

HVAC UPGRADES BRENDA VILLA AQUATIC CENTER CITY OF COMMERCE SPECIFICATIONS



Prepared for
City of Commerce
Brenda Villa Aquatic Center
5600 Harbor St., Commerce, CA 90040



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October 2, 2018

TABLE OF CONTENTS

SPECIFICATIONS

BRENDA VILLA AQUATIC CENTER HVAC UPGRADES

CITY OF COMMERCE

DRAWING LIST – All drawings dated October 2, 2018, unless otherwise noted

DIVISION 01 – GENERAL CONDITIONS

SECTION 01 1100 SUMMARY OF THE WORK

SECTION 01 1400 WORK RESTRICTIONS

DIVISION 02 – EXISTING CONDITIONS

SECTION 02 4119 SELECTIVE DEMOLITION

DIVISION 05 - METALS

SECTION 05 1200 STRUCTURAL STEEL FRAMING

SECTION 05 4000 COLD-FORMED METAL FRAMING

DIVISION 07 – THERMAL AND MOISTURE PROTECTION

SECTION 07 0150 ROOF REPAIR

SECTION 07 6200 SHEET METAL FLASHING AND TRIM

SECTION 07 9200 JOINT SEALANTS

DIVISION 09 – FINISHES

SECTION 09 9123 INTERIOR PAINTING

**BRENDA VILLA AQUATIC CENTER HVAC UPGRADES
CITY OF COMMERCE**

DIVISION 23 – HEATING, VENTILATING, AND AIR CONDITIONING

SECTION 23 0500	MECHANICAL GENERAL PROVISIONS
SECTION 23 0516	BASIC MECHANICAL MATERIALS AND METHODS
SECTION 23 0519	PIPING SPECIALTIES
SECTION 23 0529	HYDRONIC PIPING, FITTINGS, SUPPORTS AND CLEANING
SECTION 23 0548	VIBRATION AND SEISMIC CONTROL
SECTION 23 0553	HVAC PIPING & EQUIPMENT IDENTIFICATION
SECTION 23 0554	MECHANICAL IDENTIFICATION
SECTION 23 0700	MECHANICAL INSULATION
SECTION 23 0800	MECHANICAL SYSTEMS COMMISSIONING
SECTION 23 0900	CONTROLS AND INSTRUMENTATION
SECTION 23 2000	VALVES
SECTION 23 3100	DUCTWORK
SECTION 23 3300	DUCTWORK ACCESSORIES
SECTION 23 3400	DUCT CLEANING
SECTION 23 8300	SEMI-CUSTOM PACKAGED ROOFTOP UNIT
SECTION 23 8400	EXHAUST FANS
SECTION 23 9100	TESTING, ADJUSTING, AND BALANCING FOR HVAC
SECTION 23 9500	BUILDING AUTOMATION SYSTEM
SECTION 23 9600	SEQUENCES OF OPERATIONS

DIVISION 26 - ELECTRICAL

SECTION 26 0000	BASIC ELECTRICAL MATERIALS AND METHODS
SECTION 26 0519	INSULATED WIRE AND CABLE
SECTION 26 0536	WIREWAYS AND CABLE TRAYS

**BRENDA VILLA AQUATIC CENTER HVAC UPGRADES
CITY OF COMMERCE**

DIVISION 23 – HEATING, VENTILATING, AND AIR CONDITIONING

SECTION 23 0500	MECHANICAL GENERAL PROVISIONS
SECTION 23 0516	BASIC MECHANICAL MATERIALS AND METHODS
SECTION 23 0519	PIPING SPECIALTIES
SECTION 23 0529	HYDRONIC PIPING, FITTINGS, SUPPORTS AND CLEANING
SECTION 23 0548	VIBRATION AND SEISMIC CONTROL
SECTION 23 0553	HVAC PIPING & EQUIPMENT IDENTIFICATION
SECTION 23 0554	MECHANICAL IDENTIFICATION
SECTION 23 0700	MECHANICAL INSULATION
SECTION 23 0800	MECHANICAL SYSTEMS COMMISSIONING
SECTION 23 0900	CONTROLS AND INSTRUMENTATION
SECTION 23 2000	VALVES
SECTION 23 3100	DUCTWORK
SECTION 23 3300	DUCTWORK ACCESSORIES
SECTION 23 3400	DUCT CLEANING
SECTION 23 8300	SEMI-CUSTOM PACKAGED ROOFTOP UNIT
SECTION 23 8400	EXHAUST FANS
SECTION 23 9100	TESTING, ADJUSTING, AND BALANCING FOR HVAC
SECTION 23 9500	BUILDING AUTOMATION SYSTEM
SECTION 23 9600	SEQUENCES OF OPERATIONS

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SECTION 26 0536	WIREWAYS AND CABLE TRAYS

**BRENDA VILLA AQUATIC CENTER HVAC UPGRADES
CITY OF COMMERCE**

SECTION 26 0548	VIBRATION CONTROL & SEISMIC RESTRAINT
SECTION 26 0553	NAMEPLATES AND WARNING SIGNS
SECTION 26 2416	PANELBOARDS
SECTION 26 2726	WIRING DEVICES
SECTION 26 2816	ENCLOSED SWITCHES AND CIRCUIT BREAKERS

**BRENDA VILLA AQUATIC CENTER HVAC UPGRADES
CITY OF COMMERCE**

SECTION 26 0548	VIBRATION CONTROL & SEISMIC RESTRAINT
SECTION 26 0553	NAMEPLATES AND WARNING SIGNS
SECTION 26 2416	PANELBOARDS
SECTION 26 2726	WIRING DEVICES
SECTION 26 2816	ENCLOSED SWITCHES AND CIRCUIT BREAKERS

SECTION 01 11 00

SUMMARY OF THE WORK

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Project information.
 2. Project delivery method.
 3. Work covered by Contract Documents.
 4. Work by Owner.

