with a 10 wire pigtail connector.
 - 3. ALM = Alarm Line Module; provide ALM, provide & terminate cabling to associated Door Contact, and ACC. ALM mounts within J-Box at door location.
 - 4. DC = Door Contacts (recessed in door/frame); DC furnished, installed and wired by systems integrator, provide & terminate cabling to associated ALM (Alarm Line Module).
 - 5. ACC = Access Control System Controller.
 - 6. ACS = PC & Monitor for Access Control System.
 - 7. Fire Alarm System interface.
 - a. Provide and terminate cabling between applicable electronic door lock power supplies and the fire alarm system headend. Terminations to fire alarm control panel by fire alarm contractor.
 - b. Provide and terminate cabling between access control system head end and the fire

alarm system head end. Terminations to fire alarm control panel by fire alarm contractor.

2.2 UNIFIED SECURITY PLATFORM

A. General

1. The United Security Platform is defined as the Unified software package used for the IP Video, IP Audio, Access Control and Intrusion Alarm systems.
2. The Unified Security Platform (USP) shall be an enterprise class IP-enabled security and safety software solution.
3. The USP shall support the seamless unification of IP access control system (ACS), IP video management system (VMS), Intrusion detection system (IDS) and Critical Communication system (CCS) under a single platform. The USP user interface (UI) applications shall present a unified security interface for the management, configuration, monitoring, and reporting of embedded ACS, VMS, and IDS systems and associated edge devices.

a. Functionalities available with the USP shall include:

- 1) Configuration of embedded systems such as ACS, IDS, CCS, and VMS systems.
- 2) Live event monitoring.
- 3) Live video monitoring and playback of archived video including audio.
- 4) Interrogation Room Recording Management
- 5) Alarm management.
- 6) Reporting, including creating custom report templates and incident reports
- 7) Federation for global monitoring, reporting, and alarm management of multiple remote and independent ACS and/or VMS systems spread across multiple facilities and geographic areas.
- 8) Global cardholder management across multiple facilities and geographic areas each with their own independent ACS system.
- 9) Microsoft Active Directory integration for synchronizing USP user accounts and ACS cardholder accounts.
- 10) Integration to third party systems and databases via plug-ins (access control, video analytics, audio monitoring, and more).
- 11) Dynamic graphical map viewing.
- 12) Critical Communication system.
- 13) Asset management system integration.

b. Licensing

- 1) A single central license shall be applied centrally on the configuration server.
- 2) There shall be no requirement to apply a license at every server computer or client workstation. Provide a minimum of ten (10) licenses for client workstations.
- 3) Provide licenses for each camera as shown on the drawings plus 5% spare.
- 4) Based on selected options, one or more embedded systems shall be enabled or disabled.

c. Video Recording and Storage Parameters

- 1) Recording and Storage parameters shall be defined as supporting all cameras/devices detailed and as shown on the drawings for:

- a) 30 days minimum
 - b) The maximum resolution each specified camera can support.
 - c) 30 frames/images per second per camera at max resolution.
 - d) 50% (12 hours per day per camera) motion activity.
 - 2) Actual quantity of cameras per server is a function of bandwidth.
 - a) For optimal performance, each Directory Server shall support a maximum of 100 MB/sec. Provide additional Directory servers for bandwidth requirements greater than 100MB/sec.
 - b) For optimal performance, each Archiver Server shall support a maximum of 300 MB/sec. Provide additional Archiver servers for bandwidth requirements greater than 300MB/sec.
 - 3) Supply the necessary storage solution to meet these requirements and document through the submittal process how the proposed storage solution can achieve this specification requirement. Provide calculation sheets from the IP Video system manufacture with the submittal.
 - 4) Provide one server per 25 cameras. No more than 25 cameras allowed per server.
4. Manufacturer
- a. The system shall be the Security Center platform as manufactured by Genetec. Provide Genetecs' Omnicast, Synergis, and Sipelia software suites as specified herein or as manufactured by Avigilon, S2 or equal.
5. Hardware and Software Requirements
- a. The USP and embedded systems (video, license plate recognition, access control) shall be designed to run on a standard PC-based platform loaded with a Windows operating system.
 - b. The server software module (SSM) shall be 64-bit operating systems including Windows 10 and Windows Server 2016. Where updated versions of software are compatible with latest operating system (Server and client), the latest version software shall be used.
 - c. The USP database server(s) shall be built on Microsoft's SQL Server 2016 including SQL Server 2016 Express Editions.
 - d. The USP shall use the latest user interface (UI) development and programming technologies such as Microsoft WPF (Windows Presentation Foundation), the XAML markup language, and .NET software framework.
 - e. For this project, include Windows Server 2016 for all servers. Include Windows 10 for all clients and security workstations.
6. Architecture
- a. Overview
 - 1) The USP shall be based on a client/server model. The USP shall consist of a standard Server Software Module (SSM) and Client Software Applications (CSA).
 - 2) The USP shall be an IP enabled solution. All communication between the SSM and CSA shall be based on standard TCP/IP protocol and shall use encryption when enabled by the administrator.

- 3) The SSM shall be a Windows service that can be configured to start when the operating system is booted and run in the background. The SSM shall automatically launch at computer startup, irrespective of whether a user is logged onto the machine or not.
- 4) Users shall be able to deploy the SSM on a single server or across several servers for a distributed architecture. The USP shall not be restricted in the number of SSM deployed.
- 5) The USP shall support the concept of Federation whereby multiple independent ACS and VMS installations can be merged into a single large virtual system for centralized monitoring, reporting, and alarm management.
- 6) The USP shall protect against potential database server failure and continue to run through standard off-the-shelf solutions.
- 7) The USP shall support one thousand instances of Client Software Applications (CSA) connected at the same time. An unrestricted number of CSA however can be installed at any time.
- 8) The USP shall support an unrestricted number of logs and historical transactions (events and alarms) with the maximum allowed being limited by the amount of hard disk space available.
- 9) The USP shall support uninterrupted video streaming. The CSA shall keep existing video connections active in the event that a SSM (except Archiver) become unavailable.

b. Roles-Based Architecture

- 1) The USP shall consist of a role-based architecture, with each SSM hosting one or more roles.
- 2) Each role shall execute a specific set of tasks related to either core system, license plate recognition (LPR), video (VMS), or access control (ACS) functionalities, among many others. Installation shall be streamlined through the USP's abilities to allow administrators to:
 - a) Deploy one or several SSM across the network prior to activating roles.
 - b) Activate and deactivate roles as needed on each and every SSM.
 - c) Centralize role configuration and management.
 - d) Support for remote configuration.
 - e) Move roles over from one SSM to another.
- 3) Each role, where needed, shall have its own database to store events and role-specific configuration information.
- 4) Roles without databases (Federation, Active Directory, Global Cardholder Management) shall support near real-time standby without any third party failover software being required.

c. Server Monitoring Service (Watchdog)

- 1) The USP shall include a Server Monitoring Service that continuously monitors the state of the Server Software Module (SSM) service.
- 2) The Server Monitoring Service shall be a Windows service that automatically launches at system startup, irrespective of whether a user is logged into his account or not.
- 3) The Server Monitoring Service shall be installed on all PCs/servers running an SSM. In the event of a malfunction or failure, the Server Monitoring Service shall restart the failed service. As a last resort, the Server Monitoring Service shall reboot the server/PC should it be unable to restart the service.

7. Client Software Applications (CSA)

a. Overview

- 1) The Client Software Applications (CSA) shall provide the user interface for USP configuration and monitoring over any network, accessible locally or from a remote connection.
- 2) The CSA shall consist of the Configuration UI for system configuration and the Surveillance UI for monitoring. The CSA shall be Windows based and provide an easy-to-use graphical user interface (UI).
- 3) The Server Administrator shall be used to configure the server database(s). It shall be web-based and accessible locally on the SSM or across the network.
- 4) The CSA shall seamlessly merge access control, license plate recognition (LPR), and video functionalities within the same user application.
- 5) The USP shall use the latest user interface (UI) development and programming technologies such as Microsoft WPF (Windows Presentation Foundation), the XAML markup language, and the .NET software framework.
- 6) Logging on to a CSA shall be done either through locally stored USP user accounts and passwords or using the operators Windows credentials when Active Directory integration is enabled.
- 7) When integrated with Microsoft's Active Directory, the CSA and USP shall authenticate users using their Windows credentials. As such, the USP will benefit from Active Directory password authentication and strong security features.
- 8) The CSA shall support multiple languages, including but not limited to the following: English, French, Arabic, Dutch, German, Hebrew, Hungarian, Italian, Japanese, Korean, Persian (Farsi), Polish, Simplified and Traditional Chinese, and Spanish.
- 9) The Configuration UI and Surveillance UI shall support many of the latest UI concepts to enhance usability and operator efficiency such as
 - a) An OS-like (operating system) Start Menu.
 - b) Task-oriented approach for administrator/operator activities where each type of activity (surveillance, visitor management, individual reports, and more) is an operator task.
 - c) Consolidated and consistent workflows for video, LPR, and access control.
 - d) Single click functionality for reporting and tracking. The Surveillance UI shall support single-click reporting for access control, LPR, and video, as well as single-click tracking of areas, cameras, doors, zones, cardholders, elevators, LPR entities, and more. Single-click reporting or tracking shall create a new task with the selected entities to report on or to track.
- 10) Configuration UI and Surveillance UI Start Menu and Tasks
 - a) The Configuration UI and Surveillance UI shall be task-oriented.
 - b) A task shall be user interface design patterns whose goal is to simplify the user interface by grouping related features from different systems such as video and access in the same display window. Features are grouped together in a task based on their common relevance to help the user perform a specific task.
 - c) Tasks shall be accessible via the Configuration or the Surveillance

- CSA's Start Menu and sub-menus.
- d) Newly created tasks shall be accessible via the Configuration UI or the Surveillance UI taskbar.
- e) Similar tasks shall be grouped into the following categories:
- f) Operation: Access control management, LRP management, and more.
- g) Investigation: Video bookmark/motion/archive reports, access control activity reports, visitor activity reports, alarm reports, LPR activity reports, and more.
- h) Maintenance: Access control and video configuration reports, troubleshooters, audit trails, health-related reports, and more.
- i) An operator shall be able to launch a specific task only if he has the appropriate privileges.
- j) The Start Menu content shall be customizable through the use of privileges to hide tasks an operator should not have access to. Further to that, editing a USP XML file to add new tasks on the fly shall be possible.

b. Configuration User Interface (UI)

- 1) The Configuration UI application shall allow the administrator or users with appropriate privileges to change the system configuration. The Configuration UI shall provide decentralized configuration and administration of the USP system from anywhere on the IP network.
- 2) The configuration of all embedded ACS, VMS, and LPR systems shall be accessible via the Configuration UI.
- 3) The Configuration UI shall have a home page with single-click access to various tasks.
- 4) The Configuration UI shall include a variety of tools such as troubleshooting utilities, import tools, and a unit discover tool, amongst many more.
- 5) The Configuration UI shall include a static reporting interface to:
- 6) View historical events based on entity activity. The user shall be able to perform actions such as printing a report and troubleshooting a specific access event from the reporting view.
- 7) View audit trails that show a history of user / administrator changes to an entity.
- 8) Common entities such as users, schedules, alarms and many more, can be reused by all embedded systems (ACS, VMS, and LPR).

c. Surveillance User Interface (UI)

- 1) The Surveillance UI shall fulfill the role of a Unified Security Interface able to monitor video, LPR, and access control events and alarms, as well as video live and recorded video.
- 2) The Surveillance UI shall provide a graphical user interface to control and monitor the USP over any IP network. It shall allow administrators and operators with appropriate privileges to monitor their unified security platform, run reports, and manage alarms.
- 3) Dynamically Adaptive UI, Dashboard, and Widgets
 - a) The Surveillance UI shall dynamically adapt to what the operator is doing. This shall be accomplished through the concept of widgets that are grouped in the Surveillance UI dashboard.

- b) Widgets are mini-applications or mini-groupings in the Surveillance UI dashboard that let you perform common tasks and provide you with fast access to information and actions.
 - c) With a single click on an entity (e.g. door or camera) the specific widgets associated to that entity appear and other non-relevant widgets disappear dynamically (instantly). Widgets shall bring the operator information such as door status and camera stream information, as well as user actions such, door unlock, PTZ controls, and more.
 - d) Specific widgets include those for a door, camera, alarm, zone, display tile, video stream (statistics), PTZ camera, and more.
- 4) Each task within the surveillance UI shall consist of one or more of the following items:
- a) Event list.
 - b) Logical tree. Doors, cameras, zones, LPR units, and elevators shall be grouped under Areas in a hierarchical fashion.
 - c) Entities list of all entities being tracked.
 - d) Display tiles with various patterns (1 x 1, 2 x 2, and more).
 - e) Display tile menu with various commands related to cameras, doors, PTZ, and tile controls.
- 5) The Surveillance UI shall support multiple event lists and display tile patterns, including:
- a) Event/alarm list layout only
 - b) Display tile layout only
 - c) Display tile and alarm/event list combination
 - d) LPR map and alarm/event list combination
- 6) The Surveillance UI shall be able to monitor the activity of the following entities in real-time through the surveillance task, among others: areas, LPR entities, doors, elevators, cameras, cardholders, cardholder groups, zones (input points), and more. The Surveillance UI shall provide an interface to support the following access control tasks and capabilities:
- a) Monitoring and management of access events and alarms.
 - b) Viewing of cardholder picture or badge IDs.
 - c) Verification of cardholder picture IDs against live video.
 - d) Visitor management.
 - e) People counting or mustering, including resetting the people count in an area
 - f) Door control (remotely unlocking doors, overriding a door's unlocking schedules, enabling door maintenance mode).
 - g) Forgiving antipassback.
 - h) Generation of ACS configuration and activity reports.
 - i) Viewing of HTML files including alarm instructions.
- 7) The Surveillance UI shall include advanced video capabilities:
- a) Advanced live video viewing functionality.
 - b) Advanced archive playing and video playback functionality.
 - c) Monitoring and management of video system events and alarms.
 - d) Intercom or duplex audio.

- e) Generation of video reports.
 - f) Control of PTZ cameras.
- 8) The Surveillance UI's video live viewing capabilities shall include:
- a) Display of all cameras attached to the USP and all cameras attached to federated systems.
 - b) Shall support live video monitoring on each and every display tile within a task in the user's workspace.
 - c) The USP shall support uninterrupted video streaming. The CSA shall keep existing video connections active in the eventuality that a SSM (except Archiver) become unavailable.
 - d) The operator shall be able to drag and drop a camera into a display tile for live viewing.
 - e) The operator shall be able to drag and drop a camera from a map into a display tile for live viewing.
 - f) Shall support digital zoom on live camera video streams.
 - g) Shall allow for audio communication with video units with audio input and output.
 - h) The operator shall be able to control pan-tilt-zoom, iris, focus, and presets.
 - i) Shall allow operators to bookmark important events for later retrieval on any archiving camera. Operators can uniquely name each bookmark in order to facilitate future searches.
 - j) The operator shall be able to start/stop recording on any camera in the system, which is configured to allow manual recording, by clicking on a single button.
 - k) The operator shall have the capability to activate or de-activate viewing of all system events as they occur.
 - l) Shall allow operators to switch to instant replay of the video for any archiving camera with the simple click of button.
 - m) Users shall be able to take snapshots of live video and be able to save or print the snapshots.
 - n) The user shall be able to view the same camera multiple times in different tiles.
- 9) Tracking
- a) The USP shall permit the user to select multiple entities to monitor from the Surveillance UI by adding the entities one by one to the tracking list.
 - b) The Surveillance UI shall provide the option to filter which events shall be displayed in the display tile layout and/or event list layout.
 - c) It shall be possible to lock a Surveillance UI display tile so that it only tracks the activity of a specific entity, e.g. specific door or camera.
 - d) The user shall be able to drag and drop an event from an event list (or an alarm from an alarm list) onto a display tile to view a license plate read, cardholder picture ID, badge ID, or live/archived video, among other options.
 - e) Event, alarm, monitoring/tracking, and report lists shall contain cardholder pictures, where applicable.
 - f) The user shall be permitted to start or pause the viewing of events within each display tile.

10) Display Tile Packing and Unpacking

- a) The Surveillance UI shall support single-click unpacking and packing for LPR hits, LPR reads, areas, doors, zones, camera sequences, and alarms.
- b) Packing and unpacking of entities shall allow operators to quickly obtain additional information and camera views of a specific entity.
- c) Unpacking of an entity shall display associated entities. For example, unpacking a door with multiple associated cameras shall display all cameras associated to the door. Unpacking shall reconfigure the display tiles to be able to display all associated entities. For example, unpacking a door (or zone or alarm) that is currently in a 1 x 1 tile configuration and that has 3 cameras tied to it will create a 1 x 3 display tile arrangement to view all associated entities.
- d) Packing will return the display to the original tile pattern.

11) Visual Tracking

- a) The Surveillance UI shall support the ability to manually track a moving target with the single click of a button.
- b) The ability to switch from one camera view to an adjacent camera shall be done within a single display tile.
- c) Switching between camera streams shall be accomplished by simply clicking on a semi-transparent shape or overlay.
- d) Visual tracking shall be available with both live and recorded video.

12) The following additional tools or utilities shall be available from the Surveillance UI: create credentials, create cardholders, and access control troubleshooter.

d. Server Administrator

- 1) The Server Administrator shall be used to configure the SSM, as well as the Directory Role (main configuration) and its database(s), apply the license, and more.
- 2) The Server Administrator shall be a web-based application. Through the Server Administrator, it shall be possible to access the SSM across the network or locally on the server.
- 3) Access to the Server Administrator shall be protected via login name and password, as well as encrypted communications.
- 4) The Server Administrator shall allow the administrator (user) to perform the following functions:
 - a) Manage the system license.
 - b) Configure the database(s) and database server for the Directory Role,
 - c) Activate/Deactivate the Directory Role.
 - d) Manually back up the Directory Role database(s) and/or restore the server database(s), as well as configure scheduled backups of the databases.
 - e) Define the client-to-server communications security settings.
 - f) Configure the network communications hardware, including connection addresses and ports.
 - g) Configure system SMTP settings (mail server and port).
 - h) Configure event and alarm history storage options.

e. Unified Web Client

- 1) The USP shall support a unified web client (UWC) for access control, video, and LPR.
- 2) The UWC shall be a truly thin client with no download required other than an internet web browser or standard web browser plugins.
- 3) The UWC shall be platform independent and run within Microsoft Internet Explorer, Firefox, Safari, and Google Chrome.
- 4) Web pages for the web client shall be managed and pushed by the Mobile Server. Microsoft IIS or any other web hosting service shall not be required given that all the web pages shall be hosted by the Mobile Server.
- 5) Functionalities:
 - a) Login using name and password or Active Directory support shall be available.
 - b) Encrypted communications for all transactions.
 - c) Print reports, export to CSV file
 - d) User management (add, modify, delete, change partition, change group)
 - e) Customer logo customization shall be available for multi-tenant and hosted services applications.
- 6) For Video
 - a) Live video 320 x 240 @ 15 fps
 - b) 1 or 4 tiles
 - c) Basic PTZ Controls (Pan/Tilt, Zoom, go to presets, start pattern)
 - d) Start / Stop recording
 - e) Sample web page for customers to see how to view video for own development
- 7) For Access Control
 - a) Cardholder and group, credential management (add/modify/delete)
 - b) Visitor management (add/modify/delete)
 - c) Access rule management (add/modify/delete)
 - d) Area management (view and name modification)
 - e) Door management (view, name modification, add/remove access rules)
 - f) Access control reports

f. Smartphone and Tablet Apps

- 1) The USP shall support mobile apps for various off-the-shelf smartphones and tablets. The mobile apps shall communicate with the USP's Mobile Server over any WiFi or wireless IP connection.
- 2) Mobile apps shall communicate with the UPS via a Mobile Server (same as the Unified Web Client or UWC). Communication between the mobile device and the Mobile Server shall support optional encryption.
- 3) Supported devices shall include (refer to Mobile App specifications for latest compatibility list):
 - a) Apple iPod Touch, iPhone, and iPad.
 - b) RIM BlackBerry smartphones.

- c) Android-compatible smartphones and tablets.
 - 4) It shall be possible to download the mobile apps in the following ways:
 - a) Over-the-air (Android and BlackBerry)
 - b) Central application store (Apple iTunes App Store, BlackBerry App World, Android Market).
 - c) Directly from the USP Mobile Server (BlackBerry and Android devices).
 - 5) Functionalities
 - a) Live monitoring, command and control of the USP.
 - b) Receive alarm push notifications from Apple Push Notification Server, or BlackBerry Enterprise Server (BES) or Google Android push server.
 - c) Alarm management (view and acknowledge alarms, video tied to alarms)
 - d) View USP hierarchy and search for entities
 - 6) Functionality for Video
 - a) View live video.
 - b) Monitor camera status.
 - c) View up to 6 video feeds on an Apple iPad.
 - d) Control PTZ functionality of a camera, including access to PTZ presets.
 - e) Save snapshots locally on the device.
 - f) View video tied to access control events, and alarms.
 - 7) Functionality for Access Control
 - a) View cardholder picture with access-related events.
 - b) Monitor door status.
 - c) Unlock door
 - d) Override unlocking or locking schedule.
 - e) Set door in maintenance mode.
 - 8) For optimum performance, provide a dedicated server for remote connectivity of all Smartphone and Tablet Apps.
8. System Functionality
- a. Unification of Video and Access Control
 - 1) The Surveillance UI shall present a true Unified Security Interface for live monitoring and reporting of the ACS and VMS. Advanced live video viewing and playback of archived video shall be available through the Surveillance UI.
 - 2) The Configuration UI shall present a true Unified Security Interface for configuration and management of the ACS and VMS.
 - 3) User shall be able to associate one or more video cameras to the following entity types, among others: areas, doors, elevators, zones, alarms, and intrusion panels.
 - 4) It shall be possible to view video associated to access control events when viewing a report.
 - 5) It shall be possible to view video associated to intrusion panel events when viewing a report.

b. Failover and Standby Functionality

- 1) The USP shall incorporate native and off-the-shelf failover options. Failover is a project requirement and must be included.
- 2) Failover Directory
 - a) The Standby Directory shall act as a replacement SSM on hot standby, ready to take over as the acting Directory in case the primary Directory fails. The failover will occur in less than 1 minute. No action from the user will be required.
 - b) The USP shall support up to five (5) Directories on standby, lined up to take over as the acting Directory in a cascading fashion.
 - c) The Standby Directory shall keep its configuration database synchronized with the primary Directory.
 - d) The Standby Directory shall support synchronization of the configuration databases using a backup and restore mechanism. The synchronization period shall be configurable from 15 minutes to 1 week.
 - e) The Standby Directory shall support real-time synchronization of the configuration databases using SQL Mirroring mechanism.
- 3) Standby Archiver.
- 4) Off-the-shelf standby/failover options (excluding the VMS Archiver) shall include
 - a) Windows Clustering
 - b) NEC ExpressCluster X LAN

c. Third Party System Integration

- 1) The USP shall support multiple approaches to integrating third party systems. These shall include: Software Development Kits (SDKs), Driver Development Kits (DDKs), REST-based Web Service SDKs, and more.
- 2) The USP architecture shall support the addition of new connectors to integrate to third party system integration such as:
 - a) Video analytics.
 - b) Third party video systems.
 - c) Third party access control systems.
 - d) Third party IP audio monitoring and communications system.

d. Alarm Management

- 1) The USP shall support the following Alarm Management functionality:
 - a) Create and modify user-defined alarms. An unrestricted number of user-defined alarms shall be supported.
 - b) Assign a time schedule or a coverage period to an alarm. An alarm shall be triggered only if it is a valid alarm for the current time period.
 - c) Set the priority level of an alarm and its reactivation threshold.
 - d) Define the time period after which the alarm is automatically acknowledged.

- e) Define the recipients of an alarm. Alarm notifications shall be routed to one or more recipients. Recipients shall be assigned a priority level which prioritizes the order of reception of an alarm.
 - f) Define the alarm broadcast mode. Alarm notifications shall be sent using either a sequential or an all-at-once broadcast mode.
 - g) Define whether to display the source of the alarm, one or more entities, or an HTML page.
 - h) Specify whether an incident report is mandatory during acknowledgment.
 - 2) The workflows to create, modify, add instructions and procedures, and acknowledge an alarm shall be consistent for access control, LPR, and video alarms.
 - 3) Alarms shall be federated allowing global alarm management across multiple independent USP, ACS, and VMS systems.
 - 4) The USP shall also support alarm notification to an email address or any device using the SMTP protocol.
 - 5) The ability to create alarm-related instructions shall be supported through the display of one or more HTML pages following an alarm event. The HTML pages shall be user-defined and can be interlinked.
 - 6) Alarm unpacking and packing shall be supported where all the entities associated to an alarm can be display in the Surveillance UI with the single click of button.
 - 7) User shall have the ability to acknowledge alarms, create an incident upon alarm acknowledgement, and put an alarm to snooze.
 - 8) The user shall be able to spontaneously trigger alarms based on something he or she sees in the system.
- e. Health Monitoring
- 1) The USP shall monitor health of the system, log health-related events, and calculate statistics.
 - 2) USP services, roles, agents, units, and client apps will trigger health events.
 - 3) It shall populate the Windows Event Log with health events related to USP roles, services, and client apps.
 - 4) A dedicated role, the Health Monitoring Role, shall perform the following actions:
 - a) Monitor health of the entire system and logs events
 - b) Calculate statistics within specified time frame (hours, days, months)
 - c) Calculates availability for clients, server, video/access/LPR units
 - 5) A Health Monitoring task and Health History reporting task shall be available for live and historical reporting.
 - 6) Health events shall be accessible via the SDK (can be used to create SNMP traps)
- f. Advanced Task Management
- 1) The USP shall support an infrastructure for managing Surveillance UI tasks used for live monitoring, day to day activities, and reporting.
 - 2) Administrators shall be able to assign tasks and lock the operator's workspace. User management of their workspace shall be limited by their assigned privileges.

- 3) Operators shall be able save their tasks as either Public Tasks or Private Tasks and in a specific partition. Public tasks shall be available to all users. Private tasks shall only be available to the owner of the task.
- 4) Operators shall be able to share their tasks by sending them to one or more online users. Recipients shall have the option to accept the sent task.

g. Reporting

- 1) The USP shall support report generation (database reporting) for access control, LPR, video, and intrusion.
- 2) Each and every report in the system shall be a USP task, each associate with its own privilege. A user shall have access to a specific report task if he or she has the appropriate privilege.
- 3) The workflows to create, modify, and run a report shall be consistent for access control, LPR, and video reports.
- 4) Reports shall be federated allowing global consolidated reporting across multiple independent USP, ACS, and VMS systems.
- 5) Access control and LPR reports shall support cardholder pictures and license plate pictures, respectively.
- 6) The USP shall support the following types of reports:
 - a) Alarm report
 - b) Video-specific reports (archive, bookmark, motion, and more)
 - c) Configuration reports (cardholders, credentials, units, access rules, readers/inputs/outputs, and more)
 - d) Activity reports (Cardholder, cardholder group, visitor, credential, door, unit, area, zone, elevator, and more)
 - e) LPR-specific reports (mobile LPR playback, hits, plate reads, reads/hits per day, reads/hits per LPR zone, and more)
 - f) Health activity and health statistics reports
 - g) Other types of reports include visitor reports, audit trail reports, incident reports, and time and attendance reports.
- 7) Generic Reports, Custom Reports and Reports Templates
 - a) A user has the option of generating generic reports from an existing list, generating reports from a list of user-defined templates, or creating a new report or report template.
 - b) The user shall be able to customize the predefined reports and save them as new report templates. There shall be no need for an external reporting tool to create custom reports and report templates. Customization options shall include setting filters, report lengths, and timeout period. The user shall also set which columns shall be visible in a report. The sorting of reported data shall be available by clicking on the appropriate column and selecting a sort order (ascending or descending).
 - c) All report templates shall be created within the Surveillance UI.
 - d) These templates can be used to generate reports on a schedule in PDF or Excel formats.
 - e) An unrestricted number of custom reports and templates shall be supported.

- 8) A reporting task layout shall consist of panes with settings (report length, filters, go and reset commands, etc.), the actual report data in column format, and a pane with display tiles. The user shall be able to drag and drop individual records in a report onto one or more display tiles to view a cardholder's picture ID, playback a video sequence, or both.
- 9) The USP shall support comprehensive data filtering for most reports based on entity type, event type, event timestamp, custom fields, and more.
- 10) The user shall be able to click on an entity within an existing report to generate additional reports from the Surveillance UI.
- 11) The USP shall support the following actions on a report: Print report, export report to a PDF/Microsoft Excel/CSV file, automatically email a report based on a schedule and a list of one or more recipients.

h. Federation: Monitoring of Remote Systems

- 1) The USP shall support the concept of a Federation for both access control and video.
- 2) Federation shall allow multiple independent USP systems (Federated systems) to be unified into a larger virtual system (the Federation). This shall facilitate global monitoring of multiple independent USP systems shall be possible.
- 3) The Federation shall be support the unification of multiple independent video surveillance systems or VMS
- 4) The Federation shall be support the unification of multiple independent access control systems or ACS.
- 5) Entities that shall be federated and monitored centrally from the Federation shall include: alarms, areas, cameras, cardholders and cardholder groups, credentials, doors, elevators, and zones (monitored inputs).
- 6) The Federation shall support Global Alarm Management from the Surveillance UI for both access control and video.
- 7) The Federation shall support Global Report Generation from the Surveillance UI for both access control and video.
- 8) The Federation shall support dozens of operator actions on remote (federated) entities from the Surveillance UI (e.g. generate a global report taking into account events from multiple independent sites, or acknowledge remote alarms).

i. Microsoft Active Directory Integration

- 1) The USP shall support a direct connection to one or multiple Microsoft Active Directory server via the Active Directory Role(s). Active Directory integration shall enable the synchronization of information from the Active Directory server to the USP.
- 2) Active Directory integration shall permit the central management of the USP users, user groups, cardholders, and cardholder groups.
- 3) The USP shall be able to connect to and synchronize data from multiple Active Directory servers (up to 10).
- 4) When enabled, Active Directory shall manage user logon to the USP client applications through the user's Windows credentials. Logon to the USP shall utilize native Active Directory password management and authentication features.

- 5) It shall be possible to synchronize the following USP entities and their information from Active Directory to the USP:
 - a) Users (username, first and last names, email address, and more)
 - b) User groups (user group name, description, and group email address)
 - c) Cardholders (first and last names, description, email, and more)
 - d) Cardholder groups (cardholder group name, description, and group email address)
 - e) Active Directory attributes to USP custom fields.
 - 6) When enabled, the addition, removal, or suspension of a user's Windows account in Active Directory shall result in the creation, deletion, or disabling of the equivalent user account in the USP.
 - 7) When enabled, the addition, removal, or suspension of a user's Windows account in Active Directory shall result in the creation, deletion, or disabling of the equivalent cardholder account in the USP.
 - 8) Supported synchronization methods for additions, modification, and deletions of synchronized entities shall include: on first logon (users only), manual synchronization, scheduled synchronization.
- j. Zone Management
- 1) The USP shall support the configuration and management of zones for input point monitoring via the Zone Manager Role. A user shall be able to add, delete, or modify a zone if he has the appropriate privileges.
 - 2) A zone shall monitor the status of one or more inputs points. Zone monitoring or input point monitoring shall be possible through the use of a controller and one or more input modules. Inputs from video cameras or video encoders shall also be accessible via a zone.
 - 3) Supervised inputs shall be supported depending on the hardware installed. Depending on the input module used, both 3-state and 4-state supervision shall be available.
 - 4) A schedule shall be defined for a zone, indicating when the zone will be monitored.
 - 5) Custom Events shall provide full flexibility in creating custom events tailored to a zone. Users shall be able to associate custom events to state changes in monitored inputs.
 - 6) The ACS shall support one or more cameras per zone. Video shall then be associated to zone state changes.
 - 7) Input/Output (IO) Linking
 - a) Zone management shall support Input/Output (IO) Linking. IO linking shall allow one or more inputs to trigger one or more outputs.
 - b) IO linking shall be available in offline mode when communication between the server and hardware is not available.
 - c) Custom Output Behaviors shall provide full flexibility in creating a variety of complex output signal patterns: Simple pulses, periodic pulses, variable duty-cycle pulses, state changes.
 - d) Through the "trigger an output" action, the ACS shall support the triggering of outputs with custom output behaviors.

k. Asset Management Integration

- 1) The USP shall integrate with third party asset management systems via the Asset Management Role.
- 2) Communications with asset management solutions shall be over an IP network (via software communications).
- 3) Functionality available via the USPs integration of asset management systems shall include the following (where supported by the asset management systems):
 - a) Synchronize asset management system assets with USP asset entities.
 - b) Live monitoring of asset-related activity events, health events, and activity (asset online, asset offline, asset moves, low battery).
 - c) Synchronization of asset management alarms with Security Center alarms.
 - d) Viewing video tied to asset-related activity and alerts within monitoring and reporting tasks.
 - e) Acknowledge alarms in Security Center which acknowledges alerts in the asset management system and vice versa.
 - f) Real-time tracking of asset locations on a per area basis.
 - g) Asset Management Inventory reporting task that details the current location (area) of an asset.
 - h) Asset Activity reporting task that provides a historical review of asset-related events and activity.
- 4) Currently supported asset management systems include:
 - a) RF Code Asset Manager

l. User and User Group Security, Partitions, and Privileges Management

- 1) The USP shall support the configuration and management of users and user groups. A user shall be able to add, delete, or modify a user or user group if he has the appropriate privileges.
- 2) Common access rights and privileges shared by multiple users shall be defined as User Groups. Individual group members shall inherit the rights and privileges from their parent user groups. User group nesting shall be allowed.
- 3) User privileges shall be extensive in the USP. All configurable entities for the USP, including access control/video/video, shall have associated privileges.
- 4) Specific entities such as cardholders, cardholder groups, and credentials shall include a more granular set of privileges such as the right to access custom fields and change the activation or profile status of an entity.
- 5) Partitions
 - a) The USP shall limit what users can view in the configuration database via security partitions (database segments). The administrator, who has all rights and privileges, shall be allowed to segment a system into multiple security partitions.
 - b) All entities that are part of the USP can be assigned to one or more partitions.

- c) A user who is given access to a specific partition shall only be able to view entities (components) within the partition he has been assigned. Access to a user is given by assigning the user as an accepted user to view the entities that are members of a particular partition.
 - d) A user or user group can be assigned administrator rights over the partition.
 - e) It shall be possible to specify user and user group privileges on a per partition basis.
 - f) Advanced logon options shall be available such as dual logon and more.
- m. Schedules and Scheduled Tasks
 - 1) Schedules
 - a) The USP shall support the configuration and management of complex schedules. A user shall be able to add, delete, or modify a schedule if he has the appropriate privileges.
 - b) The USP shall provide full flexibility and granularity in creating a schedule. The user shall be able to define a schedule in 1-minute or 15-minute increments.
 - c) Daily, weekly, ordinal, and specific schedules shall be supported.
 - 2) Schedules Tasks
 - a) The USP shall support scheduled tasks for access control, LPR, and video.
 - b) Scheduled tasks shall be executed on a user-defined schedule at a specific day and time. Recurring or periodic scheduled tasks shall also be supported.
 - c) Scheduled tasks shall support all standard actions available within the USP such as sending an email or emailing a report.
- n. Macros and Custom Scripts
 - 1) The USP shall enable users to automate and extend the functionalities of the system through the use of macros or custom scripts for access control, LPR, and video.
 - 2) Custom macros shall be created with the USP Software Development Kit (SDK).
 - 3) A macro shall be executed either automatically or manually.
 - 4) In the Surveillance UI, a macro shall be launched through hot actions.
- o. Dynamic Graphical Maps
 - 1) The USP shall support Mapping functionality for both access control and video.
 - 2) Digital maps shall be used to represent the physical location of: cameras, doors, alarms, zones (monitored inputs), and output groups.
 - 3) It shall be possible to add advanced functionality to dynamic maps using the SDK. Any functionality available through the SDK shall be available within maps.

- 4) Various actions shall be available within maps for execution through simple and intuitive double-click, right-click, or drag-and-drop functionality. Examples of actions available through maps shall include unlocking a door and acknowledging an alarm.
- 5) It shall be possible to create maps with hierarchies to facilitate navigation within and between various sites and buildings.
- 6) Mapping shall support the following drag-and-drop user actions:
 - a) Drag-and-drop a door from a map into a display tile for viewing
 - b) Drag-and-drop a camera from a map into a display tile for viewing

p. Audit Trails (Logs)

- 1) The USP shall support the generation of audit trails. Audit trails shall consist of logs of operator/administrator additions, deletions, and modifications.
- 2) Audit trails shall be generated as reports. They shall be able to track changes made within specific time periods. Querying on specific users, changes, affected entities, and time periods shall also be possible.
- 3) The ACS shall support the following actions on an audit trail report: print report, export report to a PDF/ Microsoft Excel/CSV file.

q. Incident Reports

- 1) Incident reports shall allow the security operator to create reports of incidents that occurred during a shift. Both video-related and access control-related incident reports shall be supported.
- 2) The operator shall be able to create standalone incident reports or incident reports tied to alarms.
- 3) Incident reports shall allow entities, events, and alarms to be added to support the report's conclusions.

9. Integration Toolkits

a. Software Development Kit (SDK)

- 1) A USP SDK shall be available to support custom development for the platform.
- 2) The SDK shall include functionalities specific to the embedded license plate recognition (LPR), access control (ACS), and video (VMS) systems.
- 3) Integration with external applications and databases shall be possible with the SDK.
- 4) The SDK shall enable end-users to develop new functionality (user interface, standalone applications or services) to link the USP to third party business systems and applications such as Badging Systems, Human Resources Management Systems (HRMS), and Enterprise Resource Planning (ERP) systems.
- 5) The SDK shall be based on the .NET framework.
- 6) The SDK shall support dynamic or transactional updates to USP configuration. It shall also support change notification of USP entity configuration.
- 7) The SDK shall provide an extensive list of programming functions to view and/or configure core entities such as: users and user groups, alarms, custom events, and schedules, among others.

- 8) The SDK shall provide an extensive list of programming functions to view and configure ACS and VMS.
- 9) The SDK shall provide an extensive list of programming functions to view and configure most ACS entities such as: cardholders, cardholder groups, visitors, and credentials, access rules (modify only), and custom Fields.
- 10) The SDK shall be able to receive real time events from the USP entities: users and user groups, areas, zones, cameras, video units, doors, door controllers (units), elevators, cardholders, cardholder groups, and credentials.
- 11) The SDK shall be able to query the history of events for areas, cameras, zones, alarm, cardholders, credentials, visitors, doors, query license plate read events, license plate hit events, generate a license plate hits report, generate a license plate reads report.
- 12) The SDK shall support the following alarm functions: view alarms in real time, acknowledge alarms, change priority, change recipient

10. Video Surveillance System Functionality

a. General

- 1) The VMS shall be based on a true open architecture that shall allow for use of non-proprietary workstation and server hardware, non-proprietary network infrastructure and non-proprietary storage.
- 2) The VMS shall offer a complete and scalable video surveillance solution which allows cameras to be added on a unit-by-unit basis.
- 3) The VMS shall interface with analog-to-digital video encoders and IP cameras, hereafter referred to as digital video servers (DVS). The VMS shall support DVS from various manufacturers.
- 4) All video streams supplied from IP cameras shall be digitally encoded in MPEG-4, MPEG-2, MJPEG, H.264, Wavelet or JPEG2000 compression formats and recorded simultaneously in real time.
- 5) All audio streams supplied from IP video servers shall be digitally encoded in g711 (u-law), g721, g723 or AAC compression formats and recorded simultaneously in real time.
- 6) The VMS shall support the following industry standards to interface to IP-based physical security products:
 - a) ONVIF
- 7) Each camera's bit rate, frame rate and resolution will be set independently from other cameras in the system, and altering these settings will not affect the recording and display settings of other cameras.
- 8) The VMS shall be able to use multiple CCTV keyboards to operate the entire set of cameras throughout the system, including cameras of various manufacturer's brands, including their PTZ functionalities.
- 9) The VMS shall PTZ protocols independently of the PTZ protocols supported by the video server.
- 10) The VMS shall be able to retrieve and set the current position of PTZ cameras using XYZ coordinates.
- 11) The VMS shall support a wide range of PTZ camera protocols. Consult with Genetec for current list.
- 12) The VMS shall support a wide range of CCTV keyboard protocols. Consult with Genetec for current list.
- 13) The MVS shall support wide range of joysticks. Consult with Genetec for current list.

- 14) Audio and Video storage configuration for the SSM shall either be:
 - a) Internal or external IDE/SATA organized or not in a RAID configuration;
 - b) Internal or external SCSI/iSCSI/Fiber Channel organized or not in a RAID configuration;
 - c) It shall be possible to include within the overall storage system disks located on external PCs on a LAN or WAN as well as;
 - d) Network Attached Servers (NAS) on a LAN or WAN as well as;
 - e) Storage Area Networks (SAN);

- 15) The SSM shall not limit the actual storage capacity configured per server

b. Configuration UI

- 1) The Configuration UI shall allow the administrator or users with appropriate privileges to change video configuration.
- 2) The Configuration UI shall provide the ability to change video quality, bandwidth and frame rate parameters on a per camera (stream) basis for both live and recorded video.
- 3) The Configuration UI shall provide the ability to configure brightness, contrast and hue settings for each camera on the same DVS.
- 4) The Configuration UI shall provide the capability to enable audio recording on DVS units that support audio
- 5) The Configuration UI shall provide the ability to change audio parameters, serial port and I/O configuration of individual DVS units
- 6) The Configuration UI shall provide the capability to rename all DVS units based on system topology and add descriptive information to each DVS

c. Archiving

- 1) The Archiver (role) shall use an event and timestamp database for advanced search of audio/video archives. This database shall be Microsoft SQL 2008.
- 2) The Archiver shall protect archived audio/video files and the system database against network access and non-administrative user access.
- 3) The Archiver shall digitally sign recorded video using 248-bit RSA public/private key cryptography.
- 4) The Archiver shall offer a plug and play type hardware discovery service with the following functionalities:
 - a) Automatically discover DVS units as they are attached to the network.
 - b) Discover DVS units on different network segments including the Internet and across routers with or without network address translation (NAT) capabilities.
- 5) The Archiver shall have the capacity to configure the key frame interval (I-frame) in seconds or number of frames.
- 6) The Archiver shall provide a pre-alarm and post-alarm recording option that can be set between one second and 5 minutes on a per camera basis.
- 7) Shall provide the functionality of storing of video and audio streams based on triggering events such as:
 - a) Digital motion detection
 - b) Digital input activation
 - c) Macros

- d) Through SDK application recording
- 8) The Archiver shall perform video motion detection on each individual camera based on a grid of 1320 motion detection blocks. All of the video motion detection settings are configurable on schedule. A global sensitivity threshold is available to reduce motion detection sensitivity where video signal is noisy or a lot of false hits are incurred. Video motion detection itself can be set into four different modes:
 - a) Full Screen: All 1320 blocks on screen are activated, a general threshold for the overall motion in the entire image can be set and when reached it can trigger recording and a motion event or a custom event.
 - b) Full Screen Unit: This is the same as the Full Screen but the motion detection takes place in the DVS.
 - c) Detection Zone: Six overlapping zones can be defined in the 1320 blocks on screen, each of these zones has its own threshold and when reached each one of them can trigger recording and a motion event or a custom event. Each zone triggering its own event allows for the configuration of directional motion detection events and other complex motion detection logic.
 - d) Detection Zone Unit: This is the same as the Detection Zone but the motion detection takes place in the DVS and only one zone is supported.
 - e) Disabled: No motion detection is made on this camera.
- 9) The Archiver shall be able to detect motion in video within 200 milliseconds and not only on key frames.
- 10) The Archiver shall allow for multiple recording schedules to be assigned to a single camera, each schedule shall be created with the following parameters:
 - a) Recording mode:
 - b) Continuous
 - c) On Motion/Manual
 - d) Manual
 - e) Disabled
- 11) Time coverage
 - a) All day
 - b) Specific time range(s)
 - c) Daytime or nighttime based on the times of sunrise and sunset, automatically calculated from the time of year and a geographical location. Provision shall be given to offset the calculated sunrise or sunset time by plus or minus 3 hours.
- 12) The Archiver shall allow each camera (video source) to be encoded multiple times in the same or different video formats (MPEG-4, MPEG-2, MJPEG, H.264, Wavelet or JPEG2000), limited only by the capabilities of each DVS.
- 13) Whenever multiple video streams are available from the same camera, users shall be free to use any one of them based on their assigned usage. The standard video stream usages are:
 - a) Live
 - b) Recording

- c) Remote
 - d) Low resolution
 - e) High resolution
- 14) The Archiver shall allow the video quality to vary according to predefined schedules. Such schedules shall have the same configuration flexibility as the recording schedules mentioned earlier. The video quality shall be based on, but not limited to, the following parameters:
- a) Maximum bit rate
 - b) Maximum frame rate
 - c) Image quality
 - d) Key frame interval, etc.
- 15) The Archiver shall have the ability to dynamically boost the quality of the "recording stream" (see previous bullet) based on specific events:
- a) When recording is started manually by a user
 - b) When recording is triggered by a macro, an alarm or detected motion
- 16) The Archiver shall have the capacity to communicate with DVS using 128 bits SSL encryption.
- 17) The Archiver shall have the capacity to communicate with DVS using HTTPS secure protocol.
- 18) The Archiver shall have the capacity to receive multicast UDP streams directly from the DVS.
- 19) For network topologies that restrict the DVS from sending multicast UDP streams, the Archiver shall redirect audio/video streams to active viewing clients on the network using multicast UDP.
- 20) The Archiver shall have the capacity to redirect audio/video stream to active viewing clients on the network using unicast UDP or TCP.
- 21) The Archiver shall allow the administrator to choose the disks to use for archiving and to set a maximum quota for each.
- 22) The Archiver shall allow the administrator to spread the archiving of different cameras on different disk groups (groups of disks controlled by the same controller) so that archiving could be carried out in parallel on multiple disks.
- 23) The Archiver shall have the capacity to down-sample video streams for storage saving purposes. The down-sampling options available are the following:
- a) For H.264 streams the down-sampling options are: all key frames, 1 fps, 2 sec./frame, 5 sec./frame, 10 sec./frame, 15 sec./frame, 30 sec./frame. 60 sec./frame 120 sec./frame
 - b) For MPEG-4 streams the down-sampling options are: all key frames, 1 fps, 2 sec./frame, 5 sec./frame, 10 sec./frame, 15 sec./frame, 30 sec./frame. 60 sec./frame 120 sec./frame
 - c) For MJPEG streams the down-sampling options are: 15 fps, 10 fps, 5 fps, 2 fps, 1 fps, 2 sec./frame, 5 sec./frame, 10 sec./frame, 15 sec./frame, 30 sec./frame, 60 sec./frame 120 sec./frame

- 24) The Archiver shall support DVS with edge recording capabilities and offer the following capacity:
 - a) The ability to playback at different speeds the video recorded on the DVS
 - b) The ability to offload (video trickling) on schedule, on event or manually the video recorded on the DVS to store it on the Archiver.
- d. Auxiliary Archiver
 - 1) The Auxiliary Archiver shall be used to produce redundant archives (video, events, bookmarks) for any camera in the system, on a case by case basis.
 - 2) The Auxiliary Archiver shall have the ability to record a camera on a different schedule than the Archiver.
 - 3) The Auxiliary Archiver shall have the ability to archive any of the standard video streams for archiving. The standard video stream usages are: Live, Recording, Remote, Low Resolution, and High Resolution.
- e. Standby Archiver
 - 1) The Standby Archiver shall act as a replacement Archiver role on hot standby, ready to take over the functions of the primary Archiver role. The failover will occur in less than 1 minute. No action from the user will be required.
 - 2) The Standby Archiver assigned to an Archiver role entity shall automatically provide protection for all DVS connected to that Archiver role
 - 3) The Standby Archiver shall protect the primary Archiver role against the following failures:
 - a) Server failure (hardware or software)
 - b) Storage failure (e.g. Archiver Role detects that it cannot read or write to any of its allocated disks)
 - 4) It shall be possible for a single Standby Archiver Server to act as the Standby for one or multiple Archiver roles.
 - 5) Each Standby Archiver Server shall have priority value if multiple Archiver Roles fail at the same time.
 - 6) It shall be possible for a single Archiver Server to fail over multiple Standby Archiver servers.
 - 7) It shall be possible for any Archiver role in the system to be designated as another's standby and vice-versa.
 - 8) The Standby Archiver shall have the ability to act as a Redundant Archiver.
 - 9) The Redundant Archiver shall maintain an exact copy of everything recorded by the default Archiver, i.e. audio/video archives, events and bookmarks.
 - 10) Redundancy shall be configured on a camera by camera basis.
 - 11) The Redundant Archiver shall use a multicast video stream from the DVS and shall not require an additional connection to any DVS.
- f. Video Streaming
 - 1) The Media Router Role shall be responsible for routing video and audio streams across local and wide area networks from the source (e.g. DVS) to the destination (e.g. CSA).
 - 2) The Media Router Role shall support multiple transport protocols such as unicast TCP, unicast UDP, and multicast UDP.

- 3) The Media Router shall support IGMP (Internet Group Management Protocol) to establish multicast group memberships.
 - a) IGMP v3 including SSM (Source-Specific Multicast) shall be supported.
- 4) The Media Router Role using Redirector Agents shall be responsible to redirect a stream from a source IP endpoint to a destination IP endpoint.
- 5) The Redirector Agents shall be capable of converting a stream from and to any supported transport protocols, i.e.:
 - a) Multicast UDP to Unicast TCP
 - b) Multicast UDP to Unicast UDP
 - c) Unicast TCP to Multicast UDP
 - d) Unicast UDP to Multicast UDP
- 6) It shall be possible to protect the Media Router Role against hardware or software unavailability by configuring another Media Router Role acting as a hot standby server.
- 7) Multiple Redirector Agents shall be used on large VMS installation to increase the service availability and to provide automatic load balancing.

11. Access Control System Functionality

a. General

- 1) The ACS shall be an enterprise class IP access control software solution. It shall be fully embedded within a Unified Security Platform (USP). The USP shall allow the seamless unification of the ACS with an IP video management system (VMS).
- 2) The ACS shall be highly scalable to support configurations consisting of thousands of doors with facilities spanning multiple geographic areas.
- 3) The ACS shall support an unrestricted number of logs and historical transactions (events and alarms) with the maximum allowed being limited by the amount of hard disk space available.
- 4) The ACS shall support a variety of access control functionality, including but not limited to:
 - a) Controller (Unit) management, door management, elevator management, and area management
 - b) Cardholder and cardholder group management, credential management, and access rule management
 - c) Badge printing and template creation.
 - d) Visitor Management.
 - e) People counting, area presence tracking, and mustering.

b. Access Management

- 1) The ACS shall be based on an open architecture able to support multiple access control hardware manufacturers. The ACS shall be able to integrate with multiple non-proprietary interface modules and controllers, access readers, and other third party applications.
- 2) The ACS shall be an IP enabled solution. All communication between the ACS and hardware controllers shall be based on standard TCP/IP protocol.

3) Access Manager Role

- a) The Access Manager Role shall be the server that synchronizes all access control hardware units under its control, such as door controllers and IO modules. It shall also be able to validate and log all access activities and events when the door controllers and IO modules are online.
- b) The Access Manager Role shall maintain the communication link with the hardware controllers under its control. It shall also continuously monitor whether the controllers are online or offline.
- c) Synchronization of hardware units shall be automated and transparent to users and shall occur in the background. It shall also be possible to manually synchronize units or on a schedule.
- d) The Access Manager Role shall support doors and controllers located within one or more facilities. The Access Server shall support a minimum of 200 readers per computer.

- 4) The Access Server shall store all access events associated with the doors, areas, hardware zones (hardware input points), elevators, and controllers under its direct control.

c. Global Cardholder Management

- 1) The ACS shall support global cardholder management and synchronization between a central independent site and remote independent site, all of which can have their own Directory and databases.
- 2) It shall be possible to synchronize the following entities and their configuration data:
 - a) Cardholders (incl. custom fields)
 - b) Cardholder groups
 - c) Credentials
 - d) Badge templates
- 3) Cardholders and other synchronized entities can be added centrally and synchronized to remote sites for central cardholder management.
- 4) Cardholders and other synchronized entities can be added at remote sites and synchronized to the central site and other remote sites.
- 5) Shall support a single card per cardholder across all of an organizations sites.
- 6) Manual and scheduled synchronization shall be supported.

d. Hardware Compatibility List

- 1) The ACS shall have an open architecture that supports the integration of third party IP-based door controllers and IO modules. The ACS shall simultaneously support mixed configurations of access control hardware from multiple vendors.
- 2) The ACS shall support multiple types of hardware devices: Single-reader controllers, 2-reader controllers, 1- to 64-reader controllers, integrated readers and door controllers, Power-over-Ethernet (PoE) enabled door controllers.
- 3) The ACS shall support most industry standard card readers that output card data using the Wiegand protocol and Clock-and-Data.

- 4) The ACS shall support the following IP-enabled controllers. For a description of the capabilities of the controller, refer to the specific controller's A&E specification.
 - 5) Genetec Synergis Master Controller, which shall support the following downstream interface modules:
 - a) VertX V100 reader interface module
 - b) VertX V200 input module
 - c) VertX V300 output module
 - d) Mercury MR52 reader interface module
 - e) Mercury MR16OUT output module
 - f) Mercury MR16IN input module
 - 6) HID Corporation
 - a) VertX V2000 reader interface/network gateway
 - b) iCLASS EdgeReader integrated reader and controller (PoE)
 - c) iCLASS EdgePlus door controller (PoE)
 - d) VertX V1000 network gateway
 - e) VertX V100 reader interface module
 - f) VertX V200 input module
 - g) VertX V300 output module
- e. Software Functionality
- 1) Seamless Unification with IP Video Management System (VMS)
 - a) Through the USP (Unified Security Platform), the ACS shall support integration with an IP Video Surveillance System or MVS. Integration with an IP video surveillance system shall permit the user to view live and recorded video.
 - b) User shall be able to associate one or more video cameras to the following entity types, among others: doors, elevator, and hardware zone (input points).
 - c) The Surveillance UI shall present a true Unified Security Interface for access control and video surveillance. Advanced live video viewing and playback of archived video shall be available through the Surveillance UI.
 - d) It shall be possible to view video associated to access control events when viewing a report.
 - 2) Controller (Unit) Management
 - a) The ACS shall support the discovery, configuration, and management of IP enabled controllers and IO modules (hardware units). A user shall be permitted to add, delete, or modify a controller if he has the appropriate privileges.
 - b) The ACS shall support automatic unit discovery. The user shall set the settings for discovery ports and types of unit discovery and the ACS shall automatically detect all connected devices.
 - c) Unit Swap Utility. The ACS shall support a unit swap utility to swap out an existing controller with a new controller. The unit swap utility shall avoid the reprogramming of the system whenever a unit is replaced. All logs and events from the old unit are maintained.

3) Cardholder And Cardholder Group Management

- a) The ACS shall support the configuration and management of cardholders and cardholder groups. A user shall be able to add, delete, or modify a cardholder or cardholder group if he has the appropriate privileges.
- b) Custom fields shall be supported for both cardholders and cardholder groups.
- c) The ACS shall permit the following activation/expiration options for a cardholder's profile: delayed activation of a cardholder's profile, expiration based on the date of first use of credential, or expiration on a user-defined date
- d) It shall be possible to associate a picture to the cardholder's profile. The picture shall be imported from a file, captured with a digital camera, or captured from a video surveillance camera. When a cardholder event occurs, the picture of the cardholder shall be displayed in the Surveillance UI. The ACS shall support multiple standard picture formats.
- e) Cardholder groups shall enable the grouping of cardholders to facilitate mass changes to system settings. It shall be possible to assign cardholder groups to access rules, thus avoiding the assignment of one cardholder at a time.

4) Credential Management

- a) The ACS shall support the configuration and management of credentials, e.g. access cards and keypad PIN numbers. A user shall be able to add, delete, or modify a credential if he has the appropriate privileges.
- b) User shall be able to add Custom Fields (user-defined fields) to credentials. Creating a new credential shall be accomplished either manually or automatically.
- c) Automatic creation shall allow the user to create a credential entity by presenting a credential to a selected reader. The ACS shall read the card data and associate it to the credential entity. It shall be possible to automatically enroll any card format (128 bits or less).
- d) The ACS shall support multiple credentials per cardholder, without necessitating duplicate cardholder information. The ACS shall automatically detect and prevent attempts to register an already-registered credential.
- e) Batch enrollment of credentials shall be supported.

5) Custom Card Formats

- a) A custom card format feature shall allow the administrator to add additional custom card formats using an intuitive tool within the Configuration UI. The custom card format tool shall be flexible in the following ways:
 - Once enrolled, new custom card formats shall appear in the card format lists for manual card enrollment.
 - An unrestricted number of additional custom card formats can be added.
- b) The administrator shall be able to set the following options when defining a new format:

- 1) The order in which card fields appear in the user interface or CSA.
 - 2) Whether a field is hidden from, or visible to an operator.
 - 3) Whether a field is read only or modifiable by an operator.
 - 4) Complex parity checking schemes.
 - 5) The order and location of a field's data. Location can be defined on a bit-by-bit basis
- 6) Badge Designer
- a) The Badge designer shall be included in the bid.
 - b) The badge designer shall allow the creation of badge templates that define the content and presentation format of a cardholder badge to be printed.
 - c) Badge production shall consist of selecting the credential, the badge template, and clicking print.
 - d) Batch printing of cards shall be available.
 - e) The contents of a badge template can include: cardholder's first name, last name, picture, custom fields, bitmap graphics, lines, ovals, rectangles, dynamic text labels linked to custom fields and static text labels, barcodes (Interleaved 2 of 5, Extended Code 39).
 - f) Copy and paste of badge template objects shall be available.
 - g) It shall be possible to set the border thickness, border color, fill color of badge objects (content), and the color of text labels.
 - h) Settings such as object transparency, text orientation, and auto-sizing of text shall be available or transparent to the user.
 - i) Supported badge formats shall be (portrait and landscape): CR70 (2.875" x 2.125"), CR80 (3.37" x 2.125"), CR90 (3.63" x 2.37"), CR100 (3.88" x 2.63"), and custom card sizes.
 - j) Dual-sided badges shall be supported.
 - k) A badge template import and export function shall be available to allow the sharing of badge templates between distinct or independent ACS.
- 7) Door Management
- a) The ACS shall support the configuration and management of doors. A user shall be able to add, delete, or modify a door if he has the appropriate privileges.
 - b) The ACS shall permit multiple access rules to be associated to a door.
 - c) The ACS shall support the following forms of authentication: Card Only, Card or Keypad (PIN), or Card and Keypad (PIN). It shall be possible to define a schedule for when Card Only or Card and Keypad authentication modes shall be required.
 - d) Extended Grant Time. It shall be possible to set an extended grant time on a per-door basis (in addition to the standard grant time). Cardholder properties shall include the option of using the extended grant time. When flagged cardholders are granted access, the door shall be unlocked for the duration of the extended grant time instead of the standard grant time.
 - e) The ACS shall support doors configured solely with a lock, a REX, and a door contact but without readers.
 - f) Implementation of a readerless door shall be possible with the use of standard access hardware IO modules. External hardware such as timers shall not be required.
 - g) Unlocking schedules shall be programmable for readerless doors.

- h) Standard door activity reports shall also be possible with readerless doors.
 - i) Unlocking schedules and exceptions to unlocking schedules shall be associated to a door. An unlocking schedule shall determine when a door should be automatically unlocked. The ACS shall also support the use of a specific offline unlocking schedule. Exceptions to unlocking schedules shall be used to define time periods during which unlocking schedules shall not be applied, e.g. during statutory holidays.
 - j) The ACS shall support one or more cameras per door. Video shall then be associated to door access events, e.g. access grant or access denied.
- 8) Elevator Management
- a) The ACS shall support the configuration and management of elevators. A user shall be able to add, delete, or modify an elevator if he has the appropriate privileges.
 - b) The ACS shall be able to control access to specific floors using a reader within the elevator cab. Control shall be available through the use of a controller with an interface to a reader and to multiple output modules with relays.
 - c) Elevator floor selections shall be tracked using a controller with an interface to multiple input modules. Floor tracking shall be available within an elevator activity report.
 - d) The elevator control module shall continue to function in offline mode should communication between the ACS and the controller fail.
 - e) The ACS shall support one or more cameras per elevator cab. Video shall then be associated to elevator access events, e.g. access grant or access denied.
- 9) Visitor Management
- a) Visitor Management module shall provided.
 - b) The ACS shall support the configuration and management of visitors. A user shall be able to enroll or remove a visitor if he has the appropriate privileges. The ACS shall support check-in and check-out of visitors from the Surveillance UI.
 - c) A visitor check-in wizard shall facilitate the enrollment process, allowing a user to specify the visitor's specific information.
 - d) The ACS shall permit the following credential options during visitor check-in:
 - Use an existing credential
 - Automatically create a new credential
 - Manually create a new credential
 - e) The ACS shall support the creation of a pool of visitor credentials in advance. Existing visitor credentials shall be assigned to visitors during the check-in process.

- f) The ACS shall permit cardholder groups to be designated as "available for visitors". Users shall be able to define the access privileges for the cardholder groups (visitor cardholder groups) in advance. During visitor check-in, the user shall select the visitor cardholder group to associate with a visitor. All of the visitor cardholder group access privileges shall be automatically transferred to the visitor. This feature shall permit the creation of multiple types of visitor groups and associated privileges (for contractors, VIPs, day visitors, etc.). Visitors added to visitor cardholder group in the Surveillance UI shall be automatically updated in the Configuration UI cardholder group screen.
 - g) A visitor's profile shall support the real-time modification of visitor information after a visitor has checked-in.
 - h) The ACS shall also provide comprehensive visitor tracking and visitor reporting. Through the real-time tracking feature, the ACS shall generate a real-time and historical visitor activity listing in the Surveillance UI. The ACS shall also generate visitor-specific reports that provide comprehensive listings of visitors as well as full details on their movement.
 - i) It shall be possible to exempt a visitor from any antipassback rules in effect.
 - j) The operator shall be able to print visitor badges during the check-in process. The printing of both paper badges (visitor without an assigned credential) and actual credentials shall be supported.
 - k) Visitor management and reporting shall be available through the Web Client as well.
 - l) It shall be possible to locate a visitor's information or profile by swiping the visitor's credential (card) at a USB reader.
- 10) People Counting & Area Presence Tracking (Mustering)
- a) The ACS shall support people counting (or area presence tracking). The ACS shall be able to monitor and report the number of cardholders in an area in real-time and for all areas. Monitoring shall be based on the entire access control infrastructure, for both local areas and those in remote geographic locations. People Counting can also be used to perform mustering.
 - b) The ACS shall report area presence counts in the Surveillance UI. Area presence tracks shall dynamically track the total number of cardholders in an area. Displayed data shall be updated dynamically.
 - c) The ACS shall be able to generate an area presence report listing the cardholders located in one or more areas, accessible through the Surveillance UI. It shall be possible to filter the report by area and time period. The report shall also include activity from sub-areas (nested areas).
 - d) Through people counting, the ACS shall be able to generate First Person In and Last Person Out events. The First Person In event shall detect when the first cardholder enters an empty area. The Last Person Out event shall detect when the last cardholder leaves an area. It shall be possible to trigger actions from both events such as sending a message or triggering an alarm.

11) Custom Fields (User-Defined Fields)

- a) The ACS shall permit the creation of custom fields. Up to 1,000 custom fields shall be supported.
- b) Custom fields shall be supported for the following entities: Cardholders, Cardholder groups, Credentials, and Visitors.
- c) Supported custom fields include: Text, Integers, Decimal Numbers, Dates, Boolean, and Images (graphics).
- d) User shall be able to define a default value for a custom field.
- e) The creation of new custom field types shall be possible. New custom field types shall be based on the standard custom fields supported. They shall support user-defined values from which an operator must make a selection.
- f) Administrators have the ability to define which users can view and modify specific custom fields. This shall limit the access to custom field data to users with pre-defined privileges. The ACS shall support querying and report generation using custom fields.
- g) Custom fields can be grouped and ordered within these groups as defined by the user.
- h) Values for custom fields can be imported using the Import Tool.

12) Import Tool

- a) The ACS shall support an integrated Import Tool to facilitate the import of existing cardholder and credential data. The import of data shall be through the use of the CSV file format. The tool shall be available from the Configuration UI.
- b) The Import Tool shall also support the ability to manually import data that has been exported from a third party database if it is in CSV format.
- c) The import tool shall permit the import of the following data:
 - Cardholder name, descriptions, picture, email, and status
 - Cardholder group information
 - Credential name, status, format, and card number (including credentials with custom formats)
 - Partition information
 - Custom fields
- d) Full flexibility in selecting the fields import during an import session shall be available.
- e) The option to use a custom and unique cardholder key shall be specified during the import process to ensure that cardholders with duplicate names will not have their data overwritten. Cardholder key generation shall be automated. The end user shall have the option to select which fields will be used to create this unique key, e.g. credential number, custom fields, cardholder name.
- f) The ACS shall also support re-importing a CSV file containing new information to update existing information in the ACS database. Re-importing shall enable bulk amendments to existing access control data.

13) Interrogation Room Recording Management

- a) Investigators can initiate interrogation recording by swiping their access credential card over a reader. A light is automatically triggered by a system output to indicate that recording has begun, and confirm to the interrogator that the system is live. All recorded video and audio is encrypted, and securely archived. Interrogations are bookmarked in the system, and can be reviewed from a Security Center by authorized users.
- b) The interrogation system shall be turn-key with the ability to swipe their access card to start video recordings, officers can conduct interrogations without additional assistance to operate the surveillance system, and can review their interviews from the security center.
- c) Provide the following for a complete and operational integrated interrogation room recording management system:
- d) Audio equipment
- e) Readers
- f) Add on software
- g) Cameras and encoders with audio capabilities
- h) Red light indicator.

14) Web Client

- a) The Web Client shall allow users to perform configuration, management, and reporting activities of the ACS.
- b) The Web Client shall be accessible through Microsoft Internet Explorer. It shall be a truly thin client. It shall not require the download of any ACS-specific files or executable on the client workstation.
- c) Functionality available through the web client includes:
 - Configuration and management of cardholders and cardholder groups
 - Configuration and management of credentials
 - Configuration and management of access rules
 - Badge printing over the network
 - Assignment of access rules to doors and areas
 - Visitor management including visitor check-in and check-out and reporting
 - Advanced reporting

12. LPR-Based access control

a. AutoVu LPR based access control system.