1.2 PROJECT INFORMATION

- A. This project is called the Brenda Villa Aquatic Center HVAC Upgrades.
- B. The Brenda Villa Aquatic Center is located at 5600 Harbor Street, Commerce, California 90040.
- C. The Construction Work includes, but is not necessarily limited to, the following:
1. Demolition.
 2. Infrastructure.
 3. General Construction.
 4. HVAC System.
 5. Controls System.
 6. Electrical System.
 7. Some Structural and Architectural.
- D. The entire project scope shall be performed per the approved Contract Documents, including drawings, specifications, and approved submittals. A summary of the project is presented below, which shall include, but not be limited to, the following:
1. Demolish the existing 50-ton rooftop unit (RTU) packaged, electric DX cooling, variable air volume (VAV) unit.
 2. Provide one new 70-ton rooftop unit (RTU-1) packaged, electric DX cooling, variable air volume (VAV) in the same location unit, with the same general arrangement, serving the same areas and functions as the existing unit, but with two additional VAV zones with hot water reheat and duct distribution. The two

additional VAV terminal reheat air terminal units (VAV boxes) shall provide HVAC to the Spectator Viewing Area.

3. Include variable frequency drives (VFDs) for the supply fan and return fan of RTU-1
4. Include an economizer for RTU-1.
5. Provide two new exhaust fans, EF-1 and EF-2.
6. Provide structural anchoring of the replaced RTU per the 2016 code.
7. Provide new ductwork and two new VAV boxes with terminal reheat for the Spectator Viewing Area. New VAV boxes shall be pressure independent. Heating hot water piping shall be provided to the new VAV boxes.
8. Provide Siemens Apogee controls for the new equipment, connected into the existing Siemens Apogee energy management system (EMS) in the building.
9. Provide testing adjusting, and balancing of the RTU-1 air handling system and exhaust fans EF-1 and EF-2.

1.3 PROJECT DELIVERY METHOD

A. Contractor:

1. Contractor for this Project is Project's constructor and may be referred to as Contractor or General Contractor elsewhere in the Contract Documents.

1.4 WORK BY OWNER

A. Facilities shut-downs and support.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 01 1100

SECTION 01 14 00

WORK RESTRICTIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Work hours.
2. Coordination with Owner activities calendar.
3. Use of Project and premises.
4. Construction Staging.
5. Access to Site.
6. Work Restrictions.
7. Vehicular Access.
8. Construction-Related Parking, General.
9. Parking Permit Purchasing Options and Requirements.
10. Construction-Related Parking Permits, Types, Costs and Requirements.
11. Work Restrictions and Phasing

1.2 WORK HOURS

- A. Construction activities are permitted from 7:00 AM to 5:00 PM Monday through Friday only. Do not perform construction activities on weekends or during other hours, without advance written authorization from the Owner's Representative.

1.3 COORDINATION WITH CALENDAR AND FACILITY ACTIVITIES

- A. Holidays/No Inspection - The following is a list of holidays. No work requiring inspection should be scheduled on these dates. Verify the specific dates for each year, with the Owner's Representative.

1. New Year's Eve Day.
2. New Year's Day.
3. Martin Luther King Day.
4. Presidents' Day.
5. Cesar Chavez Day.
6. Memorial Day.
7. Independence Day.
8. Labor Day.
9. Veteran's Day.
10. Thanksgiving Day (and day following).
11. Christmas Eve Day.
12. Christmas Day.

1.4 USE OF PROJECT AND PREMISES

- A. Use of the Project Site and premises thereon are strictly limited to the Work as defined within these Contract Documents and according to the requirements in the Owner Specifications of the Contract Documents.
- B. Use of the Project Site for work and storage is restricted to the areas designated in the Contract Documents. Use of areas outside the Project Site limits are strictly off-limits and shall not to be used for storage of vehicles, material or equipment of any kind unless approved by Owner.
- C. The Brenda Villa Aquatic Center facility and all its existing equipment and systems shall remain fully operational at all times during construction. Except as noted in paragraph 1.10 below, the Owner will occupy the site, the existing building, and adjacent building(s) during entire construction period. Cooperate with Owner during construction operations to minimize conflicts and facilitate Owner usage. Perform the Work so as not to interfere with Owner's day-to-day operations. Maintain existing exits unless otherwise indicated.
 - 1. Maintain access to existing walkways, corridors, and other adjacent occupied or used facilities. Do not close or obstruct walkways, corridors, or other occupied or used facilities without written permission from Owner and approval of authorities having jurisdiction.
 - 2. Notify Owner's Representative not less than 72 hours in advance of activities that will affect Owner's operations.
- D. Owner Limited Occupancy of Completed Areas of Construction: Owner reserves the right to occupy and to place and install equipment in completed portions of the Work, prior to Substantial Completion of the Work, provided such occupancy does not interfere with completion of the Work. Such placement of equipment and limited occupancy shall not constitute acceptance of the total Work.
 - 1. Owner will prepare a Certificate of Substantial Completion for each specific portion of the Work to be occupied prior to Owner acceptance of the completed Work.

1.5 CONSTRUCTION STAGING

- A. See Owner's Representative for location and size of staging area.

1.6 ACCESS TO SITE

- A. General: Contractor shall have use of Project site for construction operations during construction period. Contractor's use of Project site is limited by Owner's right to perform work or to retain other contractors on portions of Project.
- B. Use of Site: Limit use of Project site to work in areas indicated. Do not disturb portions of Project site beyond areas in which the Work is indicated.