- 1) Provide a complete and operational LPR access control system part of the Unified Security Platform for operation of parking gates which includes but is not limited to the following:
 - a) AutoVu SC Module
 - b) SharpV (includes the SC AutoVu fixed LPR camera and connections)
 - c) SMA on SC fixed LPR camera connection
 - d) Interface with owner furnished gates

b. BackOffice

- 1) The BackOffice Platform (BO) shall be an enterprise class IP-enabled security software solution
- 2) Functionalities available with the BO shall include:
 - a) Configuration of embedded LPR systems
 - b) Live event monitoring
 - c) Alarm management
 - d) Reporting, including creating custom report templates and incident reports
 - e) Global monitoring, reporting, and alarm management of remote systems spread across multiple facilities and geographic areas
 - f) Microsoft Active Directory integration for synchronizing BO user accounts
 - g) Integration to third-party systems and databases via plug-ins (ticketing systems, HRMS, etc.)
 - h) Dynamic graphical map viewing
- 3) Licensing
 - a) A single central license shall be applied centrally on the configuration server
 - b) There shall be no requirement to apply a license at every server computer or client workstation
 - c) Based on selected options, one or more embedded systems shall be enabled or disabled.

c. Hardware and Software Requirements

- 1) The BO and embedded systems shall be designed to run on a standard PC-based platform loaded with a Windows operating system
- 2) The server software module (SSM) shall be compatible with both 32-bit and 64-bit operating systems including Windows Vista, Windows XP, Windows 7, Windows Server 2003, and Windows Server 2008
- 3) The client modules shall run on Windows XP or Windows Vista or Windows 7
- 4) The core client/server software shall be built in its entirety using the Microsoft .NET software framework and the C# (C-Sharp) programming language
- 5) The BO database server(s) shall be built on Microsoft SQL Server 2008, including SQL Server 2008 Express Edition
- 6) The BO shall use the latest user interface (UI) development and programming technologies such as Microsoft WPF (Windows Presentation Foundation), the XAML markup language, Direct3D, and .NET software framework

d. Overview

- 1) The BO shall be based on a client/server model. The BO shall consist of a standard Server Software Module (SSM) and Client Software Applications (CSA)
- 2) The BO shall be an IP-enabled solution. All communication between the SSM and CSA shall be based on standard TCP/IP protocol and shall use encryption when enabled by the administrator

- 3) The SSM shall be a Windows service that can be configured to start when the operating system is booted and run in the background. The SSM shall automatically launch at computer startup, irrespective of whether a user is logged onto the machine or not
- 4) Users shall be able to deploy the SSM on a single server or across several servers for a distributed architecture. The BO shall not be restricted in the number of SSM deployed
- 5) The BO shall protect against potential database server failure and continue to run through standard off-the-shelf solutions
- 6) The BO shall support one thousand instances of CSA connected at the same time. An unrestricted number of CSA, however, can be installed at any time
- 7) The BO shall support an unrestricted number of logs and historical transactions (events and alarms) with the maximum allowed being limited by the amount of hard disk space available.

e. Roles-Based Architecture

- 1) The BO shall consist of a role-based architecture, with each SSM hosting one or more roles
- 2) Each role shall execute a specific set of tasks related to either core system or license plate recognition (LPR). Installation shall be streamlined through the BO's abilities to allow administrators to:
 - a) Deploy one or several SSM across the network prior to activating roles
 - b) Activate and deactivate roles as needed on each and every SSM
 - c) Centralize role configuration and management
 - d) Support for remote configuration
 - e) Move roles over from one SSM to another
- 3) Each role, where needed, shall have its own database to store events and role-specific configuration information

f. Standard Roles

- 1) Directory Role
 - a) The Directory Role shall manage the central database that contains all the system information and component configuration of the BO.
 - b) The Directory Role shall authenticate users and give access to the BO based on predefined user access rights or privileges, and security partition settings
 - c) The Directory Role shall support the configuration/management of the following components:
 - Security Partitions, users and user groups
 - LPR units and cameras
 - Hotlists and permit lists
 - Alarms schedules, scheduled tasks
 - Custom events
 - Macros or custom scripts
- 2) License Plate Recognition (LPR) Role shall be responsible for synchronizing fixed LPR units (cameras) and mobile LPR applications under its control. The LPR Role shall also be able to log all LPR activities and events

g. Optional Roles

- 1) Active Directory Role shall be responsible for synchronizing user accounts and cardholder accounts with a Microsoft Active Directory server
- 2) Plug-in Manager Role shall be responsible for the communications between the BO and third party systems such as ticketing systems, HRMS, etc.
- 3) Point-of-Sale (POS) Manager Role shall be responsible for integrating the BO with third party POS systems and logging transactions
- 4) Web SDK Role shall be responsible for connecting the BO to any application or interface developed with the Web SDK

h. Server Monitoring Service (Watchdog)

- 1) The BO shall include a Server Monitoring Service that continuously monitors the state of the Server Software Module (SSM) service
- 2) The Server Monitoring Service shall be a Windows service that automatically launches at system startup, irrespective of whether a user is logged into his account or not
- 3) The Server Monitoring Service shall be installed on all PCs/servers running an SSM. In the event of a malfunction or failure, the Server Monitoring Service shall restart the failed service. As a last resort, the Server Monitoring Service shall reboot the server/PC should it be unable to restart the service

i. Overview

- 1) The Client Software Applications (CSA) shall provide the user interface for BO configuration and monitoring over any network, accessible locally or from a remote connection.
- 2) The CSA shall consist of the Configuration UI for system configuration and the Surveillance UI for monitoring. The CSA shall be Windows based and provide an easy-to-use graphical user interface (UI).
- 3) The Server Administrator shall be used to configure the server database(s). It shall be web-based and accessible locally on the SSM or across the network.
- 4) The CSA shall seamlessly merge license plate recognition (LPR) and video functionalities within the same user application.
- 5) The BO shall use the latest user interface (UI) development and programming technologies such as Microsoft WPF (Windows Presentation Foundation), the XAML markup language, and the .NET software framework.
- 6) All applications shall provide an authentication mechanism, which verifies the validity of the user. As such, the administrator (who has all rights and privileges) can define specific access rights and privileges for each user in the system.
- 7) Logging on to a CSA shall be done either through locally stored BO user accounts and passwords or using the operators Windows credentials when Active Directory integration is enabled.
- 8) When integrated with Microsoft's Active Directory, the CSA and BO shall authenticate users using their Windows credentials. As such, the BO will benefit from Active Directory password authentication and strong security features.
- 9) The CSA shall support multiple languages, including but not limited to the following: English, French, Arabic, Dutch, German, Italian, Japanese, Korean, Persian (Farsi), Simplified Chinese, and Spanish.

j. Configuration User Interface (UI)

- 1) The Configuration UI application shall allow the administrator or users with appropriate privileges to change the system configuration. The Configuration UI shall provide decentralized configuration and administration of the BO system from anywhere on the IP network.
- 2) The configuration of all embedded LPR systems shall be accessible via the Configuration UI.
- 3) The Configuration UI shall have a home page with single-click access to the following functionality:
 - a) All BO entities such as alarms, schedules, users and user groups, and more.
 - b) Three views available to users (Logical, Role, Network).
 - c) Common tools for troubleshooting and configuration.
 - d) List of recently accessed entities.
- 4) The Configuration UI shall present three views to the user:
 - a) Logical View with access to BO entities such as fixed LPR units and mobile LPR applications.
 - b) Role View with access to all the roles enabled in the BO.
- 5) The Configuration UI shall include a static reporting interface to:
 - a) View historical events based on entity activity. This reporting interface shall be in addition to the monitoring and reporting interface provided by the Surveillance UI.
 - b) View audit trails that show a history of user / administrator changes to an entity.
- 6) Common entities such as users, schedules, alarms and many more, can be reused by all embedded LPR systems.

k. Surveillance User Interface (UI)

- 1) The Surveillance UI shall provide a graphical user interface to control and monitor the BO over any IP network. It shall allow administrators and operators with appropriate privileges to monitor their BackOffice Platform, run reports, and manage alarms.
- 2) The Surveillance UI shall support many of the latest UI concepts to enhance usability and operator efficiency such as
 - a) An OS-like (operating system) Start Menu.
 - b) Dynamically adaptive interface that adjusts in real-time to what the operator is doing.
 - c) Task-oriented approach to operator activities where each type of activity (surveillance, reports, and more) is an operator task.
 - d) A taskbar that provides access to all individual tasks.
 - e) A dynamic dashboard loaded with entity-specific widgets.
 - f) Use of transparent overlays that can display multiple data in a seamless fashion.
 - g) Display tile menus and quick commands.
 - h) Consolidated and consistent workflows.

- i) Tile menus and quick commands easily accessible within every display tile of the user workspace.
 - j) Single click functionality for reporting and tracking. The Surveillance UI shall support single-click reporting on LPR events as well as single-click tracking of LPR entities. Single-click reporting or tracking shall create a new task with the selected entities to report on or to track.
- 3) Surveillance UI Start Menu and Tasks
 - a) The Surveillance UI shall be task-oriented.
 - b) Tasks shall be accessible via the Surveillance CSA's Start Menu and sub-menus.
 - c) Newly created tasks shall be accessible via the Surveillance UI taskbar.
 - d) An operator shall be able to launch a specific task only if he has the appropriate privileges.
 - e) The Start Menu content shall be customizable through the use of privileges to hide tasks an operator should not have access to. Further to that, editing a BO XML file to add new tasks on the fly shall be possible.
- 4) Dynamically Adaptive UI, Dashboard, and Widgets
 - a) The Surveillance UI shall dynamically adapt to what the operator is doing. This shall be accomplished through the concept of widgets that are grouped in the Surveillance UI dashboard.
 - b) Widgets are mini-applications or mini-groupings in the Surveillance UI dashboard that let you perform common tasks and provide you with fast access to information and actions.
 - c) With a single click on an entity the specific widgets associated to that entity appear and other non-relevant widgets disappear dynamically (instantly).
- 5) Each task within the surveillance UI shall consist of one or more of the following items:
 - a) Event list.
 - b) Logical tree. LPR units shall be grouped under Areas in a hierarchical fashion.
 - c) Entities list of all entities being tracked.
 - d) Display tiles with various patterns (1 x 1, 2 x 2, and more).
 - e) Dashboard with widgets.
- 6) The Surveillance UI shall support multiple event lists and display tile patterns, including:
 - a) Event/alarm list layout only
 - b) Display tile layout only
 - c) Display tile and alarm/event list combination

- 7) User workspace customization
 - a) The user shall have full control over the user workspace through a variety of user-selectable customization options. Administrators shall also be able to limit what users and operators can modify in their workspace through privileges.
 - b) Once customized, the user shall be able to save his workspace.
 - c) The user workspace shall be accessible by a specific user from any client application on the network.
 - d) Display tile patterns shall be customizable.
 - e) Event or alarm lists shall span anywhere from a portion of the screen up to the entire screen, and shall be resizable by the user. The length of event or alarm lists shall be user-defined. Scroll bars shall enable the user to navigate through lengthy lists of events and alarms.
 - f) The Surveillance UI shall support multiple display tile patterns, e.g., 1 display tile (1x1 matrix), 16 tiles (8x8 matrix), and multiple additional variations.
 - g) The Surveillance UI shall support as many monitors as the PC video adapters and Windows Operating System are capable of accepting.
 - h) Additional customization options include: show/hide window panes, show/hide menus/toolbars, show/hide overlaid information on video, resize different window panes, select tile display pattern on a per task basis.
- 8) The Surveillance UI shall provide an interface to support the following tasks and activities common to access control, LPR, and video:
 - a) Monitoring the events from the live security system
 - b) Generating reports, including custom reports.
 - c) Monitoring and acknowledging alarms.
 - d) Creating and editing incidents and generating incident reports.
 - e) Displaying dynamic graphical maps. Executing actions from a dynamic graphical map and floor plan.
 - f) Management and execution of hot actions and macros.
- 9) The Surveillance UI shall provide an interface to support the following LPR tasks and capabilities:
 - a) Monitoring and management of LPR events and alarms.
 - b) Viewing of license plate picture(s) and context images.
 - c) Viewing of license plate data (e.g., license plate reads)
 - d) Verification of LPR data against live and recorded video.
- 10) Tracking
 - a) The BO shall permit the user to select multiple entities to monitor from the Surveillance UI by adding the entities one by one to the tracking list.
 - b) The Surveillance UI shall provide the option to filter which events shall be displayed in the display tile layout and/or event list layout.
 - c) It shall be possible to lock a Surveillance UI display tile so that it only tracks the activity of a specific entity

- d) The user shall be able to drag and drop an event from an event list (or an alarm from an alarm list) onto a display tile to view a license plate read

11) Display Tile Packing and Unpacking

- a) The Surveillance UI shall support single-click unpacking and packing for LPR hits and LPR reads.
- b) Packing and unpacking of entities shall allow operators to quickly obtain additional information and camera views of a specific entity.
- c) Packing will return the display to the original tile pattern.

I. Server Administrator

- 1) The Server Administrator shall be used to configure the SSM, as well as the Directory Role (main configuration) and its database(s), apply the license, and more.
- 2) The Server Administrator shall be a web-based application. Through the Server Administrator, it shall be possible to access the SSM across the network or locally on the server.
- 3) Access to the Server Administrator shall be protected via login name and password, as well as encrypted communications.
- 4) The Server Administrator shall allow the administrator (user) to perform the following functions:
 - a) Manage the system license.
 - b) Configure the database(s) and database server for the Directory Role.
 - c) Activate/Deactivate the Directory Role.
 - d) Manually back up the Directory Role database(s) and/or restore the server database(s), as well as configure scheduled backups of the databases.
 - e) Define the client-to-server communications security settings.
 - f) Configure the network communications hardware, including connection addresses and ports.
 - g) Configure system SMTP settings (mail server and port).
 - h) Configure event and alarm history storage options.

m. Third-Party System Integration

- 1) The BO shall support multiple approaches to integrating third-party systems. These shall include: Software Development Kits (SDKs), Driver Development Kits (DDKs), Web-Based SDKs, and more.
- 2) The BO architecture shall support the addition of new connectors to integrate to third-party system integration such as:
 - a) Point-of-sale (POS) systems.
 - b) Human resource management systems (HRMS).

n. Alarm Management

- 1) The BO shall support the following Alarm Management functionality:
 - a) Create and modify user-defined alarms. An unrestricted number of user-defined alarms shall be supported.

- b) Assign a time schedule or a coverage period to an alarm. An alarm shall be triggered only if it is a valid alarm for the current time period.
 - c) Set the priority level of an alarm and its reactivation threshold.
 - d) Define the time period after which the alarm is automatically acknowledged.
 - e) Define the recipients of an alarm. Alarm notifications shall be routed to one or more recipients. Recipients shall be assigned a priority level which prioritizes the order of reception of an alarm.
 - f) Define the alarm broadcast mode. Alarm notifications shall be sent using either a sequential or an all-at-once broadcast mode.
 - g) Define whether to display the source of the alarm, one or more entities, or an HTML page.
 - h) Specify whether an incident report is mandatory during acknowledgment.
 - 2) The BO shall also support alarm notification to an email address or any device using the SMTP protocol.
 - 3) The ability to create alarm-related instructions shall be supported through the display of one or more HTML pages following an alarm event. The HTML pages shall be user-defined and can be interlinked.
 - 4) Alarm unpacking and packing shall be supported where all the entities associated to an alarm can be display in the Surveillance UI with the single click of button.
 - 5) User shall have the ability to acknowledge alarms, create an incident upon alarm acknowledgement, and put an alarm to snooze.
 - 6) The user shall be able to spontaneously trigger alarms based on something he or she sees in the system.
- o. Advanced Task Management
- 1) The BO shall support an infrastructure for managing Surveillance UI tasks used for live monitoring, day to day activities, and reporting.
 - 2) Administrators shall be able to assign tasks and lock the operator's workspace. User management of their workspace shall be limited by their assigned privileges.
 - 3) Operators shall be able save their tasks as either Public Tasks or Private Tasks and in a specific partition. Public tasks shall be available to all users. Private tasks shall only be available to the owner of the task.
 - 4) Operators shall be able to share their tasks by sending them to one or more online users. Recipients shall have the option to accept the sent task.
- p. Reporting
- 1) The BO shall support report generation (database reporting) for access control, LPR, video, and intrusion.
 - 2) Each and every report in the system shall be a BO task, each associate with its own privilege. A user shall have access to a specific report task if he or she has the appropriate privilege.
 - 3) The BO shall support the following types of reports:
 - a) Alarm report
 - b) LPR-specific reports (mobile LPR playback, hits, plate reads, reads/hits per day, reads/hits per LPR zone, and more)

- 4) Generic Reports, Custom Reports and Reports Templates
 - a) A user has the option of generating generic reports from an existing list, generating reports from a list of user-defined templates, or creating a new report or report template.
 - b) The BO can optionally be configured to create hit reports for specific zones or county, and have those reports automatically sent to the different individuals responsible for each particular zone or county
 - c) The user shall be able to customize the predefined reports and save them as new report templates. There shall be no need for an external reporting tool to create custom reports and report templates. Customization options shall include setting filters, report lengths, and timeout period. The user shall also set which columns shall be visible in a report. The sorting of reported data shall be available by clicking on the appropriate column and selecting a sort order (ascending or descending).
 - d) All report templates shall be created within the Surveillance UI.
 - e) These templates can be used to generate reports on a schedule in PDF or Excel formats.
 - f) An unrestricted number of custom reports and templates shall be supported.
 - 5) A reporting task layout shall consist of panes with settings (report length, filters, go and reset commands, etc.), the actual report data in column format, and a pane with display tiles. The user shall be able to drag and drop individual records in a report onto one or more display tiles to view the event.
 - 6) The BO shall support comprehensive data filtering for most reports based on entity type, event type, event timestamp, custom fields, and more.
 - 7) The user shall be able to click on an entity within an existing report to generate additional reports from the Surveillance UI.
 - 8) The BO shall support the following actions on a report: Print report, export report to a PDF/Microsoft Excel/CSV file, automatically email a report based on a schedule and a list of one or more recipients.
- q. Microsoft Active Directory Integration
- 1) The BO shall support a direct connection to a Microsoft Active Directory server via the Active Directory Role. Active Directory integration shall enable the synchronization of information from the Active Directory server to the BO.
 - 2) Active Directory integration shall permit the central management of the BO users and user groups.
 - 3) When enabled, Active Directory shall manage user logon to the BO client applications through the user's Windows credentials.
 - 4) Logon to the BO shall utilize native Active Directory password management and authentication features.
 - 5) It shall be possible to synchronize the following BO entities and their information from Active Directory to the BO:
 - a) Users (username, first and last names, email address, and more)
 - b) User groups (user group name, description, and group email address)
 - 6) When enabled, the addition, removal, or suspension of a user's Windows account in Active Directory shall result in the creation, deletion, or disabling of the equivalent user account in the BO.

- 7) System Supported synchronization methods for additions, modification, and deletions of synchronized entities shall include: on first logon (users only), manual synchronization, and scheduled synchronization.
- r. User and User Group Security, Partitions, and Privileges Management
- 1) The BO shall support the configuration and management of users and user groups. A user shall be able to add, delete, or modify a user or user group if he has the appropriate privileges.
 - 2) Common access rights and privileges shared by multiple users shall be defined as User Groups. Individual group members shall inherit the rights and privileges from their parent user groups. User group nesting shall be allowed.
 - 3) User privileges shall be extensive in the BO. All configurable entities for the BO shall have associated privileges.
 - 4) Partitions
 - a) The BO shall limit what users can view in the configuration database via security partitions (database segments). The administrator, who has all rights and privileges, shall be allowed to segment a system into multiple security partitions.
 - b) All entities that are part of the BO can be assigned to one or more partitions.
 - c) A user who is given access to a specific partition shall only be able to view entities (components) within the partition he has been assigned. Access to a user is given by assigning the user as an accepted user to view the entities that are members of a particular partition.
 - d) A user or user group can be assigned administrator rights over the partition.
 - 5) It shall be possible to specify user and user group privileges on a per partition basis.
 - 6) Advanced logon options shall be available such as dual logon and more.
- s. Event/Action Management
- 1) The BO shall support the configuration and management of events for LPR. A user shall be able to add, delete, or modify an action tied to an event if he has the appropriate privileges.
 - 2) The BO shall receive and log the following events:
 - a) System-wide events
 - b) Application events (clients and servers)
 - c) LPR events (reads, hits)
 - d) Alarm events
 - 3) The BO shall allow the creation of custom events.
 - 4) The BO shall have the capability to execute an action in response to an LPR event.
 - 5) The BO shall allow a schedule to be associated with an action. The action shall be executed only if it is an appropriate action for the current time period.

- t. Schedules and Scheduled Tasks
 - 1) Schedules
 - a) The BO shall support the configuration and management of complex schedules. A user shall be able to add, delete, or modify a schedule if he has the appropriate privileges.
 - b) The BO shall provide full flexibility and granularity in creating a schedule. The user shall be able to define a schedule in 1-minute or 15-minute increments.
 - c) Daily, weekly, ordinal, and specific schedules shall be supported.
 - 2) Scheduled Tasks
 - a) The BO shall support scheduled tasks for LPR.
 - b) Scheduled tasks shall be executed on a user-defined schedule at a specific day and time. Recurring or periodic scheduled tasks shall also be supported.
 - c) Scheduled tasks shall support all standard actions available within the BO such as sending an email or emailing a report.
- u. Macros and Custom Scripts
 - 1) The BO shall enable users to automate and extend the functionalities of the system through the use of macros or custom scripts for LPR.
 - 2) Custom macros shall be created with the BO Software Development Kit (SDK).
 - 3) A macro shall be executed either automatically or manually.
 - 4) In the Surveillance UI, a macro shall be launched through hot actions.
- v. Audit Trails (Logs)
 - 1) The BO shall support the generation of audit trails. Audit trails shall consist of logs of operator/administrator additions, deletions, and modifications.
 - 2) Audit trails shall be generated as reports. They shall be able to track changes made within specific time periods. Querying on specific users, changes, affected entities, and time periods shall also be possible.
- w. Software Development Kit (SDK)
 - 1) A BO SDK shall be available to support custom development for the platform.
 - 2) The SDK shall include functionalities specific to the embedded license plate recognition (LPR) systems.
 - 3) Integration with external applications and databases shall be possible with the SDK.
 - 4) The SDK shall enable end-users to develop new functionality (user interface, standalone applications or services) to link the BO to third party business systems and applications such as Human Resources Management Systems (HRMS) and Enterprise Resource Planning (ERP) systems.
 - 5) The SDK shall be based on the .NET framework.
 - 6) The SDK Shall support dynamic or transactional updates to BO configuration. It shall also support change notification of BO entity configuration

- 7) The SDK shall provide an extensive list of programming functions to view and/or configure core entities such as: users and user groups, alarms, custom events, and schedules, among others.
- 8) The SDK shall be able to receive real time events from the BO LPR entities.
- 9) The SDK shall be able to query the history of LPR events.
- 10) The SDK shall support the following alarm functions: view alarms in real time, acknowledge alarms, change priority, change recipient.

2.3 HARDWARE AND PERIPHERALS

A. Primary Network Video Directory and Archiver Servers

1. Each Directory and Archiver server shall have the following specifications.
 - a. Intel Xeon E-2124 3.3M for Directory service.
 - b. Intel Xeon Silver 4110 2.1G for Archive service.
 - c. Microsoft Windows Server 2016.
 - d. Windows 10 OS, regardless of proposed solution software requirements, will not be acceptable.
 - e. 32GB RAM.
 - f. (2) 500 GB hard drives in RAID1 for OS and software applications. ADDITIONAL HARD DRIVES SHALL BE PROVIDED FOR VIDEO STORAGE REQUIREMENTS. STORAGE PARAMETERS ARE SHOWN IN ABOVE SECTION. PROVIDE RAID5 ARRAY HARD DRIVES INTERNAL TO SERVER OR IF REQUIRED EXTERNAL FOR ALL VIDEO STORAGE. All long term storage configuration shall be in RAID5.
 - g. 1GB Ethernet Network Interface Card.
 - h. VGA input.
 - i. USB input.
 - j. Provide Dell R500 series or approved equal. Provide rack mount style.
 - k. Provide quantity of servers as required by manufacture based on recording parameters specified herein. Note use of solutions which do not support multicast per this specification, provide a maximum of 25 cameras per server.

B. Direct Attached Storage Device (DAS):

- ~~1.~~ Provide Direct Attached Storage units for each network video recorder server ~~and failover server.~~
2. Provide a UPS with battery backup for 10 minutes for each DAS unit.
3. The following are the minimum video storage requirements for DAS devices.
 - a. Hard Disk Space - Minimum 500 GB for Operating System and software applications. ACTUAL HARD DRIVE REQUIREMENTS WILL BE DICTATED BY STORAGE PARAMETERS AS DEFINED ABOVE.
 - b. RAID Operation
 - 1) Dual Controller
 - 2) The DAS units shall support RAID Levels 0, 1, 0+1, 3, 5, 6, 10, 30, 50, 60, NRAID, and JBOD. The DAS shall be initially designed for RAID5.
 - 3) Multiple Logical Drive Configurations, each with Different RAID Level
 - 4) Hot Spare Drive Support
 - 5) Drive Hot Swapping
 - 6) Automatic Background Rebuild
 - 7) Online Drive Expansion
 - 8) Intelligent Drive Handling

- 9) LUN Filtering - RAID Based and Centralized Access Management in SAN
- 10) 224TB Maximum Capacity with (6) multi-lane SAS expansion chassis. Actually TB storage capacity shall be a function of the storage parameters and calculation described above.
- 11) Up to 1024 LUN for Host Mapping

c. Disk Interface

- 1) 3.5", 1" high 3Gbps FC-8G to SAS / SATA-II disk drives
- 2) Automatic bad sector reassignment
- 3) Drive hot-swappable via SCA-II connectors
- 4) Dedicated bandwidth to each connected drive
- 5) Concurrent I/O commands
- 6) Variable stripe size per logical drive
- 7) Optimization setting for random or sequential I/Os

d. Host Interface

- 1) The unit shall be capable of four (4) 8G-FC host channels or four (4) 3G Serial-Attached SCSI host channels
- 2) The unit shall be capable of two (2) 8G-FC host channels or two (2) 3G Serial-Attached SCSI host channels. The unit shall be initially configured for two (2) 3G serial-attached SCSI channels.
- 3) Tagged command queuing up to 256
- 4) Variable stripe size per logical drive
- 5) Optimization setting for random or sequential I/Os

e. Management

- 1) Firmware-embedded Java-based GUI RAID manager
- 2) Centralized management of multiple arrays over in-band SCSI or Ethernet
- 3) Real-time event notification over Email, LAN broadcast, or SNMP traps
- 4) Host-side SES emulation with pass-through to back-end SES emulation
- 5) SNMP 2.0 MIBs with get and set commands
- 6) Firmware-embedded utility via LCD keypad or RS-232C port

f. Controls and Indicators

- 1) Front LCD Control Panel for Setup and Configuration
- 2) LED Indicators for Power, Battery, Controller(s), and other System Operation Status
- 3) Component Failure Indication through LCD, RS-232C, and GUI
- 4) Built-In Beeper and Alarm Mute

g. Power and Cooling

- 1) Two (2) Hot Swap Redundant High-Efficiency 530W Power Supply Units
- 2) Two (2) Separate Hot Swap Redundant Cooling Modules w/ (2) Individual Fans

h. Environmental

- 1) Operating Temperature: 5 to 40 degrees C
- 2) Non-Operating: -40 to 60 degrees C

3) Relative Humidity: 5-95%, non-condensing

- i. Provide quantity of DAS units as required to meet the storage parameters as described herein.
- j. Provide RAID Inc ARI-400 series or approved equal.

~~C. Failover/Redundant Directory and Archiver Server~~

- ~~1. Provide Failover servers for each Directory and Archiver server.~~
- ~~2. Each Directory and Archiver server shall have the following specifications:~~
 - ~~a. Intel Xeon E-2124 3.3M for Directory service.~~
 - ~~b. Intel Xeon Silver 4110 2.1G for Archive service.~~
 - ~~c. Microsoft Windows Server 2016.~~
 - ~~d. Windows 10 OS, regardless of proposed solution software requirements, will not be acceptable.~~
 - ~~e. 32GB RAM.~~
 - ~~f. (2) 500 GB hard drives in RAID1 for OS and software applications. ADDITIONAL HARD DRIVES SHALL BE PROVIDED FOR VIDEO STORAGE REQUIREMENTS. STORAGE PARAMETERS ARE SHOWN IN ABOVE SECTION. PROVIDE RAID5 ARRAY HARD DRIVES INTERNAL TO SERVER OR IF REQUIRED EXTERNAL FOR ALL VIDEO STORAGE. All long term storage configuration shall be in RAID5.~~
 - ~~g. 1GB Ethernet Network Interface Card.~~
 - ~~h. VGA input.~~
 - ~~i. (2) USB input.~~
 - ~~j. Provide Dell R500 series or approved equal. Provide rack mount style.~~
- ~~3. Provide quantity of redundant servers as required to properly backup each Primary Directory and each Archiver server.~~

D. Access Control Server

- 1. The access control server shall have the following specifications.
 - a. Intel Xeon E-2124 3.3M.
 - b. Microsoft Windows Server 2016.
 - c. Windows 10 OS, regardless of proposed solution software requirements, will not be acceptable.
 - d. 32GB RAM.
 - e. (2) 500 GB hard drives in RAID1 for OS and software applications.
 - f. 1GB Ethernet Network Interface Card.
 - g. VGA input.
 - h. DVD Drive.
 - i. (2) USB input.
 - j. Provide Dell R500 series or approved equal. Provide rack mount style.

E. Security Control/Badging Workstation (Client)

- 1. Provide security workstations with the following specifications. The security control workstation shall be used for the USP. Each workstation CPU shall be rack mounted in the MDF. Provide KVM extenders as shown below for all monitors, keyboards and mice.
 - a. Intel Core i7, 8700 3.20GHz or higher, 4 MB Cache, 1066 MHz FSB
 - b. Microsoft Windows 10 Pro.

- c. 16GB RAM.
 - d. 1TB of storage or more.
 - e. NVIDIA Quadro P620 or better. Provide with quad monitor card.
 - f. 1GB Ethernet Network Interface Card.
 - g. 16x DVD/RW Drive
 - h. Four (4) USB ports.
- 2. Provide a 27" LCD monitor with workstation.
 - 3. Provide with a USB video camera.
 - 4. Provide Dell Precision T3430 or approved equal.
 - 5. Provide (1) per console. Provide a minimum of one (1).

F. Photo Badge Printer

- 1. Provide a single sided color photo badge printer. Coordinate with the owner on exact location.
- 2. Print mode. Color dye sublimation, monochrome thermal printing and rewritable technology.
- 3. Printer interfaces. USB and Ethernet both fitted as standard.
- 4. Software drivers Windows 7 (64 bit compatible), Windows Server 2003 R2 SP2, Server 2008 (32/64 bit compatible).
- 5. Card capacity 100-card feeder, 70-card stacker.
- 6. Power source. External power supply 100-240V 50-60Hz autoranging.
- 7. Print speed. *Color standard mode: 31 seconds, *Color fast mode: 23 seconds, *Monochrome resin: 6 seconds (*single-sided card)
- 8. Operating environment. Sheltered office environment 50°F to 85°F (10°C to 30°C).
- 9. Provide one (1) Magicard Rio Pro or equal. Provide with color ribbon and cleaning kit. Provide two (2) spare color ribbons.

G. System Setup Workstation

- 1. Provide a rack mounted workstation to configure and manage all servers.
- 2. Provide with KVM extender.
- 3. Provide a 17" LCD monitor.
- 4. The workstation shall have a USB port.
- 5. Provide one (1) Eclipse ER2-17B-USB or approved equal.

H. KVM Extender

- 1. Provide CAT5 KVM extenders as required for each security workstation so all monitors, computer keyboards and computer mice can be used at each security workstation symbol as shown on the drawings.
- 2. The KVM extender must support distances at least 500 feet.
- 3. Provide Belkin Omniview CAT5 extender or Architect approved equal.

I. Core and Edge Network Switch

- 1. Provide Power over Ethernet (PoE) network switch(s) for all cameras, access control panels, encoders/decoders, security workstations, video servers, and access control servers.
- 2. Each switch shall have 20% spare capacity per closet/IDF/MDF.

3. Each closet shall support 10/100/1000 mbs per port with a minimum of 1000GB on the back bone/core switch. The fiber infrastructure shall be only utilized for connectivity from each IDF to the MDF/core switch. The use of any portion of the copper back bone shall not be allowed.
4. Provide a layer 3 core switch which shall support each IDF/remote security closet with 1000gbs bandwidth over the fiber infrastructure. In addition to the support of each closet, provide a dedicated 1000gbs for each server (access control and video). Provide 20% 1000gbs copper ports and 20% spare 1000gbs fiber ports at the core switch/head end.
5. PoE network switches must support by same manufacturer a redundant power supply option. Though not a requirement at this time, proposed network switches must have this option without replacement of network switches.
6. Each network switch shall be located in each IDF/MDF.
7. Provide HP series or approved equal for the core switch. Provide fiber GBIC cards as required to support each IDF and/or security closet as shown on the drawings and riser diagram.
8. Provide HP series or approved equal for each edge switch. Each switch shall include a minimum of one (1) GBIC card.
9. Provide an interface to the owner's LAN as required.

J. Audio/Video Encoder

1. General

- a. Provide encoders as required for a complete and operational system.
- b. Provide an encoder for each analog camera and each cell microphone. Each cell speaker/microphone shall be integrated to the Security Management System and be annunciated at the Security Workstation.
- c. Encoders shall be located in the each low voltage rack (rack is specified elsewhere within this section). Provide rack kits/shelves/cabinets as required for a neat and professional installation.
- d. The encoder must be able to deliver multiple, individually configurable video streams simultaneously at full frame rate in all resolutions up to D1 (720x480 in NTSC). This means that several video streams can be configured with different compression formats, resolutions and frame rates for different needs.
- e. The video encoder also enables users to adjust image settings such as contrast, brightness and saturation to improve images before encoding takes place.
- f. The unit includes intelligent capabilities such as enhanced video motion detection, active tampering alarm and audio detection. The encoder's external inputs and outputs can be connected to devices such as sensors and relays, enabling the system to react to alarms and activate lights or open/close doors.
- g. Support for Power over Ethernet (IEEE802.3af) enables the unit, as well as the analog camera that is connected to it, to receive power through the same cable as for data transmission. This makes for easy installation since no power outlet is needed.
- h. Supports two-way audio and has an SD/SDHC memory card slot for local storage.

2. Video Specifications

- a. H.264 and motion JPEG compression
- b. 3.0 megapixel resolution
- c. 30 fps

3. Audio Specifications

- a. Two way, half duplex audio streaming
- b. External microphone input or line input
- c. Line level output
- d. Audio detection video integration

4. Electrical Specifications

- a. Power over Ethernet IEEE 802.3
- b. (Capable of external DC voltage)

5. Provide AXIS Q7401 video/audio encoder or Architect approved equal. Provide as required.

K. Interior/Exterior Fixed Megapixel Vandal Dome Camera

1. Provide cameras with the following specifications for all indoor/outdoor fixed cameras as shown on the drawings. Provide exterior model for all exterior cameras.

- a. Image sensor: Progressive Scan RGB CMOS 1/3.2"
- b. Lens: Vari-focal, DC iris. Provide either 6mm or 12mm. The lens shall be selected based on the location of the camera and desired field of view. This should be documented in the submittals.
- c. Day/Night
- d. Shutter time: 1/28000 s to 2s
- e. Resolution: 5 megapixel
- f. Digital PTZ functions
- g. Video compression: H.264 and Motion JPEG
- h. Frame rate per camera: Can support up to 30 fps.
- i. Video streams: Multiple, individually configurable
- j. Audio streaming: Two-way

2. The power source shall be Power over Ethernet (IEEE 802.3af).

3. Provide Axis P3367-V or approved equal for all interior cameras.

4. Provide Axis P3367-VE for all exterior fixed cameras. Provide with wall/corner mounts where required.

L. Cell Cameras

1. Anti-ligature, Vandal Resistant corner mount housing.

2. 2304 x 1728 to 320 x 240

3. Lens

- a. 2.4 mm,
- b. F2.0 Horizontal field of view: 125°
- c. Vertical field of view: 95°
- d. Fixed focus, fixed iris, M12 mount

4. IR illumination.

5. Built in microphone. Can support external microphone.

6. Provide Axis Q9216-SLV with Steel finish or approved equal.

M. IP MULTI-SENSOR 180 DEGREE MEGAPIEL FIXED CAMERA [Basis of Design Axis P3807-PVE]

1. Fixed dome multi-sensor panoramic network camera

a. The fixed dome multi-sensor network camera shall meet or exceed the following design specifications:

- 1) The camera shall operate on an open source; Linux-based platform, and including a built-in web server.
- 2) The camera shall be equipped with an IR-sensitive progressive scan megapixel sensor.
- 3) The camera shall provide an automatically removable IR-cut filter, providing day/night functionality.
- 4) The camera shall be manufactured with an IP66/IP67 and NEMA 4X-rated, IK10 impact-resistant aluminum casing fitted with an repaintable weather shield.
- 5) The camera shall be equipped with 3,2 mm fixed lenses providing a
 - a) Horizontal field of view: 180°
 - b) Vertical field of view: 90°
- 6) The camera shall provide a manual 3-axis (pan/tilt/rotation) positioning to allow adjustment for optimum camera rotation and placement.
- 7) The camera shall provide a 180° panoramic overview provided by four sensors.

b. The fixed dome multi-sensor network camera shall meet or exceed the following performance specifications:

1) Illumination

a) The camera shall meet or exceed the following illumination specifications:

- 1) 0.17 lux in color
- 2) 0.05 lux B/W

2) Resolution

a) Be designed to provide video streams in:

- 8.3 MP: up to 25/30 fps with power line frequency 50/60 Hz
- 7.5 MP (dewarped): up to 12.5/15 fps with power line frequency 50/60 Hz

b) The individual cameras shall support video resolutions including:

- 1920x1080 (HDTV 1080p)
- 1280x720 (HDTV 720p)

3) Encoding

a) The camera shall support the following video encoding algorithms:

- Motion JPEG encoding in a selectable range from 1 up to 25/30 frames per second in all resolutions.

- Baseline Profile H.264 encoding with motion estimation in up to 25/30 frames per second.
 - Main Profile H.264 encoding with motion estimation and context-adaptive binary arithmetic coding (CABAC) in up to 25/30 frames per second.
 - Support High Profile H.264 encoding with motion estimation up to 50/60 frames per second.
 - b) The camera shall provide two independently configured simultaneous H.264 and Motion JPEG streams.
 - c) The camera shall in H.264 support Variable Bit Rate (VBR) for video quality adapted to scene content. To protect the network from unexpected bit rate spikes the camera shall support Constant Bit Rate (CBR) or Maximum Bit Rate (MBR).
 - d) The camera shall provide configurable compression levels.
 - e) The camera shall support motion estimation in H.264/MPEG-4 Part 10/AVC.
- 4) Transmission
 - a) The camera shall allow for video to be transported over:
 - HTTP (Unicast)
 - HTTPS (Unicast)
 - RTP (Unicast & Multicast)
 - RTP over RTSP (Unicast)
 - RTP over RTSP over HTTP (Unicast)
 - b) The camera shall support Quality of Service (QoS) to be able to prioritize traffic.
- 5) Image
 - a) The camera shall incorporate automatic and manual white balance.
 - b) The camera shall incorporate an electronic shutter operating in the range of 1/33500s to 1/10 s.
 - c) The camera shall incorporate forensic wide dynamic range functionality, providing up to 120 dB dynamic range.
 - d) The camera shall support manually defined values for:
 - Saturation
 - Contrast
 - Sharpness
 - Brightness
 - e) The camera shall incorporate a function for optimization of low light behavior.
- 6) User Interface
 - a) Web server
 - The camera shall contain a built-in web server making video and configuration available to multiple clients in a standard operating system and browser environment using HTTP, without the need for additional software.
 - Optional components downloaded from the camera for specific tasks shall be signed by an organization providing digital trust services, such as Verisign, Inc.

- b) Language Specification
 - The camera shall provide a function for altering the language of the user interface, and shall include support for at least 10 different languages.
 - c) IP addresses
 - The camera shall support both fixed IP addresses and dynamically assigned IP addresses provided by a Dynamic Host Control Protocol (DHCP) server.
 - The camera shall allow for automatic detection of the camera based on UPnP and Bonjour when using a PC with an operating system supporting this feature.
 - The camera shall provide support for IPv6.
- 7) Event functionality
- a) The camera shall be equipped with an integrated event functionality:
 - Detectors functionality
 - b) Video motion detection
 - c) Shock detection
 - Hardware functionality
 - Input Signal functionality
 - d) External input
 - e) Manual trigger / virtual Inputs
 - f) Camera tampering
 - Storage functionality
 - System functionality
 - g) Embedded third-party applications
 - h) Edge storage fail-over recording detection
 - i) Response to triggers shall include:
 - Send notification, using HTTP, HTTPS, TCP or email
 - Send images, using FTP, SFTP, HTTP, HTTPS, network share or email
 - Send video clip, using FTP, SFTP, HTTP, HTTPS, network share or email
 - Send SNMP trap message
 - Recording to local storage and/or network attached storage
 - Day/Night Vision Mode
 - Overlay Text
 - j) The camera shall provide memory for pre & post alarm recordings.
- 8) Edge storage
- a) The camera shall support continuous and event controlled recording to:
 - Local memory added to the cameras microSD-card slot
 - Network attached storage, located on the local network.
 - b) The camera shall incorporate encryption functionality for the SD card.
 - c) The camera shall be able to detect and notify edge storage disruptions.

9) Protocol

- a) The camera shall incorporate support for at least IPv6, HTTP, HTTPS, SSL/TLS, QoS Layer 3 DiffServ, FTP, SFTP, CIFS/SMB, SMTP, Bonjour, UPnP, SNMP v1/v2c/v3 (MIB-II), DNS, DynDNS, NTP, RTSP, RTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP, SOCKS, SSH, LLDP
- b) The SMTP implementation shall include support for SMTP authentication.

10) Text overlay

- a) The camera shall:
 - Provide embedded on-screen text with support for date & time, and a customer-specific text, camera name, of at least 45 ASCII characters.
 - Provide the possibility to choose different font sizes for embedded on-screen text, and to use white or black text on at least four different backgrounds.
 - Provide the ability to manually set up and configure privacy masks to the image.
 - Allow for the overlay of a graphical image, such as a logotype, into the image.

11) Security

- a) The camera shall support the use of HTTPS and SSL/TLS, providing the ability to upload signed certificates to encrypt and secure authentication and communication of both administration data and video streams.
- b) The camera shall provide centralized certificate management, with both pre-installed CA certificates and the ability to upload additional CA certificates. The certificates shall be signed by an organization providing digital trust services.
- c) The camera shall support IEEE 802.1X authentication.
- d) The camera shall provide support for restricting access to pre-defined IP addresses only, so-called IP address filtering.
- e) The camera shall restrict access to the built-in web server by usernames and passwords at three different levels.

12) API support

- a) The camera shall be fully supported by an open and published API (Application Programmers Interface), which shall provide necessary information for integration of functionality into third party applications.
- b) The camera shall conform to ONVIF profile G as defined by the ONVIF Organization.
- c) The camera shall conform to ONVIF profile S as defined by the ONVIF Organization.

- 13) Embedded applications
 - a) The camera shall provide a platform allowing the upload of third-party applications into the camera.
- 14) Installation and maintenance
 - a) The camera shall be supplied with Windows-based management software which allows the assignment of IP addresses, upgrade of firmware and backup of the cameras' configuration.
 - b) The camera shall support the use of SNMP-based management tools according to SNMP v1, 2c & 3 / MIB-II.
 - c) The camera shall allow updates of the software (firmware) over the network, using FTP or HTTP.
 - d) The camera shall provide the ability to apply a rectangle of customer-defined number of pixels to the image, which can be used as a pixel counter identifying the size of objects in number of pixels.
 - e) The camera shall accept external time synchronization from an NTP (Network Time Protocol) server.
 - f) The camera shall store all customer-specific settings in a non-volatile memory that shall not be lost during power cuts or soft reset.
- 15) Access log
 - a) The camera shall provide a log file, containing information about the 250 latest connections and access attempts since the unit's latest restart. The file shall include information about the connecting IP addresses and the time of connecting.
 - b) Provide a connection list of all currently connected viewers. The file shall include information about connecting IP address, time of connecting and the type of stream accessed.
- 16) Camera diagnostics
 - a) The camera shall be equipped with LEDs, capable of providing visible status information. LEDs shall indicate the camera's operational status and provide information about power, communication with receiver, the network status and the camera status.
 - b) The camera shall be monitored by a Watchdog functionality, which shall automatically re-initiate processes or restart the unit if a malfunction is detected.
 - c) The camera shall send a notification when the unit has re-booted and all services are initialized.
- 17) Hardware interfaces
 - a) Network interface
 - The camera shall be equipped with one 10BASE-T/100BASE-TX/1000BASE-T Ethernet-port using a RJ45 connector, and shall support auto negotiation of network speed and transfer mode (full and half duplex).

18) Enclosure

- a) The camera shall:
 - Be manufactured with an IP66-/IP67- and NEMA 4X-rated, IK10-rated impact-resistant casing with polycarbonate hard coated clear dome.
 - Be fitted with a dehumidifying membrane.

19) Power

- a) Power over Ethernet Plus (PoE+) IEEE 802.3at Type 1 Class 3
 - Max: 12.9 W
 - Typical: 7 W

20) Environmental

- a) Operate in a temperature range of -30 °C to 50 °C (-22 °F to 122 °F).
- b) Operate in a maximum temperature (intermittent) of 60 °C (140 °F)
- c) Operate in a humidity range of 10 -100% RH (condensing).

N. IP MULTI-SENSOR 360 DEGREE MEGAPIEL FIXED CAMERA [Basis of Design Axis P3717-pve]

1. Panoramic network camera

- a. The panoramic network camera shall meet or exceed the following design specifications:
 - 1) The camera shall operate on an open source; Linux-based platform, and including a built-in web server.
 - 2) The camera shall be equipped with four progressive scan megapixel sensors.
 - 3) The camera shall provide flexible positioning of four varifocal camera heads.
 - 4) The camera shall provide the following field of view:
 - a) 4x 1080p
 - Horizontal: 108° - 54°
 - Vertical: 57° - 30°
 - b) 4x 720p
 - Horizontal: 67° - 36°
 - Vertical: 37° - 20°
 - 5) The camera shall provide adjustable focus and zoom functionality.
 - 6) The camera shall provide local video storage utilizing a microSD/microSDHC/microSDXC memory card expansion.
 - 7) The camera shall be manufactured with an IP66-, NEMA 4X- and IK09-rated Die-casted aluminum casing.
 - 8) The camera shall provide:
 - a) Pan $\pm 90^\circ$
 - b) Tilt 28° - 92°
 - c) Rotate $\pm 90^\circ$

- b. The panoramic network camera shall meet or exceed the following performance specifications:
- 1) Illumination
 - a) The camera shall meet or exceed the following illumination specifications:
 - 0.3 lux in color
 - 2) Resolution
 - a) The camera shall be designed to provide 4x video streams in HDTV 1080p (1920x1080) at up to 15 frames per second (60Hz mode) or 12.5 frames per second (50Hz mode) using H.264 or Motion JPEG.
 - b) The camera shall be designed to provide 4x video streams in HDTV 720p (1280x720) at up to 30 frames per second (60Hz mode) or 25 frames per second (50Hz mode) using H.264 or Motion JPEG.
 - c) The camera shall be designed to provide quad view in resolution up to 1920x1440
 - d) The camera shall support video resolutions including:
 - 1920x1440 (Quad view)
 - 1920x1080 (HDTV 1080p)
 - 1280x720 (HDTV 720p)
 - e) The camera shall provide both landscape format (4:3 and 16:9 aspect ratio) as well as corridor format (3:4 and 9:16 aspect ratio).
 - 3) Encoding
 - a) The camera shall support the following video encoding algorithms:
 - b) Motion JPEG encoding in a selectable range from 1 up to 25/30 frames per second in all resolutions.
 - c) Baseline Profile H.264 encoding with motion estimation in up to 25/30 frames per second.
 - d) Main Profile H.264 encoding with motion estimation and context-adaptive binary arithmetic coding (CABAC) in up to 25/30 frames per second.
 - e) Support High Profile H.264 encoding with motion estimation up to 25/30 frames per second.
 - f) Support H.264 with automatic scene adaptive bitrate control in up to 25/30 frames per second.
 - g) The camera shall provide independently configured simultaneous H.264 and Motion JPEG streams.
 - h) The camera shall in H.264 support Variable Bit Rate (VBR) for video quality adapted to scene content. To protect the network from unexpected bit rate spikes the camera shall support Constant Bit Rate (CBR) or Maximum Bit Rate (MBR).
 - i) The camera shall provide configurable compression levels.
 - j) Support standard baseline profile H.264 with motion estimation.
 - k) Support motion estimation in H.264/MPEG-4 Part 10/AVC.
 - l) The camera shall for its H.264 implementation support scene adaptive bitrate control with automatic dynamic ROI to reduce bitrate in unprioritized regions in order to lowering bandwidth and storage requirements.

- 4) Transmission
 - a) The camera shall allow for video to be transported over:
 - HTTP (Unicast)
 - HTTPS (Unicast)
 - RTP (Unicast & Multicast)
 - RTP over RTSP (Unicast)
 - RTP over RTSP over HTTP (Unicast)
 - b) The camera shall support Quality of Service (QoS) to be able to prioritize traffic.
- 5) Image
 - a) The camera shall incorporate Automatic and Manual White Balance.
 - b) The camera shall incorporate an electronic shutter operating in the range of:
 - 720p: 1/28000 s to 2 s
 - 1080p: 1/22500 s to 2 s
 - c) The camera shall incorporate capture mode with the following settings:
 - HDTV 1080p 12.5/15 fps
 - HDTV 720p 25/30 fps
 - d) The camera shall support manually defined values for:
 - Color level
 - Brightness
 - Sharpness
 - Contrast
 - e) The camera shall incorporate a function for optimization of low light behavior.
 - f) The camera shall allow for rotation of the image in steps of 90°.
 - g) The camera shall incorporate local contrast functionality.
- 6) User Interface
 - a) Web server
 - The camera shall contain a built-in web server making video and configuration available to multiple clients in a standard operating system and browser environment using HTTP, without the need for additional software.
 - Optional components downloaded from the camera for specific tasks, e.g. Active X, shall be signed by an organization providing digital trust services, such as Verisign, Inc.
 - b) Language Specification
 - The camera shall provide a function for altering the language of the user interface, and shall include support for at least 10 different languages.
 - c) IP addresses
 - The camera shall support both fixed IP addresses and dynamically assigned IP addresses provided by a Dynamic Host Control Protocol (DHCP) server.
 - The camera shall allow for automatic detection of the camera based on UPnP and Bonjour when using a PC with an operating system supporting this feature.
 - The camera shall provide support for both IPv4 and IPv6.

- 7) Event functionality
 - a) The camera shall be equipped with an integrated event functionality, which can be triggered by:
 - Video Motion Detection
 - Live Stream Accessed
 - Camera tampering
 - Manual Trigger/Virtual Inputs
 - Embedded third party applications
 - Edge storage disruption detection
 - b) Response to triggers shall include:
 - Send notification, using HTTP, HTTPS, TCP, SNMP trap or email
 - Send images, using FTP, HTTP, HTTPS, network share or email
 - Send video clip, using FTP, HTTP, HTTPS, network share or email
 - Recording to local storage and/or network attached storage
 - Overlay Text
 - c) The camera shall provide memory for pre & post alarm recordings.
- 8) Edge storage
 - a) The camera shall support continuous and event controlled recording to:
 - Local memory added to the cameras SD-card slot
 - Network attached storage, located on the local network
 - b) The camera shall be able to detect and notify Edge storage disruptions.
- 9) Protocol
 - a) The camera shall incorporate support for at least IPv4/v6, HTTP, HTTPS, SSL/TLS, QoS Layer 3 DiffServ, TCP, ICMP, SNMPv1/v2c/v3 (MIB-II), RTSP, RTP, UDP, IGMP, RTCP, SMTP, FTP, DHCP, UPnP, ARP, DNS, DynDNS, SOCKS, SSH, NTP, CIFS/SMB, Bonjour.
 - b) The SMTP implementation shall include support for SMTP authentication.
- 10) Text overlay
 - a) The camera shall:
 - Provide embedded on-screen text with support for date & time, and a customer-specific text, camera name, of at least 45 ASCII characters.
 - Provide the ability to apply privacy masks to the image.
 - Allow for the overlay of a graphical image, such as a logotype, into the image.
- 11) Security
 - a) The camera shall support the use of HTTPS and SSL/TLS, providing the ability to upload signed certificates to encrypt and secure authentication and communication of both administration data and video streams.

- b) The camera shall provide centralized certificate management, with both pre-installed CA certificates and the ability to upload additional CA certificates. The certificates shall be signed by an organization providing digital trust services.
 - c) The camera shall support IEEE 802.1X authentication.
 - d) The camera shall provide support for restricting access to pre-defined IP addresses only, so-called IP address filtering.
 - e) The camera shall restrict access to the built-in web server by usernames and passwords at three different levels.
- 12) API support
- a) The camera shall be fully supported by an open and published API (Application Programmers Interface), which shall provide necessary information for integration of functionality into third party applications.
 - b) The camera shall support relevant ONVIF profiles as defined by the ONVIF Organization.
- 13) Embedded applications
- a) The camera shall provide a platform allowing the upload of third party applications into the camera.
- 14) Installation and maintenance
- a) The camera shall be supplied with Windows-based management software which allows the assignment of IP addresses, upgrade of firmware and backup of the cameras' configuration.
 - b) The camera shall support the use of SNMP-based management tools according to SNMP v1, 2c & 3 / MIB-II.
 - c) The camera shall allow updates of the software (firmware) over the network, using FTP or HTTP.
 - d) The camera shall provide the ability to apply a rectangle of customer-defined number of pixels to the image, which can be used as a pixel counter identifying the size of objects in number of pixels.
 - e) The camera shall accept external time synchronization from an NTP (Network Time Protocol) server.
 - f) The camera shall store all customer-specific settings in a non-volatile memory that shall not be lost during power cuts or soft reset.
- 15) Access log
- a) The camera shall provide a log file, containing information about the 250 latest connections and access attempts since the unit's latest restart. The file shall include information about the connecting IP addresses and the time of connecting.
 - b) Provide a connection list of all currently connected viewers. The file shall include information about connecting IP address, time of connecting and the type of stream accessed.

16) Camera diagnostics

- a) The camera shall be equipped with LEDs, capable of providing visible status information. LEDs shall indicate the camera's operational status and provide information about power, communication with receiver, the network status and the camera status.
- b) The camera shall be monitored by a Watchdog functionality, which shall automatically re-initiate processes or restart the unit if a malfunction is detected.
- c) The camera shall send a notification when the unit has re-booted and all services are initialized.

17) Hardware interfaces

- a) Network interface
 - The camera shall be equipped with one 10BASE-T/100BASE-TX PoE Fast Ethernet-port, using a standard male RJ45 connector and shall support auto negotiation of network speed (100 MBit/s and 10 MBit/s) and transfer mode (full and half duplex).

18) Enclosure

- a) The camera shall:
 - Be manufactured with an IP66-, NEMA 4X- and IK09-rated Die-casted aluminum casing.
 - Be fitted with a polycarbonate dome.

19) Power

- a) Power over Ethernet IEEE 802.3af/802.3at Type 1 Class 2
- b) Typical 4.8 W
- c) Max 5.5 W

20) Environmental

- a) Operate in a temperature range of -30 °C to +60 °C (-22 °F to 140 °F).
- b) Operate in a humidity range of 10–100% RH (condensing).

O. CAMERA – PAN, TILT AND ZOOM (PTZ) [Basis of Design Axis Q6075-E]

1. Exterior 1080p network PTZ camera

- a. The PTZ network camera shall meet or exceed the following design specifications:
 - 1) The camera shall operate on an open source; Linux-based platform, and including a built-in web server.
 - 2) The camera shall provide a removable IR-cut filter, providing day/night functionality.
 - 3) The camera shall provide autofocus functionality.
 - 4) The camera shall provide auto-iris functionality.
 - 5) The camera shall provide local video storage utilizing a SD/SDHC/SDXC memory card expansion.

- 6) The camera shall be manufactured with an IP66 and NEMA 4X rated metal casing (aluminum).
- b. The PTZ network camera shall meet or exceed the following performance specifications:
- 1) Illumination
 - a) The camera shall meet or exceed the following illumination specifications:
 - Color: 0.3 lux at 30 IRE F1.6
 - B/W: 0.03 lux at 30 IRE F1.6
 - Color: 0.5 lux at 50 IRE F1.6
 - B/W: 0.04 lux at 50 IRE F1.6
 - 2) Resolution
 - a) The camera shall be designed to provide video streams in HDTV 1080p (1920x1080) at up to 30 frames per second (60Hz mode) or 25 frames per second (50Hz mode) using H.264 or Motion JPEG.
 - b) The camera shall be designed to provide video streams in HDTV 720p (1280x720) at up to 60 frames per second (60Hz mode) or 50 frames per second (50Hz mode) using H.264 or Motion JPEG.
 - c) The camera shall support video resolutions including:
 - 1920x1080 (HDTV 1080p)
 - 1280x720 (HDTV 720p)
 - 3) Encoding
 - a) The camera shall support the following video encoding algorithms:
 - Motion JPEG encoding in a selectable range from 1 up to 25/30 frames per second (1080p).
 - Motion JPEG encoding in a selectable range from 1 up to 50/60 frames per second (720p).
 - Baseline Profile H.264 encoding with motion estimation in up to 25/30 frames per second (1080p).
 - Baseline Profile H.264 encoding with motion estimation in up to 50/60 frames per second (720p).
 - Main Profile H.264 encoding with motion estimation and context-adaptive binary arithmetic coding (CABAC) in up to 25/30 frames per second (1080p).
 - Main Profile H.264 encoding with motion estimation and context-adaptive binary arithmetic coding (CABAC) in up to 50/60 frames per second (720p).
 - Support High Profile H.264 encoding with motion estimation up to 25/30 frames per second (1080p).
 - Support High Profile H.264 encoding with motion estimation up to 50/60 frames per second (720p).
 - Support H.264 with automatic scene adaptive bitrate control.
 - b) The camera shall provide independently configured simultaneous H.264 and Motion JPEG streams.

- c) The camera shall in H.264 support Variable Bit Rate (VBR) for video quality adapted to scene content. To protect the network from unexpected bit rate speaks the camera shall support Constant Bit Rate (CBR) or Maximum Bit Rate (MBR).
 - d) The camera shall provide configurable compression levels.
 - e) Support standard baseline profile H.264 with motion estimation.
 - f) Support motion estimation in H.264/MPEG-4 Part 10/AVC.
 - g) The camera shall for its H.264 implementation support scene adaptive bitrate control with automatic dynamic ROI to reduce bitrate in unprioritized regions in order to lowering bandwidth and storage requirements.
- 4) Transmission
- a) The camera shall allow for video to be transported over:
 - HTTP (Unicast)
 - HTTPS (Unicast)
 - RTP (Unicast & Multicast)
 - RTP over RTSP (Unicast)
 - RTP over RTSP over HTTP (Unicast)
 - b) The camera shall support Quality of Service (QoS) to be able to prioritize traffic.
- 5) Image
- a) The camera shall incorporate Automatic and Manual White Balance.
 - The camera shall incorporate an electronic shutter operating in the range of:
 - 1/33000 s to 1/3 s (50 Hz)
 - 1/33000 s to 1/4 s (60 Hz)
 - b) The camera shall incorporate Wide Dynamic Range functionality providing up to 120 dB dynamic range.
 - c) The camera shall provide backlight compensation functionality.
 - d) The camera shall support manually defined values for:
 - Color level
 - Brightness
 - Sharpness
 - Contrast
 - e) The camera shall incorporate a function for optimization of low light behavior.
 - f) The camera shall allow for rotation of the image.
 - g) The camera shall provide Highlight compensation.
 - h) The camera shall incorporate automatic defog functionality.
- 6) User Interface
- a) Web server
 - The camera shall contain a built-in web server making video and configuration available to multiple clients in a standard operating system and browser environment using HTTP, without the need for additional software.

- Optional components downloaded from the camera for specific tasks, e.g. Active X, shall be signed by an organization providing digital trust services, such as Verisign, Inc.
 - b) Language Specification
 - The camera shall provide a function for altering the language of the user interface, and shall include support for at least 10 different languages.
 - c) IP addresses
 - The camera shall support both fixed IP addresses and dynamically assigned IP addresses provided by a Dynamic Host Control Protocol (DHCP) server.
 - The camera shall allow for automatic detection of the camera based on UPnP and Bonjour when using a PC with an operating system supporting this feature.
 - The camera shall provide support for both IPv4 and IPv6.
- 7) PTZ functionality
- a) The camera shall:
 - Provide more than 255 manually set preset positions.
 - Provide e-flip functionality, which will automatically rotate the image 180° electronically when following a moving object passing under the camera.
 - Provide On-screen directional indicator (OSDI) functionality.
 - Be able to record a custom PTZ tour, operated using an input device such as a joystick, mouse or keyboard, and then use and recall this as a guard tour.
 - Be able to detect and automatically follow moving objects in the cameras field of view.
 - Be equipped with accurate high-speed pan-tilt functionality with 360° endless pan range and a 220° tilt range.
 - Provide pan and tilt speed between 0.05° - 450°/sec.
 - Provide 32x optical zoom.
 - Provide 12x digital zoom.
 - Provide adjustable zoom speed.
- 8) Event functionality
- a) The camera shall be equipped with an integrated event functionality, which can be triggered by:
 - Live stream accessed
 - Video Motion Detection
 - Shock detection
 - Fan malfunctioning
 - Enter/Exit
 - Fence Detector
 - Object Removed
 - Object Counter
 - Temperature
 - Manual trigger/virtual inputs
 - PTZ functionality
 - External input

- Embedded third party applications
 - Edge storage disruption detection
 - b) Response to triggers shall include:
 - Send notification, using HTTP, HTTPS, TCP, SNMP trap or email
 - Send images, using FTP, HTTP, HTTPS, network share or email
 - Send video clip, using FTP, HTTP, HTTPS, network share or email
 - Send SNMP trap message
 - Day/Night Vision Mode
 - Overlay Text
 - Recording to local storage and/or network attached storage
 - Activating external output
 - PTZ control functionality
 - c) The camera shall provide memory for pre & post alarm recordings.
- 9) Edge storage
 - a) The camera shall support continuous and event controlled recording to:
 - Local memory added to the cameras SD-card slot
 - Network attached storage, located on the local network
 - b) The camera shall be able to detect and notify Edge storage disruptions.
- 10) Protocol
 - a) The camera shall incorporate support for at least IPv4/v6, HTTP, HTTPS, SSL/TLS, QoS Layer 3 DiffServ, TCP, ICMP, SNMPv1/v2c/v3 (MIB-II), RTSP, RTP, UDP, IGMP, RTCP, SMTP, FTP, DHCP, UPnP, ARP, DNS, DynDNS, SOCKS, SSH, NTP, CIFS/SMB, NTCIP, Bonjour.
 - b) The SMTP implementation shall include support for SMTP authentication.
- 11) Text overlay
 - a) The camera shall:
 - Provide embedded on-screen text with support for date & time, and a customer-specific text, camera name, of at least 45 ASCII characters.
 - Provide the ability to apply up to 32 individually set 3D privacy masks to the image.
 - Allow for the overlay of a graphical image, such as a logotype, into the image.
- 12) Security
 - a) The camera shall support the use of HTTPS and SSL/TLS, providing the ability to upload signed certificates to encrypt and secure authentication and communication of both administration data and video streams.
 - b) The camera shall provide centralized certificate management, with both pre-installed CA certificates and the ability to upload additional CA certificates. The certificates shall be signed by an organization providing digital trust services.

- c) The camera shall support IEEE 802.1X authentication.
- d) The camera shall provide support for restricting access to pre-defined IP addresses only, so-called IP address filtering.
- e) The camera shall restrict access to the built-in web server by usernames and passwords at three different levels.

13) API support

- a) The camera shall be fully supported by an open and published API (Application Programmers Interface), which shall provide necessary information for integration of functionality into third party applications.
- b) The camera shall conform to ONVIF profile G as defined by the ONVIF Organization.
- c) The camera shall conform to ONVIF profile S as defined by the ONVIF Organization.
 - For ONVIF profile specifications, see www.onvif.org/

14) Embedded applications

- a) The camera shall provide a platform allowing the upload of third party applications into the camera.

15) Installation and maintenance

- a) The camera shall be supplied with Windows-based management software which allows the assignment of IP addresses, upgrade of firmware and backup of the cameras' configuration.
- b) The camera shall support the use of SNMP-based management tools according to SNMP v1, 2c & 3 / MIB-II.
- c) The camera shall allow updates of the software (firmware) over the network, using FTP or HTTP.
- d) The camera shall provide the ability to apply a rectangle of customer-defined number of pixels to the image, which can be used as a pixel counter identifying the size of objects in number of pixels.
- e) The camera shall accept external time synchronization from an NTP (Network Time Protocol) server.
- f) The camera shall store all customer-specific settings in a non-volatile memory that shall not be lost during power cuts or soft reset.

16) Access log

- a) The camera shall provide a log file, containing information about the 250 latest connections and access attempts since the unit's latest restart. The file shall include information about the connecting IP addresses and the time of connecting.
- b) Provide a connection list of all currently connected viewers. The file shall include information about connecting IP address, time of connecting and the type of stream accessed.

17) Camera diagnostics

- a) The camera shall be equipped with LEDs, capable of providing visible status information. LEDs shall indicate the camera's operational status and provide information about power, communication with receiver, the network status and the camera status.
- b) The camera shall be monitored by a Watchdog functionality, which shall automatically re-initiate processes or restart the unit if a malfunction is detected.
- c) The camera shall send a notification when the unit has re-booted and all services are initialized.

18) Hardware interfaces

- a) Multifunctional connector
 - The camera shall, by using a "multi wire cable", provide connectivity for:
- b) RJ45 - 10BASE-T/100BASE-TX
- c) I/O
- d) DC power

19) Enclosure

- a) The camera shall:
 - Be manufactured with an IP66 and NEMA 4X rated metal casing (aluminum)
 - Be fitted with an sunshield
 - Be fitted with Temperature sensors
 - Be fitted with a fan

20) Power

- a) 24 V DC
 - Max: 75 W
 - Minimum: 65 W

21) Environmental

- a) The camera shall:
 - Operate in a temperature range of -20 °C to 75 °C (-4 °F to 167 °F).
 - Operate in a humidity range of 10–100% RH (condensing).

- 2. Install the MIDSPAN POE Injector that is provided with the Camera in the box, and as instructed by Axis Communications to mitigate low temperatures.

3. General Standards & Requirements:

- a. The camera shall be manufactured with an all- metal body, support operation between -20°C to +50°C (-4°F to +122°F) and be both IP66 and NEMA 4X certified.
- b. The camera shall be equipped with a progressive scan sensor, 32x optical or better zoom, so called Day/Night functionality and shall provide images down to 0.5 lux in day mode and 0.01 lux in night mode.

- c. The camera shall provide accurate high-speed pan-tilt functionality with 360° pan range and a 180° tilt range, provide pan and tilt speed between 0.2° - 200°/sec, be equipped with Auto-flip and incorporate at least 100 presets.
 - d. The camera shall be equipped with a 10BASE-T/100BASE-TX Ethernet-port, and shall include support for High Power over Ethernet according to IEEE 802.3at.
 - e. The camera shall provide simultaneous Motion JPEG and H.264 video streams and shall support at least three individually configured video streams of resolutions up to 720x480 (60Hz) / 720x576 (50Hz) pixels in full frame rate (30/25fps). The H.264 implementation shall include both unicast and multicast functionality and support Constant Bit Rate (CBR) as well as Variable Bit Rate (VBR).
 - f. The camera shall be able to trigger its embedded event functionality based on detection of video motion, PTZ position, when the local storage is full, camera temperature or in the case of fan malfunctions. Possible response to a triggered event shall include remote notification, incl. video upload, preset call-up and recording to local storage. The camera shall be equipped with a video buffer for saving pre- and post-alarm images and shall have a SD/SDHC card slot to support local storage of video.
 - g. The camera shall feature overlay text ability, that includes date and time synchronized using an NTP server. Furthermore, it shall have the ability to apply a graphical image as an overlay and at least 4 individually configurable and dynamically adjusted privacy masks in the video stream.
 - h. The camera shall support both static IP addresses and addresses from a DHCP-server, and shall support both IPv4 and IPv6. The camera shall incorporate support for Quality of Service (QoS).
 - i. For secure access to the camera as well as provided content, the camera shall support HTTPS, SSL/TLS and IEEE802.1X authentication. The camera shall also support IP address filtering and include at least three different levels of password security.
 - j. The camera shall contain a built-in web server making video and configuration available in a standard browser environment using HTTP and shall also be fully supported by an open and published API (Application Programmers Interface) providing necessary information for integration of functionality into third party applications.
 - k. The camera shall conform to the network video standard as defined by the ONVIF organization.
4. The camera shall:
- a. Be manufactured with an all-metal body
 - b. Be both IP66 and NEMA 4X-rated
 - c. Start-up and operate between -20°C to +50°C (-4°F to +122°F)
 - d. Be equipped with a 10BASE-T/100BASE-TX Ethernet interface
 - e. Be equipped with a progressive scan sensor and provide images down to 0.5 lux in day mode and 0.01 lux in night mode
 - f. Be equipped with 18x optical zoom and so called Day/Night functionality
 - g. Provide at least 3 streams of resolutions up to 720x480 (60Hz) / 720x576 (50Hz) pixels at 30/25 frames per second per stream
 - h. Support simultaneous individually configured Motion JPEG and H.264 video streams
 - i. Support both unicast and multicast H.264 with support for both Constant and Variable Bit Rate
 - j. Support Power over Ethernet according to IEEE 802.3at
 - k. Accept static IP addresses as well as addresses provided by a DHCP
 - l. Support both IPv4 and IPv6 based addresses

- m. Provide accurate high-speed pan-tilt functionality with 360° pan range and a 180° tilt range
- n. Provide pan and tilt speed between 0.2° - 200°/sec
- o. Be equipped with Auto-flip and incorporate at least 100 presets
- p. Provide text overlay that includes date/time support synchronized with an NTP server and the ability to apply a graphical image as an overlay into the video image
- q. Provide multiple user password levels, support for HTTPS and SSL/TLS and incorporate IEEE 802.1X authentication
- r. Be equipped with four I/O ports, configurable as in- or output
- s. Be equipped with an SD/SDHC memory card slot
- t. Include embedded event functionality, which may be triggered by:
 - 1) video motion detection
 - 2) PTZ position
 - 3) camera temperature outside of operative range
 - 4) fan malfunction
 - 5) local storage full
- u. Event actions supported by the camera shall include:
 - 1) remote notification, including video upload
 - 2) preset call-up
 - 3) recording to local storage
- v. Be equipped with a built-in web server
- w. Be supported by an open and published API
- x. Be conformant to the network video standard as defined by the ONVIF organization

5. License Plate Recognition (LPR) Camera

- a. Equipment is designed to provide License plate reading (LPR) functionality
- b. Each unit contains 2 cameras, an illumination source, and a processor
- c. Communication with units is via Ethernet
- d. LPR engine can be localized to enhance performances
- e. Database of international contexts available
- f. High resolution (1280 X 960 ((1.2Mpx)) progressive scan Monochrome CCD LPR camera
- g. Variable Focal lens capable of 8.5mm to 50mm
- h. Pulsed-infrared illumination for high performance license plate reading (LPR)
- i. Automated exposure control based on feedback from the LPR engine
- j. High resolution (1280 X 960 ((1.2Mpx)) progressive scan color camera for video recording and overview imaging.
- k. Variable Focal lens capable of Standard-range option: 5 - 10mm (up to 65'/20m) or Long-range option: 12.5 - 50mm (up to 105'/32m)
- l. Integrated video capture hardware
- m. Dual Opto-isolated Input/Outputs
- n. Processing rates of 30 frames per second
- o. Rugged, environmental enclosure and cabling designed for stationary applications
- p. Onboard buffering of read data in case of network loss
- q. Region of Interest to perform LPR on a polygon cropped inside the field of view (FOV)
- r. Video encoding capabilities: MJPEG, 15FPS, 1280 X 960 (1.2Mpx).
- s. Network interface - 1 X 10/100/1000 Base-T Ethernet port

- t. Advanced hardware image pre-processing that permits license plate recognition at full sensor frame rate
- u. Available in Black or Security White
- v. Processor – 1.91 GHz Intel Atom E3845 Quad core (2MB L2 cache), 4GB RAM
- w. Operating system - Windows 10 Enterprise
- x. Pulsed LED-based illumination: 20 m range (Standard) or 32 m range (Long-Range)
- y. Pulsed LED-based illumination: 850nm and 740nm wavelengths available
- z. Tamper resistant with impact-proof front window
- aa. Includes Pan / tilt Videotec mount and Pelco adaptor
- bb. Operating temperature -40°F to 140°F (-40°C to 60°C)
- cc. Water resistance: Waterproof to IP67 (1 m submersion for 48 hrs)
- dd. Power supply: PoE+ (Power-over-Ethernet - 802.3at Type 2 (25.5W)) ~20W
- ee. Dimensions 2.5 X 7.6 X 8.5 inches (63 X 192 X 214 mm)
- ff. Weight: 5.04 lbs (2.29kg)
- gg. Provide Genetec SharpV or equal.

P. Security Monitor Display

1. 50" LED

- a. NEC MultiSync E506 - 50" Class - E Series LED display - with TV tuner - digital signage - 1080p (Full HD) 1920 x 1080 -direct-lit LED
- b. Peerless SmartMount Universal Tilt Wall Mount - Peerless SmartMount Universal Tilt Wall Mount ST650 Mounting kit (bracket, tilt wall plate, security fasteners) for LCD / plasma panel - black - screen size: 39"-75" - mounting interface: 700 x 400 mm - wall-mountable.
- c. Each monitor shall be connected to the security workstation as specified herein.

Q. Reader and Input/Output (I/O)Control Panels

1. General

- a. The control panels include but no limited to card reader modules, input modules, output modules, power supply, harnesses, and batteries. Provide quantities as required for a complete working system. Each module card shall be neatly installed in a locked wall cabinet. Enclosures shall be located in each IDF/MDF or as shown on the drawings. Each controller shall be connected to the security network switch. Provide Hoffman enclosures or approved equal.

2. Features

- a. Stores a complete access control and configuration database for up to 32 Reader Interfaces (up to 64 doors) and 44,000 cardholders with expansion capability up to 250,000 cardholders.
- b. The access control system interfaces with combinations of devices with a maximum of: 32 Door/Reader interfaces (up to 64 doors/readers) or 32 input monitor interfaces 9 (up to 512 monitor points) or 32 output control interfaces (up to 384 control relays)
- c. Reports supervised inputs/alarms with 255 priorities.
- d. Includes an HTTP API, Windows® DLL API, and direct communication API.
- e. Allows local connection of a laptop computer for diagnostics and configuration.
- f. Connects to the host and other devices on a TCP/IP network.
- g. Receives and processes real time commands from the host software application.
- h. Reports all activity to the host.
- i. Controls and communicates with all connected devices.

- j. Buffers offline transactions and uploads to the host when communication is restored.
 - k. UL 294 and UL 1076 recognized component.
3. Provide Genetec SY series with Cloudlink and input/output boards as required. Provide quantity to support all doors and miscellaneous security devices as shown plus 15% spare capacity. Provide with wall mounted cabinet and locking front door equal to Hoffman.
- R. Combination Card Reader and Keypad
- 1. Provide contactless multi-class readers with keypad as shown on the drawings.
 - 2. Each reader shall operate on a 13.56MHz and 125kHz transmit frequencies.
 - 3. The reader shall have a Weigand output.
 - 4. The readers shall have both an audio and visual notification for access granted and access denied.
 - 5. The reader shall be suitable for indoor and outdoor applications.
 - 6. The reader shall operate up to 500ft on 22AWG cable.
 - 7. The reader shall be able to communicate with either 2K, 16K or 32K bit iClass cards.
 - 8. Reader shall have and/or functionality for the keypad and/or the proximity reader to allow access.
 - 9. Provide HID RPK40 multiClass readers part number 921PTNNEK00000or approved equal.
- S. Card Readers
- 1. Provide contactless multiclass readers as shown on the drawings.
 - 2. Each reader shall operate on a 13.56MHz and 125kHz transmit frequencies.
 - 3. The reader shall have a Weigand output.
 - 4. The readers shall have both an audio and visual notification for access granted and access denied.
 - 5. The reader shall be suitable for indoor and outdoor applications.
 - 6. The reader shall operate up to 500ft on 22AWG cable.
 - 7. The reader shall be able to communicate with either 2K, 16K or 32K bit iClass cards.
 - 8. Provide HID RP40 iClass readers part number 920PTNNEK00000or approved equal.
- T. Long Range UHF Reader
- 1. Provide reader designed for long-range parking and gate control.
 - 2. Provide 5class SE U90 Long Range Reader, model RDRSEU90.
 - 3. Transmit Frequency 865 - 868 MHz / 902 - 928 MHz dependent on regional regulations.
 - 4. Typical Maximum Read Range 3 to 5 meters.
 - 5. Cable Length Wiegand = 500 ft (152 m) – 22 AWG 300 ft (91 m) – 24 AWG RS-485 = 4000 ft (1,219 m) – 24 AWG.
 - 6. Dimensions 9.10" x 9.10" x 2.75" (23.1 cm x 23.1 cm x 7.0 cm).
 - 7. Housing Material UL94 Polycarbonate.
 - 8. Standards UL294/cUL (US & Canada), CB Scheme, FCC Certification (US), IC (Canada), CE (EU), IFETEL (Mexico), ANATEL (Brazil).
 - 9. Card Compatibility UHF EPC Class 1 Gen 2, ISO 18000-6C.
- U. Combination Card Reader/Keypad/Biometric Finger Print Reader
- 1. Provide combination smart card reader/keypad/biometric fingerprint reader as shown on the drawings.
 - 2. Each reader shall operate on 13.56 transmit frequency.
 - 3. The reader shall have Weigand output.

4. The readers shall have both an audio and visual notification for access granted and access denied.
5. The reader shall operate up to 500 feet on 22 AWG cable.
6. The reader shall be able to communicate with 16L or 32K bit iClass cards.
7. The reader shall contain an integral optical finger print sensor.
8. Provide (1) HID RKL40 bioclass reader or equal as shown on the drawings.

V. Contactless Printable Smart Cards

1. The smart card shall be multi-technology triple interface cards and shall be an iClass card manufactured by HID Corporation.
2. iCLASS Operating Frequency UHF Operating Frequency 13.56 MHz 860-960 MHz.
3. iCLASS Typical Maximum Read Range UHF Typical Maximum Read Range 3-4 in. (depending the reader used) 18-21 ft. (depending the reader used).
4. UHF Technology EPC Class1 Gen2 protocol compliant.
5. UHF Memory 512 bits of user memory, 128 bits of EPC memory.
6. Construction Composite with 60% PET/40% PVC.
7. Operating Temperature -40° to 158° F (-40° to 70° C).
8. iCLASS Baud Rate 14443 B2 mode - 212 kbps 15693 mode - 26 kbps.
9. iCLASS Memory Type EEPROM, Read/write.
10. iCLASS Multi-application Memory 32k bit (4K Bytes) card – 16k bits in 2 or 16 application areas plus 16k bits user.
11. Card Options Magnetic Stripe, External Card Numbering, Custom Artwork (Text or Graphics).
12. Supported Readers Any reader that can read Proximity 125 KHz, iCLASS or iCLASS SE Technology.
13. Provide HID iClass Card model 600 or approved equal.
14. Provide 200.
15. IESS contractor shall program and print the number of badges required by the owner not to exceed 150 in addition program (6) of the badges as Visitor badges coordinate privileges with owner and Label them clearly with the word Visitor on each badge.

W. Request-to-exit devices

1. Furnish and install motion request-to-exit sensors as shown on the drawings and as required. Devices shall mount directly above the each door. Utilize doors that have hardware which have integral request-to-exit switches as required. Coordinate with door hardware.
2. Provide DS 150i or approved equal with trim plate.

X. Auxiliary Power Supply

1. Provide auxiliary power supply(s) for REX sensors as required. Provide Altronix or approved equal.

Y. Electric strike/magnetic locks power supply

1. Furnished by others, wired by System Integrator.

Z. Locking Devices (Electric strike/Magnetic locks/Electric locks/Electric Hinges)

1. Furnished and installed by others. Wired by System Integrator.

AA. Beacons

1. Provide blue security beacons as shown on the drawings. The unit shall be wall or ceiling mount. The unit shall be 12/24 VDC and wired to the security management system.

BB. Duress Stations

1. Provide remote duress red mushroom push button as shown on the drawings. The device shall be designed for high security applications and shall be vandal proof. Each duress button shall be wired to the USP for camera call-up and general alarm conditions. Each button shall report and be programmed independently of one another.
2. Provide Rauland HSS8 or approved equal.

CC. Door Contacts/switches

1. Provide recessed door contacts/switches as shown on the drawings. Contacts shall be 3/4 inch and have wire leads of sufficient length for splices to be made in wiremold box or mud type box located adjacent to door. Provide DPDT contacts for all doors, GE model #1076-D or approved equal.
2. In event that circumstances prevent the use of recessed contacts in some locations, surface contacts may be used, subsequent to approval of Architect.
3. Wiring for door contacts shall be concealed.
4. Door contacts shall not be wired in series with exception of double doors which may be wired to panel as single door location.
5. There shall be no splices in door frames or jambs. Door contact connections shall be made in wiremold or mud switch box located adjacent to door.

DD. Extended Service, Preventative Maintenance and SMA Agreement

1. General
 - a. The Systems Integrator shall supply a service, preventive maintenance and SMA agreement for the duration of the warranty period. The owner shall have the option to renew the agreement upon expiration.
 - b. The agreement must be provided by the Systems Integrator which both provided and installed the entire Integrated Electronic Security System.
 - c. Equipment warranty shall be provided for a period of one year as described elsewhere within the specification.
 - d. Access to 24/7/365 phone support. A technician will be dispatched the next day of when the service call was placed.
 - e. A technician will be dispatched within 4 hours of when the call was placed for an emergency service call. Emergency service is defined as any one of the following: Video Server/ Video Workstation/Access Control Server/Access Control workstation fails, corridor camera/photo badge reader/card reader/intrusion panel or intrusion alarm keypad does not work.
 - f. A technician will be dispatched within 24 hours of when the call was placed for a normal service call.
 - g. Provide the client with 48 hours' notice of arriving for all preventative maintenance work. And provide a one-hour notice prior to arrival for all preventative maintenance work.
 - h. Provide the client a written report explaining the scope of the service call within 48 hours after completing the service call.

2. Software Maintenance Agreement (SMA)
 - a. Provide a manufacture approved SMA for the duration of the warranty period.
 - b. The agreement shall provide software patches, software updates, service packs and all new software versions that become available at no cost to the owner.
3. Preventative Maintenance
 - a. Upon a monthly basis:
 - 1) Reboot all Video servers. Verify all cameras are properly reporting and recording. Verify all workstations are reporting and working properly.
 - 2) Provide written report to end user stating the above is working properly.
 - b. Upon a quarterly basis:
 - 1) Inspect CCTV Cameras. Verify Camera Field of View and Focus.
 - 2) Verify Cameras are viewing the desired image by the customer.
 - 3) Check System Alarm and Event Logs.
 - 4) Verify Camera Programming, Naming, Image Quality Settings and Recording Settings.
 - 5) Verify System is Recording and Note Retention Period.
 - 6) Verify Recording Hard Drive Configuration and Status. Check for Drive Failures or Bad Sectors.
 - 7) Verify Motion Detection Recording Settings. Verify all cameras are capturing the expected Motion Activity. Note any discrepancies.
 - 8) Verify PTZ Control of applicable Cameras. Check Presets, Tours and Home Position Settings.
 - 9) Verify all channels of the Video Encoder (s) are working properly.
 - 10) Provide Microsoft Window updates to each Genetec Workstation and Hirsch Workstation.
 - 11) Verify network switch utilization and network switch ports are functioning.
 - 12) Check Access Control Panel / Controller Communications Status.
 - 13) Check Access Control Panel / Controller Batteries. Note Battery Type, Voltage, Amp-Hour Rating and Date Code. Test and Note Battery Voltage.
 - 14) Inspect Door Hardware for Operation, Damage & Mis-Alignment.
 - 15) Inspect and Test Operation of Access Control Equipment at each Door [Card Readers, Door Contacts, REX & Door Release Push Buttons where applicable].
 - 16) Test Operation of Ancillary Access Control Inputs and Outputs.
 - 17) Check System Alarm and Event Logs. Attach a printed copy of the logs if applicable.
 - 18) Verify Camera Call-Up upon Event / Alarm where applicable.
 - 19) Verify Door Programming, Time Schedules, Access Levels and Door Unlock Schedules. Note programming operation.
 - 20) Verify Photo Badge Reader and Workstation Photo-ID Call-up Operation.
 - 21) Verify System Time of Day is configured and is synchronizing with a time server or consistent source.
 - 22) Verify and Note Current Software Version and Device Firmware Versions.
 - 23) Verify Client and Server Computer Hardware Specifications. Verify CPU, Memory & Network Utilization. Note Performance Stats. Perform Reboot of all Computers and verify system back-online and note any changes in performance stats.
 - 24) Verify Access Control System Database is configured for a regular back-up.

- 25) Check each Intrusion motion detector, intrusion door contact, glass break device, duress button and keypad to verify its working properly.
 - 26) Provide written report to end user stating the above is working properly.
 - c. On an annual basis:
 - 1) Upgrade the complete IESS software platform to the latest version available. Include all Microsoft Window updates as required by the manufacture.
4. Hardware Support
 - a. The Systems Integrator shall perform scheduled maintenance services on all systems and equipment as specified in this section.
 - b. Components and parts that are found to be defective, have failed operationally or which exhibit signs of near term failure will be identified during each preventive maintenance inspection or test. If the component or part is covered under a current Systems Integrator or factory warranty, said part or component will be replaced at no charge to CUSTOMER including labor during normal business hours.
 - c. For any equipment requiring repair or replacement that is not covered, an estimate will be prepared and submitted for approval on a reimbursable basis and repair authorization shall be issued in writing by an authorized representative of the CUSTOMER before proceeding with the work.
5. Response Time
 - a. Should an emergency arise, the Systems Integrator personnel will assess the situation either by phone or remote diagnostics, or both, and will determine the required course of action with the CUSTOMER.
 - b. On-Site Response Time: If it is determined that a site visit is required, the Systems Integrator personnel will arrive at the affected premises within four (4) hours of the request of the CUSTOMER.

2.4 INTEGRATED COMMUNICATION AND DOOR SYSTEM

A. SYSTEMS DESCRIPTION

1. The purpose of the building Communications and Door system shall be to provide clear, two-way, remote reply intercommunication between the intercom master stations, remote intercom stations, and cells.
 - a. The basis of design is the Alphacom XE system as manufactured by Zenitel.
2. The communication system shall also encompass a security paging system. The paging system shall be programmed and wired to make paging announcements from the owner's VOIP phone system.
3. System shall be a direct-selection type with software integrated with the access control system.
4. Scope of system shall include all features and functions described herein and all equipment shown on the plans. System shall be capable of adding optional features and components listed in specifications, even if not initially included or shown on the plans.
5. The extent, size, locations, and layout of the system shall be as shown on the plans.
6. A complete and operational system shall be provided.
7. Provide SIP integration with the IESS as required.

B. SYSTEM CONFIGURATION

1. Intercom control station(s) shall be located as required and shown on the plans.
2. Provide integration with the Integrated Electronic Security System to allow camera call up when a specific intercom and/or duress button is deployed. Each duress button shall be logged into the access control database.
3. All locations within the detention area shall support the configuration of an audio threshold. Upon the breach of the set audio threshold, an alarm should be generated. This alarm, for each designated cell location shall both announce at the intercom system masters as well as logged by the access control solution.

C. SYSTEM OPERATION

1. ALL CALL

- a. An All Call page shall be possible, to designated paging speakers programmed to receive All Call, by simply pressing the All Call button on the master or desk-top paging microphone where designated, or through owner supplied telephone system. The All Call button shall function as press-to-talk. A short unique alert tone shall be heard by all stations programmed to receive All Call. All call shall include selected overhead ceiling speakers and outdoor loudspeakers, through page adapters and amplifiers.

2. PUBLIC ADDRESS ZONED PAGING

- a. It shall be possible to assign direct-select buttons on the master(s) to designated groups of overhead speakers. Paging shall be transmitted through appropriate page adapters and audio amplifiers. It shall be possible to include the P.A. paging zones in the Group Calls. Paging shall be accomplished by selecting paging zone(s), depressing the PTT button and speaking into condenser microphone on the master. A short alert tone shall sound over all speakers involved. Contractor shall furnish and install appropriate number of page adapters.
- b. Paging Zones:
 - 1) All building
 - 2) Community Room & Main Lobby
 - 3) Cell Block/Sally Port
 - 4) Officers Area – Reports, Sergeants, Roll Call
 - 5) Locker Rooms

3. AUDIO MONITORING

- a. As standard, one of the features for shall. Areas to be monitored (such as listening to elevators and parking areas) shall be selected and easily programmed by the user. When selected, the red monitor LED software graphic shall illuminate and audio from all preselected stations shall be heard over master speaker.

4. VOLUME CONTROL

- a. The master shall include two (2) incoming audio volume control buttons. Buttons shall be momentary, "press up," and "press Down." Buttons shall control volume by means of continuous digital control of the amplifier. Ordinary carbon type or wire round potentiometers, with exposed knobs, will not be acceptable.

5. SOUND DETECTION

- a. System shall provide automatic audio surveillance and sound detection in specific areas, such as cells.

D. SYSTEM STANDARD FEATURES

1. System shall include the following basic features (software based):

- a. Press-to-talk, remote-reply communications.
- b. Easily expanded
- c. Programmable functions and add-on features
- d. All-Call with unique call tone
- e. Standard Group-Call buttons (programmable)
- f. Silent monitoring of selective substations (programmable)
- g. SIP compliant.
- h. Integration with VMS platforms.

E. EQUIPMENT AND PRODUCTS

1. CENTRAL EXCHANGE AUDIO SERVER

- a. Can provide critical communications to all master and substation units for the project.
- b. Supports up to 552 IP stations.
- c. Intel IXP425 processor with HW acceleration for packet processing.
- d. 128MB SDRAM.
- e. Rack mount configuration.
- f. Provide Zenitel Alphacom XE series or approved equal.

2. IP AMPLIFIER

- a. 2x100 watt channels
- b. Digital audio processing.
- c. Line input.
- d. Dual ethernet ports.
- e. Used for general paging systems.
- f. Provide Zenitel ENA-AC series or approved equal.

3. MASTER STATIONS

- a. Provide IP audio/video master stations for each Intercom master station as shown on the drawings. Provide a minimum of (1) per dispatch console seat.
- b. Includes handset and speaker.
- c. Dual switched auto-sensing 10/100/1000 Mbps network ports.
- d. SIP compliant.
- e. 4.3 LCD display.
- f. Supports external headsets.
- g. PoE powered.
- h. Provide Zenitel model ITSV-1 or approved equal.

4. INTERCOM SUBSTATIONS

- a. Provide audio video intercom substations as shown on the drawings.

- b. Supports full duplex audio.
- c. Vandal resistant housing.
- d. Omni directional microphone.
- e. PoE powered.
- f. Provide Zenitel TCIS-3 or approved equal for audio only locations.
- g. Provide Zenitel TCIV-3 or approved equal for combo audio and video locations.

5. VoIP INTERCOM MODULE

- a. Converts analog speaker to IP.
- b. Powers up to 10 watt speaker.
- c. PoE or 24 volt power options.
- d. Provide Zenitel TKIS-2 or approved equal.

6. SPEAKERS

- a. Provide 4-inch loudspeakers for the cells as shown on the drawings. These speakers shall be two way where the master intercom station can both communicate and listen to each cell.
- b. 8 ohm, 25volt, and 70 volt options.
- c. Provides 10 watts at 8ohm.
- d. Provide Atlas model number FC104 series or approved equal.
- e. Provide with baffle and backbox kits for ceiling mount installations.
- f. Mount in light fixture (light fixture by others) for cell applications.

PART 3 - EXECUTION

3.1 GENERAL

- A. Verify the exact location prior to bid of all items that may be indicated and determine exact location of all electrical items that are not indicated on the Drawings.
- B. Include the cost of all work including sub-letting of any work that may be required to complete the work indicated in order to avoid work stoppages and jurisdictional disputes. The work to be sublet shall conform with precedent agreements and decisions of record. Jurisdictional assignment shall be a responsibility under this Section's contractual obligation.
- C. Do not install equipment and materials which have not been reviewed by the Architect. Equipment and materials which are installed without the Architect's review or without complying to comments issued with the review shall be removed from the project when so instructed by the Architect. No payment will be made for unapproved or removal if it is ordered removed. The Installer shall be responsible for any ancillary costs incurred because of its removal and the installation of the correct equipment and materials.
- D. Obtain detailed information on installation requirements from the manufacturers of all equipment to be furnished, installed or provided. At the start of construction, check all Contract Documents, including all Drawings and all Sections of the specifications for equipment requiring electrical connections and service and verify electrical characteristics of equipment prior to roughing.
- E. Equipment and systems shall not be installed without first coordinating the location and installation of equipment and systems with the General Contractor and all other Trades.

- F. Any and all material installed or work performed in violation of above requirements shall be re-adjusted and corrected by the Installer without charge.
- G. Refer to all Drawings associated with the project, prior to the installation or roughing-in of the electrical outlets, conduit and equipment, to determine the exact location of all outlets.
- H. After installation, equipment shall be protected to prevent damage during the construction period. Openings in conduits and boxes shall be closed to prevent the entrance of foreign materials.
- I. Home runs indicated are not to be combined or reduced without written consent from the Architect.
- J. All connections to equipment shall be made as required, and in accordance with the approved submittal and setting drawings.
- K. Delivery, Storage and Handling:
 - 1. Deliver, store, protect and handle products in accordance with recommended practices listed in Manufacturer's Installation and Maintenance Manuals.
 - 2. Deliver equipment in individual shipping splits for ease of handling, mount on shipping skids and wrap for protection.
 - 3. Inspect and report concealed damage to carrier within specified time.
 - 4. Store in a clean, dry space. Maintain factory protection or cover with heavy canvas or plastic to keep out dirt, water, construction debris, and traffic. Heat enclosures to prevent condensation. Meet the requirements and recommendations of NFPA 70B and the Manufacturer. Location shall be protected to prevent moisture from entering enclosures and material.
 - 5. Handle in accordance with NEMA and the Manufacturer's recommendations and instructions to avoid damaging equipment, installed devices and finish.
 - 6. The equipment shall be kept upright at all times. When equipment has to be tilted for ease of passage through restricted areas during transportation, the Manufacturer shall be required to brace the equipment suitably to insure that the tilting does not impair the functional integrity of the equipment.
- L. Site Observation:
 - 1. Site observation visits will be performed randomly during the project by the Architect. Reports will be generated noting observations. Deficiencies noted on the site visit reports shall be corrected. All work shall comply with the Contract Documents, applicable Codes, regulations and local Authorities whether or not a particular deficiency has been noted in a site visit report.
 - 2. Be responsible to notify the Architect ten working days prior to closing in work behind walls, raised access floors, ceilings, etc., so that installed work can be observed prior to being concealed.
 - 3. Work concealed prior to observation and correction of deficiencies shall be made accessible for review at the discretion of the Architect. Bear all costs for allowing worked to be reviewed.
 - 4. Areas shall stay accessible until deficiencies are corrected and accepted. Notify the Architect when all deficiencies are corrected. Return reports with items indicated as corrected prior to re-observation by the Architect.

3.2 WORK

- A. Loose materials shall not be stored on-site. A "gang box" is acceptable to be placed in a location agreeable to the Owner and the General Contractor. The Installer is responsible for all equipment and materials and for their delivery until the system is deemed complete and accepted by the Owner.
- B. Any ceilings, walls, floors, furniture, equipment, furnishings, etc., damaged by the work of this Section shall be replaced, or at the Owner's option, repaired with similar materials, workmanship and quality.
- C. Clean and touch up all equipment, materials and work sites at the completion of work in each area.
- D. Certain portions of the work area may be occupied during construction. Determine which areas and schedule work accordingly and include necessary premium time.
- E. Make sure necessary provisions to provide continuous service of all existing systems throughout all occupied areas.

3.3 EQUIPMENT RACKS, CABINETS AND BRACKETS

- A. Securely mount equipment racks, cabinets and wall mounted relay brackets to the building structure. Proper supports such as 3/8" lag screws and expansion anchors shall be used. Proper quantity of supports shall be utilized. Dry wall screws and other types of supports not specifically approved to support equipment are specifically prohibited. Submit mounting supports for approval before installation.
- B. Position racks, cabinets and wall mounted relay brackets in order to have minimum 3 foot clearance for easy access. Equipment racks, cabinets and relay brackets mounted on or against walls shall have 3 foot clearance in front of deepest component. Free standing equipment racks and cabinets shall have 3 foot clearance in front and rear of deepest components. Provide 3 foot clearance between free standing equipment racks or cabinets and any other obstruction to allow access from front to rear of rack or cabinet for maintenance.
- C. Install terminating components such as patch panels (UTP, Fiber optic); cable management, etc. into the racks, cabinets and wall mounted relay brackets.
- D. Patch Panels: Mount patch panels onto the rack(s) in top-to-bottom fashion with the first patch panel mounted at the top of the rack. Uniquely label each patch panel according to the numbering convention outlined in the SECTION on labeling. Each port shall also have color coded identifiers. Refer to details on the Drawings.
- E. Cable Management: All cables shall enter the wiring closet to within the equipment racks and/or brackets. Secure the bundle(s) to the rack strain relief and wire management behind the patch panels and cross connect block panels. Install horizontal and side-mounted vertical cable management panels and brackets for routing and management of patch cables. Maintain EIA/TIA and BICSI standards on bundling, supporting and bend radii.
- F. Once the cabling system has been installed and terminated, install all active components and surge protected power strips into the racks, cabinets and wall mounted relay brackets.
- G. Surge Protected Outlet Strips: Mount UPS and surge protected outlet strips per Manufacturer's directions. Refer to details on the Drawings for mounting location.

3.4 SEALING OF PENETRATIONS AND OPENINGS

A. Environmental Seals

1. Provide seals on raceways exposed to widely different temperatures, as in refrigerated or cold storage areas. Install seal to prevent circulation of air from warmer to colder sections through the raceway.
2. Provide seals under device plates for outlets on walls between conditioned and non-conditioned spaces.
3. Provide outlet plate gasket seals at all work area outlets on interior and exterior walls.

B. Smoke and Fire Stopping Seals

1. Firestopping is performed under Section 078400.

3.5 CABLE SUPPORTS

- A. Provide strain relief hardware for backbone cables at each floor level as they pass from one floor to the next.
- B. Provide hook and loop (Velcro) cable wraps at all panels, equipment racks and cabinets. Cable ties are specifically prohibited.
- C. Cable ties for horizontal cables shall be secured with minimum required compression in order to secure the cables properly without impeding the signal transmission rating (geometry) of the cable. Hook and loop (Velcro) cable wraps may be used in lieu of cable ties for copper cables only. Cable-ties are specifically prohibited for fiber optic cables.
- D. When pathways are not provided or specified, provide J-Hook supports from the building structure as required for cable runs to the cable drop location. Maximum distance between supports shall be five feet (1 500mm) depending on the structural elements of the building. Maximum number of cables per support shall be thirty. Provide additional supports as required when cable quantities exceeds thirty and to maintain required bending radius of cables. Cables installed exposed or in areas subject to abuse (below 10 feet (3m) above finished floor) or in accessible areas shall be installed in conduit.
- E. All cables shall be supported directly from building structure. Under no circumstance shall cable be installed using cross bracing, plumbing/sprinkler pipes, ceiling systems or any other system that is not a specifically approved method to independently support cables. Cables shall not be allowed to rest on ceiling tiles, duct work, piping, etc. Supports shall be provided as required in order for cables to avoid contact with any other building system. Bundle cables in groups by Room.

3.6 CABLE PROTECTION

- A. Provide bushings in all metal studs and the like where cables will pass through. Bushings shall be of two (2) piece construction with one piece inserted through the opening and the second piece locking it into place. Single piece bushings with locking tabs or friction fit are specifically prohibited.
- B. Cables to be installed in existing enclosed open bays or furred spaces where conduit stubs are not provided, shall be protected from chafing or any damage. The Installer shall verify that the warranty shall not be violated before installing any cabling in these locations.

- C. Provide cutting, coring, sleeves and bushings and seal as required at all penetrations.
- D. Fiber optic backbone cables shall be installed in inner duct.
- E. Cables damaged during installation shall not be repaired. They shall be completely replaced with new cable.

3.7 INSTALLATION

- A. All cabling shall be installed in conduit where indicated on plans, or shall be installed open using other methods, approved by architect, such as J-Hooks, cable tray & snake tray.
 - 1. Install wiring, per manufacturers recommendations.
 - 2. All wiring shall be new, concealed in pipe where exposed.
 - 3. Install wiring for detection and signal circuit as specified. Make wiring connections to new or existing door hardware devices as required
- B. All conduits, raceways, innerduct, etc. shall have pull strings remaining after cable is pulled.
- C. Impedance and Level Matching:
 - 1. Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
- D. Control Circuit Wiring:
 - 1. Install control circuits in accordance with NFPA 70 and as indicated. Provide number of conductors as recommended by system manufacturer to provide control functions indicated or specified.
 - 2. All housings are to be located as specified and shown on drawings.
 - 3. Make installation in strict accordance with approved manufacturer's drawings and instructions.
 - 4. The Installer shall provide necessary transient protection on the AC power feed, all station lines leaving or entering the building, and all central office trunks. All protection shall be as recommended by the equipment supplier and referenced to earth ground.
- E. Splices, Taps, and Terminations:
 - 1. Make splices, taps and terminations on numbered terminal punch blocks in junction, pull, and outlet boxes, terminal cabinets and equipment enclosures.
 - 2. Identification of Conductors and Cables:
 - 3. Use color coding of conductors and apply wire and cable marking tape to designate wires and cables so all media are identified in coordination with system wiring diagrams.
- F. Weatherproofing:
 - 1. Provide weatherproof enclosures for items to be mounted outdoors or exposed to weather.
- G. Typical Layouts and requirements of the specified systems:
 - 1. Typical layout:
 - a. Equipment racks and cabinets

- b. Backbone cabling
 - c. Headend equipment
2. Typical layout of telecommunications equipment racks and cabinets
- a. Each equipment rack and cabinet shall contain the following equipment:
 - 1) Surge protector power strip
 - 2) Patch panels - Horizontal distribution
 - 3) Horizontal distribution cable management
 - 4) Vertical cable management
 - 5) Patch cords
 - b. Provide space for the installation of network electronics equipment in the equipment racks.
 - c. Furnish and install horizontal cable management between each patch panel (fiber optics, Hub distribution, Horizontal distribution, and telephone distribution).
 - d. Furnish and install horizontal distribution patch panels in each wire center with sufficient ports to terminate all modular jacks shown on the drawings plus twenty percent spares. The exact number of modular jacks and horizontal distribution patch panels shall be obtained from the drawings.
 - e. Furnish and install all equipment racks and cabinets required to support the aforementioned equipment.
 - f. The MDF room shall contain fiber optic patch panel quantities which correspond to the total number of fiber optic patch panels located in the IDF rooms.
 - g. Grounding bars shall be installed under SECTION 26 00 10. Furnish and install the required grounding to ensure that all of the aforementioned equipment is grounded and bonded.
3. Headend
- a. The headend consists of connecting hardware for the following:
 - 1) Data System
 - 2) Voice System
 - 3) Video System
 - 4) Sound System
 - b. Furnish and install all IDC cross connect block panels and hardware for terminating telephone, video all-call, administration console system and satellite dish cabling at the headend. Terminations of these systems onto the IDC cross connect block panels at the headend shall be provided under this Section.
 - c. IDC cross connect block panels and hardware for terminating Clocks, Speakers and all control wiring shall be furnished and installed under DIVISION 27. Terminations of these systems onto the IDC cross connect block panels at the headend shall be provided under DIVISION 27.
 - d. Furnish and install the specified UTP cables from Telephone Company demarcation to headend. Terminate both ends of each cable onto IDC cross connect block panels.
 - e. Final terminations from the IDC cross connect block panels to the headend equipment shall be provided by the headend equipment installer.

- f. Coordinate with the headend equipment installer and the Electrical Subcontractor for:
 - 1) The installation of all the IDC cross connect block panels at the headend equipment. Installation shall be neat in appearance.
 - 2) The final terminations at the headend.

3.8 GROUNDING

A. General:

- 1. The Telecommunications systems comprising of cable tray, snake tray, equipment cabinets, racks and non-current carrying metallic parts shall be grounded according to the Electrical Code.
- 2. In general, the grounding shall be as specified, as indicated on the Drawings and as required by the Electrical Code and Local Authorities.

B. Methods:

- 1. Provide equipment grounding connections for integrated sound, voice and video systems as indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.
- 2. Ground equipment, conductor, and cable shields to eliminate shock hazard and to minimize to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.
- 3. The installer shall provide all necessary transient protection on the AC power feed and on all station lines leaving or entering the building.
- 4. The installer shall note in his system drawings, the type and location of these protection devices as well as all wiring information.
- 5. The installer shall furnish and install a dedicated, isolated earth ground from the central equipment rack and bond to the incoming electrical service ground buss bar.

C. Telecommunications Grounding

- 1. Raceways including wireways, conduits, cable trays, snake tray, etc. installed for low voltage or fiber optic cabling shall be made electrically continuous for grounding purposes. Provide hollow braided copper jumpers between sections equal to Belden No. 8669 (60A Ampacity). Provide equal impedance conductor for aluminum raceway.
- 2. Bond raceways to the ground bus located in the equipment cabinet. Bond raceways in each room they terminate in.

D. Telecommunications Equipment Bonding & Grounding

- 1. Provide grounding and bonding as required by EIA/TIA-607 standards, codes and the equipment manufacturers.
- 2. Make final grounding conductor connection to cabinet around bus.
- 3. Each individual piece of equipment shall have an individual grounding conductor to the ground bus within the cabinet.
- 4. All equipment shall have bonding jumpers between them (i.e. between cable tray, snake tray and equipment rack, etc.).
- 5. Equipment integral to an equipment rack (i.e. shelves, panels, cable management, etc.) shall be considered bonded.

6. Equipment that is not integral to an equipment rack (i.e. shelf mounted electronic equipment, cable tray, snake tray, etc.) require individual bonding jumpers between the equipment and the rack.
7. Properly clean and prepare all surfaces for a complete bonding and grounding termination.
8. Install grounding bus in all equipment racks and cabinets.

3.9 SLEEVING AND BUSHINGS

- A. Raceways and openings shall be laid out in advance to permit their provision in the work. Sleeves and raceway shall be set before new masonry is constructed. Any extra work required where sleeves or raceways have been omitted or improperly placed shall be performed at the expense of the Installer which made the error or omission, including coring.
 1. Existing Construction: Where raceways and cable pathways must pass vertically through existing construction, coring shall be located as per the guidelines shown on the drawings.
- B. Provide sleeves for raceways, busways, snake trays and cable trays penetrating floors, fire walls, or smoke partitions. Install approved material to provide for fire stop.
- C. Provide waterproof seals inside and outside raceway when penetrating from the exterior or underground.
- D. Except where specified otherwise sleeves shall be made of galvanized metal to finish flush with building finish lines.
- E. Provide acoustic sealer in sleeves between occupied spaces.
- F. Sleeves installed in floors shall extend two inches (50mm) above the finished floor unless specifically indicated otherwise. Sleeves for busways shall extend four inches (100mm) above the floor.
- G. Provide sleeves in masonry construction and in full height (slab to slab) walls.
- H. Provide sleeves for any openings requiring fireproofing.
- I. Bushings in all conduits shall be provided by the Electrical Subcontractor in all metal studs and other openings where cables will pass through. Bushings shall be of two piece construction with one piece inserted through the opening and the second piece locking it into place. Single piece bushings with locking tabs or friction fit are specifically prohibited.

3.10 INTEGRATED SECURITY SYSTEM TESTING

- A. Security Management System
 1. Test in accordance with manufacturer's security management systems testing procedures.

3.11 TRAINING

- A. As a minimum, training sessions shall consist of the following:
 1. General project information and review shall be by the General Foreman or Superintendent of the Trade.
 2. Specific system training shall be by a Factory Trained Representative.

3. Provide a complete review of the project and systems including, but not limited to, the following:
 - a. In a classroom environment review each Record Drawing (use of typical is acceptable).
 - b. Note equipment layouts, locations and control points.
 - c. Review each system.
 - d. Review system design operation and philosophy.
 - e. Review alarms and necessary responses.
 - f. Review standard troubleshooting techniques for each system.
 - g. Review areas served by equipment.
 - h. Identify color codes used.
 - i. Review features and special functions.
 - j. Review maintenance requirements.
 - k. Review operation and maintenance manuals.
 - l. Respond to questions (record questions and answers).
 4. After classroom training, walk the entire project, review each equipment room and typical locations. Explain equipment and proper operation.
- B. During the instruction period the Owner and Maintenance Manual shall be used and explained.
- C. The Owner and Maintenance Manual material shall be bound in 3-ring binders and indexed. On the edge of the binder provide a clear see-through plastic holder with a typed card indicating the Project name, the Architect's name, the installer's name and the Volume number (e.g., Vol. No. 1 of 2).
- D. Provide name, address and telephone number of the manufacturer's representative and service company for all items supplied so that the source of replacement parts and service can be readily obtained.
1. Include copies of manufacturer's and installer's warranties and maintenance contracts and performance bonds properly executed and signed by an authorized representative.
 2. Include copies of all test reports and certifications.
- E. Providers of the Integrated Security and Communication System shall provide training as part of their package. This comprehensive training plan shall address the following areas:
1. Training, providers of the Integrated Security and Communication System shall provide (40) hours of training as part of their package, this comprehensive training plan shall address the following areas:
 - a. System Orientation for all involved staff members.
 - b. Small group hands-on training sessions for all media center staff focusing on system-wide hardware and troubleshooting.
 - c. Small group hands-on software training sessions for all media center staff.
 - d. Small group hands-on sessions covering classroom media control equipment for all instructional staff.
 - e. Small group hands-on software training sessions for all instructional staff.
 - f. Follow-up training for media center staff.
 - g. Follow-up training for all instructional staff.

- h. System Orientation for all Involved Staff Members, providers of the Media Management System shall provide a two-hour orientation session for the entire school community prior to the system turnover date. This orientation session shall include a full demonstration of the systems working capabilities. The demonstration shall only include those features and functions that were specified. The equipment demonstrated shall be exactly the equipment installed at the facility.
- F. The Security Management System Integrator shall coordinate with the System Administrators for two 8 hour Operator training sessions on the Operational System to be conducted on-site on the actual running system.

3.12 ACCEPTANCE DEMONSTRATIONS

- A. Systems installed under this Section shall be demonstrated to the Owner and Architect. Demonstrations are in addition to necessary testing and training sessions. Notify all parties at least 7 days prior to the scheduled demonstration. Schedule demonstrations in cooperation with and at times convenient to all parties and so as to not disturb ongoing activities.
- B. Systems shall be tested prior to the demonstrations and each system shall be fully operational and tested prior to arranging the Acceptance Demonstration. Final payments will be withheld until a satisfactory demonstration is provided for all systems indicated or requested.
- C. If the demonstration is not totally complete, performing all functions, features and connections or interfaces with other systems, or if there is a failure during the demonstration, additional demonstrations shall be arranged. Provide and pay for all costs, labor and expenses incurred for all attendees for each additional demonstration required for acceptance and demonstration of complete system operation.
- D. Demonstrations shall be scheduled in ample time to complete all activities prior to final acceptance and Owner occupancy. Demonstrations shall take place at least 30 days prior to the scheduled project completion date and 30 days prior to owner's use and occupancy.
- E. As a minimum, provide demonstrations for systems indicated under "Work Included" under Part One of the Specifications. Provide demonstrations of additional systems as requested by the Owner, or Architect.

3.13 PROJECT OWNER COORDINATION

- A. Prior to Substantial Completion of the project and in ample time to address and resolve any coordination issues, request and arrange meetings between the Owner, Owner's Vendors and Consultants, Architect and General Contractor to discuss the Scope of Work for each system being provided and the interface required for a fully functional and operational system upon project completion. Initial meetings shall be scheduled three months prior to the scheduled Substantial Completion date or as soon as Submittals are submitted and reviewed for projects with shorter schedules.
- B. At these meetings the required interface with the Owner shall be reviewed, requests for information required to complete programming or for coordination shall be presented and system operation and philosophy shall be discussed.
- C. Additional meetings shall be held as requested by any party so that all issues are resolved and with the goal and intent being that all systems are fully operational and functional upon project Substantial Completion and that the responsibility for all components required is clearly established.

3.14 CLEANING UP

- A. Upon completion of all work, and testing, thoroughly inspect all exposed portions of the installation and completely remove all exposed labels, markings, and foreign material.
- B. The interior of all boxes and cabinets shall be left clean; exposed surfaces shall be cleaned and plated surfaces polished.
- C. Repair damage to finish surfaces resulting from work under this Section.
- D. Remove material and equipment from areas of work and storage areas.
- E. All equipment shall be clean from dirt, dust, and fingerprints prior to final acceptance.
- F. Touch up all damaged pre-finished equipment using materials and methods recommended by the Manufacturer.

3.15 PROJECT CLOSEOUT

- A. Provide close out submittals as required herein and in SECTION 01 78 00 - CLOSEOUT SUBMITTALS including the following close out submittals.
 - 1. Operation and Maintenance Manuals
 - 2. Record Drawings.
 - 3. Test Reports.
 - 4. Extra Materials.
- B. Obtain written receipts of acceptance close out submittals submitted. Receipts shall specifically detail what is being delivered (description, quantity and specification section) and shall be dated and signed by firm delivering materials and by the Owner's Representative.
- C. Telecommunications:
 - 1. Provide record drawings indicating actual cable routing and cable terminations and all required identifiers. Provide copy mounted in each telecommunications closet and the main cross connect.
 - 2. All sketches, drawings, and charts herein are for the purpose of providing for specifications in a simplified format. Errors and omissions in such does not relieve the Contractor of the responsibility for providing a fully complete, secure and properly operating integrated instructional technology network system suitable for the intended use. Bidders must obtain a complete set of Project Drawings and Specifications to determine the full scope of work. In case of conflict the Project Drawings and Specifications shall prevail.

END OF SECTION

SECTION 310000

EARTHWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

- A. All work specified in this Section shall conform to "Standard Specifications for Highway and Bridges" of the Massachusetts Department of Transportation, latest revision, herein referred to as "State Standards".
- B. Existing Conditions Plan compiled from the following sources:
 - 1. Existing conditions mapping taken from plan entitled "Topographic Plan of Land 1 East Union Street and 12-16 East Union Street (Route 135) Middlesex County Ashland, Mass" prepared by Guerriere & Halnon, Inc., dated April 7, 2020.
 - 2. Wetland Flags identifying wetland resource areas were placed by Pare Corporation on September 11, 2018 and located by Guerriere & Halnon, Inc.
- C. Soil erosion and sedimentation controls shall be provided in accordance with the "Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas, A Guide for Planners, Designers, and Municipal Officials" prepared by Franklin, Hampden, Hampshire Conservation Districts, reprint dated May 2003.

1.3 SUMMARY

- A. This Section includes all excavation including, but not limited to, the following:
 - 1. Excavating and backfilling for demolition of buildings and structures.
 - 2. Excavating and backfilling for utility trenches.
 - 3. Excavating and backfilling trenches for buried mechanical and electrical utilities and pits for buried utility structures.
 - 4. Geotextiles.
- B. Related Sections include:
 - 1. Section 315000 Excavation Support and Protection
 - 2. Section 312319 Dewatering
 - 3. Section 312316.26 Rock Excavation and Disposal
 - 4. Section 312316.27 Blasting

1.4 SUBMITTALS

- A. Geotextiles:

1. Technical properties including but not limited to tensile strength, puncture strength, mullen burst, elongation, equivalent opening, permittivity, and water flow rate.
 2. Provide a 12-by-12-inch sample of geotextiles and the manufacturer's recommended installation procedure.
- B. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance with the following requirements indicated:
1. Gradation Test Results for each on-site and imported soil material proposed for fill and backfill.
 2. Laboratory compaction curve according to ASTM D6938 and ASTM D1557 for each on-site and imported soil material proposed for fill and backfill.
 3. Each submittal shall include the intended use for the material with the appropriate specification section and material name corresponding to the Contract Documents to facilitate review.
- C. Copies of permits obtained for excavations that are required by state and local governing authorities and local utility companies shall be submitted to the owner's representative.

1.5 SITE INFORMATION

- A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of lack of full knowledge of existing conditions.
- B. Plans, surveys, measurements and dimensions, under which the work is to be performed, are believed to be correct to the best of the Engineer's knowledge, but the Contractor shall have examined them for himself during the bidding period, as no allowance will be made for any errors or inaccuracies that may be found herein.
- C. Data on indicated subsurface conditions are not intended as representations or warrants of continuity of such conditions between soil borings. It is expressly understood that the Owner and Engineer will not be responsible for interpretations or conclusions drawn therefrom by the Contractor.
- D. The Contractor may request to perform additional test borings and other explorations at no cost to the Owner.
- E. Soil borings and test pits have been made by qualified Contractors prior to this Contract. This information shall be made available to bidders as specified under other Sections. The Contractor is responsible to employ qualified personnel capable of interpreting geotechnical information, test pit logs, and boring logs. The results of these subsurface explorations and recommendations for work were prepared by the Engineer, consulting geotechnical engineers, and are hereby attached to this specification for information only. Procedures for dewatering, areas to receive special fill and other methods and procedures specified herein shall be supplemented by this information. For purposes of this specification, this information will be referred to as the Geotechnical Report. Where procedures within the report vary from procedures as specified herein, this specification shall override. The Geotechnical Report is available as a separate document.
- F. The Geotechnical Report states that rock and shallow bedrock is present on the site. The costs of additional rock excavation resulting from changes in the work shall be paid for as outlined in the measurement and payment section of this specification.**

- G. The Geotechnical Report states that groundwater is present on the site. The groundwater elevation is anticipated to be above the required bottom of excavation which will require dewatering. The Contractor is made aware of this condition and will not be eligible to receive additional compensation for dewatering exceeding the Contractor's initial bid.**
- H. The Geotechnical Report states that some of the materials present on site contain quantities of silt beyond the limit deemed acceptable for re-use by this specification. The Contractor is made aware of this condition and will not be eligible to receive additional compensation for imported material exceeding the Contractor's initial bid.
- I. The Geotechnical Report states that Fill material present on-site contains brick, debris, or quantities of silt that may limit re-use of this material. The Geotechnical Report allows the Contractor to screen the Fill containing debris and conduct testing at his own expense to confirm whether this material is suitable for re-use. The Contractor is made aware of this condition and will not be eligible to receive additional compensation for imported material exceeding the Contractor's initial bid.
- J. It is the responsibility of the Contractor under this Contract to do the necessary excavation, filling, grading, and rough grading to bring the existing grades to subgrade and parallel to finished grades as specified herein and as shown on the Drawings for this Work. The Contractor shall visit the site prior to submitting a bid to become familiar with the extent of the work to be done under this Contract. The Contractor shall be responsible for determining the quantities of earth materials that must be imported or hauled off the site necessary to complete the work under this Section. All imported earth materials required to construct the project shall be included in the Contractor's base bid.
- K. The Contractor is allowed to re-use excavated On-Site Ordinary Borrow as fill in accordance with this specification. All On-Site Ordinary Borrow used as backfill shall be compacted to the required percentage of maximum dry density included in Table 2 below.
1. The Contractor is made aware that On-Site Ordinary Borrow may contain large amounts of silt. Additional efforts required to reuse On-Site Ordinary Borrow are the responsibility of the Contractor and shall result in no additional expense to the Owner or a request for additional time for delays caused by its usage.
 2. The Contractor agrees to use this material at his own risk and is responsible for any additional work required to install this material in accordance with the specifications.
 3. If project delays will result from the additional time required to re-work On-Site Ordinary Borrow, placed as fill in accordance with the specifications, the Contractor shall remove material that does not meet the compaction requirements and provide imported fill meeting the specifications. This imported material shall be provided at no additional expense to the Owner.
 4. Any project delays resulting from additional time required to work this material are the responsibility of the Contractor.
- L. The Contractor shall use suitable on-site soils and fill, and soil from off-site sources, as needed. Please note that not all on-site materials will be suitable for reuse, nor will all required material gradations be present on the site. Imported materials are anticipated for this project.
- M. Contractor shall protect and adjust moisture condition of all on-site and imported materials for proper installation, compaction, and use. This includes covering, drying, and adding moisture as required to maintain suitable workability of the soil materials. Please note onsite and imported materials will not necessarily be encountered or delivered in a suitable condition as environmental factors prevalent at the time of construction will impact soil materials.

1.6 UNIT PRICES

- A. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed the limits specified in PART 3 - EXECUTION.
- B. Unit prices for rock excavation include all labor, equipment, and materials required for removal of rock and hauling of rock off-site. Unit prices for rock excavation also include all labor, equipment, and materials required for replacement of rock excavation with approved materials where the rock excavation extends beyond the specified excavation limits. Any excavation beyond the specified excavation limits must be approved by the Owner's representative prior to removal. Specified excavation limits for rock are specified in Section 3.4 ROCK EXCAVATION.

1.7 DEFINITIONS

- A. Backfill: Soil material used for fill and excavation.
 - 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
 - 2. Final Backfill: Backfill placed over initial backfill to fill a trench.
- B. Base Course: Course placed between the subbase course and asphalt paving.
- C. Bedding Course: Layer placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow: Satisfactory soil for use as fill or backfill.
- E. Boulder: A soil particle with a minimum dimension of 12 inches.
- F. Drainage Course: Course supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- G. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated on the Drawings.
 - 1. Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Owner's Representative. Additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
 - 2. Bulk Excavation: Excavation more than 6 feet in width and more than 10 feet in length for the installation of utilities, foundations, and footings.
 - 3. Trench Excavation: Excavation 6 feet in width or less for the installation of utilities, foundations, and footings.
 - 4. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Owner's Representative. Unauthorized excavation, as well as remedial work directed by Owner's Representative, shall be without additional compensation.
- H. Fill: Soil materials used to raise existing grades.
- I. Imported Material: Material obtained by the Contractor from sources off the site.
- J. Influence Area: The area within planes sloped downward and outward at an angle of 60 degrees from the horizontal from (a) 1 foot outside the outermost edge at the base of foundations or slabs;

or (b) 1 foot outside the outermost edge at the surface of roadways or shoulder; or (c) 0.5 foot outside the exterior edge at the spring line of pipes and culverts.

- K. Optimum Moisture Content: Determined by the ASTM standard specified to determine the maximum dry density for relative compaction.
- L. Relative Compaction: The ratio, in percent, of the as-compacted field dry density to the laboratory maximum dry density as determined by ASTM D1557. Corrections for oversize material may be applied to either the as-compacted field dry density or the maximum dry density, as determined by the Owner's Representative.
- M. Relative Density: As defined by ASTM D4253 or D4254.
- N. Rock: Material in beds, ledges, unstratified masses, conglomerate deposits that cannot be removed, in the opinion of the Engineer, without systematic drilling, ram hammering, blasting, or ripping. Weathered Rock that can be removed by an excavator without hammering or other mechanical means shall not meet the definition of rock.

Rock also includes boulders of rock material that exceed 2 cu. yd. for bulk excavation or 1 cu. yd. diameter for footing, trench, and pit excavation.

- 1. Bulk Rock Excavation: Rock encountered within bulk excavation as defined above.
 - 2. Trench Rock Excavation: Rock encountered within trench excavation as defined above.
- O. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- P. Subbase Course: Course placed between the subgrade and base course for asphalt pavement, or course placed between the subgrade and a cement concrete pavement or a cement concrete or asphalt walk.
- Q. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.
- R. Topsoil: Natural or cultivated top layer of the soil profile or manufactured topsoil; containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 1 inch in diameter; and free of weeds, roots, and toxic and other non-soil materials.
- S. Unsuitable Soils: Existing soils that, in the opinion of the Engineer and Owner's Representative, are unsuitable to remain in their existing location that are deposited outside the excavation limits. This does not include topsoil, subsoil, and silty-sand materials.
 - 1. Anticipated unsuitable soils: Unsuitable soils identified in the geotechnical report, drawings, specifications, test pit logs, or boring logs provided as part of the project manual.
 - 2. Unanticipated unsuitable soils: Unsuitable soils not identified in either the geotechnical report, test pits, or boring logs provided as part of the project manual.
- T. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

- U. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes. Well-graded does not define any numerical value that must be placed on the coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters. Well-graded is used to define a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

1.8 IMPORTED MATERIAL ACCEPTANCE

- A. All imported earth materials specified in this section are subject to the following requirements:
 - 1. Materials imported to the site by the Contractor for on-site use shall not contain oil and/or hazardous materials.
 - 2. All tests necessary for the Contractor to locate acceptable sources of imported material shall be made by the Contractor. Certification that the material conforms to the Specification requirements along with copies of the test results from a qualified commercial testing laboratory shall be submitted to the Engineer for approval at least 5 calendar days before the material is required for use. All material samples shall be a minimum of 40 pounds and furnished by the Contractor at the Contractor's sole expense. Samples shall be representative and be clearly marked to show the source of the material and the intended use on the project. Sampling of the material source shall be done by the Contractor in accordance with ASTM D75. Tentative acceptance of the material shall be based on an inspection of the source by the Engineer and/or the certified test results submitted by the Contractor to the Engineer at the Engineer's discretion. No imported materials shall be delivered to the site until the proposed source and the Engineer has tentatively accepted materials tests in writing. Final acceptance will be based on Quality Control and Quality Assurance tests made on samples of material taken from the completed and compacted course.
 - 3. Gradation tests by the Contractor shall be made on samples taken at the place of production prior to shipment. Samples of the finished product for gradation testing shall be taken as specified in 3.16 FIELD QUALITY CONTROL, or more often as directed by the Owner's Representative if variation in gradation is occurring, or if the material appears to depart from the Specifications. Test results shall be forwarded to the Engineer within 48 hours of testing.
 - 4. If tests conducted by the Contractor or the Engineer, indicate that the material does not meet Specification requirements; material placement will be terminated until corrective measures are taken. Material that does not conform to the Specification requirements and is placed in the work shall be removed and replaced at the Contractor's sole expense. Retesting of material that does not meet specification requirements shall be performed at the Contractor's sole expense.

1.9 QUALITY ASSURANCE

- A. Employ a qualified surveyor, registered with the State of Massachusetts as a Professional Land Surveyor, as required for all layout and to establish grades for the work being performed.
- B. Geotechnical Testing Agency Qualifications: An independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 543 shall be hired to provide required testing of earthwork materials at the Contractor's Expense.
- C. All temporary shoring and bracing shall be designed, detailed, and stamped by a Professional Engineer registered in the State of Massachusetts. Refer to SECTION 31 50 00 - EXCAVATION SUPPORT AND PROTECTION

- D. Pre-excavation Conference: Conduct conference at Project site prior to the start of construction. Date and time to be specified by the Owner's Representative.

1.10 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Owner and then only after arranging to provide temporary utility services according to requirements indicated.
 - 1. Notify Owner in no less than two weeks in advance of proposed utility interruptions in writing. Renotify 72 hours in advance of proposed utility interruptions.
 - a. Notifications should be made to the Owner's Representative.
 - b. Do not proceed with utility interruptions without Owner's written permission.
 - c. All power shutdowns shall be coordinated with the Owner.
 - 2. Contact "Dig Safe" at 1-888-Dig Safe to verify locations of existing underground utilities in areas of proposed excavation prior to commencing any excavation effort.
- B. Demolish and completely remove from site existing underground utilities indicated to be removed on the Drawings. Coordinate with utility companies to shut off services if lines are active.

1.11 EXCAVATION SAFETY

- A. The Contractor shall be solely responsible for making all excavations in a safe manner. Contractor shall comply with all Local and State OSHA requirements.
- B. Provide appropriate measures to attain a stable base, retain excavation side slopes and prevent earth slides to ensure that persons working in or near the excavation are protected.

1.12 LAYOUTS AND GRADES

- A. All line and grade work not presently established at the site shall be laid out by a survey team under the supervision of a Registered Land Surveyor or Professional Engineer employed by the Contractor in accordance with Drawings and Specifications. The Contractor shall supply all additional layout and grade control as necessary to properly implement and construct the work. The Contractor shall establish permanent benchmarks and replace as directed any which are destroyed or disturbed.
- B. The words "finished grades" as used herein shall mean final grade elevations indicated on the Drawings. Spot elevations shall govern over proposed contours. Where not otherwise indicated, project site areas outside of the building shall be given uniform slopes between points for which finished grades are indicated or between such points and existing established grades.

1.13 TOLERANCES

- A. All material limits shall be constructed within a vertical tolerance of 0.1 foot and a horizontal tolerance of 1 foot except where dimensions or grades are shown or specified as minimum. All grading shall be performed to maintain slopes and drainage as shown. No reverse slopes will be permitted.

1.14 DRAINAGE

- A. The Contractor shall control the grading in areas under construction on the site so that the surface of the ground will properly slope to prevent accumulation of water in excavated areas and adjacent properties.
- B. The Contractor shall excavate interceptor swales and ditches where necessary prior to the start of major earthmoving operations to ensure minimal erosion and to keep areas as free from surface water as possible.
- C. Should surface, rain, or ground water be encountered during the operations, the Contractor shall furnish and operate pumps or other equipment, and provide all necessary piping to keep all excavations clear of water at all times and shall be responsible for any damage to work or adjacent properties for such water. All piping exposed above ground surface for this use, shall be properly covered to allow foot traffic and vehicles to pass without obstruction.
- D. Presence of ground water in soil will not constitute a condition for which an increase in the contract price may be made. Under no circumstances place concrete fill, lay piping, or install appurtenances in excavation containing free water. Keep utility trenches free of water until pipe joint material has hardened and backfilled to prevent flotation.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. General: The Contractor may reuse excavated on-site material for fill and backfilling where the material excavated is satisfactory and conforms with the below specified gradation requirements. The Contractor is to provide imported soil materials with satisfactory properties conforming with the below specified gradation requirements when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: Soils being free of rock or gravel larger than 3 inches in any dimension, debris, broken pavement, waste, frozen materials, vegetation, and other deleterious matter and conform to the criteria listed below:
- C. Gradations of satisfactory soils are as shown in the Table below:

TABLE 1 - SOIL GRADATIONS					
Sieve Size	Sand Gravel Fill	Granular Fill	1-1/2 inch Crushed Stone	3/4 inch Crushed Stone	Coarse Sand
6-inch*	-	100	-	-	-
3-inch*	100	60-100	-	-	-
2-inch	-	-	100	-	-
1 1/2-inch*	-	-	95-100	-	-
1-inch	-	-	35-70	100	-
3/4-inch	70-100	-	0-25	90-100	-
1/2-inch	50-85	50-85	-	10-50	-
3/8-inch	-	45-80	-	0-20	100
No. 4	40-75	40-75	-	0-5	85-100
No. 10	30-60	-	-	-	20-50
No. 40	10-35	0-45	-	-	0-15
No. 100	5-20**	-	-	-	-
No. 200	0-8	0-10	<1	<1	-

* The maximum recommended stone size is three inches where placed as base course below slabs and pavement; elsewhere, maximum stone size shall be 2/3 of the loose lift thickness.

** The amount passing through the No. 100 sieve should be between 40 and 7 percent of the amount passing through the No. 40 sieve.

1. Ordinary Borrow shall be imported or excavated onsite material free of roots, sod, rubbish, debris, frozen materials, broken pavement, or other deleterious or organic matter, and conform to the following requirements.
 - a. Imported Ordinary Borrow shall conform to the specified gradation of Granular Fill in Table 1.
 - b. Onsite Ordinary Borrow shall conform to the specified gradation of Granular Fill in Table 1, but may contain no more than 15-percent by weight passing the No. 200 sieve. Onsite Ordinary Borrow shall not be placed as foundation wall backfill, as pavement base or subbase courses, as retaining wall backfill, or locations where free-draining backfill are required.
 - c. Stones from excavated onsite material retained on a 3-inch sieve, less than 6-inches in diameter, and not exceeding two-thirds of the thickness of the horizontal layers placed after compaction can be placed for construction. Materials meeting these criteria shall not be included in the analysis for gradation. Materials exceeding this size shall not be placed in backfill below paved areas.
2. Subbase Material shall be free of rock or gravel larger than 3 inches in any dimension, debris, broken pavement, waste, frozen materials, vegetation, and other deleterious matter and conform to the gradation for Granular Fill in Table 1 within this specification.
3. Base Course shall be material free of rock or gravel larger than 3 inches in any dimension, debris, broken pavement, waste, frozen materials, vegetation, and other deleterious matter and conform to the gradation for Sand Gravel Fill in Table 1 above.
4. Riprap shall conform to MA Standard M2.02.0.
5. Filter stone shall conform to the gradation for 3/4" Crushed Stone in Table 1 above.
6. Drainage Stone or Crushed Stone or 1 1/2" Crushed Stone shall be imported material conforming to the gradation for 1 1/2" Crushed Stone in Table 1 and having a maximum percentage loss of 12 percent as determined by the sodium sulfate test, AASHTO T104, and comply to the gradation provided in the table above.
7. Sand Gravel Bedding and Granular Fill Bedding shall conform to the Sand Gravel Fill and Granular Fill gradations, respectively, specified above except that 100% by weight must pass the 1 1/2" sieve.
8. Gravel Borrow shall conform to the Sand Gravel Fill Gradation in the Table 1 above.

9. Refer to the Geotechnical Report for fill material requirements below the structure.

- D. Unsatisfactory Soils are defined as soils not conforming to the satisfactory soils criteria unless otherwise approved by the Engineer.

2.2 GEOTEXTILES

- A. Permanent Turf Reinforcement Mat: Provide North American Green SC250 permanent turf reinforcement mat or approved equivalent. The permanent turf reinforcement matting shall meet the following minimum properties per the Erosion Control Technology Council Type 5A and Federal Highway Administration's FP-03 Section 713.18.

Test	Method	Nonwoven ⁽¹⁾
Performance Test Unvegetated Shear Stress (lb/ft ²)	ASTM D-6460	2.0 min
Performance Test Vegetated Shear Stress (lb/ft ²)	ASTM D-6460	6.0 min
Seedling Emergence (%)	ASTM D-7322	250 min
Tensile Strength (lb/ft)	ASTM D-6818	150 min
Material Mass / Unit Area (oz/yd ²)	ASTM D-6566	8.0 min
Thickness (in)	ASTM D-6525	0.25 min
UV Stability (% @ 500 hrs)	ASTM D-4355	80

- B. Filter Fabric: Non-woven geotextile shall be nonwoven and needle punched pervious sheets of polyester, polyethylene, nylon, or polypropylene filaments formed into a uniform pattern conforming to the MIRAFI 140N or approved equivalent. The geotextile shall have minimum properties as stated in the following table, when measured in accordance with the referenced standards.

Test	Method	Nonwoven ⁽¹⁾
Grab Tensile Strength (lbs)	ASTM D-4632	120
Puncture Strength (lbs)	Modified ASTM D-3787 Using 5/16-inch flat tipped rod	65 min
Mullen Burst (lbs/in ²)	ASTM D-3786	225 min
Elongation at Required Strength (%)	ASTM D-4632	50 min
Equivalent Opening (US Standard Sieve)	ASTM D-4751	70-100
Permittivity (sec-1)	ASTM D-4491 with 60 mm Falling Head	1.7 min
Water Flow Rate (gal/min/ft ²) at 50 mm Constant Head	(2)	80 –120

(1) All numerical values represent minimum/maximum average roll values (i.e., the average of minimum test results on any roll in a lot should meet or exceed the minimum specified values).

(2) Water flow rate in gal/min/ft² shall be determined by multiplying permittivity in sec⁻¹ as determined by ASTM D-4491 by a conversion factor of 74.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Furnish, install, and maintain shoring, sheeting, bracing, and sloping necessary to support the sides of earth and rock excavations, and to keep and prevent any movement which may damage adjacent structures, pavements, and utilities, damage or delay the work, or endanger life and

health. Furnish, install, and maintain shoring, sheeting, bracing, and sloping as required by OSHA and other applicable government regulations and agencies.

- B. All temporary shoring and bracing shall be designed, detailed, and stamped by a Professional Engineer registered in the State of Massachusetts.
- C. Provide excavation support and protection in accordance with SECTION 31 50 00 EXCAVATION SUPPORT AND PROTECTION.
- D. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent building area and walkways.
- E. The use of onsite, excavated material may require stockpiling to allow the material to dry prior to placement. Provide erosion-control measures as specified in the drawings and as required by the Owner's Representative to prevent erosion of piles during wet weather periods.

3.2 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. The Geotechnical Report prepared for this project indicates that groundwater may be present within the limits of excavation. The Contractor is made aware of this condition and shall include dewatering within his Lump Sum Bid.
- C. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
 - 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
 - 2. Install a dewatering system, specified in SECTION 31 23 19 DEWATERING, to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required at no additional expense to the Owner.

3.3 WORK IN FREEZING WEATHER

- A. Protect excavation bottoms against freezing when atmospheric temperature is less than 35 degrees Fahrenheit.
- B. In freezing weather, a layer of fill shall not be left in an uncompacted state at the close of a day's operation. Prior to terminating operations for the day, the final layer of fill, after compaction, shall be rolled with a smooth-wheeled roller to eliminate ridges of soil left by tractors, trucks and compaction equipment.
- C. The Contractor shall not place a layer of compacted fill on snow, ice, or soil that was permitted to freeze prior to compaction. Removal of these unsatisfactory materials will be required as directed by the Owner's Representative.
- D. Do not excavate to full indicated depth when freezing temperatures may be expected, unless work can be completed to subgrade or piping can be installed and backfilled the same day. Protect the excavation from frost if placing of concrete or piping is delayed.

- E. The Contractor shall keep the operations under this Contract clear and free of accumulation of snow within the limits of Contract Lines as required to carry out the work.

3.4 ROCK EXCAVATION

A. General

1. Rock excavation includes the removal of rock to the lines and grades shown on the plans and as specified within this Section and the disposal of the Rock off site by legal methods.
2. The Contractor shall obtain all necessary permit and licenses and pay all fees at no additional cost to the Owner.
3. All rock excavation shall be included within the original Contract Sum based upon the quantities provided in PART 4 - MEASUREMENT AND PAYMENT. Payment for rock excavation shall be adjusted in accordance with 4.1B.1 Quantities and Payment of Rock Excavation.
4. Unit prices for rock excavation include all labor, equipment, and materials required for removal of rock and hauling of rock off-site. Unit prices for rock excavation also include all labor, equipment, and materials required for replacement of rock excavation with approved materials where the rock excavation extends beyond the specified excavation limits. Any excavation beyond the specified excavation limits must be approved by the Owner's Representative prior to removal. Specified excavation limits for rock are specified in 3.4 ROCK EXCAVATION.
5. Prior to excavation, all rock quantities, bulk or trench, shall be reported to and verified by the Owner's Representative. A copy of all transport slips for rock removal from the site shall be provided to the Owner's Representative.
6. Rock capable of removal through standard excavation procedures shall be removed from the excavation, measured by the Contractor, and verified by the Owner's Representative.
7. The dimensions and quantity of the uncovered rock in place and the rock removed from the trench shall be measured by a Licensed Land Surveyor registered in the State of Massachusetts at the Contractor's expense. All survey information shall be supplied to the Owner's Representative for verification of the quantity. Survey information shall include the existing rock surface topography, the removed rock surface topography and the rock removal limits as specified herein.
8. If a change in the work occurs, which includes the excavation of additional rock outside the original contract limits, the Contractor shall uncover all rock to be removed. Upon uncovering rock in excavations that cannot be removed by standard excavation measures, the Contractor shall expose all faces of rock in the area that requires excavation and notify the Owner. The dimensions and quantity of the rock in place and the rock removed from the trench shall be measured by a Licensed Land Surveyor registered in the State of Massachusetts at the Contractor's expense. All survey information shall be supplied to the Owner's Representative for verification of the quantity.
9. Rock shall be removed by mechanical means and methods.