1. Limits: Confine construction operations to areas agreed to in advance of the Notice to Proceed.
2. Driveways, Walkways and Entrances: Keep driveways and entrances serving premises clear and available to Owner, Owner's employees, and emergency vehicles at all times. Do not use these areas for parking or storage of materials.
 - a. Schedule deliveries to minimize use of driveways and entrances by construction operations.
 - b. Schedule deliveries to minimize space and time requirements for storage of materials and equipment on-site.
- C. Condition of Existing Buildings: Maintain portions of existing buildings affected by construction operations in a weathertight condition throughout construction period. Repair damage caused by construction operations.

1.7 WORK RESTRICTIONS

- A. Nonsmoking Building: Smoking is not permitted on Owner property.

1.8 VEHICULAR ACCESS

- A. Investigate the conditions of available public thoroughfares and roads; of the clearances, restrictions and other limitations affecting transportation; and of ingress and egress at the Project site. Use only established roads provided under regulations prescribed by the Owner. Provide adequate protection against damage when necessary to cross existing sidewalks, curbs, and gutters. Satisfactorily repair all damage thereto, including damage to existing paving arising from the operations under the Contract. Clean up spilled materials of any kind.
- B. Maintain one lane of vehicular traffic at all times on all roads adjacent to, in the vicinity of, and around the perimeter of the project site.

1.9 CONSTRUCTION-RELATED PARKING, GENERAL

- A. General: Parking costs are subject to change at any time. Contractors shall verify current parking costs with the Owner's Representative.
- B. Any vehicle found parked in any unauthorized areas will be cited by the Owner and fined in accordance with Owner's parking regulations. In addition to the above fine, a daily fee, per vehicle, will be assessed for every calendar day that vehicles are illegally parked. Said fees will be deducted from the Contract Sum.
- C. Due to limited available parking, long and short term parking requests will be reviewed for consideration by the Owner's Representative. After review, if it is determined that parking will adversely affect any parking, the request will be denied and alternate solutions looked into.

1. Include all costs for construction parking in the bid. The Owner is not responsible for providing parking for construction activities. The Owner is not able to make any accommodation for designated parking or transportation to the job site from available parking areas.
2. Construction parking is generally allowed within the defined construction area, subject to compliance with Owner's parking rules and restrictions and as approved by the Owner.

1.10 WORK RESTRICTIONS AND PHASING

A. General:

1. The Contractor shall coordinate and cooperate with the Owner during construction operations to minimize conflicts and facilitate Owner usage. The Contractor shall perform the Work so as not to interfere with Owner's day-to-day operations. Maintain existing exits unless otherwise indicated.

B. The construction period will start on _____. However, no physical construction activities shall start until _____. Mobilization, submittals, and other non-invasive construction activities can be done in the period in between.

C. The project construction shall be complete by _____.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION

SECTION 02 4119

SELECTIVE DEMOLITION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Demolition and removal of selected site elements.
- B. Related Requirements:
 - 1. Division 01 for restrictions on the use of the premises, Existing-occupancy requirements, phasing requirements, temporary protection of existing area that are affected by selective demolition, and cutting and patching procedures.
 - 2. Division 01 "Hazardous Material Abatement".

1.3 DEFINITIONS

- A. Remove: Detach items from existing construction and legally dispose of them off-site unless indicated to be removed and salvaged or removed and reinstalled.
- B. Remove and Salvage: Carefully detach from existing construction, in a manner to prevent damage, and deliver to State.
- C. Remove and Reinstall: Detach items from existing construction, prepare for reuse, and reinstall where indicated.
- D. Existing to Remain: Existing items of construction that are not to be permanently removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.4 MATERIALS OWNERSHIP

- A. Unless otherwise indicated or requested by Owner, demolition waste becomes property of Contractor.

1.5 PREINSTALLATION MEETINGS

- A. Predemolition Conference: Conduct conference at Project site.
 - 1. Inspect and discuss condition of construction to be selectively demolished.
 - 2. Review structural load limitations of existing structure.
 - 3. Review and finalize selective demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
 - 4. Review requirements of work performed by other trades that rely on substrates exposed by selective demolition operations.
 - 5. Review areas where existing construction is to remain and requires protection.

1.6 INFORMATIONAL SUBMITTALS

- A. Proposed Protection Measures: Submit report, including drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection, for dust control, and for noise control. Indicate proposed locations and construction of barriers.
- B. Schedule of Selective Demolition Activities: Indicate the following:
 - 1. Detailed sequence of selective demolition and removal work, with starting and ending dates for each activity. Ensure Owner's on-site operations are uninterrupted
 - 2. Interruption of utility services. Indicate how long utility services will be interrupted.
 - 3. Coordination for shutoff, capping, and continuation of utility services.
 - 4. Use of elevator and stairs.
 - 5. Coordination of Owner's continuing occupancy of portions of existing building and of Owner's partial occupancy of completed Work.
- C. Inventory: Submit a list of items to be removed and salvaged and deliver to Owner prior to start of demolition.
- D. Predemolition Photographs: Submit before Work begins if required in Division 01.
- E. Warranties: Documentation indicated that existing warranties are still in effect after completion of selective demolition.

1.7 CLOSEOUT SUBMITTALS

- A. Inventory: Submit a list of items that have been removed and salvaged.
- B. Landfill Records: Indicate receipt and acceptance of hazardous wastes by a landfill facility licensed to accept hazardous wastes.

1.8 FIELD CONDITIONS

- A. Owner will occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so Owner's operations will not be disrupted.
- B. Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.
- C. Notify discrepancies between existing conditions and Drawings before proceeding with selective demolition.
- D. Hazardous Materials: Hazardous materials may be present in buildings and structures to be selectively demolished, become aware of locations where hazardous materials may be present.
- E. Storage or sale of removed items or materials on-site is not permitted.
- F. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.
 - 1. Maintain fire-protection facilities in service during selective demolition operations.
 - 2. Provide fire-watch for any facilities whose water system will be impacted.