B. Rock Removal Limits

1. The Contractor shall remove rock to elevations, which will allow the installation of all foundations, footings, utilities, structures, trees and plantings, shown on the drawings.
2. The Contractor shall remove rock to a minimum of 30 inches below finished grade in paved areas and a minimum of 24 inches below finished grade in landscaped areas.
3. Around proposed utilities, the Contractor shall remove rock to the lines and subgrade elevations indicated on drawings and as dictated within this specification. The Contractor shall remove sufficient rock to permit the installation of permanent construction without

exceeding 6 inches beneath pipe in trench, and the greater of 24 inches wider than pipe or 36 inches wide.

C. Rock Excavation for the Installation of Structures

1. Boulders and bedrock encountered during the site preparation should be removed from the building area. Any boulder or bedrock located within the building area should be removed to a depth of at least 12 inches below the foundation elevation. Voids that result from boulder removal should be backfilled with compacted Granular Fill.
2. Bedrock excavated for the building footings and slabs should be over excavated to allow for the placement of a compacted 12-inch Sand Gravel Fill cushion below the foundations and slabs placed in horizontal lifts with a maximum loose lift thickness of 12 inches. The cushion material should extend a minimum of 2 feet beyond the horizontal limits of the foundations or slab. Care should be taken when removing rock adjacent to the existing structure to prevent undermining and disturbance of the footing.

D. Rock Excavation for the Removal of Utilities and Structures

1. Remove rock directly above and to the sides of piped utilities and structures proposed for removal without exceeding the following dimensions:
 - a. 12 inches outside of concrete structures, walls, and footings.
 - b. 12 inches from either edge of piped utility and 6 inches below piped utility
 - c. 6 inches outside of edge of concrete cast against grade.
 - d. 6 inches beneath bottom of concrete pads or slabs on grade.
2. Upon uncovering rock within a trench that cannot be removed by standard excavation measures, the Contractor shall expose all faces of rock within the trench and notify the Owner. The dimensions of the rock in place shall be measured by survey instrument by a Licensed Land Surveyor at the Contractor's expense and verified by the Owner's Representative.
3. Rock capable of removal through standard excavation procedures shall be removed from the trench, measured by the Contractor, and verified by the Owner's Representative.

3.5 EXCAVATION, GENERAL

- A. Excavate to subgrade elevations. Material to be excavated will be classified as earth or rock. Do not excavate rock until it has been classified and quantified by the Contractor's land surveyor, and verified by the Owner's Representative
 1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; together with soil, boulders, and other materials not classified as rock or unauthorized excavation.
- B. All topsoil and unsuitable or excess materials shall be stripped from areas of new construction or regrading. Materials suitable for reuse shall be stored in locations and approved by the Owner's Representative that will not interfere with construction operations.
- C. Existing topsoil shall be stripped before any underlying excavating is begun.
- D. All excess and unsuitable materials shall be legally disposed of off-site by the Contractor.

3.6 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
- B. All unsuitable and fill materials shall be removed from the proposed building area to a limit defined by a 1-horizontal to 1-vertical slope extending downward and outward from two feet outside the edges of the building footing to firm undisturbed glacial till or bedrock. Cobbles and boulders greater than 6-inches in diameter encountered within these areas shall be removed to a depth of at least 12 inches below the bottom of footings. Voids that result from boulder excavations shall be backfilled with Sand Gravel Fill and compacted.
- C. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grade to leave solid base to receive other work.
 - 1. Based upon the characteristics of the on-site soils, the influence area below footings is defined as the area under footings extending from 2-feet outside the bottom edge of footing downward at an angle of 1 horizontal to 1 vertical.
 - 2. Construction staging for the proposed building should be scheduled such that construction can proceed systematically and safely to avoid excavations within the influence areas of newly installed or existing footings. Where it will be necessary to excavate within influence areas, temporary support systems will be required to retain the surrounding soil and safely support structure loads. The scheduling process should consider the construction of structures within the project area and the construction of third-party structures that are adjacent to the project area.
 - 3. The earth slope along the bottom of sloped footings (i.e., subgrade or bearing surface) should not exceed a slope of 2 horizontal and 1 vertical to allow a stable subgrade to be provided prior to the placing of concrete
 - 4. In fill areas within the building footprint, the soil subgrade shall be surface compacted with a minimum of six passes of a vibratory roller having a drum weight of at least 10,000 pounds and a dynamic force of at least 20,000 pounds. In the event that subgrade soils within the building area become disturbed during construction, they should be over-excavated and replaced with one foot of compacted Sand Gravel Fill or six inches of $\frac{3}{4}$ -inch Crushed Stone wrapped in filter fabric to stabilize the subgrade.
 - 5. If the subgrade is wet, the Contractor shall over-excavate all footing excavations by 6 inches and place a working mat of $\frac{3}{4}$ -inch Crushed Stone compacted to 95% wrapped in filter fabric (Mirafi 140N or approved equivalent). Stone shall extend 2 feet beyond the edge of the footing on all sides. This working mat shall be provided by the Contractor in wet conditions at no additional expense to the Owner.
- D. Over-excavation by the Contractor, excavation below the proposed bottom of excavation, shall be backfilled in 6-inch lifts with compacted Sand Gravel Fill. In wet conditions, over excavation shall be backfilled in 6-inch lifts with $\frac{3}{4}$ -inch Crushed Stone and a layer of filter fabric approved by the Engineer and compacted to 95% until the proposed subgrade elevation is reached and the subgrade stabilized.
- E. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended as bearing surfaces.

3.7 SUBGRADE INSPECTION

- A. Notify Owner's Representative when excavations have reached required subgrade.
- B. If the Owner's Representative determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proof-roll subgrade below the building slabs and pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
 - 1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Continue this process until the area has been proof-rolled 4-6 times. Limit vehicle speed to 3 mph.
 - 2. Proof-roll with a vibratory roller with a static weight of no less than 10,000 lbs and a dynamic weight of 20,000 lbs.
 - 3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by the Owner's Representative, and replace with compacted backfill or fill as directed.
- D. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by the Owner's Representative, without additional compensation.

3.8 EXCAVATION OF UNSUITABLE MATERIALS

- A. The Contractor shall notify the Owner's Representative and Engineer when excavations uncover potential unsuitable materials.
- B. Payment for all excavation and disposal of Unanticipated Unsuitable Soils within the limit of excavation shall be included as part of the original Contract Sum.
- C. Excavation and disposal of Unanticipated Unsuitable Soils outside the limit of excavation shall be paid for in accordance with the Unit Prices included in PART 4 - MEASUREMENT AND PAYMENT of this specification.
 - 1. Unit prices for unanticipated unsuitable soils excavation include all labor, equipment, and materials required for removal of unsuitable soils, hauling of unsuitable soils off-site, and disposal. Unit prices for unanticipated unsuitable soil also include all labor, equipment, and materials required for replacement of unsuitable soil excavation with approved materials. Any unanticipated unsuitable soil excavation must be approved by the Engineer and Owner's Representative prior to removal.
 - 2. The dimensions and quantity of the Unanticipated Unsuitable Soils excavated shall be measured by a Professional Land Surveyor registered in the State of Massachusetts at the Contractor's expense. The Surveyor shall measure the elevations of the unsuitable materials prior to excavation and the surface topography following excavation. All survey information shall be supplied to the Owner's Representative for verification of the quantity. Survey information shall include the topography of the uncovered suitable soil surface prior to excavation and the topography of the final soil surface following excavation.

3.9 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi, may be used when approved by Engineer.
- B. Concrete required to fill unauthorized excavation shall be furnished and installed at the expense of the Contractor.

3.10 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 1. Stockpile soil materials away from edge of excavations in locations approved by the Owner. Do not store within drip line of remaining trees.

3.11 BACKFILL GENERAL

- A. The contractor shall notify the Engineer and Owner's Representative a minimum of 2 days prior to backfilling utility trench to schedule inspection.
- B. Place and compact backfill in excavations promptly, but not before completing the following:
 - 1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation
 - 2. Surveying locations of underground utilities for Record Documents
 - 3. Testing and inspecting underground utilities
 - 4. Removing concrete formwork
 - 5. Removing trash and debris
 - 6. Removing temporary shoring and bracing, and sheeting
 - 7. Receiving approval from the respective Utility Company, and the Owners Representative following inspection

- C. Place backfill on subgrades free of mud, frost, snow, or ice.

3.12 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. Place and compact initial backfill conforming to the specified material requirements to the height specified on the Drawings over the utility pipe or conduit.
- C. Backfill voids with satisfactory soil while installing and removing shoring and bracing.
- D. Place and compact final backfill of satisfactory soil to final subgrade elevation.
- E. Bedding material shall be placed and compacted in maximum 6" lifts.
- F. All fill material (cobbles and boulders within the native deposits) in excess of 3-inches should be removed from the fill within 12-inches the utility to prevent damage to the utility during compaction.

3.13 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
 - 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
 - 2. Remove and replace, or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.
 - 3. The Contractor shall furnish water for compaction. Water for compaction from sources other than potable sources shall be as approved by the Owner's Representative.

3.14 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than 12 inches in loose depth for material compacted by heavy compaction equipment, and not more than 6 inches in loose depth for material compacted by hand-operated tampers.
- B. Compaction shall be completed with a vibratory roller having a static weight of 10,000 lbs and a dynamic weight of 20,000 lbs.
- C. The Contractor shall use caution when compacting near existing utilities including electric and communications duct banks. Any damage to existing utilities or structures resulting from compaction operations shall be repaired at the expense of the Contractor.
- D. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- E. Compact soil materials to not less than the following percentages of maximum dry density:

MINIMUM COMPACTION REQUIREMENTS TABLE	
Location	Percent of Maximum Dry Density ¹
Backfill below footings, within the building area and below slabs ²	95
Backfill for foundation walls and frost walls	95
Backfill within pavement base and sub base layers	95
Backfill below pavement sub base layers	95
Around and above utilities within the building area	95
Around and above utilities in paved areas	95
Backfill behind retaining walls	95 ³
Backfill within landscaped areas	92

¹ Maximum dry density as determined by the Modified Proctor test (ASTM D 1557)

² Building area is described as an area extending downward and outward from the outside edge of the footing at a 1.5H:1V slope.

³ During compaction of fill placed behind retaining walls, care shall be taken so as to maintain uniform elevation along both sides within the embedded areas, and to not overstress the wall by applying too much compactive energy at the top of the wall.

3.15 SUBBASE AND BASE COURSE

- A. Place subbase and base course on subgrades free of mud, frost, snow, or ice.
- B. Place subbase and base course on subgrade in 6-inch lifts and compact as specified.

3.16 FIELD QUALITY CONTROL

- A. Testing Agency: The Contractor shall engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing.
- B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.
- C. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
 - 1. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed every 100 feet to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by the Owner's Representative.
 - 2. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least 1 test for every 2000 sq. ft. or less of paved area or building slab, but in no case fewer than 3 tests.
 - 3. Foundation Wall Backfill: At each compacted backfill layer, at least 1 test for each 100 feet or less of wall length, but no fewer than 2 tests.
 - 4. Trench Backfill: At each compacted initial and final backfill layer, at least 1 test for each 150 feet or less of trench length, but no fewer than 2 tests.
- D. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.

3.17 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specify tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace soil material to depth as directed by Owner's Representative; reshape and recompact.
- C. Where settling occurs remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.18 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Transport surplus satisfactory soil to designated storage areas on Owner's property. Stockpile or spread soil as directed by the Owner's Representative. If directed by the Owner,

Contractor shall remove surplus satisfactory material from the site and dispose of in a legal manner.

1. Remove waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

3.19 GEOTEXTILES

- A. Install Geotextiles in accordance with Manufacturer's recommendations.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

- A. Payment for earthwork as outlined in this Section or shown on the Drawings, including, but not limited to, all design, submittals, materials, labor, equipment, and all other incidentals associated with this work shall be included in the Contractor's Base Bid.
- B. Unit prices for rock excavation include all labor, equipment, and materials required for removal of rock and hauling of rock off-site. Unit prices for rock excavation also include all labor, equipment, and materials required for replacement of rock excavation with approved materials where the rock excavation extends beyond the specified excavation limits. Any excavation beyond the specified excavation limits must be approved by the Owner's Representative prior to removal. Specified excavation limits for rock are specified in 3.4 ROCK EXCAVATION.
 1. Quantities and Payment of Rock Excavation
 - a. The Contractor shall include in his base bid **7000 cubic yards of Bulk Rock Excavation** and its removal from site.
 - 1) If the total amount of rock within bulk excavation exceeds the amount included in the Contract hereinabove, the Owner shall pay for the excess amount of rock within bulk excavation at the Unit Price included on the bid form.
 - 2) If the total amount of rock within bulk excavation is less than the amount included in the Contract hereinabove, the Contract sum will be decreased by the difference in amount multiplied by Unit Price included on the bid form.
 - b. The Contractor shall include in his base bid **500 cubic yards of Trench Rock** and its removal from site.
 - 1) If the total amount of trench rock exceeds the amount included in the Contract hereinabove, the Owner shall pay for the excess amount of trench rock at the Unit Price included on the bid form.
 - 2) If the total amount of trench rock is less than the amount included in the Contract hereinabove, the Contract sum will be decreased by the difference in trench rock multiplied by the Unit Price included on the bid form.
- C. Unit prices for unanticipated unsuitable soils excavation include all labor, equipment, and materials required for removal of unsuitable soils, hauling of unsuitable soils off-site, and disposal. Unit prices for unanticipated unsuitable soil also include all labor, equipment, and materials required for replacement of unsuitable soil excavation with approved materials. Any unanticipated unsuitable soil excavation must be approved by the Owner's Representative prior to removal.
 1. Quantities and Payment of Unanticipated Unsuitable Soil Conditions:
 - a. If unanticipated unsuitable materials are encountered beyond the limits of excavation as specified on the Drawings and Specifications, the Contractor shall notify the Owner's Representative in writing. The Contractor shall carry excavation

- deeper and replace the excavated material with appropriate specified material or concrete as directed by the Owner's Representative or Geotechnical Engineer.
- b. Removal of topsoil, subsoil, and rock layer as specified in this specification will not be considered as unanticipated unsuitable soil conditions. Similarly, removal of these materials within paved areas as specified herein will not be considered unanticipated unsuitable soil conditions.
 - c. Only changes in the work authorized in advance by the Owner's Representative in writing shall constitute an adjustment in Contract Price.
 - d. Material that is too wet or too dry for compaction of the particular material in place as determined by the Owner's Representative or the Geotechnical Engineer and/or Soil Testing Company and is disturbed by the Contractor during construction operations so that proper compaction cannot be reached shall be removed and replaced with approved material as directed by the Owner's Representative or Geotechnical Engineer at no additional cost to the Owner.
 - e. The Contractor shall follow a construction procedure, which permits visual identification of firm natural ground.
 - f. The Contractor shall carry in the Base Bid **100 cubic yards for removal of Unanticipated Unsuitable Materials** and replacement with suitable compacted fill material in place, as directed herein. The Base Bid shall cover all costs related to such excavation, removal off site, and replacement with compacted fill of approved material, overhead, and profit. No amount other than the Unit Price provided by the Contractor will be paid by the Owner for excavation herein defined.
 - 1) If the total quantity of unanticipated unsuitable materials and its replacement with compacted fill exceeds the amount included in the Contract as listed above, the Owner shall pay the excess excavation and replacement at the unit price included on the bid form.
 - 2) If the total quantity of unanticipated unsuitable material and its replacement with compacted fill is less than the amount included in the contract as listed above, the contract sum will be decreased by the difference in excavation and its replacement multiplied by the unit price included on the bid form.
- D. All quantities of unanticipated unsuitable soils and rock excavated are to be measured in place by a Professional Land Surveyor registered in Massachusetts as described above and verified by the Owner's Representative prior to removal.
- E. The Contractor shall submit signed slips showing quantities of Unanticipated Unsuitable Soils and Rock removed from excavations at the end of each workday, with a total quantity mutually agreed upon. Slips shall be signed by the Owner's on-site representatives at the end of each day signifying that the quantities are accurate. The Owner has the right to inspect individual loads, slips and quantities as they arrive at or leave from the site and as they are weighed out at the stone quarry. These quantities are for reference only and will not be used to calculate payment with the unit prices above.

END OF SECTION

SECTION 311100

SITE PREPARATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

- A. All work specified in this Section shall conform to "Standard Specifications for Highway and Bridges" of the Massachusetts Department of Transportation, latest revision, herein referred to as "State Standards".
- B. Existing Conditions Plan compiled from the following sources:
 - 1. Existing conditions mapping taken from plan entitled "Topographic Plan of Land 1 East Union Street and 12-16 East Union Street (Route 135) Middlesex County Ashland, Mass" prepared by Guerriere & Halnon, Inc., dated April 7, 2020.
 - 2. Wetland Flags identifying wetland resource areas were placed by Pare Corporation on September 11, 2018 and located by Guerriere & Halnon, Inc.
- C. Soil erosion and sedimentation controls shall be provided in accordance with the "Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas, A Guide for Planners, Designers, and Municipal Officials" prepared by Franklin, Hampden, Hampshire Conservation Districts, reprint dated May 2003.

1.3 SUMMARY

- A. The work of this Section includes the following:
 - 1. Provisions for protection of all existing utilities from damage particularly at heavy construction vehicle crossings.
 - 2. Removal, disposal, capping or plugging of drainage, sewer, gas, steam, and water piping at the locations specified on the drawings.
 - 3. Removal and disposal of catch basins, manholes, cisterns, utility structures.
 - 4. Removal and disposal of steps, stairs, signs, and fence.
 - 5. Cleaning and maintenance of the site and stormwater management system.
 - 6. Site Clearing.
 - 7. Tree Protection.
- B. Related Sections include the following:
 - 1. Section 310000 Earthwork
 - 2. Section 312319 Dewatering;
 - 3. Section 313200 Erosion and Sedimentation Control.

1.4 DEFINITIONS

- A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches in diameter; and free of weeds, roots, toxic materials, or other nonsoil materials.
- B. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

1.5 MATERIAL OWNERSHIP

- A. Unless noted otherwise, cleared materials shall become Contractor's property and shall be removed from Project site.
- B. The Owner reserves the right to claim ownership over any materials removed from the site, including earthwork. The materials claimed by the Owner shall be stockpiled on the site as directed.

1.6 SUBMITTALS

- A. Shop Drawings:
 - 1. Submit drawings or details indicating proposed provisions for protection of existing gas line and utilities as the work requires. These utilities must be protected from damage particularly by heavy construction equipment driving over the top of them.

1.7 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Owner and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Owner, Owner's Representative, and Architect not less than two weeks in advance of proposed utility interruptions in writing. Renotify in writing 72 hours in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Owner's written permission.
 - 3. Underground utilities were compiled from available record plans and visible aboveground locations and are considered approximate only. Prior to commencing any excavation effort, the Contractor shall contact "Dig Safe" at 1-888-Dig Safe to verify locations of existing underground utilities in areas of proposed excavation.
- B. The Contractor is responsible to schedule the work and determine any required temporary utility lines and connections required to keep the existing facilities in operation. The cost to furnish and install temporary utility lines and connections shall be included in the Contractor's base bid.
- C. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with the Owner and utility companies to shut off services if lines are active.
- D. Contractor shall not operate existing water gate valves and hydrants. Only utility company employees or designated personnel are authorized to operate Water System valves and hydrants.

- E. All abandoned underground utilities shall be designated on as-built drawings by the Contractor of record and provided to the Owner and Engineer in AutoCAD electrical format prior to completion of the project. All as-built drawings, (underground and above ground) shall be dimensioned from permanent benchmarks such as existing buildings and include depths at various points throughout the extent of the work, and invert elevations at all structures.
- F. Do not commence site operations until temporary erosion and sedimentation control measures are in place.

PART 2 - PRODUCTS

2.1 GENERAL

- A. The Contractor shall provide all materials and equipment in suitable and adequate quantity as required to accomplish the work shown and specified.

2.2 TREE PROTECTION MATERIALS

- A. Fencing for tree protection, as designated, shall be new four-foot (4') orange snow fencing as manufactured by Resinet, www.resinetproducts.com. Stakes for snow fence shall be six foot (6') long, 13 gauge, powder coated steel, stamped metal drive stakes, commonly used to support snow fence. Stakes shall be located 5 ft. on center, maximum, at all corners and changes in direction.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction. The Contractor shall employ a Professional Land Surveyor registered in the Commonwealth of Massachusetts to perform a benchmark and field verification survey prior to commencing work. The Contractor is responsible to provide horizontal and vertical layout of all proposed work.
 - 1. Notify Owner and Owner's Representative prior to commencing work if discrepancies are found.
- B. Locate and clearly flag trees and vegetation to remain or to be relocated. Review trees with Owner and Landscape Architect prior to removal.
- C. Protect existing site improvements to remain from damage during construction.
- D. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 REMOVE AND DISPOSE SEWER, DRAINAGE, STEAM, AND OTHER GRAVITY UTILITY PIPING

- A. All pipe or conduit designated to be removed shall be so-removed and legally disposed of off-site. Drain pipes or other pipes, ducts, etc., cut and deemed advisable to remain in the earth shall be plugged with concrete, except that metal drain pipes may be sealed with screw type plugs or caps. Drain pipes or other pipes that are cut for a new connection shall be temporarily capped and sealed water tight to prevent sediment or water from entering the utility.
- B. The Contractor shall cooperate with the Owner and utility companies so that the demolition work may be performed in accordance with their regulations and with the approval of the Owner.

3.3 REMOVE AND DISPOSE WATER

- A. Only utility company employees or designated personnel are authorized to operate Water System valves and hydrants.
- B. Once valves are closed, pipe shall be cut and cleaned prior to being capped with a watertight heavy duty cap.
- C. Cap shall be thoroughly cleaned of any dust, dirt or deposits prior to installation.
- D. Install concrete thrust block as required. If the cap and thrust block will be later removed for a connection, install the thrust block to not damage the water main upstream of the cap.

3.4 REMOVE AND DISPOSE CONCRETE UTILITY STRUCTURES

- A. All concrete utility structures designated to be removed shall be so-removed and legally disposed of off-site. The Contractor shall cooperate with the Owner and utility companies so that the demolition work may be performed in accordance with their regulations and with the approval of the Owner's Representative.

3.5 REMOVE AND DISPOSE GAS

- A. All gas mains, services, valves, and appurtenances shall be removed and demolished in accordance with Eversource gas, the utility company, requirements. Contractor shall coordinate all work adjacent to gas with Eversource gas prior to commencing work.

3.6 REMOVE AND DISPOSE CONCRETE OR STONE FOUNDATION REMNANTS

- A. The Contractor shall excavate concrete or stone foundation remnants uncovered during excavation for proposed improvements. Remove and dispose concrete and stone foundation remnants in accordance with local and State requirements.

3.7 REMOVE AND DISPOSE FLEXIBLE PAVEMENT, CEMENT CONCRETE PAVEMENT, AND SAWCUTTING

- A. Pavement edges shall be sawcut to a neat line using a saw approved for cutting through bituminous concrete or concrete materials.
- B. Remove and dispose of bituminous concrete pavement as allowed by the State Standards Specifications.
- C. Remove and dispose of cement concrete pavement as allowed by the State Standards Specifications.

3.8 REMOVE AND DISPOSE OF CURBING

- A. Remove and discard existing curb in accordance with Section 580 of the State Standards.

3.9 DISPOSAL

- A. Disposal: Remove surplus soil material, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property. Any potentially contaminated soil material encountered, as specified by the Commonwealth of Massachusetts

Department of Environmental Protection rules and regulations shall be brought to an approved landfill or another appropriately licensed waste facility for legal disposal.

- B. Separate recyclable materials produced during site clearing from other non-recyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.

3.10 CLEANING AND MAINTENANCE OF STORM DRAIN SYSTEM

- A. The Contractor shall remove sediment and debris from the existing drainage system prior to commencing work.
- B. During construction the Contractor shall be responsible to clean sediment and debris from the existing and recently installed drainage system.
- C. Prior to project completion the complete drainage system shall be cleaned of all debris and sediment.

3.11 TREE PROTECTION

- A. Trees: Trees as designated on the Contract Drawings to be protected shall be protected by the placement of a snow fence enclosure at the drip line of each tree as noted on the detail drawing. Snow fencing shall be supported with specified stakes at maximum five foot on center intervals and at all corners. Fence trees in accordance with the Drawings and as directed by the Owner's Representative.
- B. Tree protection shall remain in place until directed for removal by the Owner's Representative.
- C. Damage no trees to remain by burning, by pumping of water, by cutting of live roots or branches, or by any other means. No trees to be saved shall be used for crane stays, guys or other fastenings. Vehicles shall not be parked or be allowed to drive over root zones where damage may result to trees to be saved. Construction materials shall not be stored beneath trees to be saved. Excavation shall not take place within the tree's drip line unless approved by the Owner's Representative.
- D. Contractor liability: The Contractor shall be liable for all damage and/or disturbance to existing trees not otherwise designated for removal. Actual charges for damage to plants shall be in accordance with the schedules defined herein, with assessed charges to be deducted from sums payable under the Construction Contract.
 - 1. Damage which in the Owner's Representative's opinion can be remedied by corrective maintenance shall be repaired immediately. Only a certified Arborist shall undertake any tree work.
 - 2. Trees irreparably damaged shall, at the Owner's Representative's discretion, be replaced by the Contractor with new trees of the same size and type as determined by the Owner's Representative.
 - 3. In the event that replacement of damaged trees is infeasible, as determined by the Owner's Representative, the full replacement costs shall be assessed to the Contractor's account at a minimum value of one hundred and fifty dollars (\$150.00) per caliper inch, or greater, in accordance with the "Guide for Plant Appraisal", authored by the Council of Tree and Landscape Appraisers,.
 - 4. Damaged trees which require removal and/or replacement shall be removed according to the specification requirements for removals, including filling and repair of ground surface, with such costs to be borne by the Contractor in addition to assessed charges described herein.

- E. Contractor shall be liable for all damage and/or disturbance to existing adjacent lands beyond the Limit of Work. Actual damage to these areas, caused by the Contractor, shall be repaired to the satisfaction of the Owner's Representative, at no additional cost to the Owner. Repairs may include pruning or removing damaged vegetation, replacement of damaged vegetation, restoration of the ground plane to its original condition, and any other work required to restore the area to its original condition as depicted in the site photographs taken at the beginning of construction. The project will not be accepted until all repair work is complete.

3.12 SITE CLEARING

- A. General: Remove trees, shrubs, grass and other vegetation, improvements, or obstructions, except for those indicated on the Contract Drawings to remain, interfering with installation of new construction. Remove such items elsewhere on site or premises as specifically indicated. Removal shall include digging out stumps in their entirety and grubbing roots to at least 30 inches below existing or proposed grades, whichever is deeper, as shown on the Contract Drawings.
- B. Carefully and cleanly cut roots and branches of existing trees indicated to remain and be protected, where such roots and branches obstruct new construction. Use only hand methods for grubbing inside drip line of trees indicated to be left standing.
- C. Clearing shall consist of the felling and disposal of standing trees, and the removal and disposal of all brush, down timber, fences and rubbish. Trees, brush and down timber may be chipped and a portion of the chipped material shall be stockpiled on site in a location selected by the Architect and for dispersion into wooded areas in locations selected by Architect.
- D. In all areas that are to be cleared, all brush, grass and other vegetation, except trees, shall be cut off flush with or below the original ground surface.
- E. All lines and grade work required for this contract at the site shall be laid out by a registered land surveyor or Professional Engineer employed by the Contractor, in accordance with the Drawings and Specifications.
- F. Prior to starting site clearing operations, stake out all roads, edges of parking areas, and other future paved areas as indicated, limits of cut and fill at the edges of these areas (it limits do not coincide) and areas of trees to be saved as noted on the Drawings.
- G. Before any clearing is done, promptly upon completion of layout work, the Contractor shall arrange a conference on the site with the Architect to identify and mark trees and shrubs which are to remain. Adjustments to clearing lines shall be made at this time to save trees or other existing conditions on the edges of clearing lines. If necessary, minor grading adjustments shall be made to save these trees. Do no clearing without clear understanding of existing conditions to be preserved.
- H. The owner shall be reimbursed should individual trees, shown on the drawings to be protected, become damaged during the course of the work. All expenses incurred shall be paid by the Contractor without additional cost to the Owner.
- I. The owner shall be reimbursed should trees, which are beyond limits of clearing shown on the drawings or beyond limits of clearing approved by the Architect, be cleared or damaged and are part of larger, contiguous wooded areas.
- J. These damaged trees shall be removed from the site, the stumps grubbed and the ground surface repaired. Costs for this removal shall be borne by the Contractor and not be included as part of the above schedule.

- K. Fell trees in such a way as not to injure trees to be saved. Trees shall be cut three feet or less from existing grades. All brush or other material shall be cut flush to the ground. All material from clearing operations shall be chipped or cut into log lengths. All piles of chipped material (except those stockpiled for future inclusion in the work) and logs from clearing operations shall be removed from the site prior to or at the end of the clearing work.
- L. Limits of clearing shall be those areas shown on the Drawings with modifications as herein specified. Removal of trees, shrubs and bushes outside these areas shall be done only as noted on Drawings or approved by the Architect.
- M. No trees to be saved shall be used for crane stays, guys or other fastenings. Vehicles shall not be parked nor debris burned where damage may result to trees to be saved. Do not permit heavy equipment, materials or stockpiles within branch spread. Remove interfering branches without injury to trunks and cover scars with wound paint.

END OF SECTION

Ashland Public Safety Building
12 Union Street, Ashland, MA

HKT Architects
October 23, 2020

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SECTION 312316.26

ROCK EXCAVATION AND DISPOSAL

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. Remove and dispose of rock, and furnish acceptable material for backfill in place of excavated rock as indicated.

1.2 RELATED WORK:

- A. Section 310000: Earthwork
- B. Section 312316.27: Blasting
- C. Section 407723: Vibration Monitoring

1.3 SUBMITTALS:

- A. Submit the following in accordance with Section 01300:
 - 1. For each kind of blasting agents and explosives to be used, submit the perchlorate content provided by the suppliers and/or manufacturers. The Subcontractor has to obtain written permission from the Owner or Owner's Representative to use perchlorate-containing explosive products.
 - 2. Keep and submit to Owner or Owner's Representative and at time specified by Owner or Owner's Representative, an accurate record of each blast showing general location of blast, depth and number of drillholes, kind and quantity of explosive used, kind and number and interval of delay periods used, and other data required for a complete record.
 - 3. Provide pre-blast survey of all adjacent structures.

1.4 QUALITY ASSURANCE:

- A. Perform work conforming to Section 310000 for the following:
 - 1. Backfilling above normal depth.
 - 2. Disposal of surplus excavated rock.
 - 3. Filling excess excavation above indicated elevations.
 - 4. Filling excess excavations other than in rock beneath foundations.
- B. If rock is excavated beyond the limits of scope indicated on the drawings, specified, or authorized in writing by the Owner or Owner's Representative, backfill excess excavation, whether resulting from overbreakage or other causes, at no additional compensation and as specified in Part 3 - EXECUTION.
- C. Blasting for rock excavation to be done in accordance with Section 312316.27 – Blasting.

1.05 SAFETY REQUIREMENTS:

- A. Provide in accordance with Section 312316.27 – Blasting.

PART 2 - PRODUCTS

2.1 EXPLOSIVE PRODUCTS:

- A. Provide in accordance with Section 312316.27 – Blasting.

2.2 CONCRETE AND GRAVEL:

- A. Class A Concrete, Class B Concrete and Screened Gravel.

PART 3 - EXECUTION

3.1 PROCEDURE:

- A. Excavate rock in pipe trenches to no less than 6 in. below the proposed invert of the pipe. Backfill trench, before pipe is laid, to correct subgrade. Use thoroughly compacted, suitable material or, when so specified or indicated on drawings, same material as required for bedding pipe. Furnish and place at no additional compensation.
- B. If bedrock is encountered at the proposed foundation subgrade for structures, over-excavate rock 2 ft. beyond the foundation footprint to no less than 12 in. below the proposed foundation bottom. Remove loose rock and backfill with compacted fill, crushed stone or screened gravel in accordance with Specification 310000.
- C. Fill excess excavation below elevation of the top of bedding, cradle, or envelope when in pipe trenches with material of same type and placed and compacted in same manner as specified for bedding, cradle, or envelope.
- D. Drill and blast a single line of holes in vertical face of rock at end of trench, when shattering rock at ends of pipe or elsewhere as indicated. Provide minimum depth drill holes of 4 ft. and maximum spacing of 18 in. centers. Use sufficient explosive to shatter rock for future excavation. Complete shattering before any pipe or fitting is placed within 50 ft. of rock to be shattered.
- E. When the use of perchlorate-containing products is necessary and is approved by the Design Builder:
 - 1. Institute rigorous "housekeeping" practices: The explosive products shall be properly detonated so that perchlorates are destructed to the maximum degree possible. Also, minimize the loss of product via spills or debris that could cause environmental pollution. In the event of spills or debris, reasonable effort should be made to collect and properly manage or dispose of perchlorate-containing materials.
 - 2. Take reasonable steps to prevent and address misfires: In cases where explosives or blasting agents are washed or removed for a borehole following a misfire, reasonable efforts should be made to collect and properly manage or dispose of perchlorate-containing materials.
- F. Remove piles of boulders or loose rock encountered within limits of earth embankments to a suitable place of disposal.
- G. Use excavated rock in backfilling trenches subject to following limitations:
 - 1. Do not use pieces of rock larger than permitted under subsection "Utility Trench Backfill" of Specification 310000.
 - 2. Do not allow rock quantities used in backfill in any location to result in formation of voids.
- H. Backfill with material obtained from outside sources at no additional compensation. When material suitable for backfilling is not available in sufficient quantity from other excavations.

END OF SECTION

SECTION 312316.27
BLASTING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Perform controlled blasting and production blasting to form shear planes in the rock for excavation or in concrete for demolition.

1.02 REFERENCES, CODES AND STANDARDS:

- A. American National Standards Institute (ANSI):
 - 1. A10.7: Commercial Explosives and Blasting Agents - Safety Requirements for Transportation, Storage, Handling and Use
- B. Code of Federal Regulations (CFR):
 - 1. 27 CFR 555: Alcohol, Tobacco and Firearms (ATF) - Commerce in Explosives.
 - 2. 29 CFR 1910.109: Occupational Safety and Health Administration (OSHA) Standards - Explosives and Blasting Agents.
 - 3. 29 CFR 1926, Subpart U: Occupational Safety and Health Administration Standards - Blasting and the Use of Explosives.
 - 4. 49 CFR 177.835, Subpart B: Transportation - Loading and Unloading, Class 1 Materials.
- C. National Fire Protection Association (NFPA):
 - 1. 495: Explosive Materials Code
- D. Non-regulating Industry Support Organizations:
 - 1. Vibration Subcommittee of the International Society of Explosive Engineers (ISEE), blast monitoring equipment operation standards (1999).
 - 2. Institute of Makers of Explosives (IME) Safety Library Publications (SLPs).

1.03 DEFINITIONS:

- A. Peak Particle Velocity (PPV): The maximum vectorial summation of the three ground vibration velocities measured at any given time in the vertical, longitudinal, and transverse directions. Velocity units are expressed in inches per second.
- B. Air Overpressure: Temporary changes in ambient air pressure caused by blasting. Air overpressure is expressed in units of psi or dB.
- C. Occupied Building: Structure on or off construction limits that is occupied by humans or livestock.
- D. Residential Building: Includes single and multiple family dwellings, hotels, motels, and any other structure containing sleeping quarters.
- E. Scaled Distance (Ds): A factor describing relative vibration energy based on distance and charge-per-delay. For ground vibration control and prediction purposes, Ds is obtained by dividing the distance of concern (D) by the square root of the charge-per-delay (W), $D_s = D/\sqrt{W}$. Minimum scaled distance limits are used to establish charge weights and the units of Ds are ft $\sqrt{lb}$.

- F. Charge-per-Delay: For vibration control, any charges firing within any 8-millisecond time period are considered to have a cumulative effect on vibration and air overpressure effects. Therefore, the maximum charge-per-delay (W) is the sum of the weight of all charges firing within any 8-millisecond time period.
- G. Production Holes: Blast holes in the main body of the rock mass being removed by drilling and blasting.
- H. Stemming: Crushed stone, tamped clay, or other inert earth material placed in the unloaded collar area of blast holes for the purpose of confining explosive charges and limiting rock movement and air overpressure (air blast).
- I. Primary Initiation: The method whereby the blaster initiates the blast(s) from a remote and safe location. Primary initiation systems use pneumatic tubing or shock-tubes to convey firing energy from blasters to blast locations.
- J. Subdrilling: The portion of the blast hole that is drilled below or beyond the desired excavation depth or limit. Subdrilling is generally required to prevent the occurrence of high or tight areas of unfractured rock between blast holes.
- K. Prohibited Persons: Persons prohibited from handling or possessing explosive materials as defined by the seven categories described in Section 555.11 of 27 CFR (ATF Rules).
- L. Delay: A distinct pause of predetermined time between detonations of single charges or groups of charges.
- M. Blast Control Specialist or Blasting Supervisor: The single designated and licensed person with complete responsibility and total authority over decisions involving safe handling, use, and site storage of explosives.

1.04 PERMITS AND SAFETY REQUIREMENTS:

- A. Prior to work, the Subcontractor shall obtain the blasting permits required by:
 - 1. Commonwealth of Massachusetts
 - 2. Town of Ashland, MA.
 - 3. Any other applicable agencies having jurisdiction.
- B. The Subcontractor shall notify the Owner, Owner's Representative, fire district, local fire department, utility companies, Town of Ashland, and residents in the general blast area a minimum of two times before the scheduled blast event, or as indicated in the permits. Advertised notifications shall be sent a minimum of 14 days prior to blasting and again at 24 hours before blasting.
- C. The Subcontractor shall notify and meet with the local utilities using the Underground Service Alert (USA) system for the Commonwealth of Massachusetts a minimum of three business days prior to the blasting event.
- D. The transporting, handling, storage, and use of explosives, blasting agents, and blasting equipment shall be directed and supervised by a person of proven experience and ability in blasting operations in accordance with ANSI A10.7; 29 CFR 1910.109; 29 CFR 1926, Subpart U; 27 CFR 555; 49 CFR 177.835, and the manufacturers and the Institute of Makers of Explosives (IME).

- E. The Subcontractor shall ensure that deliveries of explosives to the worksites comply with rules and regulations issued by the Department of Transportation (DOT) and the Transportation Security Administration (TSA) for commercial transportation of explosives pursuant to the mandates of the USA Patriot Act of 2001.
- F. The Subcontractor and his employees must comply with the applicable provisions of the Occupational Safety and Health Act of 1970, as amended through January 1, 2004.

1.05 JOBSITE CONDITIONS:

- A. A geotechnical report was prepared for this Project and is attached to this specification.
- B. Conduct preconstruction and post-construction surveys of structures and utilities within 250 feet of the planned excavation.
- C. Protect structures, underground utilities, and other construction from damage caused by blasting.
- D. As specified in Section 02018, the Subcontractor is responsible for the vibration monitoring during the entire construction period.

1.06 SUBMITTALS:

- A. Submit the following qualifications at least three (3) weeks prior to the blasting work.
 - 1. Qualifications of the Blasting Subcontractor.
 - 2. Blast Plan and Vibration Monitoring Plan.
- B. Blasting Control Plan and Schedule:
 - 1. Submit a Blasting Control Plan and Schedule at least three (3) weeks prior to the work. The Blasting Control Plan shall contain the details of the drilling and blasting patterns and controls proposed for both the controlled and production blasting. The Blasting Control Plan shall be reviewed and signed by the Local fire department, Subcontractor's Site Superintendant, Owner, Owner's Representative, and any other party or worker involved in the blasting work. The Blasting Plan shall contain the following minimum information:
 - a. Site drawings showing a scaled map of the blast areas and cross-sectional views that indicate stations, free face location, bench heights, hole spacing, hole diameter, hole depth, burden, hole inclination and subdrill.
 - (1) Include layout and design of onsite explosive storage magazines, permanent and/or mobile.
 - b. Methods of drilling, including equipment descriptions and hole placement and alignment techniques.
 - c. Loading details including trade names, types, and sizes of explosives.
 - d. Indicate explosive types, typical charge weights and amounts, priming method, initiator types, sequencing, delay periods and locations, charge firing times, stemming type and quantities.
 - e. Details of controlled blasting techniques.
 - f. Manufacturer's data on material and equipment including type of explosive, cartridge size, detonator, blasting monitors (both air and vibration), and other equipment required to perform the blast.
 - (1) Submit the perchlorate content provided by the suppliers and/or manufacturers. The Subcontractor shall obtain written permission from the Owner and Owner's Representative to use perchlorate-containing explosives.
 - g. Provisions to ensure that fly rock does not result from the blasting operations.

- h. Methods to prevent destabilization of slopes and the over-blasting and loosening of blocks of rock not indicated to be removed or disturbed.
- i. Plans for preventing overbreak or ground shifting that could threaten adjacent buried utilities.
- j. Description of the preblast inspection procedure.
- k. Methods for preventing spills or losses of explosives, drilling fluids, oil, or any other pollutants to ground during handling and hole charging operations. Include details of containment and contingency plans for quickly and effectively cleaning up any spilled materials.
- l. Method of disposal of explosives packaging materials.
- m. Description of the methods of monitoring for blast-induced ground vibration and air-blast overpressure.
- n. Anticipated vibration levels and peak particle velocities at locations specified by the Owner's Representative.
- o. Anticipated decibel level at nearest dwelling.
- p. Details on the reuse and/or disposal of excavated rock.
- 2. The Blasting Control Plan submittal is for quality control and record-keeping purposes. Review of the Blasting Plan by the Owner's Representative shall not relieve the Subcontractor of their responsibility for the accuracy and adequacy of the plan when implemented in the field.
- 3. No drilling or blasting work shall be done until after the Subcontractor's Blasting Control Plan has been submitted and reviewed by the Owner's Representative.

C. Blasting Safety Plan:

- 1. The Subcontractor shall submit a Blasting Safety Plan for review a minimum of two (2) weeks prior to the commencement of any work involving explosives, including drilling. The Blasting Safety Plan shall at a minimum include:
 - a. Emergency contact telephone numbers.
 - b. Site safety meeting and training requirements.
 - c. Copies of blasting permits, licenses of blasters, and commercial driver's licenses of the explosives transporters with their Hazmat endorsements.
 - d. Copies of required blasting permits regarding explosive use and storage.
 - e. Printed copies of applicable federal, state, and local regulations governing the use and storage of explosives for this work.
 - f. Working procedures and safety precautions for storing, transporting, handling, and detonating explosives.
 - (1) Procedures shall satisfy applicable ATF, OSHA, Federal, and local regulations regarding the storage, transportation, handling and detonation of explosives.
 - (2) Procedures shall describe how explosives will be inventoried, secured, and guarded to prevent theft or unauthorized use.
 - g. Procedures that will be used to ensure personnel, staff, visitors, and other persons are at safe locations during blasting.
 - (1) Procedures shall include details on visible and audible warning signals, delineation of blast areas, access blocking methods, site security guard placement, countdown procedures, methods of communication between Blast Control Specialist and security guards, and all-clear signals.
 - h. Manufacturer's Material Safety Data Sheets for all explosives, primers, initiators and other blasting devices.
 - i. Equipment that will be used to monitor the approach of lightning storms
 - j. Emergency evacuation plans.
 - k. Detailed contingency plans for handling of misfires caused by cutoffs or other causes.

2. The Blasting Safety Plan submittal is for informational purposes only. The safety of the Subcontractor's personnel is strictly the responsibility of the Subcontractor. The review of the Blasting Safety Plan by the Owner's Representative does not relieve the Subcontractor of his responsibility to ensure the safety of onsite visitors and personnel during blasting.
 3. No drilling or blasting work shall be done until after the Subcontractor's Blasting Safety Plan has been submitted and reviewed by the Owner's Representative.
- D. Submit a copy of all of the approved permits before drilling for blasting.
- E. Submit Blast Reports and Records within 24 hours of each blast.
1. Prepare and maintain on site reports and records necessary for completion of the work, Blasting records shall be available to the Owner and Owner's Representative at all times and shall contain the following data as a minimum:
 - a. Name of Subcontractor.
 - b. Blast identification by numerical and chronological sequence.
 - c. Weather conditions (including wind direction).
 - d. Locations (referenced to stationing), dates, and times of blasts. Include drawing or sketch showing the direction of the face or faces and the physical shot layout.
 - e. Dimensions of the shot including blast hole depths, hole diameter, burden, spacing, subdrilling, stemming and powder loads.
 - f. Types and amounts of explosives, caps and delay periods.
 - g. Maximum amount of explosives per delay period of 9 milliseconds or greater.
 - h. Powder factor (pounds of explosive per cubic yard of material blasted).
 - i. Method of firing and type of circuit.
 - j. Direction and distance to nearest structure or position of concern.
 - k. Measures taken to limit air overpressure and fly rock.
 - l. Type, method and location of instrumentation. Maximum and minimum particle velocity measurements and decibel levels.
 - m. Any unusual circumstances or occurrences during blast.
 - n. Documentation of complaints regarding blasting-related damage.
 - o. Name, license number, and signature of responsible Blast Control Specialist.

1.07 QUALITY ASSURANCE:

- A. Perform work in accordance with issued permits, safety requirements, and applicable codes and standards.
- B. Test blast to develop control procedures for production blasting so that no disturbance or damage is done to utilities, equipment, buildings or structures.

PART 2 - PRODUCTS

2.01 EXPLOSIVES:

- A. Provide materials and equipment necessary to conduct blasting operations and field monitoring.
 1. Materials usage, including transportation and storage, shall conform to the permits and safety requirements as specified in Part 1.
 2. To the extent possible, avoid the use of perchlorate-containing explosive products when surface or groundwater can be affected.

2.02 CONCRETE AND GRAVEL:

- A. Provide materials and equipment for the backfilling and repairing of areas affected or disturbed by blasting, as indicated and specified in Section 03 30 00.

PART 3 - EXECUTION

3.01 TOWN OF ASHLAND BLASTING PERMIT

- A. The Subcontractor shall secure a blasting permit from the Town of Ashland.

3.02 BLASTING HOURS:

- A. Surficial blasting will be done on non-holiday weekdays between the hours of 9:00 a.m. and 4:00 p.m. If special circumstances demand the need to blast outside of these established hours, or on weekends and holidays, then the Subcontractor will be required to obtain written approval from the Owner or Owner's Representative before engaging in off-hour blasting operations. Blasting within 1,200 feet of a residence or commercial structure will be done without exception between the established non-holiday weekday hours of 9:00 a.m. and 4:00 p.m.

3.03 BLASTING OPERATIONS:

- A. Design and selection of drilling and blasting patterns, explosive types, and quantities is the responsibility of the Subcontractor.
 - 1. Ensure the specified ground motion limitations are met with respect to explosives detonated per delay period.
- B. If the drilling and blasting program yields unacceptable results, then devise and employ methods that will improve blasting outcomes; such as zone blasting, shorter holes, different delay patterns, reductions in size of individual blasts, smaller diameter blast holes, the closer spacing of blast holes, and reductions in explosives.
- C. Only properly trained and licensed specialists shall carry out the blasting.
- D. The Subcontractor is liable for injuries or damage to persons, private property, the work or existing structures that are directly caused by the blasting program.
- E. To avoid potential misfires, the Subcontractor shall at a minimum take the following precautions before bringing electric detonators to the site:
 - 1. Avoid blasting during periods of high solar flare activity.
 - 2. Evaluate the potential effects of the radio frequency energy emitted from local radar, radio, and TV stations, electronic devices (i.e., cell phones, equipment remote controls), lightning, static electricity, adjacent power lines, dust storms, or other sources of extraneous electricity.

3.04 BLASTING PROCEDURES:

- A. Use blasting mats to prevent fly rock and debris from causing injury to personnel and damage to vehicles, structures, existing improvements, and vegetation.
- B. Equipment used for drilling of holes shall have a positive means of dust control. Clean site debris generated during drilling and blasting operations at the end of each work day.

- C. Do not perform blasting closer than 20 feet to existing water, gas, sewer, or other buried utilities.
- D. Use controlled blasting techniques to keep the air blast overpressure, vibrations, and noise within the specified limits.
- E. The type, distribution, and quantity of explosive detonated per delay period shall be such that existing rock fractures will neither be opened nor new fractures created outside of the minimum excavation limits. If blasting is liable to reduce rock stability or damage pipelines or other structures, cease blasting and excavate the rock by approved chemical or mechanical means.
- F. Provide pre-blast notifications to the fire district, utility companies, Owner, Owner's Representative, Town of Ashland and residents in the general blast area as specified in Paragraph 1.04B.
- G. Five (5) minutes prior to each blast, sound an audible siren or horn capable of being heard within 1/2 mile of the blasting site.
- H. Suspend blasting operations for any of the following reasons and do not resume blasting operations until modifications have been made to correct the conditions that resulted in the suspension:
 - 1. Ground motion vibration levels exceed specified limits of particle velocity or frequency.
 - 2. Existing structural conditions are aggravated or adjacent improvements are damaged as a result of blasting, as proven by investigation.
 - 3. Blasting methods endanger the stability of intact rock outside the prescribed limits of excavation.
 - 4. Skilled operators and/or licensed foreman are not present.

3.05 BLASTING LIMITATIONS:

- A. Do not use explosives to move materials beyond the excavation limits.
- B. Design blast patterns such that the explosive energy is directed toward the developed free face and not the excavation sidewalls.
- C. The quantity, quality, and use of explosives shall not open seams or otherwise damage rock outside established excavation limits. Control the firing systems of general blast holes by the use of delay detonators. Explosives used for a single period of delay shall be the minimum required.

3.06 FIELD MONITORING:

- A. Monitor vibrations, air blast overpressures and noise levels originating from construction operations.
- B. Modify construction operation procedures if existing operation creates vibration, air blast overpressure, or noise exceeding specified amounts below:

1. Vibration

Type of Concrete	Age of Concrete, hrs	Peak Particle Velocity, in/sec
Mass Concrete (footings, mats, Slab-on-grade, fill concrete, etc.)	0-11	1.0
	11 and over	2.0
Concrete Structures (walls, columns, elevated slabs, etc.)	0-11	0.5
	11-24	1.0
	24 and over	2.0
Existing Structures, residences or utilities	-	2.0 for transient sources (e.g. blasting)
	-	0.5 for continuous sources (e.g. vibratory pile drivers)

2. Air blast overpressure

OSMRE (Office of Surface Mining and Reclamation Enforcement) limits are provided in the table below.

Recording Device Characteristics	Limit
Lower Limit of 0.1 Hz*	134 dB
Lower Limit of 2.0 Hz	133 dB
Lower Limit of 6.0 Hz	129 dB
C-weighted, slow response*	105 dBC
*To be used only with prior approval of OSMRE	

Note: Most modern seismographs with air overpressure recording capability have a frequency response of from 2-250 Hz; hence, the 133-dB limit would be appropriate where they were used for recording.

3. Noise levels

Part Number: 1910

Part Number: Title Occupational Safety and Health Standards

Subpart: 1910 Subpart G

Protection against the effects of noise exposure shall be provided when the sound levels exceed those shown in Table 1 when measured on the A scale of a standard sound level meter at slow response.

Table 1 – Permissible noise exposure ¹	
Duration per day, hours	Sound Level dBA slow response
8	90
6	92
4	95
3	97
2	100
1 ½	102
1	105
½	110
¼ or less	115

Footnote(1) When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: $C(1)/T(1) + C(2)/T(2) + \dots + C(n)/T(n)$ exceeds unity, then, the mixed exposure should be considered to exceed the limit value. C_n indicates the total time of exposure at a specified noise level, and T_n indicates the total time of exposure permitted at that level. Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

- C. If evidence of displacement or damage to utilities, equipment, or structures is observed or reported, immediately notify the Owner's Representative and discontinue operations creating the vibrations. Revise operation to reduce vibrations and submit a copy of the revised procedure to the Owner's Representative.

END OF SECTION

Ashland Public Safety Building
12 Union Street, Ashland, MA

HKT Architects
October 23, 2020
Addendum #4 December 2, 2020

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SECTION 312319

DEWATERIING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

- A. All work specified in this Section shall conform to "Standard Specifications for Highway and Bridges" of the Massachusetts Department of Transportation, latest revision, herein referred to as "State Standards".
- B. Existing Conditions Plan compiled from the following sources:
 - 1. Existing conditions mapping taken from plan entitled "Topographic Plan of Land 1 East Union Street and 12-16 East Union Street (Route 135) Middlesex County Ashland, Mass" prepared by Guerriere & Halnon, Inc., dated April 7, 2020.
 - 2. Wetland Flags identifying wetland resource areas were placed by Pare Corporation on September 11, 2018 and located by Guerriere & Halnon, Inc.
- C. Soil erosion and sedimentation controls shall be provided in accordance with the "Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas, A Guide for Planners, Designers, and Municipal Officials" prepared by Franklin, Hampden, Hampshire Conservation Districts, reprint dated May 2003.

1.3 SUMMARY

- A. The objective of this Section is to remove standing water from excavations when necessary to perform the work as specified and collect water which may enter the excavation during Contractor's excavation activity.
- B. Related Sections include the following:
 - 1. Section 310000 – Earthwork.
 - 2. Section 315000 – Excavation Support and Protection.

1.4 PERFORMANCE REQUIREMENTS

- A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control ground-water flow into excavations and permit construction to proceed on dry, stable subgrades.
- B. Maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
- C. Prevent surface water from entering excavations by grading, dikes, or other means.

- D. Accomplish dewatering without damaging existing buildings adjacent to excavation.
- E. Remove dewatering system if no longer needed.

1.5 SUBMITTALS

- A. Shop Drawings for Information:
 - 1. For dewatering system. Show arrangement, locations, and details of dewatering locations; locations of erosion controls and dewatering basins.
 - 2. Include a written report outlining control procedures to be adopted if dewatering problems arise.
- B. Record drawings at Project closeout identifying and locating capped utilities and other subsurface structural, electrical, or mechanical conditions performed during dewatering.
- C. Field Test Reports: Before starting excavation, submit test results and computations demonstrating that dewatering system is capable of meeting performance requirements.

1.6 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with water disposal requirements of authorities having jurisdiction.
 - 1. At no time is discharge to be allowed to enter an existing drainage structure without sedimentation controls. Any damage caused by dewatering will be repaired in full to match existing conditions at the Contractor's expense.
 - 2. At no time is discharge allowed to enter the existing sanitary sewer system.
 - 3. At no time shall discharge be allowed to enter directly into the MassDOT rights-of-way.

1.7 SITE INFORMATION

- A. Refer to Section 310000 for additional site information.
- B. Make additional test borings and conduct other exploratory operations necessary for dewatering.
- C. Soil borings and test pits have been made by qualified Contractors prior to this Contract. This information shall be made available to bidders as specified under other Sections. The Contractor is responsible to employ qualified personnel capable of interpreting geotechnical information, test pit logs, and boring logs. The results of these subsurface explorations and recommendations for work were prepared by the Engineer, consulting geotechnical engineers, and are hereby attached to this specification for information only. Procedures for dewatering, areas to receive special fill and other methods and procedures specified herein shall be supplemented by this information. For purposes of this specification, this information will be referred to as the Geotechnical Report. Where procedures within the report vary from procedures as specified herein, this specification shall override. The Geotechnical Report is included elsewhere in the Project Manual
- D. The Geotechnical Report states that groundwater is present on the site. The water table may be within the proposed limits of excavation in several areas on the site. The Contractor is made aware of this condition and will not be eligible to receive additional compensation for dewatering exceeding the Contractor's initial bid.

PART 2 - PRODUCTS

2.1 GENERAL

- A. The Contractor shall provide any equipment and materials necessary for dewatering at the Contractor's own expense.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Prevent surface water and subsurface or groundwater from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
- B. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
- C. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
- D. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
- E. Provide erosion controls in accordance with the Massachusetts Erosion and Sediment Control Handbook.
- F. Dewatering basins capable of handling the flows directed to them shall be supplied whenever dewatering is required.
- G. Control surface water and groundwater such that excavation to final grade is made in-the-dry, and bearing soils are maintained undisturbed, Contractor shall prevent softening, or instability of, or disturbance to, the subgrade due to water seepage.
- H. Provide protection against flotation for all work.
- I. The impact of anticipated subsurface soil/water conditions shall be considered when selecting methods of excavation and temporary dewatering and drainage systems. Type of dewatering system, spacing of dewatering units and other details of this work shall address site specific conditions.
- J. Take all necessary measures to prevent damage to adjacent structures, utilities, property(ies).
- K. Modify, redesign, and/or replace the dewatering system at no additional cost to the Owner, if design criteria are not continuously and effectively fulfilled.
- L. Repair damage to adjacent structures, utilities, and properties resulting from the operation of the Contractor's dewatering and treatment system, at no additional cost to the Owner

3.2 INSTALLATION

- A. Install dewatering system utilizing pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.

- B. Before excavating below ground-water level, place system into operation to lower water to specified levels. Operate system continuously until drains, sewers, utilities, and structures have been constructed and fill materials have been placed, or until dewatering is no longer required.
- C. Provide an adequate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of drains, sewers, utilities and other excavations.
- D. Collect precipitation or surface runoff in shallow ditches around the perimeter of the excavation, drain to sump and pump from the excavation to maintain in-the-dry conditions.
- E. Dewatering and drainage operations shall at all times be conducted in such a manner as to preserve the natural undisturbed bearing capacity of the sub grade at the bottom of the excavation. If the sub grade becomes disturbed for any reason, the unsuitable sub grade material shall be removed and replaced with concrete, compacted granular fill, or other approved material to restore the bearing capacity of the subgrade to its original undisturbed condition.
- F. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water in a manner that avoids inconvenience to others.
- G. Provide sumps, dewatering basins, sedimentation tanks, and other flow-control devices to avoid erosion and sedimentation.
- H. Direct discharges to storm drains will be unacceptable unless proper sediment and siltation removal devices are installed prior to discharge to the storm water conveyance system.
- I. Any discharge of water, generated from a dewatering operation, into wetlands or an open water body will not be permitted.
- J. Ensure that such discharge does not lead to groundwater mounding or other conditions that are not in compliance with the Massachusetts Contingency Plan (310 CMR 40.0000) or the Massachusetts Groundwater Discharge Permit Program 314 CMR 5.00. If discharge is conducted in accordance with a Pretreatment Permit, Contractor is responsible for completing applicable laboratory analysis and maintaining compliance with all permit conditions. Contractor is also responsible for all consequences of non-compliance and/or permit violations. If discharge is completed through off-site disposal, the Contractor is responsible for completing all necessary laboratory analysis to ensure material is within the permit requirements of the accepting facility.
- K. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to Owner.
- L. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches below overlying construction.
- M. Damage including but not limited to erosion or sedimentation, resulting from untreated dewatering discharges shall be restored to meet or exceed the existing condition. All remedial work shall be completed in accordance with local and State Environmental Regulations and Requirements.

3.3 PROPERTY LOSSES FROM REMOVAL OR DISTURBANCE OF GROUNDWATER

- A. Any structure, including but not limited to embankments, buildings, streets, and utilities that become unstable or vulnerable to settlement due to removal or disturbance of groundwater will be supported immediately by the Contractor. Support shall include but not be limited to bracing, underpinning, or compaction grouting.
- B. All loss or damage arising from removal or disturbance of groundwater, including but not limited to claims for subsidence and the loss of structure support, that may occur in the prosecution of the work shall be sustained and borne by the Contractor. If the Contractor needs to correct the damage resulting from his operations, the Owner may, 30 days after notifying the Contractor in writing, proceed to repair, rebuild or otherwise restore such damaged property as may be deemed necessary, and the cost thereof shall be deducted from compensation which may be or become due the Contractor under this Contract.

END OF SECTION

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12 Union Street, Ashland, MA

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October 23, 2020

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SECTION 313200

EROSION AND SEDIMENTATION CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

- A. All work specified in this Section shall conform to "Standard Specifications for Highway and Bridges" of the Massachusetts Department of Transportation, latest revision, herein referred to as "State Standards".
- B. Existing Conditions Plan compiled from the following sources:
 - 1. Existing conditions mapping taken from plan entitled "Topographic Plan of Land 1 East Union Street and 12-16 East Union Street (Route 135) Middlesex County Ashland, Mass" prepared by Guerriere & Halnon, Inc., dated April 7, 2020.
 - 2. Wetland Flags identifying wetland resource areas were placed by Pare Corporation on September 11, 2018 and located by Guerriere & Halnon, Inc.
- C. Soil erosion and sedimentation controls shall be provided in accordance with the "Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas, A Guide for Planners, Designers, and Municipal Officials" prepared by Franklin, Hampden, Hampshire Conservation Districts, reprint dated May 2003.

1.3 SUMMARY

- A. The work of this Section includes the following:
 - 1. Provision of temporary erosion and sediment controls and permanent site stabilization, specifically compost filter socks, baled hay erosion checks, temporary diversions, temporary sediment traps, and catch basin inlet protection as indicated on the drawings or as directed by the Owners Representative.
 - 2. Maintenance and cleaning of erosion and sedimentation controls specifically compost filter socks, baled hay erosion checks, temporary diversions, temporary sediment traps, and catch basin inlet protection as necessary or as directed by the Owner's Representative.
- B. Related Sections include the following:
 - 1. Section 31 00 00 Earthwork.
 - 2. Section 311100 Site Preparation;
 - 3. Section 312319 Dewatering;
 - 4. Section 325000 Stormwater Pollution Prevention Plan.

1.4 DEFINITIONS

- A. Cleaning: Cleaning consists of removing debris and accumulated sediment-laden deposits from the upstream side of perimeter controls, check dams, and temporary drainage protection and from the bottom of temporary dewatering basins and stilling basins. All material so-removed shall be legally disposed of.
- B. Compost Filter Sock: Three-dimensional tubular filtration device constructed by filling a mesh tube with a compost filter media.
- C. Maintenance: Maintenance consists of repair and restoration to original configuration of damage sustained by erosion and pollution controls caused by "normal" rainfall events.

1.5 SUBMITTALS

- A. Shop Drawings:
 - 1. Product information depicting that the products furnished meet the project specifications.
- B. Submit Storm Water Pollution Prevention Plan (SWPPP) prepared in accordance with the National Pollutant Discharge Elimination System (NPDES) Construction General Permit. Refer to Section 325000 Stormwater Pollution Prevention Plan for Contractor's requirements to prepare and implement the SWPPP.
- C. Submit one SWPPP to the Ashland Conservation Commission prior to commencement of work.

1.6 COMPLIANCE

- A. All work shall be done in compliance with the provisions of all local, state and federal regulatory agencies. Failure to comply with these provisions shall constitute grounds for the Owner ordering work to cease until such provisions are met.
- B. The Contractor shall comply with the requirements of the USEPA NPDES General Construction Permit and all other applicable requirements of governing authorities having jurisdiction. The Specifications and Drawings are not intended to be complete erosion and sediment control practices necessary to complete the work and comply with the NPDES Program requirements, but rather convey the intent to provide complete slope protection and erosion control for the adjacent properties.
- C. If required, the Contractor shall meet with the regulatory agencies for clarification regarding requirements of the execution of, and compliance with, environmental protection programs. The Contractor shall familiarize itself with the nature of the work to be performed.
- D. Refer to Section 325000 Stormwater Pollution Prevention Plan for Contractor's requirements to prepare and implement the SWPPP.
- E. Contractor shall prepare and implement sediment and erosion control plans as required for each phase of work.
- F. Contractor shall be made aware and of and comply with the requirements stated in the Massachusetts Department of Environmental Protection – Order of Conditions

- G. Contractor shall notify and coordinate with the Ashland Conservation Commission prior to commencement of any work.
- H. Contractor shall monitor weather forecasts to ensure adequate erosion controls are provided for anticipated conditions.

1.7 SITE INFORMATION

- A. Refer to Section 310000 for additional site information.
- B. Do not commence operations which disturb the ground surface until temporary erosion and sedimentation control measures are in place.

PART 2 - PRODUCTS

2.1 EROSION AND SEDIMENTATION CONTROL MEASURES

- A. Compost Filter Sock.
 - 1. Materials shall be in accordance with AASHTO Designation: MP 9-06. Compost material shall meet applicable Federal and State Regulations.
 - 2. For compost filter socks 18" or less in diameter, wooden stakes shall be 1 inch by 1 inch, at 10-foot intervals on center, and of a length that shall project into the soil 1 foot leaving 3 to 4 inches protruding above the filter sock.
 - 3. For compost filter socks greater than 18" in diameter, wooden stakes shall be 2 inch by 2 inch, at 10-foot intervals on center, and of a length that shall project into the soil 1 foot leaving 3 to 4 inches protruding above the filter sock.
- B. Haybales as described in Subsection 767.63 of the State Standards.
 - 1. Haybales shall conform to Subsection 767.63 of the State Standards.
 - 2. Haybales shall have a minimum cross section measuring 18" x 18" with a minimum 36" length.
 - 3. Wood stakes shall be oak and conform to the dimensions shown on the plans.
- C. Temporary Turf Reinforcement Mat
 - 1. Temporary turf reinforcement mats shall be North American Green Product S150 or approved equivalent.
 - 2. Temporary turf reinforcement mat shall be degradable after 12 to 24 months
 - 3. Provide a temporary turf reinforcement mat designed to stabilize a 3:1 slope or greater.
- D. Filter Fabric
 - 1. See Geotextiles in Division 2 Section 31 00 00 "Earthwork" for specification.
- E. Temporary Seed
 - 1. Provide temporary seeding per subsection M6.03.1 Temporary Seeding of the State Standards.
- F. Temporary Sediment Traps, Swales, and Diversions

1. Refer to Section 310000 Earthwork for soil materials and excavation.
2. Provide temporary seeding.
3. Provide turf reinforcement mat as required to stabilize side slopes.

G. Construction Accesses

1. Construction Accesses shall be installed in accordance with the Project details.

PART 3 - EXECUTION

3.1 PROVISION OF COMPOST FILTER SOCKS

- A. Trenching is not required, for typical installation; therefore, soil should not be disturbed upon installation. Compost filter socks shall be placed over the top of ground and wooden stakes shall be driven through the center of the filter socks to anchor them to the ground. To ensure optimum performance, heavy vegetation shall be cut down or removed and extremely uneven surfaces shall be graded to ensure that the compost filter sock uniformly contacts the ground surface.
- B. Compost filter socks may be vegetated by incorporating seed into the compost prior to placing it in the tube.
- C. The ends of the compost filter sock shall be directed upslope, to prevent stormwater from running around the end of the sock.

3.2 PROVISION OF INLET PROTECTION

- A. Install inlet protection device securely below catch basin rim in accordance with manufacturer's recommendations.

3.3 CONSTRUCTION ENTRANCE

- A. Clean and maintain construction entrance to limit tracking of sediment from site.
- B. Any sediment tracked from the site shall be immediately cleaned by the Contractor on the same work day.

3.4 TEMPORARY TURF REINFORCEMENT MAT

- A. Install turf reinforcement mat on all exposed cut/fill slopes with a slope 3:1 or greater to protect against rainfall and wind erosion and hold moisture content to enhance vegetation growth in seed where shown in the plans.
- B. Install erosion control lining in the required locations immediately after the areas has been seeded.
 1. Place the erosion control lining over the seed mulch to fit against the contours of the area. It shall be applied without stretching, lie smoothly but loosely, and be free of wrinkles and bunches. Roll the material in place and in the direction of the flow of surface water. Anchor the up-grade end of the erosion lining in a narrow trench 6" deep. Firmly tamp the trench backfill in place.
 2. In ditches and on slopes, provide check or junction slots at no greater than 50' intervals.

3. Where the erosion lining comes into contact with the edges of catch basins or other structures, place a tight fold in the edge of the material and bury it a minimum of 6" into the soil.
4. Install staples no more than 6" apart at all anchor, junction or check slots.
5. Where two lengths of erosion control lining are joined, the end of the upgrade strip shall overlap the downgrade by a minimum of 6" strip and the two strips shall be anchored together.

3.5 MAINTENANCE AND CLEANING OF EROSION AND POLLUTION CONTROLS

- A. Remove all sediment impounded by the erosion and sediment control barrier and dispose of on-site in locations that will not erode. Repair erosion controls as required to maintain erosion and sediment within the limit of disturbance and protect resource areas.
- B. Repair all erosion controls at substantial completion and get inspection and approval of the condition of the protection from the Owner's Representative.

3.6 TEMPORARY EROSION AND SEDIMENTATION CONTROL

- A. Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to the Drawings.
- B. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.
- C. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.
- D. Following stabilization of the site and the receipt of permission from the Owner's Representative, the Contractor shall remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.7 DISPOSAL

- A. Disposal: Remove surplus soil material, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property. Any potentially contaminated soil material encountered, as specified by the Commonwealth of Massachusetts Department of Environmental Protection rules and regulations, shall be brought to an approved landfill or an appropriately licensed waste facility for legal disposal.
- B. Separate recyclable materials produced during site clearing from other non-recyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.

3.8 PREPARATION

- A. Restore damaged improvements to their original condition, as acceptable to Owner, at no additional cost.

3.9 TEMPORARY SEEDING

- A. In accordance with Subsection M6.03.1 Temporary Seeding of the State Standards

END OF SECTION

SECTION 315000

EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

- A. All work specified in this Section shall conform to "Standard Specifications for Highway and Bridges" of the Massachusetts Department of Transportation, latest revision, herein referred to as "State Standards".
- B. Existing Conditions Plan compiled from the following sources:
 - 1. Existing conditions mapping taken from plan entitled "Topographic Plan of Land 1 East Union Street and 12-16 East Union Street (Route 135) Middlesex County Ashland, Mass" prepared by Guerriere & Halnon, Inc., dated April 7, 2020.
 - 2. Wetland Flags identifying wetland resource areas were placed by Pare Corporation on September 11, 2018 and located by Guerriere & Halnon, Inc.

1.3 SUMMARY

- A. This Section includes temporary excavation support and protection systems.
- B. Related Sections include the following:
 - 1. Section 312319 - Dewatering.
 - 2. Section 310000 - Earthwork.

1.4 PERFORMANCE REQUIREMENTS

- A. Design, furnish, install, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting soil and hydrostatic pressure and superimposed and construction loads.
 - 1. Provide professional engineering services needed to assume engineering responsibility, including preparation of Shop Drawings and a comprehensive engineering analysis by a qualified professional engineer.
 - 2. Prevent surface water from entering excavations by grading, dikes, or other means.
 - 3. Install excavation support and protection systems without damaging existing buildings, pavements, and other improvements adjacent to excavation.
- B. The Contractor assumes all responsibility for the excavation support systems used. In the event of a failure, all resulting damages are the responsibility of the Contractor.
- C. Vibration monitoring for excavation support systems will be performed by Subcontractor's vibration consultant and monitoring firm. Vibration due to Subcontractor's operations shall not exceed specified limits 1.04 E.

1.5 SUBMITTALS

- A. Shop Drawings for Information: Prepared by or under the supervision of a qualified professional engineer for excavation support and protection systems.
1. Include Shop Drawings signed and sealed by a qualified Registered Professional Engineer licensed in the Commonwealth of Massachusetts.
 2. Working drawings and details on the excavation support proposed by the Contractor shall be provided along with detailed calculations showing the design of the bracing and sheeting proposed also stamped by a Registered Professional Engineer licensed in the Commonwealth of Massachusetts.
 3. Working Drawings and design calculations, at a minimum, shall indicate the following:
 - a. Design criteria.
 - b. Details, arrangement and method of assembly and disassembly of proposed system and sequence of construction.
 - c. Connection details.
 - d. Method of preloading the bracing.
 - e. Full excavation depth.
 - f. Loads on support system for various stages of excavation and bracing removal.
 - g. Expected equipment loads.
 - h. Maximum design load carried by various members of support system, and preload values.
 - i. Depths below main excavation to which support system will be installed.
 - j. Methods of resolving difficulties arising from misalignment of soldier piles or steel sheetpiling exposed during excavation, and criteria for implementing procedures.
 - k. Design calculations, for various stages of excavation and bracing removal.
 - l. Existing utility facilities. After checking locations by field investigations, revise drawings to show actual locations of facilities and excavation supports interference with proposed Work, and measures proposed to overcome such interferences.
 - m. Manufacturer's product data.
 4. Design Computations: The Contractor shall also submit complete computations for the design of the sheeting and bracing system(s) proposed to be installed.
 - a. The design shall be in accordance with sound engineering practice and modern, accepted principles of soil mechanics.
 - b. The design shall include the effects of all surcharge which may be reasonably anticipated.
 - c. The minimum factor of safety for each of the design conditions required to be considered shall be 1.50.
- B. Qualification Data for Installer and Professional Engineer.
- C. Submittal Review:
1. The design and layout will be reviewed by the Engineer as to type and suitability, providing that the arrangements presented by the Contractor are satisfactory, but such review will not relieve the Contractor of the sole responsibility for the adequacy of the system, nor shall it be construed as a guarantee that the Contractor's proposed equipment, materials and methods for sheeting and bracing will be adequate for the work required at the locations of and for the work required by this contract.

1.6 SITE INFORMATION

- A. Refer to Section 310000 for additional site information.

- B. The Contractor may make test borings and conduct other exploratory operations necessary for excavation support and protection.
- C. Survey adjacent structures and improvements adjacent to the excavation support system to monitor settlement. Employ a qualified professional engineer or land surveyor to establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations during construction.
- D. During installation of excavation support and protection systems, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify Owner's Representative if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

1.7 QUALITY CONTROL

- A. Provide in accordance with the requirement as specified in Division 1 Specification Sections.
- B. Support of Excavation shall be of sufficient strength to safely sustain all loads from the sides of the excavations, together with all water pressure and reasonable surcharge.
- C. The Contractor shall, at all times, be entirely responsible for the adequacy of sheeting and bracing used:
 - 1. to permit the satisfactory and safe installation and construction of the work;
 - 2. to provide adequate protection against damage to all existing utilities, structures, and completed portions of the work; and
 - 3. to prevent injury to persons.
- D. The Contractor shall control, and pitch, the grading to prevent water from running into the excavated areas of the structures, or to prevent damage to other structures or work already accomplished.
 - 1. Welding Operations – in accordance with AWS D1.1
- E. Conform to the requirements of the OSHA Standards and Interpretations: "Part 1926 Subpart P - Excavation, Trenching, and Shoring", and all other applicable laws, regulations, rules, and codes.
- F. If required by the Owner or Owner's Representative, retain the services of an independent vibration consulting firm with the following in-house personnel to conduct the following vibration monitoring requirements:
 - 1. Preparing, reviewing, and signing of monitoring plans and daily reports, and overseeing of the monitoring and interpretation of the vibration data shall be performed by personnel with the following qualifications:
 - a. Be a Massachusetts Registered Professional Engineer.
 - b. Have a minimum of five (5) years experience in the vibration consulting field.
 - c. Have successfully completed at least five (5) projects with vibration-inducing construction operations, pile driving, and noise levels equal to or more severe than those to be encountered.
- G. Installation, monitoring and interpretation of monitoring equipment shall be performed by personnel with the following qualifications:

1. Have at least three (3) years of experience in the operation of monitoring equipment proposed for use and interpretation of records produced by such equipment.
2. Have installed, operated, monitored and interpreted equipment and records on at least three (3) projects with vibration-inducing construction operations, pile driving, and noise levels equal to or more severe than those to be encountered.

1.8 DESIGN CRITERIA

- A. This design criteria applies where the Contractor is responsible for design of the excavation support:
1. Design the excavation support system in accordance with the earth pressures and other detailed criteria indicated.
 2. Design the excavation support system to support the earth pressures, decking system and AASHTO HS20 traffic loads if any, utility loads, equipment and construction loads, and other surcharge loads to allow the safe and expeditious construction of the permanent structures without movement or settlement of the ground, and to prevent damage to, movement or settlement of, adjacent buildings, structures, or utilities.
 3. Design sheet pile and soldier pile and lagging excavation support systems to penetrate to a depth below the bottom of excavation adequate to prevent lateral and vertical earth movement, and permit lowering of the indicated bottom of excavation at least two feet without any change in the support system as installed except for additional lagging and bracing for soldier pile and lagging systems.
 4. Design the bracing system to furnish sufficient reaction against the side banks to maintain stability in such banks. Obtain such reaction by timely stressing to predetermined locations until the necessary reaction is produced against the banks, or by such other methods that may be necessary to prevent displacement of ground and movement of structures.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Structural Steel:
1. Structural Steel: ASTM A 36/A 36M, ASTM A 690/A 690M, or ASTM A 992/A 992M.
 2. Steel sheet piling – ASTM A328, ASTM A 328/A 328M, ASTM A 572/A 572M, or ASTM A 690/A 690M; with continuous interlocks.
- B. Lagging:
1. Timber Lagging: use sound, well-seasoned Douglas Fir of rectangular cross section, Grade 2 or better. Timber shall be stamped and certified ALOPB LP-22 by the American Preserves Bureau.
 2. Moisture Content shall not exceed 20%.
 3. Minimum fiber stress in bending perpendicular to the grain shall be 1200 psi.
- C. Timber Sheeting:
1. Any species of wood sheets that will satisfactorily withstand all driving and construction stresses and the loads, to which the members will be subjected, may be used for sheeting and bracing.
 2. Wood sheeting shall not be less than three (3) inches nominal thickness.
 3. All timber sheeting and bracing shall be free from worm holes, windshakes, loose knots, decayed or unsound portions or other defects which might impair its strength or tightness.

D. Other Materials:

1. The Contractor shall provide all hardware and fastenings necessary to accomplish satisfactory installation of all sheeting and bracing.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Sheeting and bracing shall be of sufficient strength to sustain all loads from the sides of the excavations, together with all water pressure and surcharge.
- B. The Contractor shall be entirely responsible for adequacy of sheeting and bracing used, and shall take all precautions necessary to prevent movement of material along the sides of excavations, and to prevent the intrusion of water beyond that which his pumping or well point system can control.
- C. Sheeting shall be permanently left in place where indicated or directed.
- D. It is expressly understood and agreed that whenever sheeting and bracing is used, it shall not relieve the Contractor of the sole responsibility for any damages, delays, or injury due to installation or failure of the sheeting or bracing, or the settling of the backfill, the pipeline, or the adjacent ground.

3.2 TIMBER SHEETING

- A. Sheeting shall be driven to sufficient depth below the deepest excavation level to maintain sufficient restraint of the adjacent soil and to prevent movement of the sheeting or excessive intrusion of groundwater.
- B. If voids occur behind the sheeting, they shall be filled immediately with proper material from earth excavation or other sources to the satisfaction of the Engineer.
- C. Withdrawal of sheeting shall be carefully performed to prevent movement of material along the sides of the backfilled excavations, to prevent damage to utilities, structures, or the work, and to avoid injury to persons.
- D. Unless otherwise permitted, sheeting shall be withdrawn in lifts of not more than four (4) feet, and all voids shall be filled immediately with selected materials and thoroughly compacted.

3.3 STEEL SHEET PILING

- A. Install in plumb position with each pile interlocked with adjoining piles for its entire length so as to form a continuous diaphragm throughout the length of each run of wall, being tightly against original ground. Use vibratory pile driver to install sheeting to depth required for design. The equipment and methods of installation, cutting, and splicing shall conform to the approved Working Drawings.
- B. Steel sheet piling located within a one to one slope from the bottom of the foundation element shall not be removed.

3.4 SOLDIER PILES AND LAGGING

- A. Provide bored holes for soldier piles adequate to accommodate pile sections shown on approved Working Drawings. Extend holes to necessary depth below level of subgrade. When pre-boring is to occur within two feet of a utility, uncover utility and install a steel drill casing to a level at least six inches below bottom of utility prior to pre-boring.
- B. Carry bottom of sheeting system to a depth below main excavation adequate to prevent lateral movement and to obtain adequate vertical support. In areas where additional excavation is required below main excavation subgrade, prevent movement of main excavation supports.
- C. Encase soldier piles with 2500 psi concrete up to lowest point of excavation adjacent to pile location. Fill remainder of hole with lean concrete, completely encasing pile.
- D. Use timber lagging secured in place to soldier piles.
- E. Follow excavation closely with placement of lagging. Do not allow height of unlagged face of excavation to exceed five feet in rock and predominately clayey soils, or three feet in sandy soils. Extend lagging to final subgrade. Decrease height as required to prevent ground movement.
- F. Do not permit height of unlagged face to exceed 15 inches if water flows from face of excavation, or if soil (of any type) in face moves towards excavation area. Decrease unlagged face height as required to prevent ground movement.
- G. Carefully perform excavation for installation of lagging to minimize formation of voids. Separate lagging members only as necessary to permit packing behind them.
- H. Pack behind lagging as installation progresses; establish tight contact between excavation face and lagging. Pack openings between lagging members with straw or other suitable material to allow free drainage of water without loss of soil or sand packing.
- I. If unstable material is encountered during excavation, take suitable measures to contain unstable material in place and prevent ground displacement, which may cause damage.
- J. Maintain sufficient quantity of material on hand for lagging, bracing and other operation for protection of Work and for use in case of accident or emergency.

3.5 SUPPORT SYSTEMS WITH INTERNAL BRACING

- A. Use walers, struts, and rakers as necessary to provide internal support of excavation faces retained by soldier piles. Internal columns are unacceptable.
- B. When walers are used, obtain tight bearing between wales and wall, and ample bearing area with starpack for load transfer.
- C. Provide struts as indicated and intermediate bracing as needed to enable struts to carry maximum design load without distortion or buckling.
- D. Provide diagonal bracing as needed for stability of system.
- E. Include web stiffeners, plates or angles as needed to prevent rotation, crippling or buckling of connections and points of bearing between structural steel members. Allow for eccentricities caused by field fabrication and assembly.

- F. Install and maintain internal bracing support members in tight contact with each other and with surface being supported. Attach struts to wales using direct end bearing vertical plate (shimmed) connections at all levels.
 - G. Design internal bracing support members for maximum forces occurring during excavation or removal stages.
 - H. Preloading:
 - 1. Preload internal bracing members, including struts, (except deck beams), shores and similar members, to 50 percent of design compression load occurring during excavation phase.
 - 2. Use procedures that produce uniform loading on bracing members without inducing appreciable eccentricities or overstressing and distortion.
 - 3. Make provisions for permanently fixing each member with steel shims or wedges welded into place.
 - 4. Accomplish preloading by jacking supports in place against soldier piles or wales.
 - 5. Do not use wooden wedges to preload bracing member.
 - 6. Include in preloading system means to determine, within five percent, amount of preload induced into bracing members.
 - I. If decking beams are not required, or if decking beams are not designed to support excavation loads, install uppermost tier of bracing at vertical distances not more than eight feet below top of excavation.
 - J. Install tiers of internal bracing with a vertical distance between them and level of excavation below of not greater than 15 feet. Reduce maximum vertical distance to nine feet where ground movement and settlement shall be minimized to prevent damage, where indicated or as directed.
 - K. Excavate below point of support as indicated. Install bracing, and preload immediately after installation and before continuing excavation.
 - L. When removing struts, increase vertical spacing provided invert slab has been place for at least ten days and support system is adequate to support, safely, adjacent structures and works.
 - M. Vertical spacing of bracing may be increased when removing struts, provided support system is adequate to support adjacent structures and works.
- 3.6 REMOVAL OF SUPPORTING SYSTEM
- A. When removing excavation support system, do not disturb or damage adjacent buildings structures, construction, or utility facilities. Fill voids immediately with lean concrete or with approved backfill compacted to the density as specified in Section 31 00 00, "Earthwork".
 - B. Except as specified herein and below, remove sheeting system to a depth of at least six feet below the ground surface.
 - C. Remove material of supporting system from the Worksite immediately.

END OF SECTION

Ashland Public Safety Building
12 Union Street, Ashland, MA

HKT Architects
October 23, 2020

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SECTION 321217

HOT MIX ASPHALT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

- A. All work specified in this Section shall conform to "Standard Specifications for Highway and Bridges" of the Massachusetts Department of Transportation, latest revision, herein referred to as "State Standards".
- B. Existing Conditions Plan compiled from the following sources:
 - 1. Existing conditions mapping taken from plan entitled "Topographic Plan of Land 1 East Union Street and 12-16 East Union Street (Route 135) Middlesex County Ashland, Mass" prepared by Guerriere & Halnon, Inc., dated April 7, 2020.
 - 2. Wetland Flags identifying wetland resource areas were placed by Pare Corporation on September 11, 2018 and located by Guerriere & Halnon, Inc.

1.3 SUMMARY

- A. This Section includes the following:
 - 1. Hot Mix Asphalt paving.
 - 2. Hot Mix Asphalt walkway paving.
 - 3. Hot Mix Asphalt patching.
 - 4. Curbing.
- B. Related Sections include the following:
 - 1. Section 310000 "Earthwork" for aggregate subbase and base courses and for aggregate pavement shoulders.
 - 2. Section 320116 "Flexible Pavement Recycling" for recycling existing bituminous concrete pavement.
 - 3. Section 321723 "Pavement Markings" for pavement marking paint.

1.4 DEFINITIONS

- A. DOT: Massachusetts Department of Transportation
- B. HMA: Hot Mix Asphalt

1.5 DESIGN REQUIREMENTS

- A. Use all means necessary to protect bituminous concrete pavement materials before, ongoing, and after installation, and to protect the installed work and materials of all other trades.
- B. In the event of damage, immediately make all repairs and replacements necessary as directed by the Owner's Representative at no additional expense to the Owner.

1.6 SUBMITTALS

- A. Product Data: For each type of product indicated include technical data, gradation, and composition of materials proposed.
- B. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
- C. Qualification Data: For manufacturer.
- D. Material Test Reports: For each paving material.
- E. Conformance Certificates: For each paving material, signed by manufacturers.
- F. Shop Drawings: Indicate pavement markings, lane separations, and defined parking spaces. Indicate, with international graphics symbol, spaces dedicated to people with disabilities.
- G. In case of settlement or other defects in new or replaced pavements, the Contractor shall cut out, replace, restore or repair the damaged pavements at no additional expense to the Owner. This requirement shall remain in effect for 2 year after the acceptance of the work by the Owner. The pavement area to be replaced, repaired or restored, shall extend from edge of pavement to edge of pavement, a minimum of 20 feet on either side of the defect; final pavement course shall be feathered to provide a smooth finish detail.
 - 1. The Contractor shall furnish a bond for the 2-year duration to the Owner insuring that the corrective repairs will be performed if necessary.

1.7 QUALITY ASSURANCE

- A. Manufacturer shall be a paving-mix manufacturer registered with and approved by the Massachusetts Department of Transportation.
- B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated, as documented according to ASTM E 548.
- C. Regulatory Requirements: Comply with the State Standards.

1.8 PROJECT CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp or if the following conditions are not met:
 - 1. Prime and Tack Coats: Minimum surface temperature of 60 deg F.
 - 2. Slurry Coat: Comply with weather limitations of ASTM D 3910.

3. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
4. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.

PART 2 - PRODUCTS

2.1 AGGREGATES

- A. Conform to State Standards.

2.2 HOT MIX ASPHALT CONCRETE SURFACE COURSE

- A. Hot Mix Asphalt Surface Course – Standard Top; conform to Section 450 or 460 as applicable and Section M3.11.00 of the State Standards.

2.3 HOT MIX ASPHALT CONCRETE BASE COURSE

- A. Hot Mix Asphalt Base/Intermediate Course- Binder; conform to Section 450 or 460 as applicable and Section M3.11.00 of the State Standards.

2.4 TACK COAT

- A. Conform to Asphalt Emulsion Tack Coat as specified in Section 460 and Section M3.11.06 of the State Standards.

2.5 SUB-BASE COURSE

- A. Provide Sub-Base Course material as specified on the Drawings. Materials shall conform to Section 310000 – Earthwork.

2.6 SUBGRADE

- A. Construct subgrade with Ordinary Borrow as specified in Section 310000 - Earthwork.

2.7 CURBING

- A. Granite curbs shall be in accordance to MassDOT Standard Specifications M9.04.1 and installed in accordance to MassDOT Std. Spec. Section 500.
- B. Precast concrete curbing shall conform to Subsection 501.63 and M4.02.14 of the State Standards.
- C. Bituminous Berm shall conform to Hot Mix Asphalt Berm Type A in Section 501.64 of the State Standards.
- D. Provide concrete curb lock on all curbing. Curb lock shall be 3,000 psi concrete.

2.8 COARSE AGGREGATE

- A. ASTM D 692, sound; angular crushed stone, crushed gravel, or properly cured, crushed blast-furnace slag.

2.9 FINE AGGREGATE

- A. ASTM D 1073, sharp-edged natural sand or sand prepared from stone, gravel, properly cured blast-furnace slag, or combinations thereof.
 - 1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.

2.10 TEMPORARY TRENCH PATCHING

- A. Conform to Section 472 of the State Standards.

PART 3 - EXECUTION

3.1 CONTRACTOR REQUIREMENTS

- A. The Contractor shall perform and complete the construction work within the limits indicated in a continuous manner so that the pavement placement work may proceed without delay.
- B. The Contractor shall, at all times, prior to acceptance of the work by the Engineer, maintain the completed work in a safe and satisfactory condition. All maintenance and repairs to the completed work shall be subject to the approval of the Engineer and the controlling municipal and State authorities. All maintenance and repairs of the completed work shall be provided by the Contractor at no additional cost to the Owner.
- C. Equipment used in the work will be subject to approval by the Engineer and shall be maintained in a satisfactory condition at all times. Unless otherwise permitted, compaction shall be performed by use of suitable power rollers. Finished surfaces of new asphaltic surface courses shall finish even with adjacent existing pavement surfaces and be free from surface irregularities.
- D. It shall be the responsibility of the Contractor to obtain from the controlling municipal authorities all required permits for cutting roadway pavements and to perform the work in accordance with all customs and requirements of the controlling authorities, in addition to those specified herein, and at no additional expense to the Owner.
- E. Existing pavements outside of the indicated work limits which are damaged as a result of the Contractor's operations, including base courses, bituminous tack coats and surface courses, shall be replaced by the Contractor in accordance with the requirements specified herein for the respective type of pavement; in a satisfactory manner and at no additional cost to the Owner.
- F. In case of settlement or other defects in new or replaced pavements, the Contractor shall cut out, replace, restore or repair the damaged pavements at no additional expense to the Owner. This requirement shall remain in effect for 2 years after the acceptance of the work by the Owner. The pavement area to be replaced, repaired or restored, shall extend from edge of pavement to edge of pavement, a minimum of 20 feet on either side of the defect; final pavement course shall be feathered to provide a smooth finish detail.
- G. The Contractor shall furnish a bond for the 2-year duration to the Owner insuring that the corrective repairs will be performed if necessary.

- H. This contract shall not be considered complete until the replacement, restoration and repair of pavements has been provided in a manner satisfactory to the Owner's Representative, and in accordance with the requirements specified herein.

3.2 CURBING

- A. Granite curbs shall be in accordance to MassDOT Standard Specifications M9.04.1 and installed in accordance to MassDOT Std. Spec. Section 500.
- B. Precast concrete curbing shall conform to Subsection 501.63 and M4.02.14 of the State Standards.
- C. Bituminous Berm shall conform to Hot Mix Asphalt Berm Type A in Section 501.64 of the State Standards.
- D. All curbing in all locations shall be installed with concrete curb lock prior to backfill to lock curb in place at all locations on-site. Curb lock shall be 3,000 psi concrete.

3.3 SUB-BASE COURSE PLACEMENT

- A. Refer to Section 310000 Earthwork.
- B. Place materials in the proper lift depths and perform compaction as specified in the earthwork section. Make proper allowance for HMA courses.
- C. All compaction shall be performed with approved equipment well suited to location and material being compacted. Use heavy vibratory rollers where heavy equipment is authorized.
- D. Do not operate heavy equipment closer to a foundation than a horizontal distance equal to height of backfill above bottom of foundation. Compact remaining area with hand tampers suitable for material being compacted. Place and compact backfill around pipes with care to avoid damage.

3.4 HOT MIX ASPHALT BASE COURSE

- A. Provide a Hot Mix Asphalt Base Course on the Sub-base in compacted thickness as shown on the drawings. The Hot Mix Asphalt Base Course shall be provided in accordance with the applicable requirements of the State Standards, Section 420 or 701 as applicable and Section M3.11.00 for materials.

3.5 HOT MIX ASPHALT SURFACE COURSE

- A. Place Hot Mix Asphalt Surface Course in compacted thickness as shown on drawings. The finished pavement surface shall conform to the proposed grades of the roadway or as directed, and shall be flush with all existing pavements unless otherwise indicated.
- B. The Hot Mix Asphalt Surface Course shall be provided in accordance with the applicable requirements of the State Standards, Section 460 or 701 as applicable and Section M3.11.00 for materials.
- C. A tack coat conforming to the State Standards shall be applied to the base course prior to the placement of the surface course.

3.6 COMPACTION

- A. The Contractor shall conform to the State Standards for pavement operations, including compaction.
- B. Immediately after the HMA mixture has been spread, struck off, and surface irregularities adjusted, it shall be thoroughly and uniformly compacted by rolling. The surface shall be rolled when the mixture is in the proper condition and when rolling does not cause undue displacement, cracking and shoving.
- C. The number, weight and type of rollers furnished shall be sufficient to obtain the required compaction while the mixture is in a workable condition. Rolling shall be continued until all roller marks are eliminated and the minimum densities have been obtained based upon 95 percent of laboratory Marshall Densities made in the proportions of the job-mix formula, AASHTO T-245.
- D. Steel-Tired, Static Weight Rollers: The maximum roller speeds for steel-tired static-weight rollers for various operations shall not exceed three miles per hour. The wheels of steel-wheel rollers shall be kept moist and clean to prevent adhesion of the fresh material, but an excess of water will not be permitted.
- E. Vibratory Rollers: The maximum roller speed for vibratory rollers shall be that which provides impact spacing less than the compacted lift thickness. When vibratory rollers are used in the static mode, roller speed shall not exceed three miles per hour.
- F. When an approved vibratory roller is used for breakdown rolling in a vibratory mode, intermediate rolling will not be required. When the vibratory roller is used for finish rolling it shall be used in the static mode. Rolling shall progress continuously until the specified density of the corresponding daily plant Marshall Density, AASHTO T-245 has been attained. Finish rolling shall continue until all roller marks are eliminated.
- G. Unless otherwise directed, rolling shall start longitudinally at the sides and gradually progress toward the center of the pavement except on super-elevated curves where the rolling shall begin on the low side and progress to the high side, overlapping on successive trips by at least one-half the width of tandem rollers and uniformly lapping each preceding track.
- H. The motion of the rollers shall be slow enough at all times to avoid displacement of the hot mixture. Any displacement resulting from reversing the direction of the rollers or from any other cause shall be satisfactorily corrected.
- I. When the base course, binder course, or wearing course fails to comply with the density requirements herein specified, additional compaction might be applied when permitted and as directed, to attain the required density. If satisfactory density cannot be attained the Contractor shall be required to remove and replace, at his own expense, any affected area that is proven to be structurally inadequate and/or incapable of maintaining material integrity.
- J. Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective, shall be removed and replaced with fresh hot mixture, which shall be compacted to conform to the surrounding area. Any area showing an excess or deficiency of HMA material shall be removed and replaced.
- K. In the event of dispute as to the creditability of the results, density shall be determined from cores taken from the pavement.

3.7 TEMPORARY TRENCH PATCHING

- A. Install temporary trench patch in accordance with to Section 460.62 of the State Standards.

END OF SECTION

Ashland Public Safety Building
12 Union Street, Ashland, MA

HKT Architects
October 23, 2020
Addendum #7 December 16, 2020

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SECTION 321313

CEMENT CONCRETE PAVEMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

- A. All work specified in this Section shall conform to "Standard Specifications for Highway and Bridges" of the Massachusetts Department of Transportation, latest revision, herein referred to as "State Standards".
- B. Existing Conditions Plan compiled from the following sources:
 - 1. Existing conditions mapping taken from plan entitled "Topographic Plan of Land 1 East Union Street and 12-16 East Union Street (Route 135) Middlesex County Ashland, Mass" prepared by Guerriere & Halnon, Inc., dated April 7, 2020.
 - 2. Wetland Flags identifying wetland resource areas were placed by Pare Corporation on September 11, 2018 and located by Guerriere & Halnon, Inc.

1.3 SUMMARY

- A. This Section includes exterior cement concrete pavement for the following:
 - 1. Sidewalks
 - 2. Vehicular Concrete Pavement
 - 3. Detectable Warning Pavers
- B. Related Sections include the following:
 - 1. Section 310000 Earthwork

1.4 Definitions

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.5 SUBMITTALS

- A. Product Data: For each type of manufactured material and product indicated. Indicate name, source, and description of each material and product.
- B. Design Mixtures:

1. Submit prior to start of Work written reports of each proposed mix for each class of concrete. Do not begin concrete production until mixes have been approved by the Engineer.
 2. For each concrete pavement mixture, include alternate mixture designs when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
- C. Qualification Data: For testing agency.
- D. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the aggregates and concrete mix with requirements indicated.
- E. Batch Ticket Information: Provide concrete delivery tickets showing job name and location, date and time of delivery, quantity of concrete, quality and type of concrete, admixtures, amount of water added, and all other relevant information as described in ASTM C-94. Submit original batch tickets and 2 copies at the end of each week.
- F. Field quality-control test reports.
- G. Sample of Detectable Warning Paver for review by Owner
- H. Submittal depicting proposed locations for expansion and control joints on all cement concrete pavement surfaces.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products who complies with ASTM C 94/C 94M requirements for production facilities and equipment.
- B. Testing Agency Qualifications: An independent agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.
1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.
- C. ACI Publications: Comply with ACI 301, "Specification for Structural Concrete," unless modified by requirements in the Contract Documents.
- D. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

1.7 DESIGN REQUIREMENTS

- A. Design formwork to support vertical loads and lateral pressures resulting from placement and vibration of concrete in accordance with the requirements of ACI 301 and ACI 347, and as specified herein.
- B. Camber the formwork to compensate for anticipated deflections due to the weight and pressure of the fresh concrete and due to construction loads.
- C. Provide shores and struts with positive means of adjustment capable of taking up formwork settlement during concrete placing operations. Use wedges or jacks, individually or in combination for adjustment.

- D. Design forms and falsework to include assumed values of live loads, dead load, weight of moving equipment operated on formwork, concrete mix, height of drop, vibrator frequency, ambient temperature, lateral stability, and other factors pertinent to the safety of the structure during construction.
- E. Provide and design forms to conform with expansion and construction joint locations

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage.
- B. Order concrete from batching plant so that trucks arrive at discharge locations when concrete is required. Avoid excessive mixing of concrete or delays in placing successive layers of concrete in forms.
- C. Deliver concrete to discharge locations in watertight agitator or mixer trucks without altering the water-cement ratio, slump, air entrainment, temperature and homogeneity.
- D. Concrete not conforming to specification, unsuitable for placement, exceeding the time or temperature limitations or not having a complete delivery batch ticket will be rejected.

1.9 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.
- B. Weather: Protect concrete from damage and reduced strength or performance due to weather extremes during mixing, placing and curing.
- C. Cold Weather: Unless special precautions are taken to protect concrete, do not Work when temperatures are below 40°F or when temperatures are expected to fall below 40°F within 72 hours after placing concrete.
 - 1. Comply with ACI 306 in cold weather.
 - 2. Maintain concrete temperature of at least 60°F. Reinforcement, forms and ground in contact with concrete, shall be free of frost.
 - 3. Keep concrete and formwork at least 50°F for at least 96 hours after placing concrete.
 - 4. The use of calcium chloride in any form is not permitted. Non-chloride accelerator shall be used when ambient temperature is below 50°F.
 - 5. Admixture manufacturer shall provide technical assistance at no additional cost. A manufacturer's representative shall be available for consultation by phone or on site upon 72-hour notice.
- D. Hot Weather: Concrete, when deposited, shall be less than 85°F. Cool the mix in a manner acceptable to the Engineer if the concrete temperature is higher.
 - 1. Comply with ACI 305 in hot weather.
 - 2. Retarder shall be used when ambient temperature exceeds 80°F.

PART 2 - PRODUCTS

2.1 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.
 - 1. Use flexible or curved forms for curves with a radius 100 feet or less.
- B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, nor adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.
- C. Forms for Exposed Finish Concrete: Construct formwork for exposed concrete surfaces with smooth faced undamaged plywood or metal, metal-framed plywood faced or other acceptable panel-type facing materials approved by Owner's Representative, to provide continuous, straight, smooth as-cast surfaces, and produce a uniform and consistent texture and pattern on the surfaces. Metal patches on forms for these surfaces will not be permitted. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on the drawings.
 - 1. Use overlaid plywood complying with U.S. Product PS-1 "A-C or B-B High Density Overlaid Concrete Form", Class I.
 - 2. Use plywood complying with U.S. Product Standard PS-1 "B-B (Concrete Form) Plywood", Class I, Exterior Grade or better, mill-oiled and edge-sealed, with each piece bearing legible inspection trademark.
- D. Forms for Unexposed Finish Concrete: Plywood, lumber, metal, or other acceptable material. Provide lumber dressed on at least 2 edges and one side for tight fit.
- E. Form Ties:
 - 1. Form Ties: For concrete structures, which will not be in view or buried below finish grade, use carbon steel factory-fabricated, removable or stay in place snap-off type form ties, designed to prevent form deflection and to prevent spalling concrete upon removal. Provide units, which will leave no metal closer than 1-1/2" to surface. Provide ties which, when removed, will leave holes not larger than 1" diameter in concrete surface. Patch all holes with non-shrink grout.
 - 2. Form ties and spreaders for walls in areas exposed to view shall be Stainless Steel Cone-Tight Tyscru by Richmond Screw Anchor Co.; Dayton Sure-Grip and Shore Co.; or substitute approved by Engineer with Plastic cone-tight type cones having a 1" setback and a taper from 1" to 1-1/4". Tycone holes shall be sealed with plastic set back plugs, color as selected by Engineer from manufacturer's standard color selection or filled with non-shrink grout. Tyscru ties shall be sized to satisfy loading requirements.
 - 3. In lieu of form ties specified above, fiberglass form tie systems shall be used. Fiberglass form ties shall be standard gray color. The concrete structure shall be finished by grinding the fiberglass form tie flush with the finish surface of the concrete structure.
 - a. If tapered architectural holes are required, dummy tapered cones having a 1" setback and a taper from 1" to 1-1/4 shall be fastened to the interior of the formwork to achieve the specified pattern on the finish structure.
- F. Chamfer Strips: Provide 3/4-inch triangular fillets to form all exposed concrete corners. Material shall be rubber or polyvinyl chloride type, or smooth clear, sealed softwood.

- G. Sleeves: Sleeves for wall and floor penetrations shall be pre-engineered Century-Line sleeves as manufactured by Thunderline Corporation or Engineer approved substitute. Sleeves shall be constructed of high impact thermoplastic with waterstop collar, reinforcing ribs and nailer end caps for positioning forms. Sleeve shall be designed to work with modular mechanical seal for through wall penetrations. Size of sleeves shall be selected according to manufacturer's recommendations for pipe sizes indicated on drawings.
- H. Seals: Sleeve/pipe seals shall be Link-Seal modular mechanical seals as manufactured by Thunderline Corporation or approved equivalent. The seal shall be modular, mechanical; type, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and the wall opening. The elastomeric element shall be sized and selected per manufacturer's recommendations and have the following properties as designated by ASTM:
 - 1. For standard service applications: (-40°F to 250°F) EPDM – ASTM D2000 M3 BA 510.
 - 2. For hydrocarbon service applications: (-40°F to 210°F) Nitrile – ASTM D2000 M1BF510.
 - 3. For high temperature or fire seal applications: (-60°F to 400°F) Silicone – ASTM D2000 M1GE505.

2.2 STEEL REINFORCEMENT

- A. Plain-Steel Welded Wire Reinforcement: ASTM A 185/A 185M, fabricated from steel wire into flat sheets.
- B. Deformed-Steel Welded Wire Reinforcement: ASTM A 497/A 497M, flat sheet.
- C. Epoxy-Coated Welded Wire Reinforcement: ASTM A 884/A 884M, Class A, plain steel.
- D. Reinforcing Bars: ASTM A 615/A 615M, Grade 60; deformed.
- E. Galvanized Reinforcing Bars: ASTM A 767/A 767M, Class II zinc coated, hot-dip galvanized after fabrication and bending; with ASTM A 615/A 615M, Grade 60 deformed bars.
- F. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M or ASTM A 934/A 934M; with ASTM A 615/A 615M, Grade 60 deformed bars.
- G. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60, deformed bars; assembled with clips.
- H. Plain-Steel Wire: ASTM A 82/A 82M
- I. Deformed-Steel Wire: ASTM A 496/A 496M.
- J. Epoxy-Coated-Steel Wire: ASTM A 884/A 884M, Class A coated.
- K. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 plain-steel bars. Cut bars true to length with ends square and free of burrs.
- L. Epoxy-Coated, Joint Dowel Bars: ASTM A 775/A 775M; with ASTM A 615/A 615M, Grade 60, plain-steel bars.
- M. Tie Bars: ASTM A 615/A 615M, Grade 60, deformed.

- N. Hook Bolts: ASTM A 307, Grade A, internally and externally threaded. Design hook-bolt joint assembly to hold coupling against paving form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.
- O. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:
- P. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
- Q. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.
- R. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating, compatible with epoxy coating on reinforcement.
- S. Zinc Repair Material: ASTM A 780.

2.3 CONCRETE MATERIALS

- A. The Contractor shall insure that the final appearance of the sidewalks is consistent throughout the whole project. Any difference in color, texture, or finish will not be accepted by the Engineer.
 - 1. Any portion of sidewalk or walkway that does not match the color, texture, or finish of previously constructed sidewalks will be removed and replaced with a sidewalk that matches the recently poured sidewalks at the expense of the Contractor.
- B. Cementitious materials for concrete sidewalks, ramps, and pads shall conform to Section M4.02.00 Cement Concrete, (4000 psi, $\frac{3}{4}$ inch, 610) of the State Standards.

2.4 CONCRETE MIXTURES

- A. Prepare design mixtures, proportioned according to the State Standards, for each type and strength of normal-weight concrete required.

2.5 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M and ASTM C 1116. Furnish batch certificates for each batch discharged and used in the Work.
 - 1. When air temperature is between 85 deg F and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.
- B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 - 1. For concrete mixes of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
 - 2. For concrete mixes larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd.

3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

2.6 PREMOLDED JOINT FILLER

- A. Provide premolded-joint filler conforming to ASTM D1752, Type I or Type II.
- B. Provide Type III self-expanding cork where specifically indicated.
- C. Provide joint filler of same thickness as expansion joint width indicated.
- D. Provide maximum length filler manufactured to minimize field splicing.

2.7 JOINT COMPOUNDS

- A. Provide joint compound for expansion joints in horizontal surfaces and surfaces inclined less than 30 degrees from the horizontal conforming to ASTM C920, Type S or M, Grade P, Class 25. Use type T in pedestrian and vehicular traffic areas and use type NT in non-vehicular areas.
- B. Provide joint compound for expansion joints in walls and surfaces inclined greater than 30 degrees from the horizontal conforming to ASTM C920, Type S or M, Grade NS, Class 25.
- C. Provide compatible joint compounds as recommended by manufacturer when they abut each other.
- D. Provide compound intended for continuous submergence in liquid containing structures.

2.8 BOND BREAKER FOR JOINT COMPOUNDS

- A. Provide polyethylene tape, coated tape or metal foil.

2.9 BACK-UP MATERIAL FOR JOINT COMPOUNDS

- A. Provide polyethylene foam or polychloroprene foam rubber.
- B. Do not use material impregnated with oil, bitumen, or similar substances.
- C. Provide back-up material as recommended by joint compound manufacturer that is compatible with the joint compound and has the same expansion/contraction capability as joint compound.

2.10 DETECTABLE WARNING PAVERS

- A. Provide precast concrete unit pavers with detectable warning surface that comply with the detectable warnings on walking surfaces section of the Americans with Disabilities Act Title 49 CFR TRANSPORTATION, Part 37.9 STANDARDS FOR ACCESSIBLE TRANSPORTATION FACILITIES, Appendix A, Section 4.29.2 DETECTABLE WARNINGS ON WALKING SURFACES).
 1. Pavers shall be 'Detectable Warning Pavers' as manufactured by Hanover Architectural Products, Hanover Pennsylvania, or approved equivalent.
- B. Detectable warning pavers shall be manufactured and installed to the sizes and dimensions indicated on the Contract Documents and approved Submittals.

- C. Concrete pavers shall conform to ASTM C936-82, Standard Specifications for Solid Concrete Interlocking Paving Units. The minimum compressive strength shall not be less than 7,200 pounds per square inch with the average compressive strength not less than 8,000 pounds per square inch. Maximum absorption shall be 5 percent or less at 50 cycles of freeze-thaw testing per section ASTM C67. Submit paver tests for freeze thaw and abrasion resistance to be approved by the Architect.
1. Paver size shall be 11- $\frac{3}{4}$ inch square with beveled top edges.
 2. Paver thickness shall be 2 inches.
 3. Width and thickness shall not vary by greater than 1/16 inch.
 4. The finish shall be non-slip texture.
 5. Paver color shall be 'Charcoal' from manufacturer's standard color range which provides a 60% color contrast from the abutting ramp pavement color, as required by the Americans with Disabilities Act.
- D. Mortar for Detectable Warning Pavers
1. Mortar for grouted joints between pavers shall be a cement mortar composed of one part Portland cement and two parts sand, by volume with sufficient water to form a workable, stiff mixture.
 2. Setting bed mortar shall conform to ASTM C 270, Type S, except that latex polymer additive shall be mixed with the cementitious materials and aggregate in lieu of water.
 3. Cement: Shall be an American portland cement conforming to ASTM C150, Type I or II, except Type III may be used for cold-weather construction, and shall exhibit no efflorescence when cast into 2 inch x 7 inch x $\frac{1}{2}$ inch (50 mm x 178 mm x 13 mm) slabs comprising the mortar under test.
 4. Water: clean, fresh and potable, from public water system.
 5. Sand: clean, washed, uniformly well-graded, conforming to ASTM C144 with 100 percent passing No. 8 sieve (2.37 mm), and not more than 35 percent passing No. 50 sieve (300um), with a fineness modulus maintained at 2.25 plus or minus 0.10.
 6. Hydrated Lime: provide plastic hydrate, conforming to ASTM C207, Type "S" as approved by the Owner's Representative.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.
- B. Proof-roll prepared subbase surface below concrete pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding.
1. Completely proof-roll subbase in one direction. Limit vehicle speed to 3 mph.
 2. Subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch require correction according to requirements in SECTION 310000 EARTHWORK.
- C. Proceed with concrete pavement operations only after nonconforming conditions have been corrected and subgrade is ready to receive pavement.
- D. Remove loose material from compacted subbase surface immediately before placing concrete.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
- B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.
- C. General:
 - 1. Construct forms as designed and in accordance with Contractor's approved working drawings conforming to ACI 347, to the exact sizes, shapes, lines, and dimensions shown, and as required to obtain accurate alignment, location, grades, level, and plumb work in finished structures.
 - 2. Provide for openings, offsets, keyways, recesses, moldings, chamfers, blocking, screeds, bulkheads, anchorages, inserts, and other features required. Use selected materials to obtain required finishes.
 - 3. Forms for concrete which accommodate work of other trades, fabricated before the opportunity exists to verify the measurements of adjacent construction, shall be accurately sized and located as dimensioned on the Drawings. In the event that deviation from the Drawing dimensions results in problems in the field, the Contractor shall be responsible for resolution of the conditions as approved by the Engineer, at no cost to the Owner.
- D. Fabrication:
 - 1. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush plates or wrecking plates where stripping may damage concrete surfaces.
 - 2. Provide temporary openings where interior area of formwork is inaccessible for cleanout, for inspection before concrete placement, and for placement of concrete. Brace temporary closures and set tightly to temporary openings on forms in as many inconspicuous locations as possible, commensurate with design requirements. Form intersecting planes to provide true, clean cut corners.
- E. Falsework:
 - 1. Erect falsework and support, brace, and maintain it to safely support vertical, lateral, and asymmetrical loads applied until complete structure has attained design strength. Construct falsework so that adjustments can be made for take-up and settlement, and access is provided for inspection.
 - 2. Provide wedges, jacks or chamfer strips to facilitate vertical adjustments. Carefully inspect falsework and formwork during and after concrete placement operations to determine abnormal deflection or signs of failure; make necessary adjustments to product work of required dimensions.
- F. Forms for Exposed Concrete:
 - 1. Drill forms to suit ties used and to prevent leakage of concrete mortar around tie holes. Do not splinter forms by driving ties through improperly prepared holes
 - 2. Provide sharp clean corners at intersecting planes, without visible edges or offsets. Back joints with extra studs or grits to maintain true, square intersections.
 - 3. Use extra studs, walers, and bracing to prevent bowing of forms between studs and to avoid bowed appearance in concrete. Do not use narrow strips of form material, which will produce bow.

G. Corner Treatment:

1. Unless shown otherwise, form chamfers with $\frac{3}{4}$ -inch by $\frac{3}{4}$ -inch strips, accurately formed and surfaced to produce uniformly straight lines and tight edge joints on exposed concrete. Extend terminal edges to required limit and miter chamfer strips at changes in direction.

H. Control Joints: Locate as indicated on the Drawings.

- I. Provision for Other Trades: Provide openings in concrete formwork to accommodate work of other trades. Verify size and location of openings, recesses and sleeves with the trade requiring such items. Accurately place and securely support items to be built into forms.

- J. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove encrusted mortar and grout, chips, wood, sawdust, dirt, and other debris just before concrete is placed. Retighten forms immediately after concrete placement as required to eliminate mortar leaks.

3.3 REMOVAL OF FORMS

- A. Formwork not supporting concrete, such as sides of walls, columns, and similar parts of the Work, may be removed after cumulatively curing at not less than 50 degrees F for 72 hours after placing concrete, provided concrete is sufficiently hard to not be damaged by form removal operation, and provided that curing and protection operations are maintained.
- B. Formwork supporting weight of concrete, such as elevated beams, joists, slabs and other structural elements may not be removed until concrete has attained 70% of its design minimum 28-day compressive strength, and has cumulatively cured for no less than 7 days. Concrete shall have sufficient strength to safely support its own weight and construction live loads and lateral pressures. Determine potential compressive strength of in-place concrete testing field-cured specimens representative of the concrete location or members in accordance with State Standards.
- C. Form facing material may be removed one day after placement, only if shores and other vertical supports have been arranged to permit removal of form facing material without loosening or disturbing shores and supports.
- D. Form ties: The concrete structure shall be finished by grinding the fiberglass form ties flush with the finish surface of the concrete structure.

3.4 REUSE OF FORMS

- A. Clean and repair surfaces of forms to be reused in the work. Split, frayed, delaminated or otherwise damaged form facing material will not be acceptable. When forms are reused for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close all joints. Align and secure joints to avoid offsets. Apply new form releasing agent to all form areas that will be in contact with concrete.
- B. Do not reuse forms if there is any evidence of surface wear and tear, splits, fraying, delamination or other damage which would impair the quality of the concrete surface or prevent obtaining the specified concrete finish.

3.5 STEEL AND WELDED WIRE FABRIC REINFORCEMENT

- A. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

- B. Place steel or welded wire fabric in conformance with the construction methods specified within the State Standards.
- C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
- D. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

3.6 CONSTRUCTION JOINTS

- A. Locate and install construction joints as indicated or, if not indicated, locate so as not to impair the strength and appearance of the structure. Submit proposed construction joint locations for approval.
- B. The Contractor shall score the concrete sidewalks in conformance with the scoring pattern shown on the Drawings where specified.
- C. Where the scoring pattern is not specified, the Contractor shall score the concrete sidewalk in conformance with the State Standards.
- D. Place construction joints perpendicular to main reinforcement. Continue reinforcement across construction joints.
- E. Key groove all construction joints unless otherwise indicated. Wall horizontal joints need not be keyed except where specifically indicated.
- F. Key grooves shall be one-third the thickness of the thinner member and 1-1/2-in. deep unless otherwise indicated.
- G. Use tapered key groove forms to permit form removal without damage to the groove. Taper not to exceed 2 inches per foot.
- H. Center waterstops in construction joints unless otherwise indicated. Secure waterstops in position by tie wire to adjacent reinforcing every 12 inches.
- I. Consolidate concrete during placement in the vicinity of key groove without damaging or dislodging waterstop.
- J. Remove all key groove forms.
- K. Clean key groove of laitance, curing compound, foreign materials and protrusions of hardened concrete. Roughen by bush hammer or lightly sandblast to expose coarse aggregate. Blow out debris and dust with oil-free compressed air.
- L. Protect exposed key groove and waterstop from damage.
- M. Expansion Joints:
 - 1. Install expansion joints in accordance with the manufacturers printed instructions and as indicated.
 - 2. Center waterstops in expansion joints unless otherwise indicated. Secure waterstops in position by tie wire to adjacent reinforcing every 12 inches.

3. Consolidate concrete during placement in vicinity of expansion joint without damaging premolded joint filler and waterstop.

3.7 PREMOLDED JOINT FILLER

- A. Treat cut surface of premolded joint filler in conformance with manufacturer's printed instructions.
- B. Place premolded joint filler against the bulkhead form and fasten to the inside of the form with noncorrosive fasteners. Remove all fasteners when bulkhead form is removed.
- C. Prevent disturbance of or damage to premolded joint filler.
- D. Fill expansion joint completely with premolded joint filler, except as specified below.
- E. Secure wood strips to expansion joint surfaces, which are to receive joint compound.
- F. Use tapered wood strips with the smaller width being the same width as the expansion joint and of depth necessary to install the joint compound and back-up materials.
- G. Use materials to secure the premolded joint filler and wood strips that will not harm concrete or affect the joint compound bond to concrete.
- H. Do not remove wood strips until forms are removed as specified in 3.3REMOVAL OF FORMS.
- I. Clean groove of laitance, curing compound, foreign materials and protrusions of hardened concrete. Blow out debris and dust with oil-free compressed air.

3.8 JOINT COMPOUND

- A. Seal the dry clean concrete in expansion joints in conformance with manufacturer's printed instruction.
- B. Install back-up and bond breaker materials.
- C. Prime concrete, fill flush with joint compound or required thickness, tool to concave shape and seal in conformance with manufacturer's printed instructions and ASTM C1193.
- D. Prevent spilling joint compound over adjoining surfaces. Use tape adjacent to joint as required. Remove all tape completely from concrete surface after installing joint.
- E. Do not prime concrete or install joint compound when compound, air or concrete temperature is less than 40 deg. F. or as required by manufacturer.

3.9 CONCRETE PLACEMENT

- A. Inspection: Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast in. Notify other trades to permit installation of their work.
- B. Remove snow, ice, or frost from subbase surface and reinforcement before placing concrete. Do not place concrete on frozen surfaces.

- C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
- D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.
- E. Do not add water to concrete during delivery or at Project site.
- F. Do not add water to fresh concrete after testing.
- G. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
- H. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
 - 1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.
- I. Place concrete in two operations; strike off initial pour for entire width of placement and to the required depth below finish surface. Lay welded wire fabric or fabricated bar mats immediately in final position. Place top layer of concrete, strike off, and screed.
 - 1. Remove and replace concrete that has been placed for more than 15 minutes without being covered by top layer, or use bonding agent if approved by Architect.
- J. Screed pavement surfaces with a straightedge and strike off.
- K. Commence initial floating using bull floats or darbies to impart an open textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.
- L. Slip-Form Pavers: When automatic machine placement is used for pavement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce pavement to required thickness, lines, grades, finish, and jointing as required for formed pavement.
 - 1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of paver machine during operations.
- M. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.
- N. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 - 1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
 - 2. Do not use frozen materials or materials containing ice or snow.
 - 3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mix designs.

- O. Hot-Weather Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
 3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.10 FINISHING

- A. General: Do not add water to concrete surfaces during finishing operations.
- B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.
- C. Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.

3.11 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
- B. Comply with ACI 306.1 for cold-weather protection.
- C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.
- D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- E. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:
1. Moist Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
 2. Water.
 3. Continuous water-fog spray.
 4. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
 5. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
 6. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall

within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.12 PAVEMENT TOLERANCES

A. Comply with tolerances of ACI 117 and as follows:

1. Elevation: 1/4 inch.
2. Thickness: Plus 3/8 inch, minus 1/4 inch.
3. Surface: Gap below 10-foot- long, unlevelled straightedge not to exceed 1/4 inch.
4. Lateral Alignment and Spacing of Tie Bars and Dowels: 1 inch.
5. Vertical Alignment of Tie Bars and Dowels: 1/4 inch.
6. Alignment of Tie-Bar End Relative to Line Perpendicular to Pavement Edge: 1/2 inch.
7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Pavement Edge: Length of dowel 1/4 inch per 12 inches.
8. Joint Spacing: 3 inches.
9. Contraction Joint Depth: Plus 1/4 inch, no minus.
10. Joint Width: Plus 1/8 inch, no minus.

3.13 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least 1 composite sample for each 5000 sq. ft. or fraction thereof of each concrete mix placed each day.
2. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
3. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mix. Perform additional tests when concrete consistency appears to change.
4. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
5. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.
6. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
7. Compressive-Strength Tests: ASTM C 39/C 39M; test 1 specimen at 7 days and 2 specimens at 28 days.
 - a. A compressive-strength test shall be the average compressive strength from 2 specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mix will be satisfactory if average of any 3 consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture

proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

- E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
- F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.
- G. Remove and replace concrete pavement where test results indicate that it does not comply with specified requirements.
- H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.14 REPAIRS AND PROTECTION

- A. Remove and replace concrete pavement that is broken, damaged, or defective or that does not comply with requirements in this Section at no expense to the Owner.
- B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with Portland cement concrete bonded to pavement with epoxy adhesive.
- C. Protect concrete from damage. Exclude traffic from pavement for at least 14 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur.
- D. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial Completion inspections.

3.15 DETECTABLE WARNING PAVERS

- A. No pavers shall be laid in inclement weather or when the temperature is 36 degrees Fahrenheit, and dropping, nor shall any work be done on rising temperatures until the temperature reaches 32 degrees Fahrenheit. Frozen mortar materials shall not be used.
- B. Concrete detectable warning pavers shall be set on a mortar setting bed over a prepared concrete base slab. All setting shall be done by competent workmen under adequate supervision. Do any cleaning necessary to cement concrete base to provide a clean base surface, free from dust, oil, grease, other impurities, or loose or friable particles.
- C. Damp the surface immediately before placing the mortar setting bed, but do not allow free water to remain on the surface.
- D. Latex modified mortar setting bed shall be spread evenly over moistened concrete base. Mortar setting bed shall be 3/4--inch thick, minimum. Back butter pavers with latex modified mortar to ensure a full bond between pavers and setting bed.
- E. Before setting, the back of each piece of concrete paver shall be dampened. Each piece shall be carefully bedded into a wet, sticky mortar mixture and tapped home to a full and solid bearing.

Particular care shall be exercised to equalize bed and joint openings and eliminate the need for redressing of exposed surfaces.

- F. Exposed surfaces of pavers shall be kept free from bed mortar at all times. Any bed mortar smears shall be immediately removed with a clean sponge and clean water before latex modified mortar can set.
- G. Pavers shall be set true to the required lines and grades in the pattern detailed on the Contract Documents.
- H. Joints between pavers shall be filled with mortar to prevent water intrusion.

END OF SECTION

Ashland Public Safety Building
12 Union Street, Ashland, MA

HKT Architects
October 23, 2020

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SECTION 321723

PAVEMENT MARKINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

- A. All work specified in this Section shall conform to "Standard Specifications for Highway and Bridges" of the Massachusetts Department of Transportation, latest revision, herein referred to as "State Standards".
- B. Existing Conditions Plan compiled from the following sources:
 - 1. Existing conditions mapping taken from plan entitled "Topographic Plan of Land 1 East Union Street and 12-16 East Union Street (Route 135) Middlesex County Ashland, Mass" prepared by Guerriere & Halnon, Inc., dated April 7, 2020.
 - 2. Wetland Flags identifying wetland resource areas were placed by Pare Corporation on September 11, 2018 and located by Guerriere & Halnon, Inc.

1.3 SUMMARY

- A. This Section includes the following:
 - 1. Pavement-marking paint.
- B. Related Sections include the following:
 - 1. Section 321217 Hot Mix Asphalt Paving

1.4 DEFINITIONS

- A. DOT: Massachusetts Department of Transportation

1.5 SUBMITTALS

- A. Product Data: For each type of product indicated include technical data and composition of materials proposed.
- B. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
- C. Shop Drawings: Indicate pavement markings, lane separations, and defined parking spaces. Indicate, with international graphics symbol, spaces dedicated to people with disabilities.
- D. Qualification Data: For manufacturer.
- E. Material Test Reports: For each paving material.

- F. Conformance Certificates: For each paving material, signed by manufacturers.

1.6 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the State Standards.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.
- B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.8 PROJECT CONDITIONS

- A. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for oil-based materials, 50 deg F for water-based materials, and not exceeding 95 deg F.

PART 2 - PRODUCTS

2.1 PAVEMENT MARKINGS

- A. Pavement markings shall be epoxy resin conforming to the State Standards Section 860 Reflectorized Pavement Markings.
- B. Pavement markings shall be "yellow" or "white" in color as specified on the Drawings.
- C. Glass Beads shall conform to State Standards Section M7.01.07.
- D. Pavement marking stripes shall measure 4 inches in width or as specified on the Drawings.
- E. Waterborne pavement markings are not acceptable.

PART 3 - EXECUTION

3.1 PAVEMENT MARKING INSTALLATION

- A. Install pavement markings in accordance with State Standards Section 860. Refer to the Drawings for the thickness and color of the pavement markings.
- B. Install letters using stencils to provide clean edges. Letters shall be standard height, font and width per the State Standards.

3.2 TRAFFIC CONTROL AND PROTECTION

- A. Place warning signs near the beginning of the work site and well ahead of the work site for alerting approaching traffic from both directions. Place small markers along newly painted lines to control traffic and prevent damage to newly painted surfaces. Mark painting equipment with large warning signs indicating slow-moving painting equipment in operation. Do not use foil-backed material for temporary pavement marking because of its potential to conduct electricity during accidents involving downed power lines.

3.3 QUALITY ASSURANCE

- A. Demonstrate success of bond of reflective media, new paint marking and the pavement surface, vacuum cured surface of new marking after a seven (7) day dry time. Inspect newly applied markings for signs of bond failure based on visual inspection.

END OF SECTION

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HKT Architects
October 23, 2020

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SECTION 323000

SITE IMPROVEMENTS

PART 1 – GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 – GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

- A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:
 - 1. New Fiberglass Flagpole
 - 2. New Bench without Back
 - 3. New Bench with Back
 - 4. New Picnic Table
 - 5. New Trash Receptacle
 - 6. New Bike Rack
 - 7. Relocate and Reset Existing Granite Monuments, Cast Iron Bell and Stand
- B. Furnish and install all accessory items including hardware, connecting angles, clip angles, bolts, welds, bracing members, etc. necessary for a complete installation.

1.3 RELATED WORK

- A. Section 024113 - Site Preparation
- B. Section 033000 - Cast in Place Concrete
- C. Section 040000 - Masonry

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Protect and handle materials, during loading, shipping, unloading at the site, storage and erection as required to prevent damage to finish surfaces, squareness, straightness and flatness of fabricated members.

1.5 DEFECTIVE MATERIALS

- A. Do not install defective materials. No patching or hiding of defects will be permitted. Refer to Owner's Representative for decision on all materials showing flaws or imperfections upon delivery to the job site. The Owner's Representative's decision as to rejection of materials shall be understood to be final. Remove rejected material from the site and replace with new material.

1.6 REFERENCES

- A. The following standards shall apply to the work of this Section:
 - 1. American Standards for Testing Materials, latest edition; Standards A-120, VA569, 1487-98 (S), and A-500 (ASTM):
 - 2. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.

3. ASTM B221 - Aluminum-Alloy Extruded Bar, Rod, Wire, Shape, and Tube.
4. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.
5. ASTM D822 - Tests on Paint and Related Coatings Using Filtered Open-Flame Carbon-Arc Exposure Apparatus.
6. ASTM D2794 - Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
7. Standard Steel Composition, American Iron and Steel Institute.
8. American Steel Institute (ASI), Standards for Structural Steel, latest edition.
9. Standards for Welding, American Welding Society, (AWS).

1.7 QUALITY ASSURANCE

A. Construction Tolerances:

1. Variations from plumb: 1/4 inch in 10 feet.
2. Variations from level: 1/4 inch in 20 feet.
3. Variation of linear line: 1/2 inch in 20 feet.
4. Variations from slope as indicated for finished surface of paving: 1/4 inch in 10 feet.
5. Variations from flush in unit to unit offset: 1/32 inch.

1.8 SUBMITTALS

- A. Manufacturer's catalog data and specification sheets for each type of manufactured product, including certification that each product complies with specified requirements. Include instructions for handling, storage, installation and protection.
- B. Shop Drawings for existing granite monuments and bell. Include in the drawings accurate sizes and shapes of existing materials to be reset, anchoring to new granite slabs and all other details required for the proper installation of the work.

1.9 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Handle and ship all items so as to prevent damage in transit. Use only material that is not subject to staining or discoloration for blocking and packing. Deliver materials to site in manufacturer's original containers with labels intact and seals unbroken.
- B. Unload and handle all items carefully so as to prevent chipping and breakage. Protect all items during handling, storage and construction against moisture, soiling, staining and physical damage. Store on wood skids or pallets, covered with non-staining, waterproof membrane. Place and stack to distribute weight evenly and to prevent breakage or cracking. Protect stored materials from weather with waterproof, non-staining covers or enclosures, but allow air to circulate around materials. Replace materials damaged in any manner.

PART 2 – MATERIALS

2.1 NEW FLAGPOLE

- A. New flagpole shall be a commercial grade fiberglass pole as available from one of the following:
 1. Flagpoles Etc., www.flagpolesetc.com.
 2. American Flagpole, a Kearney-National Inc. company, www.aflag.com.
 3. Concord Industries, Inc., concordamericanflagpole.com.

- B. Flagpole shall be 25 feet in height above finish grade and shall be delivered with the following:
 - 1. High gloss white urethane finish.
 - 2. Internal halyard.
 - 3. 10" cast aluminum cleat.
 - 4. 23" diameter fiberglass flash collar.
 - 5. Gold anodized ball ornament.
 - 6. Truck assembly, cast aluminum revolving, non-fouling type.
 - 7. Stainless steel swivel snaps.
 - 8. Fiberglass groundsleeve.
 - 9. Ground set base.
- C. Pole shall be equipped to carry a standard flag size of 4' x 6' maximum.
- D. Flagpole shall be installed with new concrete foundation, according to Drawings or as per recommended by manufacturer.

2.2 SITE FURNISHINGS

- A. New benches, trash receptacle and picnic tables shall be provided by Victor Stanley, Dunkirk MD, or approved equal.
 - 1. Backless Bench shall be the Eva bench with steel supports and lpe slats, 4' in length and surface mounted. Steel shall be finished with powdercoat.
 - 2. Bench with Backs shall be the Eva bench with steel supports and lpe slats, 6' in length and surface mounted. Steel shall be finished with powdercoat.
 - 3. Picnic Table shall be the Camille table #CAMT-83-W with steel supports and lpe slats, 8' in length and surface mounted. Table shall have an intermediate steel support. Steel shall be finished with powdercoat.
 - 4. Benches at picnic table shall be the Camille bench #CAM-53-W with steel supports and lpe slats, 8' in length and surface mounted. Benches shall be supplied with intermediate steel supports. Steel shall be finished with powdercoat.
 - 5. Trash Receptacle shall be the Ironsites #SD-45 receptacle with 45 gallon capacity and surface mounted. Receptacle shall be delivered with a rainbonnet lid. Steel shall be finished with powdercoat.
 - 6. Powdercoat color shall be chosen by Owner's Representative from the manufacturer's standard line of colors.
 - 7. Anchor bolts shall be stainless steel, provided by Contractor.
- B. New Bike Racks shall be the Hoop Rack provided by Dero, Minneapolis MN, or approved equal. Bike rack shall be fabricated from 304 grade stainless steel with satin finish, and surface mounted with anchor bolts provided by contractor.

2.3 EXISTING GRANITE MONUMENTS AND BELL

- A. Existing site items shall be salvaged by Contractor at an existing town facility, and transported to the project site. See Construction Drawings for setting details. Contractor shall verify dimensions of all items and contact Owner's Representative regarding any discrepancies with the Drawings. Existing bell shall be cleaned of all dirt prior to installation.

2.4 MISCELLANEOUS MATERIALS

- A. CONCRETE FOR FOUNDATIONS shall conform to the requirements of Section 033000, Cast in Place Concrete, of these Specifications, except that it shall conform to ASTM C94 using 3/4 inch maximum size aggregate and have a minimum compressive strength of 3,000 psi at 28 days.
- B. DOWELS shall be type 302/304 stainless steel bar stock of the sizes and shapes indicated on the Drawings and as specified herein, or if not indicated, as required to securely anchor and fasten monuments and bell in place.
- C. NON-SHRINK EPOXY GROUT shall conform to ASTM C-881 and equal to "Sikadur 32, Hi-Mod" high strength adhesive as manufactured by Sika Corporation, Lyndhurst NJ.
- D. Setting buttons, as required, shall be lead or plastic of the thickness required for the joint size indicated, and of the size required to maintain uniform joint width.

PART 3 - EXECUTION

3.1 INSTALLATION OF SITE IMPROVEMENTS - GENERAL

- A. Perform all excavation of every description and through whatever materials encountered to the depths indicated on the Drawings. In all other respects excavation shall conform to the requirements of Section 31 00 00, Earthwork, of these Specifications.
- B. Perform all work by workmen skilled and experienced in the trade in a neat and clean fashion. Install all work in accordance with the Drawings in straight and true lines, plumb and true to line and grade. Fasten items securely together.

3.2 FLAGPOLE FOUNDATION

- A. Excavate hole for foundation that is 4 to 6 times the diameter of the pole. Depth of hole shall ensure that ground sleeve is flush with finish grade. Hole diameter shall be increased if existing soil conditions are soft or sandy.
- B. Center ground sleeve in hole and fill a 2" depth of crushed stone in and around ground sleeve for drainage.
 - 1. Fill hole around ground sleeve with cement. When hole is half full of cement, plumb the sleeve by placing a level into the sleeve at 2 points 90 degrees apart. Ensure that the sleeve remains plumb when cement is filled to the top.
 - 2. CONCRETE STRENGTH: Allow concrete to attain at least 75% of its minimum 28 day compressive strength, but in no case sooner than 7 days after placement, before additional weight is installed.

3.3 FLAGPOLE INSTALLATION

- A. Prior to and during installation, plastic wrap around flagpole sections shall be left on for protection throughout installation period.
- B. When the cement is firmly set, remove the upper 2/3 of the plastic wrap from the pole, raise the pole into a vertical position and lower into the sleeve. Rotate the pole so the pulley faces in a direction away from the prevailing wind.
- C. Locate cedar shingle wedges and push them part way down between the pole and sleeve in 3 or 4 places. Use a level to plumb the pole. As the pole is tapered, the bubble will not indicate on center but should remain in the same relative position as it's placed against the pole on all sides.
- D. When the pole is plumbed on all sides, pack the area between the pole and the sleeve with dry sand and tamp firmly. Break off the shims level with the sleeve.
- E. Remove the remainder of the plastic wrap.
- F. Drill 2 cleat holes approximately 48" above finish grade and on opposite side of pulley. Secure the cleat with the self-tapping screws provided by manufacturer.

3.4 REMOVAL AND RE-INSTALLATION OF EXISTING MONUMENTS AND BELL

- A. Contractor shall carefully remove existing granite monuments and bell along with its concrete supports from two sites at the Ashland Police and Fire Departments located at 137 Main St., Ashland MA.
 - 1. Holes shall be filled with dense graded stone to finish grade.
 - 2. Bell and concrete supports and base shall be removed from existing site. Concrete base shall be detached and demolished.
 - a. Existing concrete supports shall be carefully removed from metal base. Existing anchor bolts shall be sawcut if rusted in place.
- B. Existing granite monuments shall be installed on concrete base slabs with depth of bury matching existing. Install new concrete paving around monuments with a minimum slope of 1/8 inch per foot from back of pad to front.
- C. Existing bell shall be installed on new granite supports with new stainless steel anchor bolts, core drilled and epoxy grouted into the new granite.
- D. New granite supports and existing granite plaque shall be firmly attached to the new granite base on new mortar setting bed with new stainless steel dowels. Set dowels in non-shrink epoxy grout.

3.5 INSTALLATION OF NEW SITE FURNISHINGS

- A. Assemble and install site furnishings in accordance with the Drawings and manufacturer's recommendations in a neat and clean fashion. Install benches in straight and true lines, plumb and true to line and grade. Secure in place. Install furnishings with the top of benches and table horizontal and square to paving unless otherwise shown on the Drawings.
- B. Firmly secure site furnishings to new concrete walk slabs with stainless steel, vandal resistant fasteners. Neatly drill or core into paving and set fasteners in non-shrink epoxy grout.

1. Install epoxy and sealants in strict accordance with manufacturer's written instructions.

3.6 CLEANING AND PROTECTION

- A. Protect work in progress and after completion. Keep the premises neat and clean at all times.
- B. Repair damaged surfaces and finishes after completion of installation, or replace damaged members as directed where damage is beyond satisfactory repair.

END OF SECTION
323000

SECTION 323223

SEGMENTAL RETAINING WALLS

PART 1 - GENERAL

1.1 SCOPE

- A. Work includes furnishing and installing segmental retaining wall (SRW) units to the lines and grades designated on the construction drawings or as directed by the Owner. Also included is furnishing and installing appurtenant and incidental materials required for construction of the retaining walls as shown on the construction drawings.