1.9 WARRANTY

- A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials so as not to void existing warranties. Notify warrantor before proceeding.
- B. Notify warrantor on completion of selective demolition, and obtain documentation verifying that existing system has been inspected and warranty remains in effect. Submit documentation at Project closeout.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.
- B. Standards: Comply with ANSI/ASSE A10.6.
- C. Comply with 2013 California Green Building State Code.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that utilities have been disconnected and capped before starting selective demolition operations.
- B. Survey existing conditions and correlate with requirements indicated to determine extent of selective demolition required.
- C. Survey of Existing Conditions: Record existing conditions per Division 01.
- D. Perform an engineering survey of condition of building to determine whether removing any element might result in structural deficiency or unplanned collapse of any portion of structure or adjacent structures during selective building demolition operations.
 - 1. Perform surveys as the Work progresses to detect hazards resulting from selective demolition activities.
- E. Survey of Existing Conditions: Record existing conditions by use of measured drawings and preconstruction photographs.
 - 1. Comply with requirements specified in Division 01 "Photographic Documentation."
 - 2. Inventory and record the condition of items to be removed and salvaged. Provide photographs of conditions that might be misconstrued as damage caused by salvage operations.
 - 3. Before selective demolition or removal of existing building elements that will be reproduced or duplicated in final Work, make permanent record of measurements, materials, and construction details required to make exact reproduction.

3.2 UTILITY SERVICES AND MECHANICAL/ELECTRICAL SYSTEMS

- A. Existing Services/Systems to Remain: Maintain services/systems indicated to remain and protect them against damage.
 - 1. Comply with requirements for existing services/systems interruptions specified in Division 01.
- B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off indicated utility services and mechanical/electrical systems serving areas to be selectively demolished.
 - 1. Owner will arrange to shut off indicated services/systems when requested by Contractor.
 - 2. Arrange to shut off indicated utilities with utility companies.

3. If services/systems are required to be removed, relocated, or abandoned, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
4. Disconnect, demolish, and remove fire-suppression systems, plumbing, and HVAC systems, equipment, and components indicated to be removed.
 - a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 - c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
 - f. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
 - g. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.

3.3 PREPARATION

- A. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
 1. Comply with requirements for access and protection specified in Division 01.
- B. Temporary Facilities: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.
 1. Provide protection to ensure safe passage of people around selective demolition area.
- C. Temporary Shoring: Provide and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.

3.4 SELECTIVE DEMOLITION, GENERAL

- A. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:

1. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction.
2. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping, to minimize disturbance of adjacent surfaces. Temporarily cover openings to remain.
3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
4. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain portable fire-suppression devices during flame-cutting operations.
5. Maintain adequate ventilation when using cutting torches.
6. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
7. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
8. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
9. Dispose of demolished items and materials promptly. Comply with requirements in Division 01 "Construction Waste Management and Disposal."

B. Removed and Salvaged Items:

1. Clean salvaged items.
2. Pack or crate items after cleaning. Identify contents of containers.
3. Store items in a secure area until delivery to Owner.
4. Transport items to Owner's storage area designated by Owner.
5. Protect items from damage during transport and storage.

C. Removed and Reinstalled Items:

1. Clean and repair items to functional condition adequate for intended reuse.
2. Pack or crate items after cleaning and repairing. Identify contents of containers.
3. Protect items from damage during transport and storage.
4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.

D. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by owner, items may be removed to a suitable, protected storage location during selective demolition and reinstalled in their original locations after selective demolition operations are complete.

3.5 SELECTIVE DEMOLITION PROCEDURES FOR SPECIFIC MATERIALS

- A. Roofing: Remove no more existing roofing than what can be covered in one day by new roofing and so that building interior remains watertight and weathertight.
 - 1. Remove existing roof membrane, flashings, copings, and roof accessories.
 - 2. Remove existing roofing system down to substrate.

3.6 DISPOSAL OF DEMOLISHED MATERIALS

- A. General: Except for items or materials indicated to be recycled, reused, salvaged, reinstalled, or otherwise indicated to remain Owner's property, remove demolished materials from Project site and legally dispose of them in an EPA-approved landfill.
 - 1. Do not allow demolished materials to accumulate on-site.
 - 2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
- B. Burning: Do not burn demolished materials.
- C. Disposal: Transport demolished materials off Owner's property and legally dispose of them.

END OF SECTION 02 4119

SECTION 05 1200

STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Structural steel.

1.3 DEFINITIONS

- A. Structural Steel: Elements of the structural frame indicated on Drawings and as described in AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."

1.4 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions, and directions for installation.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
- C. Shop Drawings: Show fabrication of structural-steel components.
 - 1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
 - 2. Include embedment Drawings.
 - 3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.

4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pretensioned and slip-critical, high-strength bolted connections.

1.6 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Mill test reports for structural steel, including chemical and physical properties.
- C. Survey of existing conditions.
- D. Source quality-control reports.
- E. Field quality-control reports.

1.7 QUALITY ASSURANCE

- A. Shop-Painting Applicators: Qualified according to AISC's Paint to SSPC-QP 3, "Standard Procedure for Evaluating Qualifications of Shop Painting Applicators."
- B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.
 1. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.
- B. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.
 1. Fasteners may be repackaged provided Owner's testing and inspecting agency observes repackaging and seals containers.
 2. Clean and relubricate bolts and nuts that become dry or rusty before use.
 3. Comply with manufacturers' written recommendations for cleaning and lubricating ASTM F3125/F3125M, Grade F1852 bolt assemblies and for retesting bolt assemblies after lubrication.

PART 2 - PRODUCTS

2.1 STRUCTURAL-STEEL MATERIALS

- A. W-Shapes: ASTM A992 ASTM A572 Grade 50
- B. Materials complying with third and fourth options in "Channels, Angles (, M) (, S)-Shapes" Paragraph below are widely available. Fifth and sixth options include specialty-steel materials; verify availability if required.
- C. Channels, Angles **ASTM A36/A36M**
- D. Materials complying with first option in "Plate and Bar" Paragraph below are widely available; those complying with second option are less so. Third option is a specialty-steel material; verify availability if required.
- E. Plate and Bar: [ASTM A36/A36M]
- F. Retain "Corrosion-Resisting Structural-Steel Shapes, Plates, and Bars" Paragraph below for corrosion-resisting (weathering) structural steel and indicate locations on Drawings.
- G. Cold-Formed Hollow Structural Sections: ASTM A500/A500M, Grade B structural tubing.
- H. Steel Castings: ASTM A216/A216M, Grade WCB with supplementary requirement S11.
- I. Steel Forgings: ASTM A668/A668M.
- J. Welding Electrodes: Comply with AWS requirements.

2.2 FABRICATION

- A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC 303, "Code of Standard Practice for Steel Buildings and Bridges," and to AISC 360.
 - 1. Identify high-strength structural steel according to ASTM A6/A6M and maintain markings until structural steel has been erected.
 - 2. Mark and match-mark materials for field assembly.
 - 3. Complete structural-steel assemblies, including welding of units, before starting shop-priming operations.
- B. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.
 - 1. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1/D1.1M.

- C. Bolt Holes: Cut, drill, [mechanically thermal cut] or punch standard bolt holes perpendicular to metal surfaces.
- D. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.
- E. Cleaning: Clean and prepare steel surfaces that are to remain unpainted according to SSPC-SP 1, "Solvent Cleaning."
- F. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1/D1.1M and manufacturer's written instructions.
- G. Weld Connections: Comply with AWS D1.1/D1.1M [and AWS D1.8/D1.8M] for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
 - 1. Assemble and weld built-up sections by methods that maintain true alignment of axes without exceeding tolerances in AISC 303 for mill material.

2.3 SHOP PRIMING

- A. Shop prime steel surfaces except the following:
 - 1. Surfaces to be field welded.
 - 2. Surfaces of high-strength bolted, slip-critical connections.
 - 3. Surfaces to receive sprayed fire-resistive materials (applied fireproofing).
 - 4. Galvanized surfaces.
 - 5. Surfaces enclosed in interior construction.
- B. Surface Preparation: Clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards:
 - 1. SSPC-SP 2, "Hand Tool Cleaning."
 - 2. SSPC-SP 8, "Pickling."
- C. Priming: Immediately after surface preparation, apply primer according to manufacturer's written instructions and at rate recommended by SSPC to provide a minimum dry film thickness of 1.5 mils. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.
 - 1. Stripe paint corners, crevices, bolts, welds, and sharp edges.
 - 2. Apply two coats of shop paint to surfaces that are inaccessible after assembly or erection. Change color of second coat to distinguish it from first.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Prepare a certified survey of existing conditions. Include bearing surfaces, anchor rods, bearing plates, and other embedment showing dimensions, locations, angles, and elevations.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

3.3 ERECTION

- A. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.
 - 1. Set plates for structural members on wedges, shims, or setting nuts as required.
- B. Maintain erection tolerances of structural steel within AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."
- C. Align and adjust various members that form part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that are in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
 - 1. Level and plumb individual members of structure.
- D. Splice members only where indicated.
- E. Do not use thermal cutting during erection unless approved by Structural Engineer of Record. Finish thermally cut sections within smoothness limits in AWS D1.1/D1.1M.
- F. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.
- G. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1/D1.1M and manufacturer's written instructions.

3.4 FIELD CONNECTIONS

- A. Bolts:
 - 1. Joint Type: Snug tightened

2. Retain option in "Weld Connections" Paragraph below for "High-Seismic Applications" as defined in AISC 360.
- B. Weld Connections: Comply with AWS D1.1/D1.1M [and AWS D1.8/D1.8M] for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
1. Comply with AISC 303 and AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.
- 3.5 FIELD QUALITY CONTROL
- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
1. Verify weld materials and inspect welds.
- 3.6 REPAIRS AND PROTECTION
- A. Touchup Painting: Immediately after erection, clean exposed areas where primer is damaged or missing and paint with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
1. Clean and prepare surfaces by SSPC-SP 2 hand-tool cleaning or SSPC-SP 3 power-tool cleaning.

END OF SECTION 05 1200

SECTION 05 4000

COLD-FORMED METAL FRAMING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Load-bearing wall framing.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of cold-formed steel framing product and accessory.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.

C. Shop Drawings:

1. Include layout, spacings, sizes, thicknesses, and types of cold-formed steel framing; fabrication; and fastening and anchorage details, including mechanical fasteners.
2. Indicate reinforcing channels, opening framing, supplemental framing, strapping, bracing, bridging, splices, accessories, connection details, and attachment to adjoining work.

1.03 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Welding certificates.

C. Product test reports.

D. Research reports.

1.04 QUALITY ASSURANCE

A. Product Tests: Mill certificates or data from a qualified independent testing agency.

- B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
- C. Comply with AISI S230 "Standard for Cold-Formed Steel Framing - Prescriptive Method for One and Two Family Dwellings."