1.2 REFERENCES

- A. The following standards and specifications listed below form a part of this specification where applicable.
 - 1. Segmental Retaining Wall Units.
 - a. ASTM C 140 - Sampling and Testing Concrete Masonry Units.
 - 2. Geosynthetic Reinforcement.
 - a. ASTM D 4595 -Tensile Properties of Geotextiles by the Wide-Width Strip Method.
 - b. ASTM D 5262 -Test Method for Evaluating the Unconfined Creep Behavior of Geosynthetics.
 - c. GRI:GG1 - Single Rib Geogrid Tensile Strength.
 - d. GRI:GG5 - Geogrid Pullout.
 - 3. Soils.
 - a. ASTM D 698 - Moisture Density Relationship for Soils, Standard Method.
 - b. ASTM D 422 - Gradation of Soils.
 - c. ASTM 4318 - Atterberg Limits of Soil.
 - 4. Drainage Pipe.
 - a. ASTM 3034 - Specification for Polyvinyl Chloride (PVC) Plastic Pipe.
 - b. ASTM D1248 - Specification for Corrugated Plastic Pipe.
 - 5. Where specifications and reference documents conflict, the Owner shall make the final determination of applicable document.
- B. Existing Conditions Plan compiled from the following sources:
 - 1. Existing conditions mapping taken from plan entitled "Topographic Plan of Land 1 East Union Street and 12-16 East Union Street (Route 135) Middlesex County Ashland, Mass" prepared by Guerriere & Halnon, Inc., dated April 7, 2020.
 - 2. Wetland Flags identifying wetland resource areas were placed by Pare Corporation on September 11, 2018 and located by Guerriere & Halnon, Inc.

1.3 SUBMITTALS

- A. Material Submittals.
 - 1. The Contractor shall submit manufacturers' certifications two weeks prior to start of work stating that the intended SRW units and geosynthetic reinforcement meet the requirements of Section 2 of this specification.
 - 2. Submit representative block samples for selection of color and texture of exposed wall face(s) to the Owner.
- B. Design Submittal:

1. The Contractor shall submit two sets of detailed design calculations and construction drawings for review and acceptance at least two weeks prior to the beginning of wall construction. All calculations and drawings shall be prepared, signed and sealed by the Wall Design Engineer, a Professional Engineer experienced in SRW wall design and licensed in the Commonwealth of Massachusetts.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Contractor shall check materials upon delivery to assure that specified type and grade of materials have been received and proper color and texture of SRW units have been received.
- B. Contractor shall prevent excessive mud, wet concrete, epoxies, and like materials that may affix themselves by unintentional contact with SRW materials.
- C. Contractor shall store and handle materials in accordance with manufacturer's recommendations.
- D. Contractor shall protect materials from damage. Damaged materials shall not be incorporated into the retaining wall.
- E. Exposed faces of precast modular block units shall be reasonably free of chips, cracks, or stains when viewed from a distance of 10 feet.

PART 2 - PRODUCTS

2.1 SEGMENTAL RETAINING WALL

- A. SRW units shall be machine formed, Portland Cement concrete blocks specifically designed for retaining wall applications.
- B. Color of SRW units to be selected by the Owner. See Materials submittal requirements for further information in selection of applicable color(s).
- C. SRW units shall be solid through the full depth of the unit.
- D. SRW units shall have a depth (front face to rear) to height ratio of 2:1, minimum.
- E. SRW units shall be interlocked with connection pins, designed with proper setback to provide 8:1 vertical to horizontal batter (a 7 degree cant from vertical).
- F. SRW units shall be capable of being erected with the horizontal gap between adjacent units not exceeding 1/8 inch.
- G. For any corners shown on the construction plans, SRW units shall be capable of providing overlap of units on each successive course so that walls meeting at corner are interlocked and continuous. SRW units that require corners to be mitered shall not be allowed.
- H. SRW units shall be capable of providing a split face, textured surface for all vertical surfaces that will be exposed after completion of wall, including any exposed sides and backs of units.
- I. SRW units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or permanence of the structure. Cracking or excessive chipping is grounds for rejection. Units showing cracks longer than 1/2"

shall not be used within the wall. Units showing chips visible at a distance of 30 feet from the wall shall not be used within the wall.

- J. Concrete used to manufacture SRW units shall have a minimum 28-day compressive strength of 3,000 psi and a maximum moisture absorption rate, by weight, of 8% as determined in accordance with ASTM C 140. Compressive strength test specimens shall conform to the saw-cut coupon provisions of Section 5.2.4 of ASTM C140 with the exception that the Coupon shall be taken from the least dimension of the unit of a size and shape representing the geometry of the unit as a whole.
- K. SRW units' molded dimensions shall not differ more than + 1/8 inch from that specified, except height which shall be + 1/16 inch as measured in accordance with ASTM C140.

2.2 SEGMENTAL RETAINING WALL UNIT CONNECTION PINS

- A. SRW units shall be interlocked with connection pins, of the material, size, and dimension as recommended and by the wall system manufacturer.

2.3 GEOSYNTHETIC REINFORCEMENT

- A. Geosynthetic reinforcement shall consist of geogrid or geotextile manufactured as a soil reinforcement element. The manufacturers/suppliers of the geosynthetic reinforcement shall have demonstrated construction of similar size and types of segmental retaining walls on previous projects.
- B. The type, strength, and placement location of the reinforcing geosynthetic shall be determined by the Wall Design Engineer, and shown on the design submittal.

2.4 LEVELING PAD

- A. Material for leveling pad shall consist of compacted sand, gravel, or combination thereof and shall be a minimum of 6 inches in depth. Lean concrete with a 28 day compressive strength of 200-300 psi and three inches thick maximum may also be used as a leveling pad material. The leveling pad should extend laterally at least a distance of 6 inches from the toe and heel of the lowermost SRW unit.

2.5 DRAINAGE AGREGATE

- A. Drainage aggregate shall be angular, clean stone or granular fill meeting the following gradation as determined in accordance with ASTM D422.

<u>Sieve Size</u>	<u>Percent Passing</u>
1 inch	100
3 / 4 inch	75 – 100
No. 4	0 – 60
No. 40	0 – 50
No. 200	0 - 5

2.6 DRAINAGE PIPE

- A. The drainage collection pipe shall be a perforated or slotted PVC, or corrugated HDPE pipe. The drainage pipe may be wrapped with a geotextile to function as a filter.
- B. Drainage pipe shall be manufactured in accordance with ASTM D 3034 and/or ASTM D 1248.

2.7 REINFORCED (INFILL) SOIL

- A. The reinforced soil material shall be free of debris. Unless otherwise noted on plans prepared by the Wall Design Engineer, the reinforced material shall consist of the inorganic USCS soil types GP, GW, SW, SP, SM meeting the gradation for common borrow as indicated in Earthwork (Section 02200).
- B. The maximum particle size of poorly-graded gravels (GP) (no fines) should not exceed 3/4 inch unless geosynthetic strength is reduced to account for additional installation damage from particles larger than this maximum.
- C. The plasticity of the fine fraction shall be less than 20.

2.8 SOIL

- A. The following soil parameters shall be for preparation of final design documents by the Wall Design Engineer, unless otherwise directed by the Owner:

<u>Strata</u>	<u>Unit Weight (pcf)</u>	<u>Internal Friction Angle (degrees)</u>	<u>Cohesion (c) (psf)</u>
Reinforced Fill	125	33	0
Retained Soil	125	30	0
Foundation Soil	125	30	0

- B. The design of the permanent wall system shall include an allowance of at least a two foot (2 ft) depth uniform vertical soil surcharge loading where walls retain roadway fills. This provision is applicable when the distance from the face of wall to the edge of road is less than the design wall height.
- C. The wall system may also be designed to account for reasonable temporary surcharge conditions during construction, such as those due to stockpiling of soil or other construction materials.
- D. The construction drawings shall indicate the design limitations of the wall system.
- E. Should the actual soil conditions observed during construction differ from those assumed for the design, the Wall Design Engineer shall review the design.
- F. The Wall Design Engineer shall perform the field work and testing necessary to determine the bearing capacity of foundation soils at no additional cost to the Owner.

2.9 DESIGN

- A. The design provided by the Contractor and prepared by their Wall Design Engineer shall consider the internal and local stability of the reinforced soil mass and shall be in accordance with acceptable engineering practice and these specifications.
- B. The Wall Design Engineer shall confirm that the global stability limit states of sliding, overturning, and the allowable bearing pressure on foundation soil(s) have not been exceeded for the design conditions. Minimum factors of safety for design of permanent conditions are as follows:

Overturning	2.0
Sliding	1.5
Bearing Pressure	2.0

- C. Where other site development features are to be installed adjacent to walls by the Contractor, the design of the wall system shall be developed to accommodate the potential for geotextile penetrations, such as fence and/or guardrail posts.
- D. The Wall Design Engineer shall incorporate headwalls, lintels, or other structural systems in the segmental retaining wall to provide pipe penetrations in the locations indicated on the plans. Exposed portions of the structural members shall have color and texture similar to the block selected by the Owner.

PART 3 - EXECUTION

3.1 INSPECTION

- A. The Owner is responsible for verifying that the Contractor meets all the requirements of the specification. This includes all submittals for materials and design, qualifications, and proper installation of wall system.
- B. Contractor's field construction supervisor shall have demonstrated experience and be qualified to direct all work at the site.

3.2 EXCAVATION

- A. Contractor shall excavate to the lines and grades shown on the project grading plans. Contractor shall take precautions to minimize over-excavation. Over-excavation shall be filled with compacted infill material, or as directed by the Owner, at the Contractor's expense.
- B. Contractor shall verify location of existing structures and utilities prior to excavation. Contractor shall ensure all surrounding structures are protected from the effects of wall excavation. Excavation and/or adjacent structure or utility support, if required, is the design and installation responsibility of the Contractor.
- C. Slope or shore excavation as necessary for safety and for conformance with applicable OSHA requirements.

3.3 FOUNDATION PREPARATION

- A. Following the excavation, the foundation soil shall be examined by the Owner to assure actual foundation soil strength meets or exceeds the assumed design bearing strength. Soils not meeting the required strength shall be removed and replaced with infill soils, as directed by the Owner.
- B. Foundation soil shall be proof rolled or otherwise compacted to 95% modified Proctor density (ASTM D 1557) and inspected by the Owner prior to placement of leveling pad materials.

3.4 LEVELING PAD CONSTRUCTION

- A. Leveling pad shall be placed as shown on the construction drawings with a minimum thickness of 6 inches. The leveling pad should extend laterally at least a distance of 6 inches from the toe and heel of the lower most SRW Unit.
- B. Soil leveling pad material shall be compacted to provide a firm, level, bearing surface on which to place the first course of units. Well-graded sand can be used to smooth the top 1/2 to 1/4

inch of the leveling pad. Compaction will be with mechanical plate compactors to achieve 95% of maximum modified Proctor (ASTM D 1557) density.

3.5 SRW UNIT INSTALLATION

- A. All SRW units shall be installed at the proper elevation and orientation as shown on the wall profiles and details on the construction plans or as directed by the Owner. The SRW units shall be installed in general accordance with the manufacturer's recommendations. The specifications and drawings shall govern in any conflict between the two requirements.
- B. First course of SRW units shall be placed on the leveling pad. The units shall be leveled side-to-side, front-to-rear and with adjacent units, and aligned to ensure intimate contact with the leveling pad. The first course is the most important to ensure accurate and acceptable results. No gaps shall be left between the front of adjacent units. Alignment may be done by means of a string line or offset from base line to the back of the units.
- C. Clean all excess debris from top of units and install next course.
- D. Insert two connection pins through pinholes of each upper course unit into receiving slots in the lower course units. Pins shall be fully seated in the pin slot below. Push units forward to remove any looseness in the unit-to-unit connection and then check alignment. Check level and alignment of the units.
- E. Layout of curves and corners shall be installed in accordance with the plan details or in general accordance with SRW manufacturer's installation guidelines. Walls meeting at corners shall be interlocked by overlapping successive courses.
- F. Repeat procedures to extent of wall height.
- G. The wall face cant (batter) shall not differ more than ± 2 degrees from that specified.

3.6 GEOSYNTHETIC REINFORCEMENT PLACEMENT

- A. All geosynthetic reinforcement shall be installed at the proper elevation and orientation as shown on the wall profiles and details on the final construction plans or as directed by the Owner.
- B. At the elevations shown on the final plans, the geosynthetic reinforcement shall be laid horizontally on compacted infill and on top of the concrete SRW units. Embedment of the geosynthetic in the SRW units shall be consistent with SRW manufacturer's recommendations. Correct orientation of the geosynthetic reinforcement shall be verified by the Contractor to be in accordance with the geosynthetic manufacturer's recommendations. The highest strength direction of the geosynthetic must be perpendicular to the wall face.
- C. Geosynthetic reinforcement layers shall be one continuous piece for their entire embedment length. Overlap of the geosynthetic in the design strength direction (perpendicular to the wall face) shall not be permitted.
- D. Tracked construction equipment shall not be operated directly on the geosynthetic reinforcement. A minimum of 6 inches of backfill is required prior to operation of tracked vehicles over the geosynthetic. Turning should be kept to a minimum. Rubber-tired equipment may pass over the geosynthetic reinforcement at slow speeds (less than 5 mph).

- E. The geosynthetic reinforcement shall be in tension and free of wrinkles prior to placement of soil fill. The nominal tension shall be applied to the reinforcement and secured in place with staples, stakes or by hand tensioning until reinforcement is covered by six inches of fill.

3.7 DRAINAGE MATERIALS

- A. Drainage aggregate shall be installed to the line, grades, and sections shown on the final plans. Drainage fill shall be placed to the minimum thickness shown on the construction plans between and behind units.
- B. Drainage collection pipes shall be installed to maintain gravity flow of water outside the reinforced soil zone. Unless shown otherwise on the plans, drainage collection piping shall daylight into a storm sewer manhole or along a slope at an elevation lower than the lowest point of the pipe within the aggregate drain.

3.8 BACKFILL PLACEMENT

- A. The reinforced backfill shall be placed as shown in the construction plans in the maximum compacted lift thickness of 10 inches and shall be compacted to a minimum of 95% of modified Proctor density (ASTM D 1557) at a moisture content within 2% of optimum. The backfill shall be placed and spread in such a manner as to eliminate wrinkles or movement of the geosynthetic reinforcement and the SRW units.
- B. Backfill placement shall commence at the back of the wall and progress towards the retained material.
- C. Only hand-operated compaction equipment shall be allowed within 3 feet of the front of the wall face. Compaction within the 3 feet behind the wall face shall be achieved by at least three (4) passes of a lightweight mechanical tamper, plate, or roller.
- D. At the end of each day's operation, the Contractor shall slope the last level of backfill away from the wall facing to direct water runoff away from the wall face.
- E. At completion of wall construction, backfill shall be placed level with final top of wall elevation. If final grading, paving, landscaping, and/or storm drainage installation adjacent to the wall is not placed immediately after wall completion, temporary surface drainage shall be provided to ensure water runoff is not directed at the wall nor allowed to collect or pond behind the wall until final construction adjacent to the wall is completed.

3.9 SRW CAPS

- A. SRW caps shall be properly aligned and attached to underlying units with a suitably flexible, high-strength concrete adhesive. Rigid adhesives or mortar will not be accepted.
- B. Caps shall overhang the top course of units by 3/4 to 1 inch. Slight variation in overhang is allowed to correct alignment at the top of the wall.

3.10 CONSTRUCTION ADJACENT TO COMPLETED WALL

- A. The Contractor is responsible for ensuring that construction adjacent to the wall does not disturb the wall or place temporary construction loads on the wall that exceed design loads, including loads such as water pressure, temporary grades, or equipment loading. Heavy paving or grading equipment shall be kept a minimum of three feet behind the back of the wall face. Contractor to ensure water runoff is directed away from the wall structure until final grading and surface drainage collection systems are completed.

END OF SECTION

SECTION 325000

STORMWATER POLLUTION PREVENTION PLAN

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

- A. Guidance Manual—"Storm Water Management for Construction Activities, Developing Pollution Prevention Plans and Best Management Practices" (EPA 832-R-005).
- B. Summary of Guidance Manual—"Storm Water Management for Construction Activities, Developing Pollution Prevention Plans and Best Management Practices" (EPA).
- C. National Pollution Discharge Elimination System General Permit for Discharges from Construction Activities, February 16, 2017, EPA.
- D. Massachusetts Stormwater Management Standards Handbook, February 2008.
- E. All work specified in this Section shall conform to "Standard Specifications for Highway and Bridges" of the Massachusetts Department of Transportation, latest revision, herein referred to as "State Standards".
- F. Existing Conditions Plan compiled from the following sources:
 - 1. Existing conditions mapping taken from plan entitled "Topographic Plan of Land 1 East Union Street and 12-16 East Union Street (Route 135) Middlesex County Ashland, Mass" prepared by Guerriere & Halnon, Inc., dated April 7, 2020.
 - 2. Wetland Flags identifying wetland resource areas were placed by Pare Corporation on September 11, 2018 and located by Guerriere & Halnon, Inc.
- G. Soil erosion and sedimentation controls shall be provided in accordance with the "Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas, A Guide for Planners, Designers, and Municipal Officials" prepared by Franklin, Hampden, Hampshire Conservation Districts, reprint dated May 2003.

1.3 SUMMARY

- A. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
 - 1. Section 312500 – EROSION CONTROL.

1.4 DESCRIPTION OF WORK

- A. This Section specifies requirements for implementation of the Storm Water Pollution Prevention Plan (SWPPP), which shall be provided by the Contractor prior to construction.

- B. The storm water pollution prevention measures contained in the SWPPP are the minimum required by US Environmental Protection Agency (EPA). The Contractor shall provide additional measures to prevent pollution from storm water discharges in compliance with the NPDES and all other local, state and federal requirements. The Contractor shall be responsible for complying with the provisions of the SWPPP.
- C. The Contractor shall NOT begin construction without submitting evidence that a "National Pollution Discharge Elimination System" (NPDES) Notice of Intent governing the discharge of storm water from the construction site for the entire construction period has been filed at least two weeks prior to construction.
- D. The Contractor shall conduct the storm water management practices in accordance with local regulations and governing authorities, the Federal NPDES permit requirements and for any enforcement action taken or imposed by Federal or State agencies. The cost of any fines, construction delays and remedial actions resulting from the Contractor's failure to comply with all provisions of local regulations and Federal NPDES permit requirements shall be paid for by the Contractor at no additional cost to the Owner.
- E. As a requirement of the EPA's NPDES permitting program, the Owner, each Contractor and Subcontractor shall execute a Contractor's Certification form, a copy of which is included in the SWPPP.
- F. Dust control shall be the responsibility of the Contractor and dust control operations shall meet the requirements of the Commonwealth of Massachusetts Department of Environmental Protection 310 CMR 7.09: Air Pollution Control Regulations.
- G. Water shall be used to control dust.

1.5 SUBMITTALS

- A. The Stormwater Pollution Prevention Plan.
- B. Contractor's Certification for Contractor and each Subcontractor.
- C. Copies of Contractor's inspection reports.
- D. Names, addresses, and telephone numbers of Contractors and Subcontractors responsible personnel who can be contacted under emergency conditions.
- E. A construction schedule which indicates specific activities related to the SWPPP.
- F. A supplemental Plan indicating location of laydown and staging areas, and their incorporation into the SWPPP.

1.6 INSPECTIONS

- A. The Contractor will conduct the inspections per the SWPPP. The Contractor will implement any actions to maintain full compliance with the SWPPP.
- B. A maintenance inspection report shall be prepared after each inspection, by the Contractor. The Contractor shall identify one individual who will be responsible keeping the site in full compliance with the SWPPP and maintaining an up-to-date copy of the SWPPP onsite.

PART 2 - PRODUCTS

2.1 WATER FOR DUST CONTROL:

- A. Water used shall be clean, non-polluted water obtained from sources approved by the Owner and/or Engineer.

PART 3 - EXECUTION

3.1 EROSION CONTROL DEVICES:

- A. Erosion Control Devices shall be constructed as shown on the SWPPP and as specified in the plans and specifications.

3.2 STORM WATER POLLUTION PREVENTION PRINCIPLES

- A. The following general principles shall be followed by the Contractor during the construction phase:
 - 1. Protect and maintain existing vegetation wherever possible.
 - 2. Minimize the area of disturbance.
 - 3. To the extent possible, route unpolluted flows around disturbed areas.
 - 4. Install mitigation devices as early as possible.
 - 5. Minimize the time disturbed areas are left unstabilized.
 - 6. Maintain siltation control devices in proper condition.

3.3 STORM WATER POLLUTION PREVENTION PLAN

- A. The Contract drawings and specifications identify a portion of the required facilities and temporary erosion control devices. The Contractor shall prepare a SWPPP in accordance with NPDES requirements which identifies the location of construction facilities and proposes additional erosion control measures as necessary to minimize pollution. The SWPPP shall include provisions for but not be limited to the following:
 - 1. Construction Trailers
 - 2. Laydown Areas
 - 3. Equipment Storage Areas
 - 4. Stockpile Areas

- B. Reproducibles of one or more of the Contract Drawings will be provided to the Contractor to serve as a base for the Contractor's SWPPP.

3.4 APPLICATION – WATER:

- A. The application of water shall be under the control of the Contractor at all times. It shall be applied only at the locations, and at such times, and in the amount as may be directed by the Owner. Quantities of water wasted or applied without authorization will not be paid for.
- B. The Contractor shall have available and maintain in an operable condition at all times, sufficient equipment for the purpose of applying water for dust control.
- C. Watering equipment shall consist of pipelines, tanks, tank trucks, distributors, pumps, meters, hose or other devices, approved by the Owner, which are capable of applying a uniform spread of water over the surface. A suitable device for a positive shut-off and for regulating the flow of water shall be located so as to permit positive operator control.

END OF SECTION

Ashland Public Safety Building
12 Union Street, Ashland, MA

HKT Architects
October 23, 2020

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SECTION 329000

LAWNS AND PLANTING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 – GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

- A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:
- B. Preparation of final subgrades in lawns and plant beds; testing, furnishing and spreading of topsoil and planting soil; fine grading; application of soil conditioners; edging and mulching new plant beds; erosion control; broadcasting and hydroseeding of seed mixes; planting of trees, shrubs, perennials and grasses; maintenance, and guarantee.

1.3 RELATED WORK

- A. Section 310000 – Earthwork
- B. Section 311100 – Erosion and Sediment Control
- C. Section 323000 – Site Improvements

1.4 REFERENCES

- A. ASNS: "American Standard for Nursery Stock", American Association of Nurserymen, 1973 Edition.
- B. ASTM: American Society for Testing and Materials.
- C. Federal Specification JJJ-S-181b, Seeds, Agricultural.
- D. Federal Specification O-F-241c(1), Fertilizers, Mixed, Commercial.
- E. SPN: "Standardized Plant Names", American Joint Committee on Horticultural Nomenclature, 1942 Edition.
- F. SRA-156: U.S. Department of Agriculture Rules and Regulations under the Federal Seed Act.

1.5 CERTIFICATES, INSPECTIONS, TESTS AND SUBMITTALS

- A. Provide a complete soil analysis for topsoil from all sources by a competent laboratory approved by Owner.
 - 1. Perform analysis in accordance with ASTM D422. Include in the analysis tests for physical properties, grain size, hydrogen-ion value, organic matter content and available nitrogen, phosphoric acid, potash and iron. Also include tests for soluble salts, lead and other toxic elements or conditions which may be detrimental to plant growth.
 - 2. Include recommendations for the kinds and quantities of soil amendments to be used in the report of the analysis. Submit the report of the analysis to Owner at least 30 days prior to delivery of topsoil to the site or use in the work. The cost of laboratory tests shall be paid by the Contractor.

- B. At least 30 days prior to intended use, the Contractor shall provide the following samples and submittals for approval in conformance with the requirements of General Conditions Section 007000, SUBMITTALS. Do not order materials until Owner's approval of samples, certifications or test results has been obtained. Delivered materials shall closely match the approved samples. Acceptance shall not constitute final acceptance. The Owner reserves the right to reject on or after delivery any material that does not meet these Specifications.
1. Material Sampling and Testing of Loam Borrow from Off-Site Sources, and Organic Compost shall be specified, performed and paid for under this Section.
 - a. No planting soil, loam borrow or compost from off-site sources shall be delivered until the review of samples and test results by the Owner, but such review shall not constitute final acceptance. The Owner reserves the right to reject on or after delivery any material which does not meet specifications or match the sample.
 2. Fertilizer: Submit product literature of seeding and planting fertilizers and certificates showing composition and analysis.
 3. Seed: Submit a manufacturer's Certificate of Compliance to the Specifications with each shipment of each type of seed. These certificates shall include the guaranteed percentages of purity, weed content and germination of the seed, and also the net weight and date of shipment. No seed may be sown until the Contractor has submitted the certificates.
 4. Hydroseeding: Prior to the start of hydroseeding, submit a certified statement for approval as to the number of pounds of materials to be used per 100 gallons of water.
 5. All Amendments required to amend a specific soil in order shall meet these specifications.
- C. Plants shall be subject to inspection and approval by the Owner at their place of growth, and upon delivery for conformity to specification requirements. Such approval shall not obviate the right of inspection and rejection during the progress of the work.
1. Submit a written request to the Owner at least 10 calendar days prior to digging for inspection of plant materials at their place of growth. State in the written request the place of growth and quantity of plants to be inspected. The Owner reserves the right to refuse inspection at this time if, in his judgment, a sufficient quantity of plants are not available for inspection.
- D. Comply with all applicable State and Federal laws in respect to inspection for plant diseases and infestation for all plants including seed. Provide certificates of inspection with the invoice for each shipment as may be required by laws for transportation. File certificates with Owner prior to acceptance of material. Inspection by State and Federal governments at place of growth does not preclude rejection of material at the site.
- E. Submit samples of the following materials in the quantities indicated for approval prior to use.
1. Mulch for planting: .5 cubic foot.
 2. Compost: .5 cubic foot.
- 1.6 DELIVERY, STORAGE AND HANDLING
- A. Do not deliver TOPSOIL to the site until soil analysis has been approved by the Owner. Do not deliver topsoil to the site in a frozen or muddy condition.

- B. Deliver all SOIL AMENDMENTS to the site in manufacturer's standard containers showing weight, analysis, name of manufacturer and warranty. Append a summary of this product information to each invoice. Store in a weatherproof storage place in such a manner that they will be kept dry and their effectiveness not impaired. Caked or otherwise damaged soil amendments shall be rejected.
- C. Deliver SEED in original sealed standard sized containers. Label all seed in accordance with State regulations and SRA-156. Store seed in such a manner that it will be protected from damage by heat, moisture, rodents or other causes. Seed which has become wet, moldy or otherwise damaged shall be rejected.
- D. PLANT MATERIAL
 - 1. Immediately before digging spray all plant material in full leaf with anti-transpirant, applying an adequate film over trunks, branches, twigs and foliage. Do not prune plants before delivery.
 - 2. Dig, ball and burlap (B&B) plants with firm natural balls of earth of diameter not less than that recommended by ASNS, and of sufficient depth to include the fibrous and feeding roots. Dig balls for collected material at least 1/3 greater in diameter than above. Double burlap all plants which are 6 inches in caliper and larger.
 - 3. Dig up and prepare plants for shipment in a manner that will not cause damage to branches, shape and future development of the plants after replanting. Cover all plant material while in transit.
 - 4. Do not remove container grown material from containers until ready for planting.
 - 5. Protect plants at all times from sun or drying winds. Keep plants that cannot be planted immediately upon delivery in the shade, well protected with soil, wet moss or other acceptable material and keep well-watered. Plants shall not remain unplanted for longer than 3 days after delivery.
 - 6. Do not bind plants with wire or rope at any time so as to damage the bark or break branches. Lift and handle plants from the bottom of ball only. Plants with cracked or broken balls before or during planting operations shall be rejected.

1.7 QUALIFICATIONS

- A. Fine grading and seeded lawn installation and planting shall be performed by personnel familiar with the accepted procedure of lawn construction and planting and shall be under the constant supervision of a qualified foreman.

PART 2 - MATERIALS

2.1 TOPSOIL

- A. TOPSOIL stripped and stockpiled as required by Section 310000, EARTHWORK, of these Specifications shall be used for part of this work. It shall be free of any admixture of subsoil, stones larger than one (1) inch, clods of hard earth, plant roots, sticks or other extraneous materials.
 - 1. The Contractor shall be responsible for estimating the quantity of topsoil stockpiled.

- B. TOPSOIL shall be provided from an off-site source to supplement the existing topsoil stripped from the site. It shall be fertile, friable, natural loam capable of sustaining vigorous plant growth. Topsoil shall be a "sandy loam" or a "fine sandy loam" of uniform composition as determined by mechanical analysis and based on the USDA classification system. In addition it shall meet the requirements above as well as the following mechanical analysis:

<u>Sieve Size</u>	<u>% Retained</u>
1 inch	0
1/2 inch	0-3
No. 100	40-60

1. The clay content of the material passing U.S.S. No. 100 mesh shall not be greater than 60% as determined by the Bouyoucous Hydrometer or by the Decantation Method. The organic content shall be 5% to 20% as determined by the Thomas Rapid Test Method or by loss on ignition on moisture free samples dried at 100 degrees C. The pH value shall be between pH 6.0 and pH 6.5. It shall contain no toxic materials. Soluble salts shall not be greater than 75 parts per million. If soil amendments are required, they shall be added at no additional cost to the Owner.

2.2 SOIL AMENDMENTS

- A. GENERAL: All soil amendments shall conform to the standards of the Association of Agricultural Chemists and shall comply with State and Federal regulations.
- B. LIMESTONE, if required, shall be free flowing Agricultural Grade Dolomitic Limestone ground to such fineness that 50% will pass a 100 mesh sieve and 98% will pass a 20 mesh sieve. Limestone shall contain at least 50% total oxides and not less than 85% total carbonates.
- C. ALUMINUM SULFATE, if required, shall be unadulterated commercial grade.
- D. GYPSUM, if required, shall be unadulterated commercial grade Calcium Sulfate.
- E. COMMERCIAL FERTILIZER shall be a complete fertilizer, uniform in composition and free flowing. At least 50% of the Nitrogen shall be derived from natural or synthetic organic sources. Available Phosphoric Acid shall be from superphosphate, bone or tankage. Potash shall be derived from Muriate of Potash containing at least 60% Potash. Percentages of Nitrogen, Available Phosphoric Acid and Water-soluble Potash in the fertilizer mix shall be based on laboratory test recommendations as approved by the Owner.
1. Fertilizer for new shrubs and trees shall be 5-10-5.
 2. Fertilizer for new lawns shall be 3-1-2.
- F. BONEMEAL shall be finely ground commercial raw bonemeal with 4% minimum Nitrogen and 20% minimum Phosphoric Acid.
- G. ORGANIC COMPOST shall be mature leaf compost, mature composted animal manure, other aged, composted vegetable materials that meet the requirements of the EPA and the State of Massachusetts for intended use. Raw (uncomposted or unprocessed) organic matter shall not be accepted.
1. Peat moss or other material the harvesting of which depletes natural wetlands shall not be used.
 2. Organic material shall contain no bulking agents, such as visible, uncomposted wood chips, and be free from hard lumps. It may be shredded or granular in form. No plastic shall be present. The material shall be free of noxious odor. Organic compost shall be

tested for % organics, carbon: nitrogen ratio, ammonium nitrate, moisture content, pH, and sieve analysis and test results shall be submitted for review before use may be approved as a soil component.

3. Manure shall be well rotted, unleached cattle manure, free of harmful chemicals and other injurious substances. Manure shall be free of sawdust and refuse of any kind and shall not contain more than 25% straw, shavings, leaves or other organic material. Manure shall be not be aged more than 2 years or less than 9 months.

- H. MYCORRHIZAL FUNGI shall be 'PHC PLANT SAVER 4-7-4' manufactured by Lebanon Seaboard Corporation, tel: 800-233-0628, or approved equal.

1. After plants have been installed and prior to placement of mulch, place 1 packet of "PHC Plant Saver 4-7-4" around the plant in the top 1/2" of planting soil. Work into planting soil so that the material is incorporated.

2.3 PLANTING SOIL

- A. PLANTING SOIL for use in new plant beds and as backfill around new shrub and tree plantings shall consist of eight (8) parts topsoil and one (1) part organic compost by volume. It shall have a pH value between 6.0 and 6.5.

2.4 ANTI-TRANSPIRANT

- A. ANTI-TRANSPIRANT shall be suitable for spray application which upon drying shall produce a gas permeable, but water retarding, colorless film, having a moisture vapor transmission value of not more than 2.5 in accordance with ASTM E96. It shall be equal to "Wilt Pruf" by Nursery Specialty Products, Inc., Greenwich Conn. Apply in accordance with manufacturer's instructions.

2.5 GRASS SEED

- A. Shall be fresh, clean, dry, new crop seed which meets the standards of sra-156. Seed shall be of the following varieties, mixed in proportion by weight and testing the minimum percentages of purity and germination. Submit manufacturer's certificates of compliance.

1. Weed seed shall not exceed 0.5% by weight.
2. If special conditions exist which may warrant a variance in the above seed mixture, submit a written request to the Owner stating conditions and proposed variance. Permission will be given if, in the opinion of the Owner, the variance is warranted.

- B. SEED FOR LAWNS: shall be the 'Drought and Salt Tolerant' custom seed mix, available at Charles C. Hart Seed Co., 304 Main ST., Wethersfield, CT, tel: 860-529-2537, or approved equal. Apply seed at 8 pounds per 1,000 square feet minimum.

1. Mix contains: 30% Rhizing Moon Turftype Tall Fescue, 30% Nightcrawler Turf Type Tall Fescue, 20% Tumalo Kentucky Bluegrass, 20% Doubletime Perennial Ryegrass.

- C. SEED MIX FOR MEADOW GRASS MIX: shall be a slope mix containing fescues, ryegrass and wildflowers, supplied by The Charles C. Hart Seed Co., tel: 860-529-2537, or approved equal, with species as described below. Wildflower mix shall be broadcast first on prepared soil, with grass mix hydroseeded after.

1. Partial Shade Wildflower Mix: shall contain Forget Me Not, Baby Blue Eyes, Purple Coneflower, Rocket Larkspur, Annual Candytuft, Gayfeather, Annual Gailardia and Scarlet Sage.

2. Partial Shade Slope Mix: shall contain 30% Creeping Red Fescue, 30% Chewings Fescue, 30% Hard Fescue and 10% Intermediate Ryegrass. Hydroseed Rate: Hydroseed at 10 pounds per 1,000 square feet.
- C. SEED MIX FOR DOG AREAS: shall be the "Hart MicroClover Seed Blend" supplied by The Charles C. Hart Seed Co., tel: 860-529-2537, or approved equal.
1. Mix contains: 70% Hart's Triple Team Tall Fescue, 20% Tumalo Kentucky Bluegrass, 6% Molalla Perennial Ryegrass, 4% MicroClover. Apply seed at 5.5 pounds per 1,000 square feet.
- D. SEED MIX FOR SWALES: shall be the Shaded Swale Mix supplied by The Charles C. Hart Seed Co., tel: 860-529-2537, or approved equal.
1. Mix contains: 40% Creeping Red Rescue, 30% Chewings Fescue and 30% Intermediate Ryegrass. Broadcast seed at 7.5 pounds per 1,000 square feet, or hydroseed at 11 pounds per 1,000 square feet.
- 2.6 FILTER BARRIER
- A. The Contractor shall keep the site erosion free throughout the duration of planting and seeding. Refer to Section 311100 – Erosion and Sediment Control, of this Specification for filter barrier options. Approval of the method by Owner does not free Contractor of responsibility for controlling erosion.
- 2.7 PLANT MATERIALS
- A. PLANTS shall be of specimen quality, exceptionally heavy, symmetrical, tightly knit plants so trained or favored in development and appearance so as to be unquestionably and outstandingly superior in form, number of branches, compactness and symmetry.
1. Plants shall be nursery grown in accordance with good horticultural practices, unless specifically authorized to be collected, and grown under climatic conditions similar to those in the locality of the project for at least two years. They shall have been root pruned within the past two years.
 2. Plants shall be freshly dug at time of delivery. No heeled-in plants or plants from cold storage will be accepted.
 3. Plants shall be sound, healthy and vigorous, well branched and densely foliated when in leaf. They shall be free of disease, insect pests, eggs or larvae and shall have healthy, well developed fibrous root systems. They shall be free from physical damage or adverse conditions that would prevent thriving with the specified result.
 4. Plants shall be true to species and variety and shall conform to the measurements specified in the Plant List except that plants larger than specified may be used without an increase in Contract price if approved by the Owner. Substitutions of plant materials will not be permitted unless authorized in writing by the Owner.
 5. Plants shall be measured when branches are in their normal position. Height and spread dimensions specified refer to the main body of the plant and not from branch tip to tip.
 6. If a range of size is given, no plant shall be less than the minimum size and not less than 50% of the plants shall be as large as the upper half of the specified range. The measurements specified are the minimum size acceptable and are the measurements after pruning where pruning is required.
 7. Plants that meet the measurements specified, but do not possess a normal balance between height and spread shall be rejected. Thin, poorly branched or sparsely rooted plants will be rejected, regardless of whether they meet the minimum technical requirements of ASNS.

8. Container grown material shall have sufficient roots to hold the soil together, firm and intact after removal, without being root bound.
9. In case of any discrepancy between the Plant List and the Planting Plan, the Planting Plan will govern.

2.8 MULCH FOR PLANTED AREAS

- A. MULCH for planting shall be shredded pine bark, passing a one inch square mesh and retained on a 1/8 inch square mesh. Moisture content shall not exceed 35%.

2.9 WOOD CELLULOSE FIBER MULCH

- A. Mulch to cover hydroseeded areas with slopes flatter than ten to one (10:1) shall be fiber processed from whole wood chips and clean recycled newsprint in a 1:1 proportion manufactured specifically for standard hydraulic mulching equipment. Fiber shall not be produced from recycled material such as sawdust, paper, or cardboard.
 1. Moisture content shall not exceed 10 percent, plus or minus 3 percent as defined by the pulp and paper industry standards. Fiber shall have a water holding capacity of not less than 900 grams water per 100 grams fiber.
 2. The mulch shall be of such character that the fiber will be dispersed into a uniform slurry when mixed with water. It shall be nontoxic to plant life or animal life.
 3. The mulch shall contain a non-petroleum based organic tackifier and a green dye to allow for easy visual metering during application but shall be non-injurious to plant growth.

2.10 GUYING APPARATUS

- A. WOOD STAKES shall be 2" x 2" x 8 feet in length from sound Cedar pointed at one end and reasonably free of knots. Binding and guying shall be with biodegradable webbing. Stake fastenings shall be galvanized 10 penny nails. Trees shall not be wrapped.

2.11 WATER

- A. WATER shall be free of substances harmful to plant growth. Contractor shall provide all labor and water required to establish turf and plantings. During the maintenance period the Contractor shall water as required to insure that a minimum of one inch of water per week is applied to all turf areas and plant beds and that soil moisture is maintained to a depth of two inches or greater at all times.
 1. The Contractor shall furnish sufficient watering equipment to maintain required water levels in the soil.

PART 3 - INSTALLATION

3.1 PREPARATION OF SITE

- A. Fully protect all trees and other site features to remain in the construction area during these operations. Remove existing lawn vegetation in areas of new seeded lawn and scarify surface of areas to receive topsoil by mechanical means using caution not to disturb or damage existing tree roots. Thoroughly till the subgrade to a depth of 6 inches by an approved method. Aerate in different directions such that each area receives at least 4 passes by the aerator. Break up resulting plugs with a power rake or other approved means.

- ### 3.2 ADDITION OF SOIL AMENDMENTS

- ### 3.3 SCHEDULE FOR SEEDING AND PLANTING

- LAWNS & PLANTING
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2.	Perennials and Grasses	Spring:	April 1 to May 15
		Fall:	September 1 to October 30
3.	Seeded Lawns and Meadow Mixes	Spring:	April 1 to May 15
		Fall:	August 15 to October 1

3.4 SEEDING

- A. Seed all fine graded topsoil areas as indicated on the Drawings within the limit of work not covered by paving and plant beds, and all areas disturbed by construction inside and outside the limit of work. All lawn areas disturbed outside the limit of seeding shall be prepared and seeded as specified herein at no additional cost.
1. To prevent loss of soil via water and wind erosion and to prevent the flow of sediment, fertilizer, and pesticides onto roadways, sidewalks, and into catch basins, seed loam areas within 5 Days of spreading the loam.
- B. Seeding of all new seeded lawn and meadow mix areas shall be done using the Broadcast and/or Hydroseeding Methods specified below. When delays in operations extend the work beyond the most favorable planting season for species designated or when conditions are such that satisfactory results are not likely to be obtained, halt work as directed and resume only when conditions are favorable or when approved alternate or corrective measures and procedures have been effected. No seeding shall be done when the ground is frozen, excessively wet or otherwise nontillable. If Contractor chooses to seed by a different method, he or she must present this alternative to the Owner's Representative for approval.
1. BROADCAST METHOD: Broadcast seed with a drop spreader evenly onto a firm seed bed. Lightly rake seed into the soil bed to increase seed to soil contact. Sow half the seed with the sower moving in one direction and the remainder with the sower moving at right angles to the first sowing. Do not broadcast seed when wind velocity exceeds 15 mph.
2. HYDROSEEDING METHOD: After seed mix has been broadcast, Hydroseeding can be started.
- a. Hydroseed with wood cellulose fiber mulch at a rate of 92 pounds per 1,000 square feet or 4,000 pounds per acre.
- b. For the hydroseeding process, a mobile tank with a capacity of at least 500 gallons shall be filled with water and the mixture noted above in the specified proportions. The resulting slurry shall be thoroughly mixed by means of positive agitation in the tank. Apply the slurry by a centrifugal pump using the hose application techniques from the mobile tank. Only hose application shall be permitted. At no time shall the mobile tank or tank truck be allowed onto the prepared hydroseed beds. The hose shall be equipped with a nozzle of a proper design to ensure even distribution of the hydroseeding slurry over the area to be hydroseeded and shall be operated by a person thoroughly familiar with this type of seeding operation.
- c. Hydroseeding shall be a two-step process:
1. Step one shall consist of spreading 100 percent of the required seed uniformly over the prepared loam bed so that the seed comes into direct contact with the soil. To mark the progress of the hydroseeding operation the Contractor may add 10 percent of the wood cellulose fiber mulch to the slurry.
2. For slopes flatter than ten to one (10:1) step two shall consist of a separate application of wood cellulose fiber mulch immediately following the first step of

hydroseeding noted above. Apply the wood cellulose fiber mulch at a rate of 2,000 pounds per acre.

- B. In the event that the construction goes too late in the fall to allow for seeding of lawns in season, the Contractor will return in the spring to complete this work.
 - 1. Any weed growth that has occurred on recently spread topsoil shall be removed by the Contractor prior to seeding. Seeding shall occur in season for Spring, with dates noted in this specification.

3.5 MULCHING AT NEW AND EXISTING TREES

- A. All new and existing trees (except for trees planted at tree box filters) located within the limit of work shall be mulched with five foot diameter circles of shredded bark mulch at two inch depth. Mulch shall be held a minimum of 12" away from trunks of trees.

3.6 WOOD CELLULOSE FIBER MULCH

- A. Mulch to cover hydroseeded areas with slopes flatter than ten to one (10:1) shall be fiber processed from whole wood chips and clean recycled newsprint in a 1:1 proportion manufactured specifically for standard hydraulic mulching equipment. Fiber shall not be produced from recycled material such as sawdust, paper, or cardboard.
- B. Moisture content shall not exceed 10 percent, plus or minus 3 percent as defined by the pulp and paper industry standards. Fiber shall have a water holding capacity of not less than 900 grams water per 100 grams fiber.
- C. The mulch shall be of such character that the fiber will be dispersed into a uniform slurry when mixed with water. It shall be nontoxic to plant life or animal life.
- D. The mulch shall contain a non-petroleum based organic tackifier and a green dye to allow for easy visual metering during application but shall be non-injurious to plant growth.

3.7 PLANTING

- A. Inform the Owner when planting will commence and the anticipated delivery date of plant material. Failure to notify the Owner in advance, in order to arrange proper scheduling, may result in loss of time or removal of any plant or plants not installed as specified or directed.
- B. EXCAVATION OF PLANT PITS:
 - 1. Stake out on the ground locations for plants and obtain approval of Owner before excavation is begun. Make adjustments in locations as directed.
 - 2. Establish finish grades for new plant beds and tree pits. Excavate to depths required and regrade subgrade as necessary. Separate subgrade soils from upper "topsoil" portions and remove subgrade soils immediately wherever encountered during planting operations. Loosen top 6 inches of subgrade in pits and beds immediately prior to placing planting soil.
 - 3. If stone, underground construction work, tree roots, poor drainage or obstructions are encountered in the excavation of plant pits, alternate locations may be selected by the Owner without additional cost. Where locations cannot be changed as determined by the Owner submit cost required to remove obstructions to a depth of not less than 6 inches below the required pit depth. Proceed with work only after approval of Owner.
 - 4. Notify Owner in writing of all soil or drainage conditions which the Contractor considers detrimental to the growth of plant material.

C. PLANTING OPERATIONS FOR TREES, SHRUBS, PERENNIALS AND GRASSES

1. Set plants at the same relationship to finished grade as they bore to the ground from which they were dug. After settlement, the crown of the plant ball shall not be more than one inch lower than the surrounding finished grade. Backfill planting soil in layers of not more than 8 inches and tamp each layer before the next layer is placed. When plants have been backfilled approximately 2/3 full, water thoroughly before installing remainder of planting soil to top of bed, eliminating all air pockets. Do not backfill beds with planting soil until the exact location of all plants is approved by the Owner.
2. Set plants in the center of pits, plumb and straight. Brace rigidly in position until the planting soil has been tamped solidly around the ball and roots. Cut ropes or strings from top of ball after plant has been set. Remove majority of burlap wrapping from around ball.
3. Mulch and water all plants immediately after planting. Flood plants with water twice within 24 hours of planting. Smooth planting areas to conform to specified grades after full settlement has occurred and mulch has been applied. Form mulch saucers around trees planted in lawn areas.
4. After plants have been installed and prior to placement of mulch, place 1 packet of "PHC Tree Saver" in the top 1/2" of planting soil. Work into planting soil so that the material is incorporated.

D. FERTILIZING

1. For Spring planting only add commercial fertilizer to the planting soil at the rate recommended in the topsoil analysis. Mix thoroughly.
2. Fertilize Fall planting at time of planting. Place fertilizer for plant material over planting area and work into upper soil layer. Use commercial fertilizer at the following rates:

Trees:	2 pounds per inch of caliper
Plant Beds:	4 pounds per 100 square feet

E. PRUNING

1. Prune new plants only at time of planting and in accordance with American Association of Nurserymen standards in such a manner as to preserve the natural character of the plant. Pruning shall be done by experienced personnel under the supervision of the Owner.
2. Remove all dead wood, suckers and badly bruised or broken branches. In addition, remove approximately 1/4 of all small branching leaf canopy of deciduous plants by thinning out and shortening branches. Do not cut the leader. Trees with leaders removed shall be rejected. Use only clean sharp tools. Make all cuts flush with the trunk or branch.

F. CLEANUP: Upon completion of planting and pruning operations, remove all excess soil and debris from the site and repair any damage caused by these operations.

3.8 PLANT BEDS

- A. New plant beds shall be edged in a smooth, continuously curving line as demonstrated on site, and as shown on the Drawings.
1. New plant beds shall be mulched with a 2" depth of mulch.
 2. New plant beds will have a minimum twelve inch depth of planting soil.

3.9 PLANTING MAINTENANCE AND PROTECTION

- A. Maintenance and protection shall begin immediately upon completion of planting and operations and after each plant is planted and shall continue until acceptance or for at least 30

days or as long as necessary to substantial completion, whichever is later with the following requirements.

1. Maintenance of new planting shall consist of pruning, watering, cultivating, weeding, mulching, resetting plants to proper grades and/or upright position, tightening and repairing of guys and restoration of planting saucers.
2. Maintenance shall begin immediately after an area is planted and shall continue until final acceptance. The minimum maintenance period shall be 90 days after completion of the planting of all plant materials.
3. Furnish and apply such pesticides as are necessary to keep these areas free of insects and disease. Pesticides shall be approved by the Owner prior to use. Use in accordance with the specifications of the prevailing Public Health Authority.
4. Protect planting areas and plants at all times against trespassing and damage of all kinds for the duration of the maintenance period. If any plants become damaged or injured, treat or replace them as directed by the Owner at no additional cost to the Owner.

3.10 LAWN MAINTENANCE AND PROTECTION

- A. Maintenance and protection shall begin immediately upon completion of seeding operations and shall continue until acceptance or for at least 30 days or as much longer as necessary to establish a uniform stand of the specified grasses or until substantial completion, whichever is later with the following requirements.
1. In the event that lawn operations are completed too late in the Fall for adequate germination and/or growth of grass, maintenance shall continue into the following Spring.
 2. Maintenance of lawn areas shall consist of keeping the grass in a healthy growing condition and shall include replacements, watering, weeding, cultivating, fertilizing, re-seeding as necessary to establish a uniform and knitted stand of the specified grasses and mowing.
 3. During the maintenance period, any decline in the condition of seeded areas shall require immediate action to identify potential problems and to undertake corrective measures.
 4. Reseed areas greater than one foot square which fail to show a uniform stand of grass. To be acceptable, a stand of grass shall have a uniform count of at least 100 plants per square foot.
 5. In seeded areas, keep soil moist during germination period. After germination, supplement natural rainfall to produce a total of 2 inches per week. Water lawns not less than twice per week until acceptance.
- B. WATERING shall be done in a manner that will provide uniform coverage, prevent erosion due to application of excessive quantities over small areas, and prevent damage to the finished surface by the watering equipment.
1. The Contractor shall provide all labor and arrange for all watering necessary to establish an acceptable lawn. In seeded areas, Contractor shall keep soil continuously moist during the two to three week germination period. After germination, supplement natural rainfall to produce a total of 2 inches per week. Water lawns not less than twice per week until acceptance or as often as necessary to maintain moist soil to a depth of at least 2 inches for newly seeded areas.
 2. At no time shall a tank truck be allowed on the newly seeded lawns and plant beds.
- C. PROTECTION
1. Protect new tree installations, plant beds and new seeded lawn areas at all times against trespassing and damage of all kinds for the duration of the maintenance period. If any

plants become damaged or injured, treat or replace them as directed by the Owner's Representative at no additional cost to the Owner.

- a. Newly seeded lawn areas shall be protected by a 4-foot high barrier of Tenax 4 ft. x 50 ft. Saf-T-Sno HD Snow Fence, 4 ft. HDPE snow fence, or approved equal. Color shall be orange or red.
2. Provide additional temporary protection fences and barriers in other locations where deemed necessary.
3. Remove temporary protection devices at the completion of maintenance period.

D. MOWING

1. Do not attempt first mowing of lawn areas until newly seeded areas reach 2-1/2 inches in height. Do not remove more than 40% of the grass leaf in initial or subsequent mowings. Maintain grass at 2 inches in height. Remove grass clippings. Lawns shall receive at least 3 mowings before acceptance. Meadow and swale seeded areas shall have one mowing prior to end of the summer season.

3.11 INSPECTION AND ACCEPTANCE

- A. At the end of the maintenance and protection period, submit a written request to the Owner to inspect all work for acceptance at least 10 calendar days before the anticipated date of inspection.
- B. Until this portion of the work is finally accepted, the Contractor shall be required to repair and replace any lawn area that is defective or becomes damaged when, in the judgment of the Owner, such defects or damages are the result of poor workmanship or failure to meet the requirements of the specifications. The cost of necessary repairs or replacements shall be borne by the Contractor.
- C. Acceptance of plant material by the Owner shall be for general conformance to the specified size, character and quality and shall not relieve the Contractor of responsibility for full conformance to the Contract Documents including correct species.
- D. If a substantial number of plants are sickly or dead at the time of inspection, acceptance will not be granted, and the Contractor's responsibility for maintenance of all plants shall be extended until replacements are made. Replacements shall conform in all respects to the Specifications for new plants and shall be planted in the same manner.
- E. The Owner will be responsible for the maintenance of new lawns and planting upon acceptance of the work and continuing through the guarantee period.

3.12 GUARANTEE PERIOD AND REPLACEMENTS

- A. The guarantee period for plant material shall begin at the date of acceptance. All plant material shall be guaranteed by the Contractor, for a period of one year from the date of acceptance, to be in a good healthy and flourishing condition.
- B. Lawn turf installed in the fall shall be guaranteed until the spring.
- C. Replace without cost to the Owner, and as soon as weather permits, and within a specified planting period, all dead plants and all plants not in a vigorous, thriving condition, as determined by the Owner during and at the end of the guarantee period. Plants shall be free of dead or dying branches and branch tips, and shall bear foliage of a normal density, size and

color. Replacements shall closely match adjacent specimens of the same species. Replacements shall be subject to all requirements stated in this Specification. Make all necessary repairs due to plant replacements at no additional cost to the Owner.

- D. The guarantee of all replacement plants shall extend for an additional period of one year from the date of their acceptance after replacement. In the event that a replacement plant is not acceptable during or at the end of said extended guarantee period, the Owner may elect subsequent replacement or credit for each item.
- E. Make periodic inspections as necessary, at no extra cost to the Owner, during the guarantee period to determine what changes, if any, should be made to the Owner's maintenance program. Submit in writing to the Owner and Owner any recommended changes.

3.13 FINAL INSPECTION AND ACCEPTANCE

- A. At the end of the guarantee period, submit a written request to the Owner to inspect all guaranteed work for final acceptance at least 10 calendar days before the anticipated date for final inspection.

END OF SECTION
329000

SECTION 329500

VEGETATED ROOF ASSEMBLIES

(Part of Work of Section 070001 - WATERPROOFING, DAMPPROOFING AND CAULKING, Filed Sub-Bid Required)

~~(Part of Work of Section 070002 - ROOFING AND FLASHING, Filed Sub-Bid Required)~~

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

- A. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:
 - 1. Continuous vegetated roof assemblies.
- B. Alternates: Not Applicable.
- C. Items To Be Installed Only: Not Applicable.
- D. Items To Be Furnished Only: Not Applicable.
- E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
 - ~~1. Section 075400 - THERMOPLASTIC MEMBRANE ROOFING:~~
 - 2. **Section 071400 - FLUID-APPLIED WATERPROOFING for membrane installed as part of Vegetated Roof Assembly.**
 - 3. **Section 072100 - THERMAL INSULATION.**

1.3 DEFINITIONS

- A. Captured Water: Water that is retained in the drainage layer of a vegetated roof assembly after new water additions have ceased and that cannot escape the roof except through evaporation or plant transpiration.
- B. Finish Elevation: Elevation of finished growing-media surface of planting area.
- C. Planting Area: Areas to be planted.
- D. Plant, Plants, Plant Material: Vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

- E. Growing Medium: Manufactured, lightweight soil mixture that promotes good growing conditions for specific varieties of plants.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For vegetated roof assembly. Include roof plans, slopes, and drain locations; details of vegetated roof assembly, walkway pavers and accessories; depth of growing media; and attachments to other work.
- C. Samples for Verification: For each of the following components of vegetated roof assembly:
 - 1. Preplanted Vegetative Mat: 12 by 12 inches (300 by 300 mm).
 - 2. Growing Media: 1-quart (1-liter) volume of each growing medium, in sealed plastic bags labeled with content and source. Each Sample shall be typical of the lots of growing media to be furnished. Provide an accurate representation of texture and composition.
 - 3. Moisture-Retention Mat: 12 by 12 inches (300 by 300 mm).
 - 4. Molded-Sheet Drainage Panels: 12 by 12 inches (300 by 300 mm).
 - 5. Root Barrier: 12 by 12 inches (300 by 300 mm).
 - 6. Walkway paver, full size, in each color and texture required; include installation accessories to illustrate assembly.
 - 7. Separation Geotextile: 12 by 12 inches (300 by 300 mm).
 - 8. Access Boxes: One in each size and color required.
 - 9. Soil Retainer: Manufacturer's standard size to verify configuration and color selected.
- D. Qualification Data: For qualified Installer.
- E. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:
 - 1. Manufacturer's certified analysis of standard products.
 - 2. Analysis of other materials by a recognized laboratory, according to methods established by the Association of Official Analytical Chemists, where applicable.
- F. Product Test Reports: For each growing medium, including complete analysis demonstrating compliance with specified requirements.
- G. Field quality-control reports.
- H. Maintenance Data: Recommended maintenance plan including procedures for inspection and care of vegetated roof assembly and plants during a calendar year. Submit before start of required warranty and maintenance periods.
- I. Warranty: Sample of each special warranty.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified vegetated roof assembly Installer, approved, authorized, or licensed by membrane roofing manufacturer, whose work has resulted in successful establishment of vegetated roofs.

1. Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
 2. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the Professional Landcare Network:
 - a. Certified Landscape Technician - Exterior, with installation, maintenance and irrigation specialty area(s), designated "CLT-Exterior."
 - b. Certified Ornamental Landscape Professional, designated "COLP."
 - B. Source Limitations: Obtain vegetated roof assembly components, growing medium, walkway pavers and setting bed or supports separation geotextile and accessories from single source from single manufacturer.
 - C. Preinstallation Conference: Conduct conference at Project site.
- 1.6 DELIVERY, STORAGE, AND HANDLING
- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.
 - B. Bulk Materials:
 1. Do not dump or store bulk materials on or near structures, utilities, walkways and pavements, or existing roof areas or plants.
 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of debris-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 3. Accompany each delivery of bulk materials with product certificates.
- 1.7 PROJECT CONDITIONS
- A. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.
- 1.8 WARRANTIES
- A. Special Warranty for Vegetated Roof Assembly: Installer agrees to repair or replace vegetated roof assembly and components that fail in materials or workmanship within specified warranty period.
 1. Failure includes, but is not limited to, ponding water or prolonged wetness of growing medium caused as a result of failure of the assembly to properly drain.
 2. Warranty Period: Five years from date of Substantial Completion.
 - B. Special Warranty for Plant Growth: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

1. Foliage Cover: Planted materials shall grow to achieve and maintain at least 80 percent foliage cover over planting area commencing 24 months after planting, through the duration of this warranty.
2. Failures include, but are not limited to, death and unsatisfactory growth except for defects resulting from abuse, lack of adequate maintenance, neglect by Owner, or incidents that are beyond Contractor's control.
3. Warranty Periods from Date of Substantial Completion:
 - a. Trees and Shrubs: Five years.
 - b. Ground Covers, Perennials, Vines, and Ornamental Grasses: Two years.
4. Include the following remedial actions as a minimum:
 - a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
 - b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
 - c. A limit of one replacement of each plant will be required except for losses or replacements due to failure to comply with requirements.
5. Provide extended warranty for period equal to original warranty period, for replaced plant material.

1.9 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Provide maintenance by skilled employees of vegetated roof assembly Installer approved by membrane roofing manufacturer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than the following maintenance period:
 1. Maintenance Period: 24 months from date of Substantial Completion.
- B. Continuing Maintenance Proposal: From vegetated roof assembly Installer approved by membrane roofing manufacturer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

PART 2 - PRODUCTS

2.1 VEGETATED ROOF ASSEMBLY COMPONENTS

- A. Growing Medium.
- B. Molded-Sheet Drainage Panels: ~~Manufacturer's standard drainage board formed from geotextile-faced, molded plastic sheet with a geotextile face and "cups" of the molded sheet facing upward like small reservoirs to retain water while allowing excess water to drain away below the board.~~ **As specified in Section 071400 - FLUID-APPLIED WATERPROOFING.**
- C. Extruded-Polystyrene Board Insulation: Compressive strength of 16 psi minimum, square edged and acceptable to roofing system manufacturer.

- D. Moisture-Retention Mat: Manufacturer's standard water-retaining fabric manufactured from recycled synthetic fibers.
- E. Root Barrier: Manufacturer's standard black plastic sheet manufactured from recycled polyethylene or polypropylene plastic; formulated to resist root growth and bacteria.
- F. Protection Board: As recommended by membrane roofing manufacturer.
- D. Membrane: **As specified in Section 071400 - FLUID-APPLIED WATERPROOFING.**
 - ~~1. CCW-500, 90 mil thickness.~~
 - ~~2. Reinforcing fabric.~~
 - ~~3. CCW-500, 120 mil thickness.~~
- ~~E. Contact Adhesive: As recommended by membrane roofing manufacturer.~~

2.2 VEGETATED ROOF ASSEMBLIES

- A. Continuous Vegetated Roof Assembly: Continuous-coverage assembly consisting of manufacturer's standard vegetated roof assembly components for installation over membrane roofing.
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Carlisle Coatings and Waterproofing.
 - b. Soprema, Inc.
 - c. Tremco, Inc.
 - 2. Basis of Design: Carlisle Coatings and Waterproofing; CCW Green Roof with Insulation.
 - 3. Soil Depth: 6 inches.
 - 4. Plantings: Sedum as selected by Architect from manufacturer's standard varieties.

2.3 MANUFACTURED GROWING MEDIA

- A. Growing Medium: Vegetated roof assembly manufacturer's lightweight, manufactured soil mixture designed for assembly indicated.
 - 1. General Condition at Time of Planting: Free of stones 1/2 inch or larger in any dimension; free of roots, plants, sod, clods, clay lumps, pockets of coarse sand, paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials harmful to plant growth; free of weeds and other botanical pests; not infested with nematodes, grubs, or other pests or pest eggs; free of disease-causing plant pathogens and other undesirable organisms; friable and with sufficient structure to give good tilth and aeration.
 - 2. **Extensive System: 6 to 10 inch depth system.**

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine each area to receive vegetated roof assembly for compliance with requirements for installation tolerances and other conditions affecting performance.
 - 1. Verify that roof insulation over membrane roofing is in place, secure, and flush along all seams.
 - 2. Verify that perimeter and other flashings are in place and secure along entire lengths where they will be covered by vegetated roof assembly.
- B. Flood Testing: Flood test each deck area for leaks, according to recommendations in ASTM D 5957, after completing and protecting membrane roofing but before placing overlaying construction. Install temporary containment assemblies, plug or dam drains, and flood with potable water.
 - 1. Flood to an average depth of 2-1/2 inches (65 mm), with a minimum depth of 1 inch (25 mm) and a maximum depth of 4 inches (100 mm). Maintain 2 inches (50 mm) of clearance from top of sheet flashings.
 - 2. Flood each area for 24 hours.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.
- D. Inspect growing medium. If growing medium is contaminated by foreign or deleterious material or liquid, remove growing medium and contamination and replace with new growing medium.

3.2 PREPARATION

- A. General: Protect structures, utilities, sidewalks, pavements, and other facilities and areas from damage caused by installation.
- B. Protection Course: Cover membrane roofing with protection board with butted and fully taped joints before membrane roofing is subject to vegetated roof assembly installation work.

3.3 INSTALLATION, GENERAL

- A. Install vegetated roof assembly according to manufacturer's written instructions.
- B. Small Plant Stabilization: Install erosion-control fabric over planting area to secure small plants according to manufacturer's written instructions.
- C. Access Boxes: Install access box at each drain, valve, and switch beneath the finish elevation of growing medium and at locations shown on Drawings.

3.4 PLANTING

- A. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in growing medium within a planting area.

- B. Do not mix or place growing medium during frozen, wet, or muddy conditions.
- C. Suspend spreading, grading, and planting operations during periods of excessive moisture until the moisture content in growing medium reaches acceptable levels to attain the required results.
- D. Uniformly moisten an excessively dry growing medium that is too dusty or not workable.
- E. Planting Individual Plants: Perform planting as indicated on Drawings and required by vegetated roof assembly manufacturer's written instructions. Perform digging carefully so as to prevent damage to membrane roofing below the vegetated roof assembly.

3.5 SOIL-RETAINER INSTALLATION

- A. Install soil retainer where indicated according to manufacturer's written instructions. Secure with adhesive.

3.6 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage ~~Division 7~~ **Section 071400 - FLUID-APPLIED WATERPROOFING** membrane roofing manufacturer's authorized service representative to provide inspection of vegetated roof assembly installation and prepare inspection reports.
- B. Correct deficiencies in work that do not comply with requirements.
- C. **Coordinate with requirements of Section 071400 - FLUID-APPLIED WATERPROOFING.**

3.7 PLANT MAINTENANCE

- A. General: During maintenance period, maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing devices, resetting plants to proper elevations or vertical position, and performing other operations as required to establish healthy, viable plantings. Spray or treat as required to keep trees and shrubs free of insects and disease.
- B. Replace growing medium that becomes displaced or eroded because of settling or other processes.
- C. Apply treatments as required to keep plant materials, planted areas, and growing medium free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.
- D. Use only products and methods acceptable to membrane roofing manufacturer.

3.8 CLEANING AND PROTECTION

- A. During planting and maintenance, keep adjacent areas and construction clean and maintain work area in an orderly condition.
- B. Protect vegetated roof assemblies from damage due to planting operations and operations of other contractors and trades. Repair or replace damaged vegetated roof assemblies.

Ashland Public Safety Building
12 Union Street, Ashland, MA

HKT Architects
October 23, 2020
Addendum #4 – December 2, 2020

END OF SECTION

SECTION 331100

WATER UTILITY DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

- A. All work specified in this Section shall conform to "Standard Specifications for Highway and Bridges" of the Massachusetts Department of Transportation, latest revision, herein referred to as "State Standards".
- B. All water distribution work shall be designed and constructed in accordance with the "Water Construction Standards" prepared by the Town of Ashland Department of Public Works Water and Sewer Division or latest revision, herein referred to as "Town Standards".

- C. Existing Conditions Plan compiled from the following sources:

- 1. Existing conditions mapping taken from plan entitled "Topographic Plan of Land 1 East Union Street and 12-16 East Union Street (Route 135) Middlesex County Ashland, Mass" prepared by Guerriere & Halnon, Inc., dated April 7, 2020.
- 2. Wetland Flags identifying wetland resource areas were placed by Pare Corporation on September 11, 2018 and located by Guerriere & Halnon, Inc.

- D. American Water Works Association (AWWA):

- 1. AWWA B300: Standard for Hypochlorites
- 2. AWWA B301: Standard for Liquid Chlorine
- 3. AWWA C104: Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
- 4. AWWA C110: Standard for Ductile-Iron and Gray-Iron Fittings for Water
- 5. AWWA C111: Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
- 6. AWWA C150: Standard for the Thickness design of Ductile Iron Pipe.
- 7. AWWA C151: Standard for Ductile Iron Pipe, Centrifugally Cast.
- 8. AWWA C153: Standard for Ductile-Iron Compact Fittings for Water Service
- 9. AWWA C605: Standard for Installation of Polyvinyl Chloride Water Mains and Their Appurtenances
- 10. AWWA C651: Standard for Disinfecting Water Mains.
- 11. AWWA C900: Standard for PVC Pressure Pipe and Fabricated Fittings
- 12. AWWA C906: Standard for Polyethylene (PE) Pressure Pipe

- E. American Society for Testing and Materials (ASTM):

- 1. ASTM D-638: Tensile Properties
- 2. ASTM D1784: Rigid Poly (Vinyl Chloride)(PVC) Compounds and Chlorinated Poly (Vinyl Chloride)(CPVC) Compounds

3. ASTM D-1238: Flow Rates of Thermal Plastics
4. ASTM D-1505: Density of Plastics by Gradient Technique
5. ASTM D-2837: Hydrostatic Design Basis for Thermal Plastics
6. ASTM D-3261: Butt Heat Fusion for Polyethylene (PE)
7. ASTM D-3350: Specification for Polyethylene Pipe and Fittings
8. ASTM F-714: Polyethylene (PE) Plastic Pipe (SDR-PR)
9. ASTM F-1248: Environmental Stress Crack Resistance (ESCR)

F. Other Publications:

1. ASME B32.8: Hydrostatic Testing Guidelines
2. ANSI B31.3: Fittings, Flanges and Valves
3. JM Eagle Blue Brute / Big Blue / Ultra Blue Installation Guide
4. Plastic Piping Institute Best Practices TR 31/9-79

1.3 SUMMARY

- A. This Section includes water distribution piping and related components outside the building for water service and fire service mains.

1.4 SUBMITTALS

A. Product Data and Shop Drawings:

1. Contractor shall coordinate and obtain approval from the local Water Department prior to furnishing materials.
2. For each type of product indicated.
3. Shop drawing of temporary connection backflow preventer used for testing and disinfection.
4. Detail of temporary connection between existing and new water pipelines.

B. Field quality-control test reports and disinfection notification:

1. The Contractor shall initially notify and subsequently provide the test reports to the Owners Representative upon completion of the disinfection and pressure testing.
2. Include certified reports of the required bacteriologic test from an approved qualified independent testing laboratory.
3. Provide a copy of the test reports to the Owner and Engineer.

C. Operation and Maintenance Data: For water valves and specialties to include in emergency, operation, and maintenance manuals.

D. A copy of any permits required by the utility company or local authorities having jurisdiction shall be submitted to the Engineer prior to commencing work on the water system.

E. Certificate of Compliance:

1. Each shipment of valves, tapping sleeves and appurtenances shall be accompanied with the manufacturer's notarized certificate certifying conformance with the requirements of the Specifications.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with requirements of the Owner, Town of Ashland, and the National Standard Plumbing Code including requirements pertaining to the tapping of water mains and backflow prevention.
 2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
 3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
- B. Piping materials shall bear label, stamp, or other markings of specified testing agency.
1. Marking of all pipes and fittings shall conform to the requirements of AWWA C900, latest revision.
 2. Marking of all tapping sleeves shall conform to the requirements of AWWA 110 latest revision and marking of all valves shall conform to the requirements of AWWA 509 latest revision.
 3. Marking of all ductile iron pipes shall conform to the requirements of AWWA C151, latest revision, and marking of all fittings shall conform to the requirements of AWWA C153, latest revision.
- C. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.
- D. All water pipe and appurtenances shall be "American Made".
- E. Any water pipe, fitting, or appurtenance that does not meet the specifications, field quality testing, or is damaged during installation, shall be removed and disposed from the project site and replaced with new material conforming to this specification at no additional cost to the Owner.

1.6 MANUFACTURER'S REPRESENTATIVE

- A. The Contractor shall furnish, at no additional expense to the Owner, the services of pipe manufacturer's representatives for instruction of the Contractor's personnel who will be installing the pipe, tapping sleeves, transition couplings, and valves. The instruction shall include proper handling, installation, and jointing and other construction areas, and shall be for such lengths of time required to fully familiarize the Contractor's personnel with the proper techniques. This information shall be bound and indexed for each type of unit as herein specified.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Preparation for Transport: Prepare valves according to the following:
1. Ensure that valves are dry and internally protected against rust and corrosion.
 2. Protect valves against damage to threaded ends and flange faces.
 3. Set valves in best position for handling. Set valves closed to prevent rattling.
- B. During Storage: Use precautions for valves, according to the following:
1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
 2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.
 3. Do not store PVC or HDPE piping, fittings, or appurtenances within sunlight.

- C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use hand wheels or stems as lifting or rigging points.
- D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.
- E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.
- F. Protect flanges, fittings, and specialties from moisture and dirt. Piping or materials damaged during delivery storage or handling shall be replaced at the expense of the Contractor.

1.8 PROJECT CONDITIONS

- A. Interruption of Existing Water-Distribution Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water-distribution service according to requirements indicated:
 - 1. Notify Owner and Owner's Representative in writing no fewer than 2 weeks in advance of proposed interruption of service.
 - 2. Do not proceed with interruption of water-distribution service without Owner's and Owner's Representative's written permission.

1.9 COORDINATION

- A. Coordinate connection to water main with Town of Ashland Department of Public Works prior to commencing work.
- B. The Contractor shall contact "Dig Safe" at 1-888-Dig Safe to verify locations of existing underground utilities in areas of proposed excavation prior to commencing any excavation effort.

1.10 PERMITS

- A. The Contractor shall obtain and pay fees for any permits required by the Town of Ashland Department of Public Works or local authorities having jurisdiction.
- B. Permits shall be obtained prior to commencing work on the water system.

1.11 QUALITY CONTROL

- A. Sampling for laboratory analysis following disinfection shall be conducted by qualified personnel familiar with sampling procedures and protocols.
- B. Reference Standards: Except as modified or supplemented herein, the testing of the pipeline system shall meet the requirements of the following standard specifications:
 - 1. AWWA C600, Latest Revision - Pressure and Leakage Tests; and C651, Latest Revision - Disinfecting Water Mains.
 - 2. NSF/ANSI 60: National Sanitation Foundation Standard for Drinking Water Treatment Chemicals
 - 3. NSF/ANSI 61: National Sanitation Foundation Standard for Drinking Water System Components

PART 2 - PRODUCTS

2.1 GENERAL

- A. All water piping, fitting, and appurtenances shall conform to the Town Standards.
- B. All materials, coatings, lubricants and/or protective oils used on materials that will eventually be in contact with potable water must be ANSI/NSF approved standard 60 or 61 as appropriate.

2.2 DUCTILE-IRON PIPE AND FITTINGS:

- A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end used only where connections to fittings are made.
 - 1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - 2. Glands, Gaskets, and Bolts: AWWA C111, ductile iron glands, rubber gaskets, and steel bolts.
 - 3. Piping shall have a working pressure rating of 200 psi minimum.
 - 4. Lubrication material is to be food grade quality, kept in original container and stored according to Manufacturer's recommendations.
- B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end used where no connection to fittings is required.
 - 1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile iron standard pattern or AWWA C153, ductile iron compact pattern.
 - 2. Piping shall have a working pressure rating of 200 psi minimum.
 - 3. Gaskets: AWWA C111, rubber.
- C. Ductile Iron Pipe shall be Class 52 and shall conform to AWWA C150 and C151, latest revision. Pipe shall have a petroleum-asphaltic on all exterior surfaces.
- D. Interior pipe surfaces shall be covered with a double cement-mortar continuous lining not less than 1/16" thick, of materials, and applied in accordance with, ANSI/AWWA C104/A21.4 standards.
- E. Ductile Iron Pipe shall be manufactured by one of the following.
 - 1. American Ductile Iron Pipe
 - 2. Approved Equivalent

2.3 JOINTS

- A. If mechanical joints or fittings are utilized at any location, the recommendation of the mechanical fitting manufacturer must be followed.

2.4 TAPPING SLEEVES AND TAPPING VALVES

- A. Tapping sleeves shall comply in all respects to AWWA Standard C153 and the following design standards.
- B. The tapping sleeve and valve shall consist of a split cast-iron sleeve tee with mechanical joint ends on the main and a flange on the branch, and a tapping-type resilient wedge valve with one

(1) flanged and one (1) mechanical joint end. The valve shall conform to the requirements hereinbefore specified for resilient wedge valves. The contractor shall be responsible for verifying the outside diameter of the pipe to be tapped.

- C. Before backfilling, all exposed portions of any bolts used to hold the two (2) halves of the sleeve together shall be heavily coated with two (2) coats of bituminous paint comparable to Inertol No. 66 Special Heavy. Sleeves shall be of cast iron conforming to ASTM A-126 Class B, furnished with rubber gaskets. Gaskets shall cover the entire area of flange surfaces.
- D. Tapping sleeves and valves shall be made by Ludlow-Rensselaer Valve Co., Inc., Troy, New York; Eddy-Iowa Div., James B. Clow & Sons, Inc., Chicago, Illinois; A.P. Smith Mfg. Co., East Orange, New Jersey; Mueller Valve Co., Decatur, Illinois, or be approved equal products.

2.5 GATE VALVES

- A. Resilient wedge valves shall be the products of the Mueller Valve Co., Decatur, Illinois, or Kennedy Valve Manufacturing Co., Elmira, New York, or approved equal. Resilient wedge valves shall only be permitted on hydrant laterals.
- B. Resilient wedge valves shall be iron body, resilient seated type. The valves shall be designed for two hundred (200) pounds per square inch working pressure and four hundred (400) pounds per square inch test pressure. Valves are to have o-ring seals and a nonrising stem. Valves shall have a two-inch operating nut. Valves shall open left.
- C. Resilient wedge valves shall meet the most recent version of the AWWA standard C501. Resilient wedge valves shall have mechanical joint ends. Valves shall be connected directly to anchor tees on all hydrant branches.

2.6 GATE VALVE ACCESSORIES AND SPECIALTIES:

- A. Cast iron valve boxes shall be two-piece adjustable style, sliding type. Barrel inside diameter shall be 5¼ inches with 26 inch top section and 48 inch bottom section lengths adjusted to finish grade.
- B. Covers shall be cast iron, 5¼ inch, with the word "WATER" and a direction to open arrow imprinted thereon. The boxes and covers shall be compatible with the valves to which they attach. Covers shall be the heavy, non-tilting 2" drop style recessed in the top to prevent plow breakage.
- C. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.
- D. An approved operating wrench shall be provided to the Owner.

2.7 THRUST RESTRAINTS

- A. Restraining devices shall be utilized on all mains under the following conditions:
 - 1. Pipeline direction changes (tees, bends)
 - 2. Dead end lines (caps or plugs)
 - 3. Transition pieces (reducers)
 - 4. Couplings
 - 5. All mechanical joints
- B. Mechanical restraining devices may be utilized on bends, mechanical joints, valves where applicable.

1. Unless otherwise directed, thrust restraint of mechanical joint pipe bends or other fittings, for use with standard push-on C900 PVC and Ductile Iron pipe, shall be provided via ductile iron restraint gland mechanism conforming to ANSI/AWWA C111/A21.11, C110/A21.10 and C153/A21.53, latest revisions.
 2. Restrained joint pipe lengths (restrained length) shall be sufficient to restrain thrust imparted by $1\frac{1}{2}$ times the anticipated working pressure but not less than 200 psi.
 3. Restraint mechanisms used for restraint beyond the mechanical joint locations shall be suitable for push-on pipe bells of the pipe specified herein.
 4. Pipe restrained joints shall be the Series 1100 or 2000PV (as appropriate) Megalug restraining system, as manufactured by EBAA Iron Sales, Inc.
- C. Concrete thrust blocks may be used to thrust restraint. Thrust blocks shall be designed to withstand the force imparted by the main with a minimum $1\frac{1}{2}$ times the anticipated working pressure but not less than 200 psi. Maximum lateral bearing capacity shall be 1,500 lb/sf. Sizing guidelines for thrust blocks are detailed on the project Drawings.
- D. All valves shall be anchored with concrete blocks. Provide straps or stirrups to secure valve to block. Anchorage shall be provided in accordance with manufacturer's recommendations.
- E. Thrust restraint utilizing tie-rods shall not be utilized unless approved by the Owner or specifically indicated. Tie-rod diameters shall be 2 times the diameter required to restrain the main. All rods shall be protected from corrosion with two coats of bituminous paint or epoxy.

2.8 HYDRANTS

- A. The hydrants shall conform to the requirements of AWWA Standard for Dry Barrel Fire Hydrants for Ordinary Water Works Service, Designation: C502-80, or latest revision.
- B. The hydrants shall have one (1) pumper of four and one-half ($4\frac{1}{2}$) inches and two (2) hose connections of two and one-half ($2\frac{1}{2}$) inches, NST, with a six-inch mechanical joint shoe. The hydrant shall be equipped with a main valve of five and one-fourth ($5\frac{1}{4}$) inches and shall have bronze-to-bronze seatings and open left. Hydrants shall also have an eight-inch ductile-iron lower barrel and a fusion-bonded epoxy-coated shoe. There will be a travel-stop nut located on the upper stem to prevent damage due to excessive force. Upper stem threads will be lubricated by the use of an all-temperature grease and sealed by double o rings.
- C. For the purpose of standardization, hydrants will be the Waterous Pacer-WB 67 or the U.S. Pipe Metropolitan.
- D. The hydrants shall be thoroughly cleaned and given two (2) shop coats of paint in accordance with the above-mentioned AWWA Specification C502, latest edition. Paint color shall be federal safety red, as manufactured by Hydrant Hyde Paint, with reflective white bonnet and white caps.
- E. The hydrant, with its buried valve and valve box, shall be set plumb and centered with the valve box directly over the valve. Backfill around the hydrant and valve shall be thoroughly compacted to a distance of four (4) feet on all sides of the box or to the undisturbed trench face if less than four (4) feet. The hydrant connecting pipe shall have at least five and one-half ($5\frac{1}{2}$) feet of cover. The hydrant shall be set upon a slab of stone or concrete not less than four (4) inches thick and fifteen (15) inches square. The side of the hydrant opposite the pipe connections shall be firmly wedged against the vertical face of the trench with a poured concrete thrust block as indicated on the standard details. No less than five (5) cubic feet of broken stone shall be placed around the base of the hydrant at the location of the drain holes. Strict attention shall be given to ensure drainage holes are kept free of any concrete. Fifteen-pound roofing felt shall be placed between the concrete thrust block and the hydrant and drainage gravel. Backfill around the hydrant shall be thoroughly compacted to the grade line in a satisfactory manner. The hydrant and valve shall

have the interiors cleaned of all foreign matter before installation and shall be inspected in both the open and closed position.

- F. The bury of the hydrant shall be of sufficient length to allow the hydrant to be set at the proper elevation, as shown on the standard details. Extensions shall be furnished and installed at the contractor's expense when required for greater depths.
- G. All hydrants shall be mechanically connected to the water mains using a main line anchoring tee, fitted to take a six-inch resilient wedge valve mechanically connected on the side outlet, and a six-inch mechanical joint cement-lined cast-iron pipe to the hydrant. Retaining glands shall be used at all joints between the shutoff valve up to and including the hydrant. All bolts shall be torqued to manufacturer's specification.
- H. Before exposure to the weather and after thorough cleaning to remove all rust, dirt, grease and other foreign matter, the equipment and appurtenances specified herein shall be painted in the shop as specified hereinafter. Ferrous surfaces which will be submerged shall be cleaned by sandblasting to remove all foreign matter. Following cleaning, the surfaces shall be painted in the shop as follows: interior and exterior surfaces of valves and valve appurtenances shall be given a shop finish of an asphalt varnish conforming to Federal Specification TT-V-51C, for Varnish Asphalt. Ferrous surfaces obviously not to be painted shall be given a shop coat of grease or other suitable protective coating.

2.9 TESTING PRODUCTS

- A. Liquid Chlorine
 - 1. Liquid chlorine shall conform to AWWA Standard B301, current edition.
- B. Hypochlorite
 - 1. Hypochlorite shall conform to AWWA Standard B300, current edition.
- C. Backflow Preventer for testing only.
 - 1. Backflow prevention device for any connection between the existing water system and new water pipes prior to acceptance of pressure test, disinfections, and flushing, shall be of the appropriate size as required, testable, and shall be double check-reduced pressure type as manufactured by Watts, Febco, Hersey, or approved equivalent.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Refer to Section 31 0000 - Earthwork for excavating, trenching, and backfilling.

3.2 PIPE INSTALLATION

- A. General:
 - 1. Contractor shall verify the locations of all potentially conflicting utilities and structures as indicated on the Drawings.
 - 2. Lay out piping as shown on the Drawings. Any deviation from the layout shown must be approved by the Engineer.

3. Piping shall be cut from measurements taken at the site and not from the plans. Hydraulic squeeze cutters are not acceptable for cutting ductile iron pipe. Travel-type cutters and guillotine or rotary-type abrasive saws may be used. All cut ends shall be examined for possible defects caused by cutting. All necessary provisions shall be taken in laying out piping to provide for expansion and contraction caused by temperature fluctuations.
4. Pipe shall be carried manually or by mechanical equipment with flat forks or fabric slings. Cables and chains shall not be used. Pipe shall be assembled and welded immediately adjacent to its final location and set or carefully rolled into position. Pipe shall not be dragged on the ground.
5. Cleaning and Inspection: The interior of all pipe, fittings, valves, and appurtenances shall be thoroughly cleaned of all foreign material and inspected for cracks, flaws, or other defects before installation, and shall be kept clean until the work is accepted.
6. Pipelines shall be constructed in dry trenches and shall not be laid when the conditions of the trench or the weather is unsuitable for such work.
7. Any damaged pipe shall be removed from the site and replaced by the Contractor at no additional cost to the Owner.
8. Temporary plugs. At all times when pipe laying is not actually in progress, the open ends of pipe shall be closed by temporary watertight plugs or other approved means. If water is in the trench when work is resumed, the plug shall not be removed until all danger of water entering the pipe has passed.

B. Storage:

1. Pipe shall be stored on a clean, level, dry ground. If the pipe must be stacked for storage, such stacking should be done in accordance with the pipe supplier's recommendations. The handling of the pipe should be done in such a manner that the pipe is not damaged by dragging over sharp objects or cut by lifting equipment.
2. Segments of pipe having cuts or gouges in excess of 10% of the wall thickness shall not be incorporated into the system.

C. Inspection of Piping:

1. Carefully inspect all pipe fittings before installation, removing all dirt. The pipe shall be installed with the markings up for visual inspection and verification.
2. All pipe shall have smooth exterior and interior surfaces, be first quality, be free from cracks, blisters, and other imperfections, and be true to shape or form throughout each length. Piping judged by the Owner or Engineer to be unacceptable shall be removed from the site and new undamaged pipe shall be provided at no extra cost to the Owner.
3. The interior of the pipeline shall be kept free from all dirt, joint material, and other foreign materials as the work progresses. Tight fitting stoppers or bulkheads shall be securely placed at the ends and any other openings of the pipe when work is stopped temporarily or at the end of the workday to prevent dirt or refuse from entering the pipe.

D. Installation:

1. PVC, PE, and Ductile Iron Pipe:
 - a. Sections of PVC pipe shall be joined together as required by the manufacturer. No machine shall be used to push pipe sections together even with blocking.
 - b. Bending of the pipe during installation shall be limited and shall not exceed the pipe system supplier's recommendations.
 - c. The trench bottom and gravel bedding shall be shaped and compacted to give substantially uniform unyielding circumferential support to the lower fourth of the full length of each pipe. Pipe and fittings shall be laid accurately to the lines and grades indicated on the drawings or as required. Care shall be taken to ensure a good

- alignment both horizontally and vertically. The pipe shall be laid on wood blocks, with two (2) blocks required for each length of pipe for support.
- d. Holes for the bells shall be excavated so that after placement the pipe and coupling receives uniform bearing pressure from the trench bottom.
 - e. Each pipe shall be laid to the line and grade and in such a manner as to form a close concentric joint with the adjoining pipe and to prevent sudden offsets of the flow line.
 - f. As the work progresses, the interior and exterior of the pipes and couplings shall be cleaned of all dirt and superfluous material of every description.
 - g. To keep interior of pipe clean, a suitable drag shall be kept in the pipe and pulled forward past each joint immediately after the jointing has been completed.
 - h. At times when work is not in progress, open ends of pipe and fittings shall be securely closed so that no trench water, earth or other substance will enter the pipe or fitting.
 - i. Any pipe that has been disturbed after laying shall be taken up and re-laid.
 - j. All materials found to be defective during the progress of the work will be rejected by the Owner and the Contractor shall promptly remove such defective material from the site of the work and replace with new material at no additional expense to the Owner.
 - k. The Contractor shall be responsible for the safe storage and proper handling of all materials.
 - l. No shims or mounds of earth shall be used to raise the pipe to grade.
 - m. All pipe shall be maintained accurately to the required line and grade.
 - n. No pipe shall be covered until the Owner or Engineer has inspected the joints.
 - o. The pipeline shall not be used to convey trench drainage during construction.
 - p. Pipes shall be protected at all times during construction against flotation. They shall be thoroughly secured, properly supported and bedded to prevent settlement or disturbance. Compaction of bedding and backfill material shall be in strict accordance with Section 31 0000 – Earthwork.
 - q. Bends, crosses, tees, caps, plugs, and other appurtenances shall be strapped and clamped where indicated and/or as directed. Steel bars, rods and plates shall be of structural steel. Straps, bridle rods, clamps, anchors and such other parts shall be provided to the details as directed and as approved. After installation, all parts of the strapping and clamping devices shall be given two (2) heavy coats of an approved coal tar base protective coating.
 - r. All lumps, burrs, excessive coatings, and irregularities on the plain and socket ends of the pipe, valves, sleeves, and appurtenances shall be removed.
 - s. Field cutting of the pipe is to be square and free of any burrs and defects.
 - t. Water shall be laid with a minimum horizontal separation of 5' from all utilities and 10' from sewer lines. Sewer lines crossing over water lines shall be constructed of ductile iron or sleeved in ductile iron for 10 feet on either side of crossing regardless of vertical separation distance. Sewer lines crossing under water lines shall be constructed with a minimum vertical separation of 18" or the sewer shall be constructed of ductile iron or encased in concrete for 10 feet on either side of crossing.
 - u. The pipe shall be installed with a minimum of five and one-half (5 1/2) feet of cover. Where the pipe cannot be reasonably installed with this cover, the contractor shall furnish and install insulation as approved by the Division. The contractor must have permission from the WSD to install any pipe with less than five and one-half (5 1/2) feet of cover, prior to installation.
 - v. Connect to water-supply source and construct water-service piping to a point 5 feet from the outside face of the building wall in locations and pipe sizes indicated on Drawings. It is the responsibility of the plumber to construct the required piping from this point through the building wall.
 - w. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, and other supports.

- x. Valves shall be set in the pipeline as directed. Blocking or supports of a permanent nature shall be placed under each valve to ensure against settlement.
- y. Each valve shall be tightly closed before being placed in the line and shall remain so until the joints on each side are completely tightened.
- z. All Building connections to the Water System or at any potential cross connection shall have a backflow prevention device installed.

E. Pipe Embedment and Backfill:

- 1. PVC, PE, and HDPE, or Ductile Iron pipe systems and fittings shall be installed in full compliance with the manufacturer's recommendations.
- 2. The pipe shall be surrounded with sand bedding, haunching, and initial backfill materials that provide stable and permanent support to the pipe. These materials are as shown on the Drawings.
- 3. Backfill of the trench up to a level of twelve (12) inches above the top of the pipe shall be done by hand shovel with earth fill free from stones having any dimension greater than three (3) inches. This area of backfill is considered the zone around the pipe and shall be thoroughly compacted before the remainder of the trench is backfilled. Compaction of the zone around the pipe shall be done by use of power-driven tampers weighing at least twenty (20) pounds. Care shall be taken that material close to the bank, as well as in all other portions of the trench, is thoroughly compacted to a density of ninety-five percent (95%)
- 4. Care should be taken to ensure that the haunching of the pipe is performed without disturbing the pipe. Initial backfill shall be placed in 6-inch layers and hand tampered to assure compaction.
- 5. The remainder of the trench above the zone around the pipe shall be backfilled and compacted. Compaction of backfill in the remainder of the trench shall be done in layers not exceeding twelve (12) inches in depth and by use of power-driven tampers weighing at least twenty (20) pounds. Water jetting shall be used only when approved by the WSD.
- 6. Reference Specification Section 31 0000 – Earthwork.
- 7. Contractor shall not flood excavations to compact backfill.

F. Tracer Wire Installation:

- 1. All PVC, PE, or HDPE pipe shall be installed with an electrically continuous tracer wire for the purpose of locating the pipe with an electronic pipe locator subsequent to water main installation. Tracer wire shall be installed over the entire length of the PVC/PE/HDPE pipe at the centerline of the pipe at the 3 o'clock position. Tracer wire shall be taped to the pipe every 8 feet on center.
- 2. Each segment of tracer wire shall be no greater than 500 feet. At one end of the tracer wire shall be a tracer wire access box and at the other end shall be a grounding rod.
- 3. Splice kits shall be used only as necessary and as approved by the Engineer. Where possible, tracer wire shall be installed in continuous lengths with no breaks or splices.

G. Joint Construction:

- 1. Make ductile iron pipe joints according to the following:
 - a. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.
 - b. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.
- 2. No pipes shall be jointed until couplings and ends of pipe have been inspected to determine that the joint surfaces are free from any defects in materials or workmanship, and free from dirt or other foreign matter.

3. Pipe, pipe fittings and accessories shall be stored, installed, jointed and protected by the Contractor in strict accordance with the printed recommendations of the manufacturer of the piping material, and as approved.
4. For buried ductile-iron pipelines, the contractor shall use push-on-joint-type pipe. All fittings for push-on-joint pipe shall have mechanical joint ends. The pipe and fittings shall be cement-lined and coated. The pipe joints shall have rubber gaskets.
5. Field assembled joints shall be checked with a suitable gauge as recommended by the manufacturer to ensure that the rubber rings are properly located.
6. If inspection indicates that the rings are improperly located, the contractor shall disassemble, and properly install the pipe.
7. Pipe stoppers shall be installed, sealed and blocked in such a manner as to prevent any leakage and so as to withstand an internal hydrostatic pressure of no less than 5 psi.
 - a. Timber blocking shall be of adequate size and arrangement to prevent the stopper from being blown off the line.
 - b. Timber bracing shall extend back to the undisturbed end of the trench.

3.3 THRUST RESTRAINTS

- A. Install mechanical restraining devices on all bends, mechanical joints, valves, tees, plugs and caps, bends, crosses, valves, and hydrant branches. Anchorages and restrained-joint types that may be used include the following:
 1. Concrete thrust blocks.
 2. Megalug Restraining System or approved equivalent.
 3. Locking mechanical joints.
 4. Reinforced concrete wall anchors
- B. The Contractor shall provide the type of anchorage or restrained joint as specified by the Engineer.
- C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.4 VALVE, TAPPING SLEEVES, COUPLING, AND APPURTENANCE INSTALLATION

- A. General:
 1. All tapping sleeves, valves, and accessories shall be carefully inspected by the Contractor for defects before installation and all defective, unsound, or damaged materials shall be rejected.
 2. The Owner will make such additional inspections as deemed necessary and the Contractor shall furnish all necessary assistance for such inspection.
 3. Proper implements, tools, and facilities satisfactory to the Owner shall be provided by the Contractor for the proper and satisfactory execution of the work.
- B. Tapping sleeves, valves, couplings, and appurtenances shall be new and unused and shall be of the types and materials specified as indicated or as directed.
- C. The interior of tapping sleeves, valves, and fittings shall be thoroughly cleaned of foreign matter before being lowered into the trench and shall be kept clean during laying operation.
- D. Tapping sleeves, valves, and fittings shall be constructed in dry trenches and shall not be laid when the conditions of the trench or the weather are unsuitable for such work.

- E. Tapping sleeves, valves, and couplings shall be laid to the line and grade in such a manner as to form a close concentric joint with the adjoining pipe and to prevent sudden offsets of the flow line.
- F. At times when work is not in progress, open ends of tapping sleeves, valves, couplings, and fittings shall be securely closed so that no trench water, earth or other substances will enter.
- G. Any tapping sleeves, valves, couplings, or fittings that have been disturbed after laying shall be taken up and re-laid.
- H. All materials found to be defective during the progress of the work will be rejected by the Owner and the Contractor shall promptly remove such defective material from the site of the work and replace with new material at no additional expense to the Owner.
- I. The Contractor shall be responsible for the safe storage and proper handling of all materials.
- J. No shims or mounds of earth shall be used to raise the equipment to grade.
- K. No tapping sleeve, valve, or appurtenance shall be covered until the joints have been inspected.
- L. Installed materials shall be protected at all times during construction against flotation; they shall be thoroughly secured, properly supported and bedded to prevent settlement or disturbance. Compaction of bedding and backfill material shall be in accordance with Section 31 0000 – Earthwork.
- M. Tapping sleeves shall be installed where indicated or as directed by the Owner and shall be installed according to the manufacturer's recommended procedures.
- N. Valves and joint restraints shall be installed where indicated or as directed by the Owner and shall be installed according to the manufacturer's recommended procedures.
- O. Should asbestos cement pipe be encountered during the work it shall be abandoned in-place. The Contractor shall not crush any asbestos cement pipe. Should removal be required to facilitate the connection to the existing water main, the Contractor shall make arrangements for the legal disposal of the asbestos cement pipe sections.

3.5 SETTING VALVES AND VALVE BOXES

- A. Valves shall be set in the pipelines as directed. Blocking or supports of a permanent nature shall be placed under each valve to ensure against settlement. Concrete Anchoring for each valve shall be provided. Construct anchoring in accordance with PVC pipe manufacturer's recommendations. Provide straps to secure valve to anchor.
- B. Each valve shall be tightly closed before being placed in the line and shall remain so until the joints on each side are completely tightened.
- C. Each valve shall be provided with a box. Covers shall have two (2) lifting holes, and the word "WATER" cast on the top. The top of the cover shall be flush with the top of the box rim.
- D. Valve boxes shall be tar-coated cast iron and of the adjustable sliding, heavy pattern type. They shall be so designed and constructed as to prevent the direct transmission of traffic loads to the pipe or valve. The upper or sliding section of the box shall be provided with a flange having sufficient bearing area to prevent undue settlement. The lower section of the box shall be designed to enclose the operating nut and stuffing box of the valve and to rest on the backfill. The

boxes shall be adjustable through at least six (6) inches vertically without reduction of the lap between sections to less than six (6) inches.

- E. The inside diameter of boxes shall be at least four and one-half (4 1/2) inches, and the lengths shall be as necessary to suit the ground elevation [normal pipe cover five and zero-tenths (5.0) feet].
- F. Buried valves and valve boxes shall be set plumb and centered with the valve boxes directly over the valves. Earth fill shall be carefully tamped around the valve box to a distance of four (4) feet on all sides of the box or to undisturbed trench face, if less than four (4) feet.

3.6 FIELD QUALITY CONTROL

- A. Hydrostatic Tests: After the pipe has been laid and the trench has been backfilled, all newly laid pipe or any valve section thereof, shall be subjected to a pressure and leakage test in accordance with AWWA C600-latest edition and as approved by the Owner. The Contractor shall provide all pumps, pipe, connections, gages, measuring devices, and all other apparatus necessary for the test and shall conduct the test in the presence of and to the satisfaction of the Owner. The Owner will supply water to the Contractor for testing purposes at no expense to the Contractor. All tests shall be performed or observed by the Utilities Department or its authorized representative.
 - 1. Test Pressure -The pressure and leakage test shall consist of first raising the water pressure (based on the elevation of the lowest point of the section under test and corrected to the gauge location) to a pressure of two hundred (200) pounds per square inch. If the contractor cannot achieve the specified pressure and maintain it for a period of one (1) hour, the section shall be considered as having failed to pass the pressure test.
 - 2. Test Leakage - Following or during the pressure test, the contractor shall make a two-hour leakage test by metering the flow of water into the pipe while maintaining in the section being tested a pressure of one hundred fifty (150) pounds per square inch. If the average leakage is equal to or less than that allowed under AWWA Standard C600, latest revision, for installation of that specific pipe, the section shall be considered as having passed the leakage test.
 - 3. Air Removal - Prior to performance of the test the pipeline shall be completely filled with water for a period of 24 hours. Expel air by means of air relief valves, hydrants or other means as required. If permanent air vents or taps are not located at all high points, the Contractor shall install corporation stops at such points so air can be expelled. After the tests are completed, plug all temporary taps.
 - 4. Allowable Leakage shall be less than or equal to that allowed under AWWA Standard C600, latest revision.
 - 5. Repair of Leaks - If the test discloses leakage greater than the allowable leakage the Contractor shall, at his own expense, locate and repair the defective joints until leakage is within the specified allowable. The Contractor shall repair any specific leaks regardless of the test results if, in the opinion of the Owner, they are serious enough to endanger the future serviceability of the pipeline.

3.7 DISINFECTIONS OF POTABLE WATER LINES & PUMP SYSTEMS

- A. Coordinate all testing of water lines with the Town of Ashland Department of Public Works.
- B. General:
 - 1. Flushing and disinfection of potable water lines and pump systems shall be done in accordance with the procedure set forth in AWWA C651 - Disinfecting Water Mains, latest edition, and shall be witnessed by the Engineer unless otherwise approved. Furthermore, any chlorine used in the disinfection of the potable water systems shall be NSF 60 certified.

The Contractor shall provide all temporary blowoffs, pumps, chlorination equipment, chlorine, and all other necessary apparatus required.

2. All new valves shall be operated during the disinfection procedure in order to ensure complete disinfection.
3. The form of chlorine proposed by the Contractor for disinfection shall be approved by the Owner.
4. The Contractor shall take adequate measures to prevent backflow of flushing water and chlorinated water into the existing water distribution system.
5. Contractor shall not make physical connection to the existing water system prior to satisfactory results of chlorination. An approved backflow prevention device shall be utilized to transfer water from the existing system to the new piping network. A closed gate valve shall not constitute a separation from the existing system and new work.

C. Pipe Cleaning:

1. If the pipe contains dirt or heavy encrusted matter that, in the opinion of the Engineer, will not be removed during the flushing operation, the Contractor shall clean and swab the interior of the pipe with a one (1) percent hypochlorite disinfecting solution.
2. The pipeline shall be flushed to remove all remaining foreign material prior to disinfection, except when the tablet method is used. The flushing operation shall develop a minimum velocity of 2.5 ft/s. It will be the Contractor's responsibility to properly size and locate corporations within test sections to adequately flush all piping at least 2 times its volume at the desired velocity. The Contractor must coordinate all flushing operations with the Owner. If in the Owner's opinion flushing of the new main will cause a significant disruption to the existing system, the Owner may require the Contractor to perform flushing at times designated by the Owner or in a manner that the Owner views as suitable. The Contractor shall not be entitled to additional monies as a result of the Owners requirements for flushing. It may be necessary for the Contractor to utilize a pump to achieve the minimum required velocity for flushing. If a pump is necessary, the Contractor shall utilize a pump at no additional cost to the Owner.

D. Chlorine Application:

1. In general, chlorine shall be applied using the continuous feed method, as specified in AWWA C651. Chlorine used for disinfection shall be NSF 60 certified for potable water use.
2. The contractor shall furnish all equipment and materials necessary to do the work of disinfecting and shall perform the work in accordance with the procedure outlined in the AWWA Standard for Disinfecting Water Mains, Designation: C651, latest revision, as approved by the WSD's representative. The chlorine dosage shall be such as to produce not less than ten (10) milligrams per liter residual after a contact time of twenty-four (24) hours. During the disinfection period, care shall be exercised to prevent contamination of water in existing mains.
3. After disinfecting treatment, the main shall be flushed with clean water until the residual chlorine content does not exceed zero and two-tenths (0.2) milligrams per liter.

E. Final Flushing:

1. After the required retention period, flush all heavily chlorinated water from the main until the chlorine concentration is no higher than that prevailing in the system, or is acceptable for domestic use. The Contractor shall be responsible for satisfactory disposal of all flushing water and chlorinated water at no additional expense to the Owner.
2. Prior to discharging, a reducing agent shall be applied to the water to be wasted, to neutralize thoroughly the chlorine residual remaining in the water. Where necessary,

Federal, State and local regulatory agencies should be contacted to determine special provisions for the disposal of heavily chlorinated water.

F. Bacteriologic Tests/VOCs:

1. A bacteriological sample shall be taken and submitted to a laboratory approved by the WSD's representative with all costs borne by the contractor. Test results from the laboratory are to be sent directly to the Ashland Water and Sewer Division, Box 9, Ashland, Massachusetts, 01721, by the laboratory.
2. Sample sets will be required for each isolated section of pipe tested.
3. Collect samples in sterile bottles, treated with sodium thiosulfate, from a standard corporation stop with gooseneck assembly installed in the main. Do not collect samples using a hose or fire hydrant.

- G. Repetition of Procedure - If the original disinfections fail to produce satisfactory bacteriological samples, repeat the disinfections procedure until satisfactory results are obtained at no additional expense to the Owner.

3.8 IDENTIFICATION

- A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Section 310000 – Earthwork.

3.9 RECORD DRAWINGS

- A. All installed underground utilities shall be designated on as-built drawings by the contractor of record and provided to the Owner and Engineer in AutoCad format prior to completion of the project. All as-built drawings, (underground and above ground) shall be dimensioned from permanent benchmarks such as existing buildings and include depths at various points throughout the extent of the work, and invert elevations at all structures. Top of pipe elevations shall be provided on the as-built at every bend and every 50 linear feet along a straight run of piping.

END OF SECTION

SECTION 332313

GEOHERMAL WELL FIELD

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

- A. The closed-loop ground source heat exchanger (CLGSHX) system consists of geothermal wells configured into well circuits that will serve as the heating and cooling source or sink circulation loops connected to the load side of a building HVAC system utilizing water-to-water ground source heat pump units. The vertical wells are connected by polyethylene heat fusion joined piping formed into vertical loops connected by horizontal headers installed to the geothermal wells. All underground piping shall utilize the reverse return method to equalize the pressure drop through all the supply and return branch circuits. The system shall be charged with a 20% solution of inhibited propylene glycol by volume.
- B. The Work includes furnishing and installing all equipment, materials and labor for the installation and testing for the CLGSHX system as indicated in the Contract Documents.
- C. The Work in this Section includes but is not be limited to:
 - 1. Drilling and installation of the geothermal wells including advancement through all subsurface materials including obstructions, at the locations and to the depths required. Pre-drilling, pre-excavation, or other methods, if required to overcome obstructions, shall be performed using techniques proposed by the Contractor and approved by the Owner's Representative.
 - 2. Installation of 1-1/2-inch diameter SDR 13.5 Double U-Bend HDPE Pipe assemblies and grouting into geothermal wells.
 - 3. Flushing, flow testing, and pressure testing.
 - 4. Trench excavation and backfilling for all exterior geothermal piping headers and circuits.
 - 5. Installation of HDPE horizontal piping and connection to the geothermal wells, pipe bedding, and backfilling.
 - 6. Installation of pipe bedding surrounding the horizontal pipe headers prior to backfilling.
 - 7. Provide as-built documentation to the Owner's Representative after the completion of the project.
 - 8. Procure and payment for any permits and licenses required to perform the work.
 - 9. Preservation and protection of existing and new site features and improvements during the course of the work.
 - 10. Furnish and charge all the vertical pipe, supply and return branch circuit pipes and supply and return main pipes up to the manifold with a 20% by volume solution of inhibited propylene glycol and water that shall meet the quality requirements of the component manufacturer's specification or the IGSHPA recommended water quality values (2017), whichever is greater.

1.3 RELATED DOCUMENTS

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections and Drawings that directly relate to work of this Section include, but are not limited to:
1. Section 312000 – Earthwork
 2. Drawing GT-1.1 – Geothermal Well Field Layout and General Notes
 3. Drawing GT-1.2 – Geothermal Well Details
 4. Section 312319 – Dewatering

1.4 PROJECT CONDITIONS

- A. Site Conditions and Available Subsurface Information
1. Before submitting bids, the Contractor shall visit the site and inform themselves as to the location, nature of the work, equipment and facilities needed, general and local conditions prevailing at the site and all matters which may affect the work of this Section.
 2. Before submitting bids, the Contractor shall examine all sources of information concerning subsurface conditions. Each bidder shall draw their own conclusions concerning how these affect their work. Conditions which would not permit the Contractor to fulfill the intent of the contract shall be brought to the attention of the Owner.
 3. Existing Geothermal Test Well Information:
 - a. A report entitled “Formation Thermal Conductivity Test Report for Geothermal Test Well” dated October 21, 2020 was prepared by McPhail Associates, LLC providing data from the drilling of one, approximate 600-foot deep geothermal test well installed with a 1-1/2-inch diameter SDR 13.5 HDPE Double U-Bend Pipe.
 - b. This report is available as part of the overall project specifications, refer to Division 01 - General Requirements. Data and information contained in these reports is incorporated herein by reference.
- B. Subsurface Information
1. The Owner assumes no responsibility for the accuracy of the existing subsurface information. They are included only as a general indication of the materials likely to be found at the site. The Contractor shall examine this data and conduct their own investigations/collect other additional data if they deem it necessary. The Contractor shall base their bid on their opinion of the conditions likely to be encountered.
 2. The bidder's submission of their proposal shall be considered “prima facie” evidence that they have made their examination as described in this Section.
- C. Permitting
1. It shall be the responsibility of the Contractor to procure any permits and licenses required to perform the ground heat exchanger installation, including dewatering, prior to the commencement of the work, including preparation of any drawings and documentation to procure the required permits from all local, state and federal agencies and the payment of the required fees shall be the responsibility of the Contractor. Subsequent to the ground heat exchanger installation, the Contractor shall furnish to the Owner's Representative an original copy of the aforementioned permits or licenses.

1.5 SUBMITTALS

- A. In general, corrections or comments or lack thereof, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final installation confirming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.
- B. Pre-Construction Submittal Package. A Pre-Construction Submittal Package shall contain all of the following listed below. No work shall commence prior to complete review of the Pre-Construction Submittal Package.
- C. Licenses and certifications as follows:
 - 1. Submit the name and prior experience of each person who will be performing the installation. Indicate name and address of at least three (3) commercial geothermal projects completed by each installer completed in the last three (3) years. Additionally, provide name and address of at least three (3) commercially completed geothermal projects in the last three (3) years by this drilling and heat exchanger installation Contractor.
 - 2. For all drilling contractors, whether employed directly by the Contractor or by hire as a subcontractor, provide proof of current, annual registration as a Massachusetts registered well drilling contractor.
 - 3. For all personnel involved in system installation, whether employed directly by the Contractor or by hire as a subcontractor or subcontracted employee, provide proof of System Fabricators and Installers Certified Installer accreditation from IGSHA or approved manufacturers' certification program.
 - 4. For all personnel involved in heat fusion, whether employed directly by the Contractor or by hire as a subcontractor or subcontracted employee, Proof of IGSHA Certified Heat Fusion Technician or equal certification.
- D. Identify all means and methods of fabrication and installation including the following:
 - 1. Description of method to control and containerize water and drill cutting spoils.
 - 2. Schedule for mobilization, set-up, and well drilling, including sequence.
 - 3. Methods, equipment and devices to be used to advance the wells.
 - 4. Methods of pipe installation.
 - 5. Methods of tremie grouting.
 - 6. Proposed mix design of grouts.
 - 7. Alternate methods of backfilling the boreholes in the event that more than 20% formation loss during grouting occurs.
 - 8. Pipe bedding and backfill.
 - 9. Pipe and fittings including joining methods and pipe fusion equipment.
 - 10. Pipe manufacturer shall supply a Certificate confirming compliance with the specifications of this Section and governing agencies.
 - 11. Inside and outside diameter of surface casing and tremie tube.
 - 12. Methods and materials to join surface casings.
 - 13. Diameter of all bits to be used.
 - 14. Proposed material to be used for Sand Bedding and Ordinary Borrow, including documentation demonstrating that these materials meet specified requirements.
- E. All permits and approvals required to perform the Work.
- F. Submit manufacturer's product data and cut sheets for all equipment, materials and products to be supplied to complete the Work.

- G. Submit Shop Drawings that consist of detailed layout drawings of the Work Area Layout and System including but not limited to:
1. Plans showing the location of proposed geothermal wells and horizontal well piping, including depths, sizes and material types.
 2. Location and description of equipment, vehicles, laydown areas, water collection systems, storage areas, and other relevant features.
 3. System piping including pipe lengths and U-bend assemblies.
 4. Submit manufacturer's technical product data and instructions for interior building piping manifold, including for pipe, valves, and accessories.
 5. Dimensioned locations of each borehole.
 6. Locations of site utilities.
 7. Alignment and grade of horizontal header geothermal loop heat exchanger piping.
 8. Erosion control plan.
 9. Location for on-site stockpile area.
 10. Water treatment and water discharge plan.
- H. Provide warranty documentation showing that the Contractor and pipe manufacturer will meet the warranty requirements indicated herein.
- I. Written Flushing and Testing Plan detailing the means and equipment to be used for system purging, flushing, and hydrostatic testing as required herein, including:
1. Shop drawings showing flush, flow testing, and hydrostatic testing set up and methods.
 2. Cut sheets of flow meters and pressure gages to be used, including range and smallest dial readings and recent calibration logs.
 3. Cut sheet of pumps to be used for hydrostatic testing and hydrostatic testing methods.
 4. Proposed forms to be used to collect and maintain purge, flow, and hydrostatic pressure test data both for testing at individual wells and for circuits.
- J. Construction Records. During construction, the following records shall be submitted on the day the activity is undertaken:
1. Photo-documentation of installed piping systems for each circuit and header trench system.
 2. Flushing, flow, and hydrostatic tests with separate records for each of these tests conducted at:
 - a. Each individual well.
 - b. Each circuit.
 3. Completed well drilling logs indicating conditions encountered, depth of installed casing, water encountered, drilling time, down-time, methods used, top of geologic rock, date of installation, date of grouting, and other relevant information to record conditions encountered and as-built conditions.
 4. Logs of recorded water flow measurements encountered during drilling.
 5. Minimum of three (3) results of exchanger grout sample testing for hydraulic conductivity and thermal conductivity.
- K. Post-Construction Submittal Package. A Post-Construction Submittal Package shall contain all of the following listed below.
1. The Post-Construction Submittal Package shall be submitted within 10 days of project completion.
 2. Record drawings showing all final dimensions, elevations, and locations of all work performed under this contract including locations of the geothermal wells, and all underground utilities within.
 3. All paperwork and registrations as required by the Massachusetts DEP, including submission of well completion reports to the respective agencies.
 4. All inspections and approvals from the governing authorities and submit to the Owner's Representative.

- L. Submit proposed propylene glycol mix, including water quality testing results for the source water to be used to fill the geothermal system.

1.6 STANDARDS AND REFERENCES

- A. Closed Loop Ground Source Heat Pump Systems Installation Guide, prepared by Oklahoma State University, Division of Engineering and Technology, Stillwater, Oklahoma, 74076-1688.
- B. Commercial/Institutional Ground Source Heat Pump Owner's Engineering Manual – 1995 Issues, American Society of Heating, Refrigerating and Air-Conditioning Owner's Representatives, Inc. 1791 Tullie Circle NE, Atlanta, GA 30329.
- C. ASTM D-3350 – Standard Specification for Polyethylene Pipe and Fittings Materials.
- D. ASTM D-3261 – Standard specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe Tubing.
- E. ASTM D-2683 – Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe Tubing.
- F. ASTM D-2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications.
- G. ASTM D-1693 – Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.
- H. Federal, State and Local Department of Environmental Protection Requirements.
- I. Closed-Loop/Geothermal Heat Pump Systems, Design and Installation Standards 2017 Edition published by International Ground Source Heat Pump Association (IGSHPA) 374 Cordell South, Oklahoma State University, Stillwater, Oklahoma 74078.
- J. Grouting for Vertical Geothermal Heat Pump Systems published by IGSHPA 374 Cordell South, Oklahoma State University, Stillwater, Oklahoma 74078.
- K. Grouting Procedures for Ground Source Heat Pumps Systems published by IGSHPA 374 Cordell South, Oklahoma State University, Stillwater, Oklahoma 74078.
- L. ANSI/AWWA A100-06 Standard for Water Wells published by the American Water Works Association, December 2007.
- M. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.7 DELIVERY, STORAGE AND HANDLING

- A. All materials shall be inspected for size, quality, and quantity against approved shop drawings upon delivery.
- B. Coordinate all deliveries and storage locations with Owner's Representative and other site contractors.

- C. All equipment delivered and placed in storage shall be stored with protection from the weather, humidity, temperature variations, dirt, dust, and other contaminants.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- E. Protect piping systems from entry of foreign materials and water by temporary covers, completing sections of work, and isolating parts of completed system.

1.8 WARRANTY

- A. Contractor shall provide a minimum 50-year warranty to the Owner for the HDPE piping materials. Warranty shall name the Owner as the beneficiary and the Contractor and pipe manufacturer as the warranty providers.
- B. Contractor shall provide a minimum 5-year warranty for parts, equipment, and labor provided for the system from the date that the project has achieved substantial completion as determined by the Owner's Representative. Warranty shall name the Owner as the warranty beneficiary and the Contractor as the warranty provider.
- C. If the manufacturer's standard warranty period exceeds the minimum required, manufacturer's standard warranty shall be provided to the Owner without additional cost to the Owner.

1.9 PAYMENT

- A. The lump sum bid for the geothermal well field shall include the number and type of geothermal wells, including all the permanent steel casing, grouting assuming 20% formation loss, supplemental measures to backfill each borehole if more than 20% formation loss with grouting occurs, piping, the manifold, a charged system with a 20% propylene glycol and suitable water supply, other materials, and required testing indicated on the Contract Drawings and as specified herein.
- B. Unit prices shall be provided to account for:
 - 1. Additional Mobilizations
 - 2. 600-Foot Deep Geothermal Well with a 1-1/2-inch diameter SDR 13.5 Double U-Bend Pipe and associated well circuit piping.
 - 3. Permanent Steel Well Casing, Per Foot.

PART 2 - PRODUCTS

2.1 WELL MATERIALS

- A. Drilling Equipment: Truck-mounted (rubber tire) vehicles capable of advancing wells as specified herein under site conditions at the planned time of installation.
- B. ~~Casing shall be flush threaded steel casing with no external couplings.~~ Casing shall conform to AWWA Standards and shall have a minimum wall thickness of 0.25-inch or sufficient wall thickness to allow installation into soil and competent bedrock without having to drill an oversized hole through the soil and bedrock.
 - 1. Well casing shall be installed to a minimum depth of 10 feet into competent bedrock.

2.2 HDPE DOUBLE U-BEND/ HORIZONTAL PIPE ASSEMBLY AND MATERIALS

- A. All U-bend and horizontal piping shall be of high-density polyethylene (HDPE) material and shall be manufactured by Performance Pipe – Charter Plastics, DriscoPlex, Lamson Vylon, NuMex Plastics, Versaprofiles, or approved equal. HDPE pipe must meet the specifications as follows:
 - 1. All HDPE Pipe Dimensions for horizontal piping shall be manufactured in accordance with ASTM D-3035 and utilize Standard Dimension Ratio (SDR)-11.
 - 2. All piping used for the double U-bend heat exchanger (pipe located in the borehole) shall be manufactured in accordance with ASTM D-3350 and utilize SDR 13.5 and have factory hot-stamped lengths impressed on the side of the piping indicating the length of the heat exchanger to that point. The length shall read zero on the U-bend end and the actual heat exchanger total length on the other end. The entire U-bend heat exchanger for each specific geothermal well shall be a pre-manufactured, single-piece U-bend with the total length customized to the specific geothermal well depth. Fusing a U-bend to two HDPE pipes to form a U-bend on site is not acceptable.
 - 3. HDPE fittings shall meet the requirements of ASTM D-2683 (for socket fusion fittings) or ASTM D-3261 (for butt/saddle fusion fittings), and 780 CMR 71.00 Section 7104.2. For connections to equipment and valves with threaded connections, furnish fused transition with reinforced threads. Barbed type fittings shall not be used.

2.3 EXCHANGER GROUT

- A. Exchanger grout shall be CETCO High TC Geothermal Grout, GeoPro TG Select, or an approved equal high solids cement-bentonite grout having a thermal conductivity equal to or greater than 1.2 BTU/hr-ft-°F and having a hydraulic conductivity less than 1×10^{-7} cm/sec.
- B. Grouting manufacturer shall provide a minimum of three (3) thermal conductivity test results of the site-mixed grouting materials to verify the “as mixed” thermal conductivity value.

2.4 UNDERGROUND PIPE MARKERS

- A. Manufacturers: Seton, Reef Industries, Inc. or approved equal
- B. Detectable Warning Tape: Magnetic detectable conductor, brightly colored plastic covering, imprinted with “Caution Geothermal Piping Buried Below” in large letters.

2.5 ANTIFREEZE

- A. The Driller/Ground Loop Contractor (aka Geothermal Contractor) shall furnish and charge all the vertical pipe and circuit pipes with a 20% by volume solution of inhibited propylene glycol. The volume of the outside portion is approximately 5,200 gallons of fluid total (~1,040 gallons propylene glycol). Note that these volumes are provided as a courtesy and the Geothermal Contractor shall perform their own calculations as they relate to meeting the specification requirements. The HVAC Contractor shall be responsible for filling the interior portion of the HVAC system (inside limited to the heat pumps source side) and for topping off and adjusting the total quantity and percentage of inhibited propylene glycol in the system (inside and outside) during their final commissioning.
- B. The volume of antifreeze shall be sufficient to freeze protect to 19 degrees Fahrenheit.

- C. The propylene glycol shall contain a corrosion inhibitor/biocide concentration which the manufacture will guarantee is sufficient to prevent corrosion or biological growth at a 20% glycol concentration.
 - 1. Propylene glycol shall conform to ASTM D1384 requirements.
 - 2. Propylene glycol shall be mixed with a suitable source of water to 20% concentration. Source water shall meet the quality requirements of the component manufacturer's specification or the IGSHPA recommended water quality values (2017), whichever is greater.
 - 3. pH of solution shall be between 9.5 and 10.5.
- D. Propylene glycol shall be environmentally friendly and approved by the Environmental Protection Agency, the State and all local authorities having jurisdiction.

2.6 VALVED MANIFOLD ASSEMBLY

- A. Piping and circuit valves shall be HDPE. All 3" manifold circuit valves shall be butt or socket fusion HDPE Full Port, nitrile seats, stainless steel stems and poly propylene operators, or approved equal.
- B. P/T Plugs: Shall be constructed of solid brass and have a dual seal core of Nordel, rated up to 3500°F for water. Plugs shall be rated zero leakage from 0 to 1,000 psig and are capable of receiving a pressure or temperature probe.
- C. Butterfly Manifold Valves: Shall be constructed of a cast iron body, 416 stainless steel stem with a lever/lug type shut off system. A valve shall be provided on all supply and return piping. Valve shall be same size as pipe.
- D. 90 Degree Elbows: Shall be molded out of High-Density Polyethylene resins in accordance with the requirements of ASTM D3261.
- E. Branch and Service Saddles: Shall be molded out of High-Density Polyethylene resins in accordance with the requirements of ASTM D3261.
- F. Hangers/Support: Support piping manifold as required from building floor/wall structure.
 - 1. All hanger rods shall be hung from C-clamps on steel beams or bar joists, from inserts in concrete, or from coach screw threaded rods in wood construction.
 - 2. Hangers for Pipe Sizes 1/2 to 1-1/2-Inch: Carbon steel, adjustable swivel, ring type or adjustable, clevis.
 - 3. Hangers for Pipe Sizes 2 to 4 Inches: Carbon steel, adjustable, clevis.
 - 4. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Notify Dig-Safe and utility companies to mark location of existing underground services. Do not begin work of this section until existing underground services are marked.
- B. Protect underground utilities and structures near the Work from damage.

- C. Provide barricades, shields or temporary wall strictures to protect adjacent structures, parking lots, roadways, vehicles, pedestrians, from water or debris thrown from drilling or excavating process.

3.2 WATER MANAGEMENT, TREATMENT, AND DISCHARGE

- A. Construct and provide containers, sheeting, bins, hoses, pumps, and other equipment necessary to collect water from the wellhead such that the water does not leave the rig area or cause erosion.
- B. The Contractor shall utilize an adequate containment system to contain and remove offsite any drilling, grouting and piping runoff as a result of this Contractor's work. The disposal of this discharge in the sewer or drain lines is strictly prohibited.
- C. The Contractor must make all attempts to prevent any material that could be construed as a contaminant from entering the boreholes. In the event a borehole or boreholes become contaminated due to negligence by the Contractor, they shall, at their expense, perform such work and supply materials as necessary to remediate the contamination.
- D. Disposal of any drilling fluids or wastewaters, cutting and spoils shall be in accordance with state and local laws.
- E. The use of sediment tanks to contain sediment and manage water during the drilling process is expected. Once the sediment has settled out, the water can be recharged on-site at a location to be coordinated with the Owner's Representative. Refer to Specification Section 312319 – Dewatering for additional requirements.

3.3 DRILLING

- A. Drilling activities shall conform to the Contract Documents and submittals that are approved by the Owner's Representative. No work shall be performed unless it is conducted under the observation of the Owner's Representative, and in accordance with the submitted work plan.
- B. The vertical bore shall be drilled with the best drilling technique needed to achieve the desired depth with the known geology/formation information. The Contractor shall account for all manpower, tooling, air, and equipment required to achieve the depth specified herein.
- C. The completed bore depth shall be within 1% of the design bore depth for the specific project.
- D. The heat exchanger well head shall be buried below grade at a minimum of 5 feet after completion of the installation.
- E. The finished borehole diameter shall not be greater than 6-7/8-inch. Larger or smaller diameters, if required, must be approved by the Owner's Representative.

3.4 VERTICAL HEAT EXCHANGER GROUT INSTALLATION

- A. Grout pump test to be performed with tremie tube on the surface before grouting of the first test bore. This pump test will determine the pump rate and size of the tremie needed to properly and timely grout the borehole.

- B. Grouting material shall be mixed according to manufacturer's written instructions.
- C. Placing grout into borehole before mixing is not allowed.
- D. Grout must be pumped through a tremie pipe from the original bottom of the well or boring upward to the surface.
- E. The bottom of the tremie pipe must be inserted to within 10 feet of the bottom of the well or boring and remain submerged in grout while grouting.
- F. The tremie pipe shall be raised 20 feet after each batch of grout has been pumped, and water shall be run through the tremie while the next batch of grout is being mixed. This prevents the grout from setting up in the tremie tube between mixing.
- G. The discharge end must remain submerged in grout while grouting.
- H. If a zone of grout loss is encountered, using pea gravel or hole plug to bridge the zone off is required, then resume grout placement to determine if loss is still occurring. If grout is still being lost, repeat the above procedure until the loss zone is plugged and then continue grouting the rest of the hole. There may be several loss zones in an individual hole and pea gravel may need to be added several times.
- I. Options to Bridge Fractures:
 - 1. Option 1: Mix the proper amount of 3/8-inch bentonite chips with pea gravel and placing in the borehole to bridge the fracture.
 - 2. Option 2: Pump Bentonite grout mix through the fracture to the top of borehole.
 - 3. Option 3: Contractor to submit a proposed solution.
- J. The grout plug mixture shall have a maximum permeability rate equal to or less than 1×10^{-7} cm/s as determined by independent testing using ASTM D-5084 Method "C".
- K. Settling of grout may occur after initial lift has been pumped. The Contractor shall monitor the borehole for 72 hours and continue adding grout until the grout depth is visible at the surface and has not settled more than 12 inches.
- L. Evidence of complete bore sealing must be visible at ground surface.
- M. Grouting process shall conform to state and local regulations, the manufacturer's instructions, and "Grouting for Vertical Geothermal Heat Pump Systems - 2000 Engineering Design and Field Procedures Manual", as published by IGSHPA.
- N. The Contractor's attention is directed to the geothermal test well installed at the site which was initially grouted with a volume of grout approximately equivalent to the theoretical borehole volume plus 20% formation loss and no visible grout return was observed which subsequently required the borehole to be backfilled with 3/8-inch bentonite chips followed by silica sand. The Contractor shall account for 20% formation loss and alternative methods to backfill the borehole in their base bid lump sum.

3.5 U-BEND INSTALLATION

- A. The double U-bend shall be lowered to the bottom of the borehole in a controlled manner and shall not be allowed to free fall down the borehole.

- B. The boreholes shall be grouted in one continuous operation and manner from bottom to the top using a tremie or conductor pipe, withdrawing the tremie pipe as needed to place the grout correctly.
- C. Each U-bend shall be pressure tested individually before it is lowered into the geothermal well and after the well is grouted.

3.6 INSTALLATION OF PIPING

- A. Install horizontal ground loop piping in a reverse-return scheme as shown on the drawings. Each U-bend shall be connected in parallel to one supply and return branch on shown on the drawings. Use pipe reducers/increasers as required. Ground loop piping is shown on the drawings schematically. No sharp bends are allowed.
- B. The outside geothermal heat exchanger supply and return branch circuit piping in the horizontal trenches must be buried under a minimum of 5 feet ground cover inside all trenches, pipe sleeves, and headers. The ground cover shall be a minimum of 5 feet.
- C. Branch circuit pipe penetrations through walls shall be sleeved and sealed. Install a manifold with multiple piping circuits and associated valves and accessories in the mechanical room to interface with HVAC piping work. The manifold shall allow flushing, flow and pressure testing of the ground loop independent of the HVAC piping inside the building.
- D. The only acceptable method for joining buried pipe shall be by a heat fusion method.
- E. All piping passing through all the exterior walls shall be provided with mechanical seals, utilizing an adequately sized sleeve, and a link seal type, made by Thunderline Corporation or approved equal, to fill up the space between the wall opening and the pipe.
- F. All buried geothermal piping passing within 5 feet of any wall, structure, storm drain pipe, sanitary sewer pipe, water pipe, manhole or within 4 feet of surface exposed to outside elements shall be insulated with ½-inch thick rigid foam board insulation.
- G. Trench width for geothermal return and supply pipes shall meet the requirements of ASTM D2321 and shall be sufficient to ensure working room to properly and safely place and compact hunching and other backfill materials. The minimum trench width shall be 1.25 times the pipe outside diameter plus 12 inches.
- H. Connect manifold piping to geothermal loop heat exchanger supply and return piping and adapt to building system manifold inside mechanical room as detailed on Contract Drawings.

3.7 GROUND LOOP HIGH DENSITY POLYETHYLENE PIPING PRESSURE TESTING

- A. Each individual U-bend assembly shall be pressure tested after installation and grouting of the borehole. Pressure test with water at a minimum of 90 psi for a minimum of two (2) hours.
- B. All horizontal ground loop piping shall be pressure tested prior to backfill of trenches.
- C. Each ground loop circuit shall undergo pressure testing, individually:
 - 1. Each circuit (including multiple U-bend pipe and HDPE horizontal piping) shall be pressure-tested with water at 100 psi for 30 minutes prior to backfilling of header trench.

3.8 FLUSHING, PURGING, FLOW TESTING AND HYDROSTATIC PRESSURE TESTING

- A. Flushing shall be performed for each vertical well before connection to the lateral header. The Contractor shall perform flushing with equipment which has been approved by the Owner's Representative on the Contractor's flushing, flow testing, and purging plan.
- B. Each circuit shall be flushed and purged of air and debris individually in both directions. The flushing and purging shall be scheduled to allow the Engineer to observe the final flushing to confirm that there is no visible air during purging.
- C. The flush shall be considered complete when no less than 20 times volumes have circulated through the system without cleaning required in the strainers.
- D. Air separators may be used to aid in the removal of air during the process. To validate the flush, a sample of flushed water shall be drawn into a clear container and set aside for 24 hours without disturbance. The sample shall be visually inspected after 24 hours for sediment at the bottom of the container. If sediment is present, the system shall be flushed again and tested until no visual sediment is present.
- E. Before the system is filled with propylene glycol, flushing shall be performed at a velocity no less than 135% of design flow, but in no case less than 2 feet per second (FPS) through the vertical loops and 4 FPS through the horizontal circuit piping. Based on these requirements, the anticipated flushing flow rate per circuit is 155 GPM which may result in a head loss of approximately 90' W.C. A portable temporary purging unit (aka flush cart) shall be utilized and shall consist of the following: purge pump-high volume and high head; open reservoir; filter assembly with by-pass; flow meter; pressure gage; connecting piping; and connection hoses.
- F. Each circuit shall be flow tested individually. The test flow rate shall be 150%, 100%, and 50% of the design flow rate, respectively, which will be determined based on the approved submitted heat pump requirements. The measured flow rate and pressure drop data shall be compared to calculated data to determine if any blockage or kinks in the piping exist.
- G. Each circuit shall undergo a hydrostatic pressure test. Hydrostatic pressure test shall be according to the HDPE manufacturer's instructions. Hydrostatic pressure test for each circuit shall be no less than 4 hours.
- H. The entire ground loop system shall undergo a hydrostatic pressure test. The test shall be no less than 4 hours.
- I. All hydrostatic pressure testing shall be performed prior to backfilling of the trenches unless site conditions dictate that this is not possible.
- J. After thorough flushing and purging, the system shall be charged with a 20% solution of inhibited propylene glycol by volume. They shall then circulate the fluid for 24 hours and measure the percentage of propylene glycol and add 100% propylene glycol to make up for any deficiency, circulate for 24 hours and confirm. In no way shall compressed air be used in the ground loop system. The propylene glycol shall be rated for use in ground source heat pumps systems and ground loops. The charged volume specified herein is the volume of the entire project system including vertical pipe, supply and return branch circuit pipes and supply and return main pipes. The propylene glycol shall contain a corrosion inhibitor/biocide concentration which the manufacture will guarantee is sufficient to prevent corrosion or biological growth at a 20% glycol concentration. The finished system shall be pressurized to between 15 and 25 psi.

3.9 BACKFILLING AND COMPACTION

- A. Prior to laying pipe in excavation, place sand bedding. Bedding fill shall be placed in layers not to exceed 9 inches in thickness as measured before compaction. Each layer shall be compacted by a minimum of four (4) coverages with hand-guided vibratory equipment or mechanical tampers as approved by the Owner Representative.
- B. Detectible underground warning tape shall be laid above all horizontal piping 12 inches to 18 inches below finished grade.
- C. After piping has been installed in trench bed and all hydrostatic testing and purging is completed, trenches shall be backfilled.
- D. Backfilling procedure for both vertical heat exchangers and horizontal return and supply pipes shall include prevention of any sharp-edged rocks from coming into contact with the pipe by removal of the rocks before bedding and backfilling.

3.10 MATERIAL DISPOSAL

- A. Any trees, wood or tree roots shall be chipped and removed from site with no charge to the Owner.
- B. Any excavated asphalt material shall be removed from site with no charge to the Owner.
- C. Any excess excavated material shall be removed offsite in conformance with all existing applicable laws and regulations with no charge to the Owner.
- D. Remove any excess excavated material from the site as instructed by the Owner's Representative at no charge to the Owner.

3.11 CHARGING OF THE COMPLETED SYSTEM

- A. Before the completed system is filled with propylene glycol, velocity flushing of all ground heat exchanger piping shall be performed to remove air & debris as discussed herein in Paragraph 3.8.
- B. Connection of the supply and return mains from the well field to the mechanical system shall not be attempted unless isolation valves are in place and closed or the outside heat exchanger installation is pressure tested, leak free, air has been purged from the system and the system has been flushed in the presence of the Owner's Representative. The Contactor shall ensure that the inside piping is tested, cleaned and flushed, all in the presence of the Engineer and/or Owner's Representative.
- C. At the completion of the fill and circulation, the Driller/Ground Loop Contractor shall provide the Owner a water analysis of the completed system indicating that the levels of glycol and water parameters meet the specification details described herein.

END OF SECTION

Ashland Public Safety Building
12 Union Street, Ashland, MA

HKT Architects
October 23, 2020
Addendum #4 December 2, 2020

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SECTION 333000

SANITARY SEWERAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

- A. All work specified in this Section shall conform to "Standard Specifications for Highway and Bridges" of the Massachusetts Department of Transportation, latest revision, herein referred to as "State Standards".
- B. Existing Conditions Plan compiled from the following sources:
 - 1. Existing conditions mapping taken from plan entitled "Topographic Plan of Land 1 East Union Street and 12-16 East Union Street (Route 135) Middlesex County Ashland, Mass" prepared by Guerriere & Halnon, Inc., dated April 7, 2020.
 - 2. Wetland Flags identifying wetland resource areas were placed by Pare Corporation on September 11, 2018 and located by Guerriere & Halnon, Inc.
- C. All sanitary sewers and appurtenances shall be designed and constructed in accordance with TR-16, "Design and Construction of Sanitary and Storm Sewers" as prepared by the Technical Advisory Board of the New England Interstate Water Pollution Control Commission.
- D. All work shall conform to the following standards
 - 1. ASTM D 3034 Type PSM Polyvinyl Chloride (PVC) Sewer Pipe and Fittings.
 - 2. ASTM D 3212 Joints for Sewer Pipes using Flexible Elastomeric Seals Federal Specification.

1.3 SUMMARY

- A. This Section includes gravity-flow, nonpressure sanitary sewerage outside the building, with the following components:
 - 1. Precast concrete and Cast-in-place concrete manholes.
 - 2. Gravity Sewer Piping.

1.4 DEFINITIONS

- A. PVC: Polyvinyl chloride plastic.

1.5 PERFORMANCE REQUIREMENTS

- A. Pipe used for sanitary sewers shall be SDR 35 unless specified otherwise on the Drawings.

1.6 SUBMITTALS

- A. Provide Shop Drawings for the following:
 - 1. Manholes: Include plans, elevations, sections, details, and frames and covers. Include design calculations, and concrete design-mix report for cast-in-place manholes.
 - 2. Pipe: Include specifications on pipe materials, dimensions, and physical characteristics.
- B. Conformance Certificates: Each shipment of castings, concrete manholes, pipe, pipe fittings, and appurtenances, shall be accompanied by the manufacturer's notarized certification and cylinder testing that materials meet specified requirements.
- C. Permits
 - 1. Provide Engineer with copy of all permits required prior to commencing work.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic pipe and fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage.
- C. Handle manholes according to manufacturer's written rigging instructions.
- D. Deliveries shall be scheduled so that the progress of the work is at no time delayed and also so that large quantities of products shall not be stored for excessive lengths of time in crowded locations or in locations where large storage areas might be considered objectionable.
- E. Avoid damage to pipe from impact, bending, compression, or abrasion during handling and storage.
- F. Ship rubber gaskets in cartons and store in a clean area away from grease, oil, ozone producing electric motors, heat, and the direct rays of the sun.
- G. Use only nylon-protected slings to handle pipe. The use of hooks or bare cables will not be permitted.
- H. The Contractor shall dispose of pipe damaged during delivery, handling, or storage and replace at no cost to the Owner.

1.8 PROJECT CONDITIONS

- A. Interruption of Existing Sanitary Sewerage Service: do not interrupt service to facilities occupied by Owner or others.

1.9 PERMITS

- A. The Contractor shall obtain any permits required by the local authority prior to commencing with work affecting the sanitary sewer system.
- B. No work shall commence until the Contractor has acquired all required permits and receives authorization from the Engineer.

1.10 MARKINGS

- A. Mark pipe with the following information applied at intervals of not more than 5 feet:
1. Manufacturer's name or trademark.
 - a. Nominal pipe size;
 - b. PVC cell classification;
 - c. Applicable dimension ratio;
 - d. Date and location of manufacturer;
 - e. Applicable standard designation number.

PART 2 - PRODUCTS

2.1 IDENTIFICATION

- A. Underground-Type Line Markers for Non-Metallic Pipelines: Manufacturer's standard permanent detection tape, bright-colored, continuous printed polyethylene tape with a metallic core for each detection of non-metallic underground installations, intended for direct-burial service; not less than 6" wide x 4 mils thick. Provide green detection tape with black printing reading "CAUTION SEWER LINE BURIED BELOW" as manufactured by Seton or approved equivalent.