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AllSteel & Gypsum Products, Inc.
 - 2. California Expanded Metal Products Company.
 - 3. ClarkWestern Building Systems, Inc.
 - 4. Consolidated Fabricators Corp.; Building Products Division.
 - 5. Craco Mfg., Inc.
 - 6. Custom Stud Inc.
 - 7. Design Shapes in Steel.
 - 8. Dietrich Metal Framing; a Worthington Industries company.
 - 9. Formetal Co. Inc. (The).
 - 10. MarinoWARE.
 - 11. MBA Building Supplies, Inc.
 - 12. Nuconsteel; a Nucor Company.
 - 13. Olmar Supply, Inc.
 - 14. Quail Run Building Materials, Inc.
 - 15. SCAFCO Corporation.
 - 16. Southeastern Stud & Components, Inc.
 - 17. State Building Products, Inc.
 - 18. Steel Construction Systems.
 - 19. Steel Network, Inc. (The).
 - 20. Steel Structural Systems.
 - 21. Steeler, Inc.
 - 22. Super Stud Building Products, Inc.
 - 23. Telling Industries, LLC.
 - 24. United Metal Products, Inc.
 - 25. United Steel Manufacturing.

2.02 PERFORMANCE REQUIREMENTS

- A. AISI Specifications and Standards: Unless more stringent requirements are indicated, comply with AISI S100 and AISI S200.
- B. Fire-Resistance Ratings: Comply with ASTM E 119; testing by a qualified testing agency.

1. Indicate design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.

2.03 COLD-FORMED STEEL FRAMING, GENERAL

- A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

2.04 LOAD-BEARING WALL FRAMING

- A. Steel Studs: Manufacturer's standard C-shaped steel studs, of web depths indicated, punched, with stiffened flanges, and as follows:
 1. Minimum Base-Metal Thickness: As indicated on Drawings.
 2. Flange Width: 1-5/8 inches.
- B. Steel Track: Manufacturer's standard U-shaped steel track, of web depths indicated, unpunched, with straight flanges, and matching minimum base-metal thickness of steel studs.
- C. Steel Box or Back-to-Back Headers: Manufacturer's standard C-shapes used to form header beams, of web depths indicated, unpunched, with stiffened flanges, and as follows:
 1. Minimum Base-Metal Thickness: As indicated on Drawings.
 2. Flange Width: 1-5/8 inches.

2.05 FRAMING ACCESSORIES

- A. Fabricate steel-framing accessories from steel sheet, ASTM A 1003/A 1003M, Structural Grade, Type H, metallic coated, of same grade and coating weight used for framing members.
- B. Provide accessories of manufacturer's standard thickness and configuration.

2.06 ANCHORS, CLIPS, AND FASTENERS

- A. Steel Shapes and Clips: ASTM A 36/A 36M, zinc coated by hot-dip process according to ASTM A 123/A 123M.
- B. Anchor Bolts: ASTM F 1554, Grade 36, threaded carbon-steel hex-headed bolts and carbon-steel nuts; and flat, hardened-steel washers; zinc coated by hot-dip process according to ASTM A 153/A 153M, Class C or mechanically deposition according to ASTM B 695, Class 50.

- C. Expansion Anchors: Fabricated from corrosion-resistant materials, with allowable load or strength design capacities calculated according to ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing per ASTM E 488 conducted by a qualified testing agency.
- D. Power-Actuated Anchors: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with allowable load capacities calculated according to ICC-ES AC70, greater than or equal to the design load, as determined by testing per ASTM E 1190 conducted by a qualified testing agency.
- E. Mechanical Fasteners: ASTM C 1513, corrosion-resistant-coated, self-drilling, self-tapping, steel drill screws.
 - 1. Head Type: Low-profile head beneath sheathing, manufacturer's standard elsewhere.

2.07 MISCELLANEOUS MATERIALS

- A. Galvanizing Repair Paint: ASTM A 780.
- B. Cement Grout: Portland cement, ASTM C 150, Type I; and clean, natural sand, ASTM C 404. Mix at ratio of 1 part cement to 2-1/2 parts sand, by volume, with minimum water required for placement and hydration.
- C. Nonmetallic, Nonshrink Grout: Premixed, nonmetallic, noncorrosive, nonstaining grout containing selected silica sands, portland cement, shrinkage-compensating agents, and plasticizing and water-reducing agents, complying with ASTM C 1107/C 1107M, with fluid consistency and 30-minute working time.
- D. Shims: Load bearing, high-density multimonomer plastic, and nonleaching; or of cold-formed steel of same grade and coating as framing members supported by shims.
- E. Sealer Gaskets: Closed-cell neoprene foam, 1/4 inch thick, selected from manufacturer's standard widths to match width of bottom track or rim track members.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Install load bearing shims or grout between the underside of load-bearing wall bottom track and the top of foundation wall or slab at locations with a gap larger than 1/4 inch to ensure a uniform bearing surface on supporting concrete or masonry construction.
- B. Install sealer gaskets at the underside of wall bottom track or rim track and at the top of foundation wall or slab at stud or joist locations.

3.02 INSTALLATION, GENERAL

- A. Cold-formed steel framing may be shop or field fabricated for installation, or it may be field assembled.
- B. Install cold-formed steel framing according to AISI S200 and to manufacturer's written instructions unless more stringent requirements are indicated.
- C. Install cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened.
- D. Install framing members in one-piece lengths.
- E. Install temporary bracing and supports to secure framing and support loads comparable in intensity to those for which structure was designed. Maintain braces and supports in place, undisturbed, until entire integrated supporting structure has been completed and permanent connections to framing are secured.
- F. Do not bridge building expansion joints with cold-formed steel framing. Independently frame both sides of joints.
- G. Install insulation, specified in Section 072100 "Thermal Insulation," in built-up exterior framing members, such as headers, sills, boxed joists, and multiple studs at openings, that are inaccessible on completion of framing work.
- H. Fasten hole reinforcing plate over web penetrations that exceed size of manufacturer's approved or standard punched openings.
- I. Erection Tolerances: Install cold-formed steel framing level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet and as follows:
 - 1. Space individual framing members no more than plus or minus 1/8 inch from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.