2.2 POLYVINYL CHLORIDE GRAVITY SEWER PIPE

1. PVC pipe. Pipe and fittings for main sewer pipe may be polyvinyl chloride (PVC) made by a manufacturer of established reputation, meeting the requirements of ASTM-D-3033 or D-3034-77 or the latest revision thereto, with a pipe diameter to wall thickness ratio (SDR) of thirty-five (35). Maximum pipe length shall be thirteen (13) feet with elastomeric ring, bell and spigot style joint, meeting the requirements of ASTM-D3212-76 or the latest revision thereto.
2. Laterals. Pipe and fittings for laterals shall be polyvinyl chloride (PVC), six (6) inches in size and meeting the same requirements as for the main pipe. Fittings shall be molded one-piece construction, and a PVC cap, designed for use on the bell end of the pipe, shall be used where necessary.
3. The pipe and fittings shall be homogeneous throughout and free from visible cracks, holes, foreign inclusion, or other injurious defects. The pipe shall be as uniform as commercially practical in color, capacity, density, and other physical properties.
4. Joints shall be bell and spigot. The bell shall consist of an integral wall section with a solid cross section rubber ring factory-assembled, securely locked in place to prevent displacement. Joints shall conform to ASTM Standard D 3212. For SCH 40 PVC piping, joints shall be glued with a PVC cement approved by the manufacturer.
5. All fittings and accessories shall have dimensions as recommended by the manufacturer and have bell and/or spigot configurations compatible with that of the pipe.
6. Pipe shall pass impact resistance test in accordance with ASTM D 2444 and minimum pipe stiffness test at 5% deflection in accordance with ASTM D 2412.
7. The normal length of 12-inch size and smaller pipe shall be 12.5 feet and 15-inch size shall be no longer than 20 feet.
8. Pipe and fittings shall be manufactured in the United States of America and shall be accompanied by the manufacturer's certificate of compliance, in addition to meeting the performance tests specified hereinafter.
9. If required by the Owner's representative, prior to installation, six specimen lengths each 6-inches long of each size pipe shall be furnished by the Contractor for impact resistance test and three specimen lengths each 6-inches long of each size pipe for pipe stiffness test. These tests are to be made in accordance with ASTM D 2444 and ASTM D 2412,

respectively, at the expense of the Contractor. No pipe shall be accepted if the tests do not meet the test requirements.

10. Sanitary building sewer connections. Wyes shall be required for all sanitary building sewer connections to the public sewer main and shall be the same type of material and manufacture as the pipe. Connections to an existing public sewer main shall be accomplished by the use of a cast-iron saddle with stainless steel strap and bolts.

- B. PVC pipe shall be SCH 40 where pipe has less than 2 feet of cover or as directed by the Engineer.

1. PVC pipe shall meet ASTM F794, latest revision.
2. Joints shall be bell and spigot. Joints shall be glued with a PVC cement approved by the manufacturer.

2.3 NONPRESSURE-TYPE PIPE COUPLINGS

- A. Flexible Couplings: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end as manufactured by Fernco, Inc. or approved equivalent.

2.4 MANHOLE MATERIALS

- A. Cement shall be Portland cement conforming to ASTM C150, Type III, high early strength.
- B. Aggregate: shall conform to ASTM C330 and shall be graded, crushed stone with a resulting unit weight of concrete of up to one hundred fifty five (155) pounds per cubic foot, and a minimum unit weight of not less than one hundred forty-eight (148) pounds.
- C. Water: shall be clear and free of injurious and deleterious substances.
- D. Concrete: shall have a minimum strength of 5000 psi at twenty eight (28) days and a strength of 3000 psi at the time of form release.
- E. During the process of manufacturing of the units not less than two (2) test cylinders shall be tested at time release of the form and two (2) at age twenty-eight (28) days.
- F. All compression test cylinders shall be made, cured and stored in accordance with ASTM C31.
- G. Cylinders shall be tested in accordance with ASTM C39.
- H. All concrete shall be air entrained as specified per RIDOT Standard Specifications.
- I. Admixtures shall only be used after prior approval of the Engineer.
- J. All reinforcing bars shall conform to the requirements of ASTM designation: A615, Grade 60.
- K. Welded wire fabric shall conform to the requirements of ASTM designation: A185.

2.5 PRECAST CONCRETE MANHOLES AND BRICK

- A. Construction. Manholes shall be constructed of reinforced precast concrete monolithic base sections, barrel sections and dome sections and shall meet the applicable requirements of ASTM Specification C478-7OT, latest revision, design based upon H-20 loadings. All manholes delivered to the site must be approved by the Superintendent. In general, reasons for rejection will include, but not be limited to, porous or cracked walls, misformed joints and pipe connectors

which vary more than one (1) inch from those indicated on the plans. Rejected manholes shall be removed from the site by the licensed pipelayer.

- B. Preliminary inspection. All precast manhole sections shall be delivered to the construction site without exterior coatings. Upon on-site approval by the Superintendent, the licensed pipelayer shall apply, by roller or brush, a heavy application of emulsified asphalt waterproofing compound.
- C. Unless otherwise noted on the Drawings, sanitary manholes less than or equal to ten (10) feet deep shall have an interior diameter of 48 inches. Manholes greater than ten (10) feet shall have an interior diameter of 60 inches unless otherwise noted. All manholes with interior drops shall have an interior diameter of 60 inches unless otherwise noted. Manholes with an interior diameter of 72 inches shall be utilized where indicated on the Drawings.
- D. Openings for pipe insertions shall be round and shall be precast or cored only. The diameter of the opening shall be adequate to install a rubber boot seal. The cored or precast opening shall maintain a minimum undisturbed distance of 6" from manhole section joints. Flexible rubber boot shall be neoprene with stainless steel clamps and bands.
- E. All concrete manholes shall have a 6 inch concrete collar integrally cast as part of the base section. Concrete collars shall be the same depth as the base of the structure

2.6 MANHOLE FRAMES AND COVERS

- A. Manhole Frames and Covers shall be cast iron and conform to the details on the drawings. Cast iron shall conform to ASTM A-48, Class 25. The underside of the cover and upper side of lip frame must present parallel plane surfaces, and at these points of contact, the frames and covers shall be machined to prevent covers from rocking in the frames under traffic.
- B. Frame and covers shall be capable of withstanding H-20 highway loading.
- C. Covers shall bear evenly in the frame and both frame seats and covers shall be accurately fabricated so that covers are interchangeable for use with any and all frames. Where indicated, frames and covers shall be watertight, and locked. The sizes and weights (medium duty, heavy duty, etc.) are shown on the detail sheets for special manholes.
- D. Mortar shall consist of one part cement and two parts clean sand. No lime shall be used.
- E. Covers shall have a non-slip surface and shall have the word "SEWER" inscribed.
- F. Frames and covers shall be installed on the manholes as indicated on the drawings. They shall be well bedded and encased in cement mortar and accurately set to the grades indicated or as directed. Red clay brick with cement mortar shall be used to adjust grade of frame and cover. One half inch of cement mortar plaster cast shall be applied to exterior of red clay bricks.

2.7 MANHOLE STEPS

- A. Manhole steps shall be aluminum alloy 6061 T6, extruded, safety-type, cast in place, twelve (12) inches on center, in the barrel and dome sections, and the portion of the step imbedded in concrete, plus two (2) inches, shall be coated with aluminum oxide.
- B. Steps may be constructed of continuous grade 60 steel bar, three-eighths (3/8) inch outside diameter, molded within polypropylene plastic with a safety tread surface. All interior steps shall be installed during manhole manufacture.

2.8 WATERPROOFING FOR UNDERGROUND STRUCTURES

- A. Elastomeric waterproofing membrane shall conform to ASTM C836.
- B. All exterior surfaces of underground manholes shall receive one coat of waterproofing.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Section 31 0000 - Earthwork.

3.2 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground sanitary sewerage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Gravity-Flow, Non-pressure Sewer Piping: Use the following pipe materials as specified on the Drawings:
 - 1. SDR 35 sewer pipe and fittings; gaskets; and gasketed joints.
- C. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.
- D. The area below the pipe and extending to six (6) inches above the crown of PVC pipe and D.I. pipe shall be backfilled with compacted granular material, as specified under pipe laying, and thoroughly tamped by light tampers as placed. The remainder of the side fill to a minimum depth of twenty-four (24) inches above the top of pipe shall be a select, fine ordinary borrow material, approved for such use by the Superintendent, placed in twelve-inch layers and compacted by hand tamping. No stones larger than three (3) inches across the largest dimension will be allowed within this stratum of backfill.
- E. The remainder of backfill to the surface of the ground or to the bottom of the gravel subbase in roadway locations shall be ordinary borrow, approved by the Superintendent, placed in twelve-inch layers and thoroughly compacted by mechanical rammers or vibrators. No rock larger than twelve (12) inches in diameter will be allowed within this stratum of backfill, and all voids within rock backfill must be completely filled. Alternate methods for compaction within this stratum presented by the licensed pipelayer will be considered by the Superintendent, and the licensed pipelayer shall be required to demonstrate to the Superintendent's satisfaction that his proposed method of compaction will produce the intended results for the various conditions and materials encountered.
- F. Install gravity-flow, non-pressure, drainage piping according to the following:
 - 1. Install piping pitched down in direction of flow, to the slope indicated on the Drawings. An even alignment of the pipe shall be maintained.
 - 2. Install piping with 36-inch minimum cover unless specified otherwise on the Drawings.
 - 3. The Contractor shall excavate around the bell portion of the pipe so the pipe barrel bears on the prepared bed.

4. Blocking is not permitted.
 5. All pipes shall be clean and free of dirt before laying and open ends shall be kept covered and free of dirt during construction.
 6. Where new pipes are to adjoin existing structures, extreme care shall be taken in coring into existing structure. Tight waterproof connections shall be made without interrupting service.
- G. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.
- H. Pipe elevation. All sanitary building sewer pipe shall be laid to a minimum slope of one-fourth (1/4) inch per foot unless otherwise approved by the Superintendent. The sanitary building sewer should be brought to the building on a uniform slope and at an elevation appropriate to the connection with the existing sanitary building drain. In any building in which the building drain is too low to permit gravity flow to the public sewer, sanitary sewage carried by such building drain may be lifted by an approved means and discharged to the sanitary building sewer.
- I. The Contractor shall install piping as specified to within 5 feet of the building foundation. The Plumbing Contractor shall make the connection to the sanitary sewer from this point.
- J. Where installing pipe below standing water table, trench shall be dry and free of water and pipe bedding. Below bottom of pipe can be replaced with 1 1/2" crushed stone.
- K. Glue all joints for Sch 40 PVC pipe.

3.3 PIPE JOINT CONSTRUCTION

- A. Join gravity-flow, non-pressure, drainage piping according to ASTM D 2321 and ASTM D 2751 for elastomeric-seal joints and manufacturer's recommendations.
1. Machinery shall not be used to push the pipe into place. The pipe shall be pushed into place by hand. The use of a hammer or mallet is permitted, with the use of a board to shield the end of the pipe being struck by the hammer. The pipe shall not be directly contacted with a hammer or mallet.

3.4 MANHOLE INSTALLATION

- A. General: Install manholes complete with appurtenances and accessories indicated.
- B. Install precast concrete manhole sections with sealants according to ASTM C 891.
- C. Construct cast-in-place manholes as indicated.
- D. Form continuous concrete or brick channels and benches between inlets and outlet as specified on Drawings.
- E. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Red clay brick for table, invert and grade adjusting courses shall be hard burned of uniform Grade B. Red clay brick shall be laid with all joints completely filled with mortar and the inside and outside faces covered with mortar and troweled smooth. The maximum height allowable for grade adjustment of the manhole frame with the brick masonry shall be twelve (12) inches.
- F. Set manhole barrel and cone sections vertically and in true alignment.

- G. Concrete Base Slabs for manholes and shall have a full thickness of 12 inches extending 6 inches beyond the outside walls. Manhole joints. The joint between the base section and the barrel section shall be brushed clean and a strip of butyl rubber shall be placed completely around the joint prior to placement of the barrel section. Once the barrel section has been placed, a timber shall be placed across the top of the section and a controlled downward pressure shall be applied with the hydraulic excavating machine to the complete joint. The same method shall be used in making the joints between the remaining barrel section and dome section. Precast concrete flat slab top sections shall be used if height limitations prohibit the use of a dome section.
- H. Manhole installation. The licensed pipelayer shall excavate to a depth of six (6) inches below the bottom of the manhole base, compact and fine grade and install washed screened gravel subbase material. The base section shall be placed to grade and the pipes connected. Pipes shall extend approximately one (1) inch inside the interior wall, with clamps on the connector tightened and mortar troweled on the inside face of the manhole-to-pipe connection.
- I. Bottom riser sections of reinforced concrete manholes and catch basins may be either cast-in-place or precast concrete. The top edges, of cast-in-place bottom sections, shall be formed with a removable steel ring template designed to fit the tongue end of the precast riser sections.
- J. Inverts and table shall be constructed of red clay brick with mortar joints. Care shall be taken in construction of brick inverts that the width of the invert shall be slightly larger than the inside diameter of the larger of the pipes entering the manhole wall. Bricks shall be laid in a full bed of mortar with push joints, and all brick shall be thoroughly wet immediately before laying.
- K. Manhole table. The table shall be constructed at an elevation even with the top of the pipe and shall slope up toward side walls. Inverts shall be constructed in a manner to provide smooth flow through manholes, with no sharp turns or projecting portions of brick. Bottom sections of straight line manhole inverts may be constructed using one-half (1/2) section of pipe cut longitudinally and carefully set to grade, upon approval of the Superintendent. The half-pipe section must be securely braced during installation of concrete fill around the invert to prevent flotation. Brick for inverts shall be placed on edge and laid flat for table.
- L. Joints: Pipe joints into manholes shall be constructed in accordance with the details shown on the plans. Complete details of the boot manufacture and installation shall be submitted for approval. Pipe-to-manhole connection shall be made with a flexible rubber boot and stainless steel clamp. The flexible rubber boot pipe-to-manhole connector shall be installed during manufacture of precast manhole sections and shall include a stainless steel screw clamp designed specifically for use on the size and type of pipe utilized on the project. If PVC pipe is used, a continuous bead of silicone shall be applied to the inside of the boot at the clamp location prior to installation of the pipe.
- M. Sealing of joints. Once the manhole has been assembled and prior to backfill, hydraulic cement shall be applied to all lift holes and manhole joints, including exterior boot-to-manhole joint.
- N. Bricks shall be laid in a workmanlike manner, true to line, and the joints shall be carefully struck and pointed on the inside. Bricks shall be thoroughly wet when laid and each brick shall be laid in mortar so as to form full bed, end and side joints in one operation. The outside of the brickwork shall be neatly plastered with ½" layer of cement mortar as the work progresses. The brickwork shall be satisfactorily bonded to the concrete and cast iron frame. No brick masonry shall be laid in water, or any water allowed to rise on the brickwork until the masonry has set for at least 24 hours.
- O. Waterproofing: All exterior surfaces of underground manholes shall receive one coat of waterproofing.

- P. Backfilling. Once the vacuum test has been completed, select ordinary borrow shall be backfilled around the manhole, with no stone larger than three (3) inches within eighteen (18) inches of the concrete wall. Material shall be placed leveled and compacted in twelve-inch lifts.

3.5 IDENTIFICATION

- A. Materials and their installation are specified in Section 31 00 00 - Earthwork. Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.

1. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.6 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.

1. Defects requiring correction include the following:
 - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
 - b. Deflection: A mandrel shall be pulled through the pipe to check overall deflection, and the pipe through which a mandrel cannot be pulled without extreme force shall be considered failed. The mandrel shall have an outside diameter seven percent (7%) less than the pipe inside diameter and shall be supplied by the pipe manufacturer for this purpose..
 - c. Crushed, broken, cracked, or otherwise damaged piping.
 - d. Infiltration: Water leakage into piping.
 - e. Exfiltration: Water leakage from or around piping.
2. The Contractor shall repair any defects or corrections required by the Engineer.
3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified at no expense to the Owner.
4. Reinspect and repeat procedure until results are satisfactory at no expense to the Owner.

- B. Testing Manholes:

1. All sanitary manholes shall be vacuum tested prior to backfilling.
2. Install vacuum tester and inflate compression band to affect a seal between the vacuum base and the new manhole, connect vacuum pump to the outlet part with the valve open, draw a vacuum of 10 inches of mercury, (HG), and close the valve.
3. The manhole shall pass the test if the vacuum remains at 10 inches of HG in a time greater than 60 seconds for a manhole up to 10 feet deep, time greater than 75 seconds for a manhole 10.1 to 15 feet deep, and time greater than 90 seconds for a manhole 15-25 feet deep.
4. If the manhole fails the initial test, the Contractor shall make proper repairs or replace the manhole and re-test at no additional compensation.

- C. Testing Gravity Sewers:

1. Low Pressure Air Test:
 - a. After completing backfill of the pipeline, the Contractor shall, at his expense, conduct a line acceptance test. The test shall be performed according to stated procedures and in the presence of the Engineer. The line shall be flushed and cleaned prior to testing.
 - b. Test guidelines. All testing shall be done by an individual or company experienced and equipped in this type of work. A certification of the test results shall be required

for each section between manholes, with the stationing corresponding to the submitted plans. The Superintendent shall be notified forty-eight (48) hours in advance of testing. At no time shall construction proceed further than two thousand (2,000) feet from the last section tested.

- c. All pneumatic plugs shall be seal-tested before being used in the actual test installation. One (1) length of pipe shall be laid on the ground and sealed at both ends with the pneumatic plugs to be checked. Air shall be introduced into the plugs to 25 psig. The plugs shall hold against this pressure without bracing and without movement of the plugs out of the pipe.
 - d. After a manhole-to-manhole reach of pipe has been backfilled and cleaned, and the pneumatic plugs are checked by the above procedure, the plugs shall be placed in the line at each manhole and inflated to 25 psig. Low-pressure air shall be introduced into this sealed line until the internal air pressure reaches 4 psig greater than the average backpressure of any groundwater that may be over the pipe. At least two minutes shall be allowed for the air pressure to stabilize.
 - e. After the stabilization period (3.5 psig minimum pressure in the pipe), the air hose from the control panel to the air supply shall be disconnected. The portion of line being tested shall be termed "acceptable". If the time required in minutes for the pressure to decrease from 3.5 to 2.5 psig (greater than the average back pressure of any groundwater that may be over the pipe) shall not be less than one and zero-tenths (1.0) minute per inch diameter of the particular pipe being tested.
 - f. If the installation fails the air test, the Contractor shall, at his expense determine the source of leakage. He shall then repair or replace all defective materials and/or workmanship to Engineer's satisfaction and the pipeline shall be re-tested, all performed at no additional compensation to the Contractor.
2. Infiltration Test:
- a. The infiltration test shall be conducted at such time as the ground water level is at a height of not less than one foot above the top of the pipe for the full length of the section of sewer being tested.
 - b. Each manhole-to-manhole reach shall be tested separately. At no time will the Contractor be allowed to test more than one manhole-to-manhole reach.
 - c. The Contractor shall construct such weirs or other means of measurement as shall be required and shall do such pumping as shall be necessary to enable the tests to be made satisfactorily.
 - d. The groundwater leakage into the pipes will be measured by the Engineer after a minimum of one hour and the infiltration rate shall not exceed 50 gallons per day per mile per inch-diameter.

D. Pipe Deflection:

1. Pipe provided shall be so installed that there be a maximum deflection of 7 percent. Such deflection shall be computed by multiplying the amount of deflection (nominal diameter of the pipe less minimum diameter when measured) by 100 and dividing by the nominal pipe diameter.
2. The Contractor shall measure the amount of deflection by pulling a specially designed gauge assembly through the completed section after 120 days of installation. The gauge assembly shall be in accordance with the recommendations of the pipe manufacturer and be acceptable to the Engineer.
3. Should the installed pipe fail to meet this requirement, the Contractor shall do all work to correct the problem as the Engineer may require without additional compensation.

E. Leaks and loss in test pressure constitute defects that must be repaired. All repairs shall be at the expense of the Contractor.

- F. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.7 CLEANING

- A. Interior of piping and manholes shall be cleaned of dirt and superfluous material prior to acceptance of sanitary sewer.

3.8 CLOSING ABANDONED SANITARY SEWERAGE SYSTEMS

- A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:
 - 1. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.
- B. Abandoned Manholes: Excavate around manhole as required and use either procedure below:
 - 1. Remove manhole and close open ends of remaining piping.
 - 2. Remove top of manhole down to at least 60 inches below final grade

3.9 RECORD DRAWINGS

- A. All installed underground utilities shall be designated on as-built drawings by the contractor of record and provided to the Owner and Engineer in AutoCad electrical format prior to completion of the project. All as-built drawings, (underground and above ground) shall be dimensioned from permanent benchmarks such as existing buildings and include depths at various points throughout the extent of the work, and invert elevations at all structures.

END OF SECTION

Ashland Public Safety Building
12 Union Street, Ashland, MA

HKT Architects
October 23, 2020

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SECTION 334000

STORM DRAINAGE UTILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

- A. All work specified in this Section shall conform to "Standard Specifications for Highway and Bridges" of the Massachusetts Department of Transportation, latest revision, herein referred to as "State Standards".
- B. Existing Conditions Plan compiled from the following sources:
 - 1. Existing conditions mapping taken from plan entitled "Topographic Plan of Land 1 East Union Street and 12-16 East Union Street (Route 135) Middlesex County Ashland, Mass" prepared by Guerriere & Halnon, Inc., dated April 7, 2020.
 - 2. Wetland Flags identifying wetland resource areas were placed by Pare Corporation on September 11, 2018 and located by Guerriere & Halnon, Inc.

1.3 SUMMARY

- A. This Section includes gravity-flow, nonpressure storm drainage outside the building, with the following components:
 - 1. Pipe
 - 2. Precast concrete drain manholes
 - 3. Precast concrete catch basins
 - 4. Grates
 - 5. Subdrainage
 - 6. Trench drains
 - 7. PVC Barrier
 - 8. Cleanouts
 - 9. Area Drains
 - 10. Underground Detention System

1.4 DEFINITIONS

- A. PVC: Polyvinyl chloride plastic.
- B. HDPE High Density Polyethylene.
- C. RCP Reinforced Concrete Pipe
- D. PE: Polyethylene

1.5 SUBMITTALS

- A. The Contractor shall submit for approval, manufacturer's printed recommendations for the storage, protection, handling, installation and testing of stormwater piping, fittings and appurtenances, which shall be strictly adhered to by the Contractor.
- B. Shop Drawings: For the following:
 - 1. Manholes: Include plans, elevations, sections, details, and frames and covers. Include design calculations, and concrete design-mix report for cast-in-place manholes.
 - 2. Catch Basins: Include plans, elevations, sections, details, and frames, covers, and grates.
 - 3. Trench Drain: Include plans, elevations, section details and grates.
 - 4. Pipe of all materials.
 - 5. PVC Barrier: Include specifications on materials, dimensions, and physical characteristics. Indicate manufacturer's recommended method for joining and bonding multiple sections.
- C. Conformance Certificate: Each shipment of castings and concrete manholes and catch basins shall be accompanied with the manufacturer's notarized certification and cylinder testing results that materials meet specified requirements.
- D. Record Drawings: All installed underground utilities shall be designated on as-built drawings by the contractor of record and provided to the Owner and Engineer in AutoCad electrical format prior to completion of the project. All as-built drawings, (underground and above ground) shall be dimensioned from permanent benchmarks such as existing buildings and include depths at various points throughout the extent of the work, and invert elevations at all structures.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Protect pipe, pipe fittings, and seals from dirt and damage.
- B. Handle catch basins and manholes according to manufacturer's written rigging instructions.
- C. Use only nylon-protected slings to handle pipe. The use of hooks or bare cables will not be permitted.
- D. Avoid damage to castings from impact, abrasion, or corrosion during handling and storage.
- E. Do not store PVC piping and fittings in the sunlight for extended periods of time. Store pipe in accordance with manufacturer's recommendations.
- F. Ship rubber gaskets in cartons and store in a clean area away from grease, oil, ozone producing electric motors, heat and the direct rays of the sun.
- G. Use all means necessary to protect precast concrete units and materials before, during and after installation and to protect the installed work and materials for all other trades.
- H. In case of damage, immediately make all repairs and replacements necessary to the approval of the Owner's Representative at the Contractor's expense.
- I. Pipe, pipe fittings, and other associated appurtenances damaged during deliver handling or storage shall be replaced at no additional cost to the Owner.

1.7 PROJECT CONDITIONS

- A. The Contractor shall provide means of stormwater management during construction to control runoff and protect downstream areas from damage resulting from stormwater runoff.
- B. The Contractor is responsible for any damage resulting from stormwater runoff during construction, including damage from flooding.

1.8 QUALITY CONTROL

- A. All precast concrete shall be the product of a manufacturer who has demonstrated capability to produce precast concrete products of the quality specified. A manufacturer must be able to show that he has experienced personnel, physical facilities, established quality control procedures, and a management capability sufficient to execute the work of this contract. When requested by the Owner's Representative, the Contractor shall submit written evidence of the above requirements.
- B. Experienced plant personnel shall closely supervise the manufacturing process, and daily records of concrete strength shall be kept and submitted to the Owner's Representative for control.
- C. Provide at least one person who shall be present at all times during execution of this portion of the work and who shall be thoroughly trained and experienced in the installation of the precast concrete structures and shall direct all work performed under this Section.

PART 2 - PRODUCTS

2.1 PVC PIPE AND FITTINGS

- A. PVC Profile Gravity Pipe and Fittings: ASTM F 794 pipe, with bell-and-spigot ends; ASTM D 3034 fittings, with bell ends.
- B. The pipe and fittings shall be homogeneous throughout and free from visible cracks, holes, foreign inclusion or other injurious defects. The pipe shall be as uniform as commercially practical in color, capacity, density and other physical properties.
- C. Joints shall be bell and spigot. For SDR-35 PVC pipe, the bell shall consist of an integral wall section with a solid cross section rubber ring factory-assembled, securely locked in place to prevent displacement. Joints shall conform to ASTM Standard D 3212. For SCH 40 PVC piping, joints shall be glued with PVC cement approved by the manufacturer.
- D. All fittings and accessories shall have dimensions as recommended by the manufacturer and have bell and/or spigot configurations compatible with that of the pipe.
- E. Pipe shall pass impact resistance test in accordance with ASTM D 2444 and minimum pipe stiffness test at 5% deflection in accordance with ASTM D 2412.
- F. The normal length of 12-inch size and smaller pipe shall be 12.5 feet.
- G. Pipe and fittings shall be manufactured in the United States of America and shall be accompanied by the manufacturer's certificate of compliance, in addition to meeting the performance tests specified hereinafter.
- H. PVC pipe shall be SCH 40 where pipe has less than 2 feet of cover or as directed by the Owner's Representative.

- I. PVC perforated pipe shall conform to ASTM/ANSI D 2759 or ASTM F 810. Perforations shall be 5/8" holes on 5" centers.

2.2 HIGH-DENSITY POLYETHYLENE PIPE AND FITTINGS

- A. High-Density Polyethylene Pipe and fittings shall be ADS N-12 IB ST Smooth Interior Pipe, ADS N-12 IB ST High Capacity Large Diameter Pipe or approved equivalent. Joints shall be soil-tight and include a rubber gasket on the spigot end of the pipe. When installed into the bell end, the joint shall be sealed.
- B. Pipe shall conform to AASHTO M294 (Type 'S') for the specified diameters and strength classes.
- C. Pipe shall be rated to withstand H-20 Loading Criteria with 18" of cover.

2.3 REINFORCED CONCRETE PIPE

- A. Reinforced-Concrete Pipe and Fittings: ASTM C 76 (ASTM C 76M), with bell-and-spigot ends and sealant joints with ASTM C 990 (ASTM C 990M), bitumen or butyl-rubber sealant.
- B. Pipe shall conform to AASHTO M170 for the specified diameters and strength classes. The minimum cement content shall be 564 pounds per cubic yard.
- C. Strength class of reinforced concrete pipe shall be Class III unless specified otherwise on the drawings.
- D. Joint of reinforced concrete pipe shall be made with flexible watertight rubber gaskets and the remaining exterior void of the joint shall be sealed with Portland cement mortar.

2.4 FLEXIBLE PIPE COUPLINGS

- A. Flexible Couplings: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end as manufactured by Fernco Inc. or approved equivalent.

2.5 CLEANOUTS

- A. Cast-Iron Cleanouts: Frame and cover shall be able to withstand HS-20 loading criteria.
- B. PVC cleanouts: PVC body with PVC cap and screw type cover set no more than 6" below cast iron frame and cover. The cast iron cover shall be set to finish grade and secured with concrete as shown in the Drawings. Frame and cover shall be able to withstand H20-44 loading criteria.

2.6 MANHOLE AND CATCH BASIN MATERIALS

- A. Cement shall be Portland cement conforming to ASTM C150, Type III, high early strength.
- B. Aggregate: shall conform to ASTM C330 and shall be graded, crushed stone with a resulting unit weight of concrete of up to one hundred fifty-five (155) pounds per cubic foot, and a minimum unit weight of not less than one hundred forty-eight (148) pounds.
- C. Water: shall be clear and free of injurious and deleterious substances.

- D. Concrete: shall have a minimum strength of 5000 psi at twenty-eight (28) days and a strength of 3000 psi at the time of form release.
- E. During the process of manufacturing of the units not less than two (2) test cylinders shall be tested at time release of the form and two (2) at age twenty-eight (28) days.
- F. All compression test cylinders shall be made, cured and stored in accordance with ASTM C31. Cylinders shall be tested in accordance with ASTM C39.
- G. All concrete shall be air entrained as specified per MADOT Standard Specifications.
- H. Admixtures shall only be used after prior approval of the Engineer.
- I. All reinforcing bars shall conform to the requirements of ASTM designation: A615, Grade 60.
- J. Welded wire fabric shall conform to the requirements of ASTM designation: A185.

2.7 PRECAST CONCRETE MANHOLES, CATCH BASINS AND BRICK

- A. Precast Concrete Manhole and Catch Basin sections shall be equal to that shown on the drawings and shall conform to ASTM Specifications C-478 and C-76 Class IV Wall "B". The horizontal joints between sections shall be sealed using a flexible butyl resin sealant and shall conform to ASTM C-990. In addition, the horizontal joints on the inside and outside of the manhole and catch basin shall be sealed with a "Quick Plug" as manufactured by Parson or approved equal.
- B. Brick shall conform to ASTM Specification C-32, except that the table therein is amended to provide that the required minimum compressive strength in pounds per square inch shall be for any individual brick 3,000 or 5,000 for the average of five bricks selected at random. The maximum absorption of water by five-hour boiling test shall not exceed 16% for any individual brick or 12% for the average of any five bricks selected at random.
- C. Unless otherwise noted on the Drawings, manholes less than fifteen (15) feet deep shall have an interior diameter of 48 inches. Manholes fifteen (15) feet and deeper shall have an interior diameter of 60 inches unless otherwise noted. Manholes with an interior diameter of 72 inches shall be utilized where indicated on the Drawings. All catch basins shall have an interior diameter of 48 inches unless specified otherwise.
- D. Openings for pipe insertions shall be round and shall be precast or cored only. The diameter of the opening shall be adequate to install a rubber boot seal. The cored or precast opening shall maintain a minimum undisturbed distance of 6" from manhole section joints. Flexible rubber boot shall be neoprene with stainless steel clamps and bands.
- E. Weirs for diversion manholes may be constructed with concrete block joined with mortar or cast into the structure. Contractor shall form each weir as depicted on the plans. Provide a watertight seal with no gaps between weir wall and structure wall. Weirs shall be connected to structure wall using epoxy coated steel rebar reinforcement.

2.8 MANHOLE FRAMES AND COVERS

- A. Manhole Frames and Covers shall be cast iron and conform to the details on the drawings. Cast iron shall conform to ASTM A-48, Class 25. The underside of the cover and upper side of lip frame must present parallel plane surfaces, and at these points of contact, the frames and covers shall be machined to prevent covers from rocking in the frames under traffic.

- B. Covers shall bear evenly in the frame and both frame seats and covers shall be accurately fabricated so that covers are interchangeable for use with any and all frames. Where indicated, frames and covers shall be watertight, and locked. The sizes and weights (medium duty, heavy duty, etc.) are shown on the detail sheets for special manholes.
- C. Mortar shall consist of one part cement and two parts clean sand. No lime shall be used.
- D. Covers shall have a non-slip surface and shall have the word "DRAIN", inscribed.
- E. Frames and covers shall be installed on the manholes as indicated on the drawings. They shall be well bedded and encased in cement mortar and accurately set to the grades indicated or as directed. Red clay brick with cement mortar shall be used to adjust grade of frame and cover. One half inch of cement mortar plaster cast shall be applied to exterior of red clay bricks.
- F. All concrete manholes shall have a 6 inch concrete collar integrally cast as part of the base section. Concrete collars shall be the same depth as the base of the structure.

2.9 CATCH BASIN FRAMES AND GRATES

- A. Catch Basin Frames and Grates shall be cast iron and conform to the details on the drawings. Cast iron shall conform to ASTM A-48, Class 25. The underside of the grate and upper side of lip frame must present parallel plane surfaces, and at these points of contact, the frames and grates shall be machined to prevent grates from rocking in the frames under traffic.
- B. Grate shall bear evenly in the frame and both frame seats and grates shall be accurately fabricated so that grate is interchangeable for use with any and all catch basin frames.
- C. Beehive grates shall be installed on the catch basins as indicated on the drawings.
- D. Gratings shall have a non-slip surface.
- E. Gratings shall be installed on the catch basins as indicated on the drawings. They shall be well bedded and encased in cement mortar and accurately set to the grades indicated or as directed. Red clay brick with cement mortar shall be used to adjust frame and grate. One half inch of cement mortar plaster cast shall be applied to exterior of red clay bricks.

2.10 MANHOLE STEPS

- A. Manhole steps shall be manufactured of Copolymer Polypropylene plastic with ½" grade 50 steel reinforcement.
- B. Steps shall conform to ASTM D-4101 under Type II.
- C. The capacity of each step shall be 1000 lb. at 5-1/8 inch distance from wall and 1500 lb. at 4-inch distance from wall.
- D. Steps shall measure 12 inches wide (min.) and extend 5-1/8 inches from wall.
- E. Manhole steps shall be provided in each base, riser and top section and shall be integrally cast in each; 12 inches O.C.

2.11 TRENCH DRAINS

- A. Trench Drain shall be a Series 8 trench drain system manufactured by MultiDrain, Inc. or approved equivalent.
- B. Use 4,000 psi concrete confirming to Section 030000 Concrete.
- C. Grate shall be cast iron and rated to withstand H-20 loading criteria.
- D. Trench Drain shall be rated to withstand H-20 loading criteria.

2.12 GEOTEXTILES

- A. Refer to Section 310000 for requirements regarding geotextile filter fabrics.

2.13 PVC BARRIER

- A. Barrier shall be a PVC membrane of sufficient tensile strength to withstand perforation including cracking, tearing, and breaking during installation and backfill.
- B. Barrier shall be a minimum of 30 mils thick and constructed of PVC.
- C. Barrier shall have no holes, gaps, or perforations.
- D. Geomembrane/liner must have factory seemed and welded on a roll, NOT FOLDED on pallets.

2.14 IDENTIFICATION

- A. Underground-type line markers for non-metallic pipelines: manufacturer's standard permanent detection tape, bright-colored, continuous printed polyethylene tape with a metallic core for each detection of non-metallic underground installations, intended for direct-burial service; not less than 6" wide x 4 mils thick. Provide green detection tape with black printing reading "Caution Drain Line Buried Below" as manufactured by Seton or approved equivalent.

2.15 CATCH BASIN HOODS

- A. All catch basin outlet pipes on new catch basins and all outlet pipes on existing catch basins shall be fitted with a catch basin hood.

2.16 OUTLET CONTROL STRUCTURES

- A. Provide precast control structures, outlet structures shall conform to the dimensions shown on the plans and details and shall include a including galvanized steel bar grate fastened to the top of the unit. Outlet control structures shall be precast concrete units designed for AASHTO HS20-44 loading, with openings as shown on the detail drawings.

2.17 STORMWATER HYDRODYNAMIC SEPERATOR

- A. Acceptable suppliers may be Vortsentry Contech Stormwater Solutions, Hydroguard by Hydroworks, Downstream Defender, or approved equivalent.
- B. Materials and Design

1. Concrete for precast stormwater treatment systems shall conform to ASTM C857 and C478 and meet the following additional requirements:
 - a. In all cases the wall thickness shall be no less than the minimum thickness necessary to sustain HS20 loading requirements.
 - b. Sections shall have tongue and groove or ship-lap joints with a butyl mastic sealant conforming to ASTM C990.
 - c. Cement shall be Type I, II, or III Portland cement conforming to ASTM C150.
 - d. All sections shall be cured by an approved method. Sections shall not be shipped until the concrete has attained a compressive strength of 4,000 psi (28 MPa) or other designate suitable handling strength.
 - e. Pipe openings shall be sized to accept pipes of the specified size(s) and material(s), and shall be sealed by the Contractor with a hydraulic cement conforming to ASTM C595M.

C. Performance

1. Each stormwater treatment system shall have treatment, sediment storage, and oil storage capacities equal to or greater than that shown on the table on the project plans. For the purpose of determining equivalency, the treatment capacity shall be defined as the flow rate at which the stormwater treatment system removes 80% of an unground silica sample having an average particle size equal to or less than 240 microns. Treatment capacity shall be additionally defined as the maximum flow rate prior to which bypass of any flow occurs. Calculations must be provided to show the criteria are met with the shop drawing for the treatment system submitted.
2. Each stormwater treatment system shall provide documented full-scale testing that corroborates the capacities as listed in the table above and defined above. Said documentation shall include at a minimum testing for removal capabilities and sediment wash-out characteristics at the treatment capacities listed in table above.
3. Each stormwater treatment system shall have the capability of bypassing high flow internally as well as controlling through the treatment chamber so as to avoid wash-out of previously captured pollutants under high flow conditions.
4. Each stormwater treatment system shall include a circular chamber with a tangential inlet to induce a swirling flow pattern within the treatment chamber. The outlet from the treatment chamber shall be located in the center of the chamber so as to maximize the particle flow path within the treatment system.
5. Each stormwater treatment system shall be of a hydraulic design that includes flow controls designed and certified by a professional engineer using accepted principles of fluid mechanics that raise the water surface inside the tank to a pre-determined level in order to prevent the re-entrainment of trapped floating contaminants.
6. Each stormwater treatment system shall be designed to not allow surcharge of the upstream network during dry weather conditions.
7. Each stormwater treatment system shall be contained within one concrete manhole structure.

2.18 CONCRETE VAULT DETENTION SYSTEM

- A. Manufacturer shall be StormTrap, LLC, United Concrete Products, Concrete Systems Inc, or approved equivalent.
- B. Stormwater detention modules shall be engineered, precast units with dimensions per the plans.
- C. Concrete:

1. Minimum Compressive Strength: 6,000 psi at 28 days.
2. Entrained Air Content: 5 to 8 percent.
3. Maximum Slump: 4 inches.
4. Reinforcing Bars: ASTM A 615, Grade 60.
5. Cover for Reinforcing Bars: ACI 318.

D. Joint Tape:

1. ASTM C990
2. 7/8-inch diameter, preformed mastic joint sealer.
3. Approved by Manufacturer.

E. Minimum Structural Design Loading: ASTM C 857.

1. Total Cover Maximum and minimum shall be per the plans
2. Concrete chamber shall be designed for AASHTO HS-20 wheel load and applicable impact.
3. Minimum soil pressure shall be 2,000 psf.
4. Vertical and lateral soil pressures shall be determined using the groundwater elevation shown on the plans.

F. Concrete chamber designed for AASHTO HS-20 Highway Loading Min Soil Pressure 2000 PSF.

G. The system shall be per the dimension shown on the plans.

H. The system shall be water tight.

I. Contractor shall submit calculations showing the system is not buoyant.

2.19 AREA DRAINS

- A. PVC surface drainage inlets shall include the drain basin type as indicated on the contract drawing and referenced within the contract specifications.
- B. The ductile iron grates for each of these fittings are to be considered an integral part of the surface drainage inlet and shall be furnished by the same manufacturer.
- C. Drain basins grates in hardscaped areas shall be ADA compliant. Drain basin grates in landscaped areas shall be standard grates.
- D. The drain basins required for this contract shall be manufactured from PVC pipe stock, utilizing a thermoforming process to reform the pipe stock to the specified configuration. The drainage pipe connection stubs shall be manufactured from PVC pipe stock and formed to provide a watertight connection with the specified pipe system. This joint tightness shall conform to ASTM D3212 for joints for drain and sewer plastic pipe using flexible elastomeric seals. The flexible elastomeric seals shall conform to ASTM F477. The pipe bell spigot shall be joined to the main body of the drain basin or catch basin. The raw material used to manufacture the pipe stock that is used to manufacture the main body and pipe stubs of the surface drainage inlets shall conform to ASTM D1784 cell class 12454.
- E. The grates and frames furnished for all surface drainage inlets shall be ductile iron and shall be made specifically for each basin so as to provide a round bottom flange that closely matches

the diameter of the surface drainage inlet. Grates for drain basins shall be capable of supporting various wheel loads as specified. Ductile iron used in the manufacture of the castings shall conform to ASTM A536 grade 70-50-05. Grates and covers shall be provided painted black.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavation, trenching, and backfilling are specified in Section 310000 "Earthwork."

3.2 PIPE INSTALLATION

- A. Reinforced Concrete Pipe: The method of joining reinforced concrete pipe sections shall be such that the ends are fully entered, and the inner surfaces are reasonably flush and even. Joints shall be made with rubber gaskets and Portland Cement grout. The completed joints shall be protected against rapid drying by suitable covering material.
- B. Use only nylon-protected slings to handle pipe. The use of hooks or bare cables will not be permitted.
- C. PVC Piping: No machinery shall directly contact the PVC pipe to push the pipe into place. The pipe shall be pushed into place by hand. The use of a hammer or mallet is permitted, with the use of a board to shield the end of the pipe being struck by the hammer. The pipe shall not be directly contacted with a hammer or mallet. Any pipe damaged while being pushed into place or while being laid in the trench shall be removed from the site and replaced at the expense of the Contractor.
- D. Pipe shall be inspected before any backfill is placed. Any pipe determined by the Owner's Representative to be out of alignment, unduly settled, or damaged shall be taken up and re-laid or replaced at no additional cost to Owner.
- E. General Locations and Arrangements: Drawing plans and details indicate location and arrangement of underground storm drainage piping. Install piping as indicated, following piping manufacturer's written instructions.
- F. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
- G. If conflicts between utilities, the Contractor shall stop work on the utilities, contact the Engineer, and await direction from the Engineer.
- H. Install piping with 36-inch minimum cover unless otherwise specified on the Drawings.
- I. Install piping with a minimum slope as specified on Drawings.
- J. Install PVC piping according to ASTM D 2321, ASTM F 1668, and manufacturer's recommendations.
- K. Install reinforced-concrete piping according to ASTM C 1479 and manufacturer's recommendations.

3.3 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extension from drain pipe to cleanout at grade. Cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.
- B. Set cleanout frames and covers in earth in a cast-in-place concrete block, 12 by 12 by 8 inches deep. Top of concrete block shall be laid 3" below finished grade. Top of frame shall be set flush with finish grade where laid in earth.
- C. Set cleanout frames and covers in bituminous concrete and concrete pavement or slabs with tops flush with pavement surface. Top of concrete block shall be laid at the bottom of the bituminous binder course where laid in pavement surface.

3.4 MANHOLE INSTALLATION

- A. Excavation and backfilling requirements for installation of manhole and catch basin structures shall be in accordance with the requirements as specified in Section 310000, Earthwork.
- B. Manhole and catch basin barrel and cone sections shall be set so as to be vertical and in true alignment.
- C. Where required for future connections, openings shall be cast in the manholes and catch basins at the proper location and shall be sealed with watertight brick bulkheads or plugs.
- D. The inverts of all manholes shall be constructed of brick and formed to the details shown on the contract drawings.
- E. Concrete Base Slabs for manholes and catch basins shall have a full thickness of 12 inches shall extend 6 inches beyond the outside walls.
- F. Bottom riser sections of reinforced concrete manholes and catch basins may be either cast-in-place or precast concrete. The top edges, of cast-in-place bottom sections, shall be formed with a removable steel ring template designed to fit the tongue end of the precast riser sections.
- G. Inverts: Where pipe alignment permits, and where directed by the Owner's Representative, the pipe shall be continued through the manhole and the top half carefully and evenly cut away. Where changes in alignment occur, unless otherwise authorized by the Engineer, inverts shall be constructed of brick and mortar with a smooth flow line and an even curve in accordance with the plans.
- H. Joints: Pipe joints into manholes and catch basins shall be constructed in accordance with the details shown on the plans. Complete details of the boot manufacture and installation shall be submitted for approval. All areas around pipes passing through walls of manholes and catch basins shall be completely filled with waterproof cement mortar to tightly fill any space through which water can pass. All manhole and catch basin joints between sections shall be sealed with 1" diameter Butyl rubber sealant with hydraulic cement and coated with bitumastic sealant on the exterior.
- I. Bricks shall be laid in a workmanlike manner, true to line, and the joints shall be carefully struck and pointed on the inside. Bricks shall be thoroughly wet when laid and each brick shall be laid in mortar so as to form full bed, end and side joints in one operation. The outside of the brickwork shall be neatly plastered with ½" layer of cement mortar as the work progresses. The brickwork shall be satisfactorily bonded to the concrete and cast iron frame. No brick masonry shall be laid

in water, or any water allowed to rise on the brickwork until the masonry has set for at least 24 hours.

- J. Water-proofing: All exterior surfaces of manholes and catch basins shall receive at least one coat of asphalt water-proofing.

3.5 TRENCH DRAIN SYSTEM INSTALLATION

- A. Install Trench Drain System at elevations indicated.
- B. Install Trench Drain System according to manufacturer's requirements and specifications.
- C. Set tops of grating frames and grates flush with finished surface, unless otherwise indicated.

3.6 PVC BARRIER INSTALLATION

- A. Install in accordance with manufacturer's recommendations.
- B. Install barrier at the elevations indicated on the plans.
- C. No holes or gaps shall be made during installation and backfill or to hold the barrier in place. Barrier shall be impervious.

3.7 STORMWATER HYDRODYNAMIC SEPERATOR INSTALLATION

- A. The stormwater treatment system shall be installed in strict accordance with the manufacturer's recommendations.
- B. Excavation, bedding, backfill and compaction for the structure shall be as specified in Section 31 00 00, EARTHWORK.
- C. The structure shall be watertight upon the completion of the installation.

3.8 AREA DRAIN INSTALLATION

- A. Install according to manufacturer's requirements and specifications.
- B. Set tops of grating frames and grates flush with finished surface, unless otherwise indicated.
- C. The specified PVC surface drainage inlet shall be installed using conventional flexible pipe backfill materials and procedures.
- D. The backfill material shall be crushed stone or other granular material meeting the requirements of class 1 or class 2 material as defined in ASTM D2321. Bedding and backfill for surface drainage inlets shall be well placed and compacted uniformly in accordance with ASTM D2321.
- E. The drain basin body will be cut at the time of the final grade. No brick, stone or concrete block will be required to set the grate to the final grade height.
- F. For load rated installations, a concrete slab shall be poured under and around the grate and frame. The concrete slab must be designed taking into consideration local soil conditions, traffic loading, and other applicable design factors.

3.9 CONCRETE VAULT DETENTION SYSTEM

- A. Examine area to receive storm water detention modules. Notify Engineer if area is not acceptable. Do not begin installation until unacceptable conditions have been corrected
- B. Verify in field before installation, dimensions and soil conditions, including groundwater and soil bearing capacity.
- C. Install storm water detention modules in accordance with manufacturer's instructions and ASTM C 891.
- D. Install modules plumb, on line, and to proper elevation.
- E. Install modules plumb, on line, and to proper elevation.
- F. Place modules on level, cast-in-place concrete foundation with 1-foot overhang as indicated on the Drawings.
- G. Cast-in-place concrete for foundation shall be as specified in Section 033000 (03 30 00) and as follows:
 - 1. Minimum Compressive Strength: 4,000 psi at 28 days.
 - 2. Entrained Air Content: 5 to 8 percent.
 - 3. Maximum Slump: 4 inches.
- H. Joint Tape:
 - 1. Seal perimeter horizontal joint of modules to concrete foundations with joint tape in accordance with ASTM C 891, 8.8 and 8.12.
 - 2. Prepare surfaces and install joint tape in accordance with manufacturer's instructions.
- I. Joint Wrap:
 - 1. Seal exterior joints between adjacent modules with joint wrap in accordance with ASTM C 891.
 - 2. Prepare surfaces and install joint wrap in accordance with manufacturer's instructions.
- J. Fill:
 - 1. Deposit fill on both sides of modules at same time and to approximate same elevation.
 - 2. Prevent wedging action against structure by stepping or serrating slopes bounding or within area to be backfilled.
 - 3. Do not disrupt or damage joint wrap from joints during backfilling.
- K. Excavation and fill shall be as specified in Section 31 00 00 (31 00 00).
- L. Do not use stormwater detention modules that are damaged, as determined by manufacturer.

3.10 CLOSING ABANDONED STORM DRAINAGE SYSTEMS

- A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use procedure below:
 - 1. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.
- B. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:
 - 1. Remove manhole or structure and close open ends of remaining piping.
 - 2. Remove top of manhole or structure down to at least 48 inches below final grade. Fill manhole below this point with gravel borrow and compact to 92%
 - 3. Backfill to grade according to Section 310000 - Earthwork.

3.11 IDENTIFICATION

- A. Materials and their installation are specified in Section 310000 - Earthwork. Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.
 - 1. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.12 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
 - 1. Defects requiring correction include the following:
 - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
 - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
 - c. Crushed, broken, cracked, or otherwise damaged piping.
 - d. Infiltration: Water leakage into piping.
 - e. Exfiltration: Water leakage from or around piping.
 - 2. The Contractor shall, at his own expense, replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
 - 3. The Contractor shall repair any defects or corrections required by the Owner's Representative.

3.13 CLEANING

- A. The Contractor shall clean interior of piping and structures of dirt, debris, and superfluous materials prior to commencing work, during construction and prior to acceptance of stormwater drainage system.
- B. The Contractor shall also clean downstream portions of the stormwater conveyance system which recovered silt deposits from the construction activity.

3.14 RECORD DRAWINGS

- A. All installed underground utilities shall be designated on as-built drawings by the contractor of record and provided to the Owner and Engineer in AutoCAD electrical format prior to completion of the project. All as-built drawings, (underground and above ground) shall be dimensioned from permanent benchmarks such as existing buildings and include depths at various points throughout the extent of the work, and invert elevations at all structures.

END OF SECTION

Ashland Public Safety Building
12 Union Street, Ashland, MA

HKT Architects
October 23, 2020

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SECTION 344100

ROADWAY SIGNALING AND CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

- A. All work specified in this Section shall conform to "Standard Specifications for Highway and Bridges" of the Massachusetts Department of Transportation, latest revision, herein referred to as "State Standards".
- B. Existing Conditions Plan compiled from the following sources:
 - 1. Existing conditions mapping taken from plan entitled "Topographic Plan of Land 1 East Union Street and 12-16 East Union Street (Route 135) Middlesex County Ashland, Mass" prepared by Guerriere & Halnon, Inc., dated April 7, 2020.
 - 2. Wetland Flags identifying wetland resource areas were placed by Pare Corporation on September 11, 2018 and located by Guerriere & Halnon, Inc.

1.3 SUMMARY

- A. This work consists of removing old and installing new traffic control equipment and performing associated roadway improvements at the intersection of Union Street and Waverly Street with East Union Street in Ashland, Massachusetts, as indicated in the Contract Drawings.
- B. The existing equipment to be removed, stockpiled and reset at this location includes the following:
 - 1. Six (6) traffic signal heads
 - 2. One (1) video detection camera
- C. The Contractor shall remove and dispose or remove and salvage at the engineer's discretion the remaining equipment including one (1) controller cabinet, two (2) strain poles and all associated wiring.
- D. The Contractor shall tag all equipment to be stockpiled. The tag shall note the intersection from which the components were stockpiled, the date of the stockpiling operation, and some means of identifying the other associated equipment. All stockpiled traffic signal equipment shall be returned to the intersection of Union Street and Waverly Street with East Union Street at the appropriate time to be installed at modified locations.
- E. The new equipment to be installed at this location includes the following:
 - 1. Four (4) traffic signal heads
 - 2. Two (2) mast arms
 - 3. One (1) signal pedestal
 - 4. Three (3) emergency preemption detectors

5. One (1) emergency preemption confirmation beacon
6. One (1) emergency preemption phase selector
7. Two (2) video detection cameras
8. One (1) video detection system hardware unit
9. One (1) controller cabinet
10. Two (2) manual preemption switches

- F. The Contractor shall install all conduit, wiring, pull boxes and service connections associated with this equipment, as indicated on the Contract Drawings. Additionally, all sidewalks and pedestrian ramps shall be reconstructed as indicated on the Plans and repaired, as necessary, to existing or ADA acceptable slopes and grades and any disturbed curbing shall be replaced.
- G. Further, the Contractor shall install wireless radio units being procured independently by the Town to provide communication of preemption calls to the adjacent signal at the intersection of Union Street and Fountain Street. The Town will be installing similar wireless radio units at this intersection. The Contractor shall coordinate the installation schedule with that of the adjacent signal.

1.4 DEFINITIONS

- A. AASHTO: American Association of State Highway Transportation Officials
- B. ADA: Americans with Disabilities Act
- C. APD: Accessible Pedestrian Detector
- D. MassDOT: Massachusetts Department of Transportation
- E. MUTCD: Manual on Uniform Traffic Control Devices

1.5 SUBMITTALS

- A. Product Data: For each type of manufactured material and product indicated. Indicate name, source, and description of each material and product.

Shop Drawings: Design calculations are required for the mast arm and foundation as described in Section 2.3 of these specifications.

1.6 QUALITY ASSURANCE

- A. Design Requirements
1. Signal mast arms, posts, and foundations shall be designed in accordance with MassDOT MAST ARM & FOUNDATION Details Standard Drawings as described in Section 2.3 of these specifications.

1.7 PROJECT CONDITIONS

- A. Traffic Control: Access for vehicular and pedestrian traffic through the project area is required at all times.

PART 2 - PRODUCTS

2.1 SIGNAL EQUIPMENT

A. Signal equipment shall include:

1. Ten (10) traffic signal heads – six (6) salvaged
2. Two (2) mast arms
3. One (1) signal pedestal
4. Three (3) emergency preemption detectors
5. One (1) emergency preemption confirmation beacon
6. One (1) emergency preemption phase selector
7. Three (3) video detection cameras – one (1) salvaged
8. One (1) video detection system hardware unit
9. One (1) controller cabinet
10. Two (2) manual preemption switches

B. The traffic control equipment installed at this intersection shall be Gloss Black which shall match Color Number 17038 of the Federal Standard 595C "Colors Used in Government Procurement", with the exception of the inside of the visors, which shall be Flat Black in accordance with Federal Color Number 37038.

2.2 EMERGENCY VEHICLE PREEMPTION SYSTEM

- A. The new traffic signal shall provide Optical Emergency Vehicle Preemption. The system shall be compatible with the Town's existing preemption equipment. The emergency vehicle preemption system shall be Global Traffic Technologies (GTT) Opticom Priority Control System model 700 series.
- B. The emergency vehicle preemption control system shall consist of a data-encoded phase selector to be installed within the traffic control cabinet. This unit will serve to validate, identify, classify and record the signal from the optical detectors located on support structures at the intersection. Upon receiving a valid signal from the detector, the phase selector shall generate a preempt call to the controller initiating a preemption operation as shown on the plans.
- C. The optical detectors shall be single input, single output units used to control one approach. The optical detectors shall be GTT Opticom model 711. The optical confirmation beacon shall be GTT Opticom model 768.
- D. The phase selector shall be a rack-mounted plug-in four channel, multi-mode, dual priority device manufactured by GTT Opticom model 764. The phase selector shall plug into the Loop Detector Rack or plug into a shelf-mounted single card slot chassis GTT Opticom Model 760 series. Programming the phase selector shall be via a PC-based computer utilizing unit specific software. One copy of software, on compact disc shall be supplied and licensed to the Town of Ashland. A hard copy of final programming data shall be left in the control cabinet. The Contractor shall supply a complete set of interface cables for phase selector to laptop connection
- E. The Contractor shall install a confirmation strobe at the traffic signal location as shown on the plans. The confirmation strobe shall serve to validate to the driver of the emergency vehicle that the traffic signal has recognized the preemption call and will initiate the proper preemption sequence. The confirmation strobe shall have a clear lens. The strobe light for the emergency vehicle preemption system shall not be energized by a spare traffic signal conductor. It shall be connected to the cabinet by its own cable/wire.

- F. The Contractor shall install one (1) manual preemption switch adjacent to the eastern garage bay and one (1) manual preemption switch in the dispatch room. Associated conduit and wiring shall be run from the controller cabinet to the building and within the building.

2.3 MAST ARMS AND FOUNDATIONS

- A. This work consists of designing and installing mast arms and their foundations in accordance with the MassDOT MAST ARM & FOUNDATION Details Standard Drawings. The mast arms and foundations shall be installed at the locations indicated on the Plans.
- B. The Contractor is responsible for both the design and construction of the foundation required for each mast arm. The foundation design shall be based on the geotechnical data provided in the boring logs included in these specifications. See Section 3.3 of these specifications for mast arm loading.
- C. Shop drawings shall include a surveyed cross section of the proposed mast arm location. All utilities, both overhead and underground shall be included on the cross section to confirm required clearances.

2.4 VIDEO DETECTION SYSTEM

- A. This item of work shall include furnishing and installing a Video Detection System comprised of three (3) Video Detection Cameras and one (1) Video Detection System Hardware Unit connected by Video Detection Cable. The Video Detection System shall monitor vehicles approaching the intersection via the processing of video images and provide detector outputs to the traffic controller. The Video Detection System shall be capable of providing detection for each approach to the intersection, up to and including two (2) travel lanes. Each Video Detection System Camera is to be mounted on the signal mast arm as indicated on the Plans and the Video Detection Hardware Unit is to be rack-mounted within the traffic signal cabinet.
- B. The Video Detection System shall provide flexible, user configurable detection zone placement at any orientation within the field of view of each Video Detection System Camera. It shall be possible to overlap detection zones. The Video Detection System shall provide failsafe operation whereby it places continuous vehicle calls to the traffic signal controller on all detection zones in the event it senses unacceptable video from the Video Detection System Cameras. The Video Detection System shall be capable of detecting bicycle traffic in addition to vehicular traffic.
- C. Video Detection System Hardware
 - 1. The Video Detection System Hardware Unit shall operate without degradation over a temperature range of -34 to 74 degrees Celsius at a relative humidity of 10% to 90%.
 - 2. The Video Detection System Hardware Unit shall include an interface device which shall be installed in the traffic control cabinet.
 - a. The interface device shall be used to terminate the traffic controller cabinet end of the Video Detection System Cable.
 - b. The interface device shall contain transient suppression devices for all signals transported on the Video Detection System Cable, including but not limited to video, data, and power.
 - c. The interface device shall contain a switch that shall allow the user to turn off AC service to all components of the Video Detection System.

3. The Video Detection System Hardware Unit shall include all necessary electronics for processing the video signal from the Video Detection System Cameras, if necessary, and providing detection signals to the traffic signal controller.
4. The Video Detection System Hardware Unit shall include all necessary cables for interconnection to the traffic signal controller and AC power service.
5. The Video Detection System Hardware Unit shall provide indicators on the front of the unit which will illuminate when each detection zone is occupied by a vehicle.

D. Video Detection System Cameras

1. The Video Detection System Cameras shall be mast arm mounted as shown on the plans.
2. The Video Detection System Cameras shall be housed in a water resistant, dust proof NEMA-4 housing. The housing shall include a rear connector for connection of the Video Detection System Cable. The housing shall be field rotatable to allow for proper alignment between the camera and the traveled road surface.
3. The Video Detection System Cameras shall have a heater to prevent the formation of ice and condensation in cold weather and allow the camera to operate correctly while exposed to precipitation and direct sunlight.
4. The Video Detection System Cameras shall have a sunshield to protect the lens from direct sunlight and direct precipitation exposure.
5. The Video Detection System Cameras shall provide useable video and resolvable features in the video image when those features have luminance levels as low as 0.1 lux at night, and as high as 10,000 lux during the day. The Video Detection System Cameras shall contain an automatic gain control (AGC) to provide a satisfactory image over the full range of light levels.
6. The Video Detection System Cameras shall operate without degradation over a temperature range of -34 to 60 degrees Celsius at a relative humidity of 10% to 90%.

E. Video Detection Cable

1. The video detection cable shall connect the Video Detection System Hardware Unit, located within the traffic signal cabinet, to the Video Detection System Cameras, mounted to the signal mast arm as indicated on the Plans.
2. Video feed shall be run to/within the building to the dispatch room.
3. The Video Detection Cable shall transport all required signals between the Video Detection Hardware Unit and the Video Detection Cameras.
4. The cable shall be capable of withstanding the rigors of outdoor environments, including all combinations of precipitation, heat and cold from -34 to 74 degrees Celsius, and direct sunlight exposure without exhibiting any signs of deterioration over time. The Video Detection System Cable shall be installed with a suitable drip loop to prevent the entrance of water into the housing.

PART 3 - EXECUTION

3.1 SIGNAL EQUIPMENT

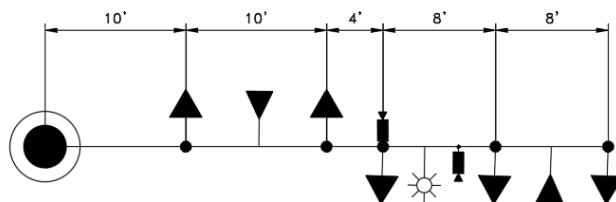
- A. Precaution should be taken to avoid damage to any existing materials that are to remain in place. If damage occurs, it shall be repaired by the Contractor at no additional cost to the Town. The methods employed in performing the work, including all equipment, tools, and machinery used in handling material and executing any part of the work, shall be subject to the approval of the Engineer prior to the commencement of work. If the proposed methods are found unsatisfactory, they shall be changed to the Engineer's specifications and approval.
- B. All improvements, equipment, and existing surfaces disturbed, damaged, or removed in performing this item of work shall be replaced to the satisfaction of the Engineer at no expense to the Town. This item of work shall not commence until directed by the Engineer.
- C. The intersection shall remain open to traffic while work is being performed on the traffic signal. It is the responsibility of the Contractor to maintain access to adjacent driveways during construction. The Contractor shall plan and schedule the work accordingly.

3.2 EMERGENCY VEHICLE PREEMPTION SYSTEM

- A. The Contractor shall be responsible for the proper programming of the phase selector, orientation of the optical detectors, and all other work necessary to provide a complete and operating emergency vehicle preemption system.
- B. The Contractor may be required to field adjust the location of the optical detectors for optimum line of sight detection in the presence of the Engineer to properly detect preemption calls from approaching vehicles.

3.3 MAST ARMS AND FOUNDATIONS

- A. In designing mast arms and mast arm foundations, the contractor shall refer to the boring logs attached to these specifications. For loading, the contractor shall account for signal head spacing as indicated on the Plans for the mast arm serving the Union Street and East Union Street approaches. For the mast arm serving the Waverly Street approach, the mast arm and foundation shall be designed to account for a 40' mast arm and five (5) 3-section signal heads as shown in the below configuration to allow the Town of Ashland flexibility to reconfigure the geometry of the intersection in the future. Additionally, the final position and geometry of the mast arm shall be coordinated with Eversource to stay clear of conflicts with the existing overhead wires. An arched mast arm may be necessary.



3.4 VIDEO DETECTION SYSTEM

- A. Prior to installation of the Video Detection System a detailed site survey shall be conducted by a factory trained and certified representative. The site survey shall ensure that the design of each camera, camera location, camera optics, and video/data interconnect is appropriate for the

application. The supplier of the Video Detection System shall supervise the installation and testing of the Video Detection System. A factory certified representative from the supplier shall be on site during installation.

- B. All components of the Video Detection System shall be installed in accordance with the manufacturer's recommendations. The locations of the video detection zones shown on the plans are approximate. Final size and locations of the video detection zones shall be positioned in the field and tested in cooperation with the Engineer to ensure that detection zones are established to cover the approach width and that the detection system is functioning to the satisfaction of the Engineer.
- C. Video Detection System Cameras
 - 1. The Video Detection System Cameras shall be bracket mounted to the mast arm as indicated in the Plans. The camera mounting bracket shall be a maximum of 23" long. The Video Detection System Cameras shall be installed based on the recommendations of the manufacturer.
- D. Video Detection Cable
 - 1. The Video Detection Cable shall be furnished, handled, stored, and installed in accordance with the requirements within Subsection 813 of the Massachusetts Standard Specifications for Highways and Bridges, 2020 Edition, the recommendations of the manufacturer, and as directed by the Engineer.

3.5 METHOD OF MEASUREMENT

- A. ROADWAY SIGNALING AND CONTROL EQUIPMENT for Union Street / Waverly Street / East Union Street, as defined and including all elements described above, will be measured as a lump sum item.

3.6 BASIS OF PAYMENT

- A. The accepted quantities of ROADWAY SIGNALING AND CONTROL EQUIPMENT for Union Street / Waverly Street / East Union Street will be paid for as a lump sum item. The price so-stated constitutes full and complete compensation for all labor, materials, and equipment, and all other incidentals required to finish the work complete and accepted by the Engineer.

END OF SECTION 344100

Ashland Public Safety Building
12 Union Street, Ashland, MA

HKT Architects
October 23, 2020

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SECTION 407723

VIBRATION MONITORING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Furnish, install, maintain, monitor, and remove vibration monitoring equipment as specified and as indicated.
- B. Monitor vibrations, and noise levels originating from construction operations as indicated or specified.
- C. Modify construction operation procedures if existing operation creates vibration, or noise exceeding specified amounts.

1.02 QUALITY ASSURANCE:

- A. Provide in accordance with Section 01400.
 - 1. Installation, monitoring and interpretation of monitoring equipment shall be performed by personnel with the following qualifications:
 - a. Have at least three (3) years of experience in the operation of monitoring equipment proposed for use and interpretation of records produced by such equipment.
 - b. Have installed, operated, monitored and interpreted equipment and records on at least three 3 projects with vibration-inducing operations, and noise levels from similar construction activities.

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01300.
 - 1. Two weeks prior to commencement of vibration inducing operations, submit in writing the plan for monitoring operations and equipment to be used to assure compliance with the vibration, and noise limitation. As a minimum, this plan shall provide for the following:
 - a. Recommended vibration limiting methods to meet the specified peak particle velocity limitations and locations for taking measurements.
 - b. Manufacturer's brochures and written operation instructions for seismograph recording equipment intended to be used for each vibration occurrence.
 - 2. Daily reports, while performing vibration-inducing operations, detailing each source of vibration, location of monitoring, and the vibration records highlighting peak particle velocities.

PART 2 - PRODUCTS

2.01 EQUIPMENT:

- A. Provide a low frequency sensitive three-component seismic recording instrument with wave paper trace, variable trigger level setting, peak particle velocity memory operation (in inches/second) and sound level readout capability that meets the following criteria:
 - 1. Seismic Frequency Range: 2 to 200 Hz (+/- 3 dB)
 - 2. Acoustic Frequency Range: 2 to 200 Hz (+/- 1 dB)

3. Velocity Range: 0.02 to 4.0 inches per second.
4. Sound Range: 90 to 140 dB linear.
5. Transducer: Three mutually perpendicular axes: radial, transverse, and vertical.
6. Recording: Time-history of waveform capability.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Monitor vibrations and record the entire particle velocity wave train, not just peak velocities. Obtain accurate, legible seismometer records of monitored vibrations.
- B. Perform all vibration-inducing operations so that vibrations reaching adjacent structures and facilities are within specified limits.
- C. Monitor vibrations by measuring the peak particle velocity in the vicinity of work. The peak particle velocity at the location as specified in the submitted vibration monitoring plan, shall not exceed the limits specified below:

Type of concrete	Age of Concrete (hrs)	Peak Particle Velocity (in/sec)
Mass Concrete (footings, mats, Slab-on-grade, fill concrete, etc.)	0-11	1.0
	11 and over	2.0
Concrete Structures (walls, columns, elevated slabs, etc.)	0-11	0.5
	11-24	1.0
	24 and over	2.0
Existing Structures, residences or utilities	-	2.0*
		0.5**

* for transient sources (e.g. blasting)

** for continuous sources (e.g. vibratory pile drivers)

- D. In the event any recordings indicate that vibration limits are being exceeded, immediately suspend all vibration-inducing operations and submit a report to the Owner or Owner's Representative. Revise operations to reduce vibrations and submit a copy of the revised procedure to the Design Builder.
- E. If evidence of displacement or damage to utilities, equipment, or structures is observed or reported, immediately notify the Owner or Owner's Representative and discontinue operations creating the vibrations. Revise operation to reduce vibrations and submit a copy of the revised procedure to the Owner or Owner's Representative.
- F. Restore or replace utilities, equipment, or structures damaged by vibrations at no additional cost.

END OF SECTION