3.03 LOAD-BEARING WALL INSTALLATION

- A. Install continuous top and bottom tracks sized to match studs. Align tracks accurately and securely anchor at corners and ends, and at spacings as follows:
 - 1. Anchor Spacing: As shown on Drawings.
- B. Squarely seat studs against top and bottom tracks with gap not exceeding of 1/8 inch between the end of wall framing member and the web of track. Fasten both flanges of studs to top and bottom tracks. Space studs as follows:
 - 1. Stud Spacing: As indicated on Drawings.
- C. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar configurations.

- D. Align studs vertically where floor framing interrupts wall-framing continuity. Where studs cannot be aligned, continuously reinforce track to transfer loads.
- E. Align floor and roof framing over studs. Where framing cannot be aligned, continuously reinforce track to transfer loads.
- F. Anchor studs abutting structural columns or walls, including masonry walls, to supporting structure as indicated.
- G. Install headers over wall openings wider than stud spacing. Locate headers above openings as indicated. Fabricate headers of compound shapes indicated or required to transfer load to supporting studs, complete with clip-angle connectors, web stiffeners, or gusset plates.
 - 1. Frame wall openings with not less than a double stud at each jamb of frame as indicated on Shop Drawings. Fasten jamb members together to uniformly distribute loads.
 - 2. Install runner tracks and jack studs above and below wall openings. Anchor tracks to jamb studs with clip angles or by welding, and space jack studs same as full-height wall studs.
- H. Install supplementary framing, blocking, and bracing in stud framing indicated to support fixtures, equipment, services, casework, heavy trim, furnishings, and similar work requiring attachment to framing.
 - 1. If type of supplementary support is not indicated, comply with stud manufacturer's written recommendations and industry standards in each case, considering weight or load resulting from item supported.
- I. Install horizontal bridging in stud system, spaced vertically 48 inches. Fasten at each stud intersection.
 - 1. Bridging: Cold-rolled steel channel, welded or mechanically fastened to webs of punched studs with a minimum of two screws into each flange of the clip angle for framing members up to 6 inches deep.
 - 2. Bridging: Combination of flat, taut, steel sheet straps of width and thickness indicated and stud-track solid blocking of width and thickness to match studs. Fasten flat straps to stud flanges and secure solid blocking to stud webs or flanges.
 - 3. Bridging: Proprietary bridging bars installed according to manufacturer's written instructions.
- J. Install steel sheet diagonal bracing straps to both stud flanges, terminate at and fasten to reinforced top and bottom tracks. Fasten clip-angle connectors to multiple studs at ends of bracing and anchor to structure.
- K. Install miscellaneous framing and connections, including supplementary framing, web stiffeners, clip angles, continuous angles, anchors, and fasteners, to provide a complete and stable wall-framing system.

3.04 FIELD QUALITY CONTROL

- A. Testing: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Field and shop welds will be subject to testing and inspecting.
- C. Testing agency will report test results promptly and in writing to Contractor and Architect/Engineer.
- D. Remove and replace work where test results indicate that it does not comply with specified requirements.
- E. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.05 REPAIRS AND PROTECTION

- A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on fabricated and installed cold-formed steel framing with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.
- B. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that cold-formed steel framing is without damage or deterioration at time of Substantial Completion.

END OF SECTION 05 4000

SECTION 07 0150

ROOF REPAIR

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Repair of existing roofing system disturbed as a result of construction work that is a part of new additions and remodeling including the following:
 - a. At new openings.
 - b. At existing openings being filled in.
 - c. At added mechanical unit curbs and supports

B. Related Requirements:

1. Division 01 - General Requirements.

1.2 SUBMITTALS

A. Comply with Division 01, unless otherwise indicated.

B. Product Data: Manufacturer's specifications and technical data including the following.

1. Detailed specification of construction and fabrication.
2. Manufacturer's installation instructions, specifically written for this Project.

C. Shop Drawings: Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures.

D. Roofing Work Program:

1. Written outline indicating methods and materials proposed for accomplishing the Work.
2. Base program upon requirements inspection of existing field conditions made jointly by roofing installer and representative of the manufacturer of the roofing materials to be installed.

1.03 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Not less than five years experience in the actual production of specified products.
- B. Installer's Qualifications: Firm experienced in installation or application of systems similar in complexity to those required for this Project, plus the following.
 1. Acceptable to or licensed by manufacturer.
 2. Not less than three years experience with systems.
 3. Successfully completed not less than five comparable scale projects using this system.
- C. Pre-installation Conference: Owner's representative, Contractor, installer, manufacturer's representative, and representatives of other affected trades shall meet at Site to review procedures, acceptance of substrate surfaces, and coordination with other trades.
 1. Schedule meeting at least one week before start of installation.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Storage and Protection: Comply with manufacturer's recommendations.

1.05 WARRANTY

- A. Prior to start of work, confirm warranty status of existing roof with Owner's representative.
- B. If the roof is covered by warranty, make repairs in compliance with the warrantor's requirements to maintain the warranty.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Insulation: Match existing. Provide tapered insulation as required.
- B. Roofing System: Match existing.
- C. Sheet Metal: Match existing.
- D. Roof Accessories: Provide new to match existing.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper or timely completion.
 - 1. Do not proceed until unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Protection:
 - 1. During installation of new materials and until openings are completely closed, protect building interior from damage by weather.
- 2. Apply materials to roof deck using methods that will protect building interior from damage.

3.03 INSTALLATION

- A. Remove existing roofing system where necessary.
- B. Perform cutting required in existing roofing membrane.
- C. Install tapered insulation to provide slope of roof surface to drains. Install to match existing roof system construction.
- D. Repair existing roofing membrane and flashings where new openings or platforms are installed, and where existing openings are closed.
- E. Install curbs as detailed or per equipment manufacturer's recommendation.
- F. Install top of new blocking and roof insulation flush with top of existing roof insulation.
- G. Form and install flashings as indicated or if not indicated to match existing.
- H. Strip in flashing at roof penetrations to match roof system.
- I. Install flashings and counter flashings at adjacent walls to match existing.
- J. Roof Accessory Installation: Install accessories into roofing system to comply with manufacturer's recommendations

END OF SECTION 07 0150

SECTION 07 6200

SHEET METAL FLASHING AND TRIM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Fabricated flashing, drip edges, counterflashing, and work as indicated.

1.3 COORDINATION

- A. Coordinate sheet metal flashing and trim layout and seams with sizes and locations of penetrations to be flashed, and joints and seams in adjacent materials.
- B. Coordinate sheet metal flashing and trim installation with adjoining roofing and wall materials, joints, and seams to provide leakproof, secure, and noncorrosive installation.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review construction schedule. Verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
 - 2. Review special roof details, roof drainage, roof-penetration flashing, equipment curbs, and condition of other construction that affect sheet metal flashing and trim.
 - 3. Review requirements for insurance and certificates if applicable.
 - 4. Review sheet metal flashing observation and repair procedures after flashing installation.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each manufactured product and accessory.

- B. Shop Drawings: For sheet metal flashing and trim.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Detail fabrication and installation layouts, expansion-joint locations, and keyed details. Distinguish between shop- and field-assembled work.
 - 3. Include identification of material, thickness, weight, and finish for each item and location in Project.
 - 4. Include details for forming, including profiles, shapes, seams, and dimensions.
 - 5. Include details for joining, supporting, and securing, including layout and spacing of fasteners, cleats, clips, and other attachments. Include pattern of seams.
 - 6. Include details of termination points and assemblies.
 - 7. Include details of roof-penetration flashing.
 - 8. Include details of special conditions.
 - 9. Include details of connections to adjoining work.
 - 10. Detail formed flashing and trim at scale of not less than 1-1/2 inches per 12 inches.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For fabricator.

1.7 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For sheet metal flashing and trim, and its accessories, to include in maintenance manuals.

1.8 QUALITY ASSURANCE

- A. Fabricator Qualifications: Employs skilled workers who custom fabricate sheet metal flashing and trim similar to that required for this Project and whose products have a record of successful in-service performance.
 - 1. For copings and roof edge flashings that are SPRI ES-1 tested and FM Approvals approved, shop shall be listed as able to fabricate required details as tested and approved.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Do not store sheet metal flashing and trim materials in contact with other materials that might cause staining, denting, or other surface damage. Store sheet metal flashing and trim materials away from uncured concrete and masonry.
- B. Protect strippable protective covering on sheet metal flashing and trim from exposure to sunlight and high humidity, except to extent necessary for period of sheet metal flashing and trim installation.

1.10 WARRANTY

- A. Special Warranty on Finishes: Manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows evidence of deterioration of factory-applied finishes within specified warranty period.
 - 1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
 - b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
 - 2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General: Sheet metal flashing and trim assemblies shall withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Completed sheet metal flashing and trim shall not rattle, leak, or loosen, and shall remain watertight.
- B. Sheet Metal Standard for Flashing and Trim: Comply with NRCA's "The NRCA Roofing Manual" and SMACNA's "Architectural Sheet Metal Manual" requirements for dimensions and profiles shown unless more stringent requirements are indicated.
- C. FM Approvals Listing: Manufacture and install copings and roof edge flashings that are listed in FM Approvals' "RoofNav" and approved for windstorm classification, Class 1-120. Identify materials with name of fabricator and design approved by FM Approvals.
- D. SPRI Wind Design Standard: Manufacture and install copings and roof edge flashings tested according to SPRI ES-1 and capable of resisting design pressure: Per code requirements
- E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes to prevent buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 SHEET METALS

- A. General: Protect mechanical and other finishes on exposed surfaces from damage by applying strippable, temporary protective film before shipping.
- B. Metallic-Coated Steel Sheet: Provide zinc-coated (galvanized) steel sheet according to ASTM A 653/A 653M, G90 coating designation; prepainted by coil-coating process to comply with ASTM A 755/A 755M.
 - 1. Surface: Smooth, flat and with manufacturer's standard clear acrylic coating on both sides.
 - 2. Exposed Coil-Coated Finish:
 - a. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 3. Color: Custom as selected by Architect.
 - 4. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with minimum total dry film thickness of 0.5 mil.

2.3 MISCELLANEOUS MATERIALS

- A. General: Provide materials and types of fasteners, solder, protective coatings, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation and as recommended by manufacturer of primary sheet metal or manufactured item unless otherwise indicated.
- B. Fasteners: Annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads and recommended by manufacturer of primary sheet metal or manufactured item.
 - 1. General: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.
 - a. Exposed Fasteners: Heads matching color of sheet metal using plastic caps or factory-applied coating. Provide metal-backed EPDM or PVC sealing washers under heads of exposed fasteners bearing on weather side of metal.
 - b. Blind Fasteners: High-strength aluminum or stainless-steel rivets suitable for metal being fastened.
 - 2. Fasteners for Zinc-Coated (Galvanized) Steel Sheet: Series 300 stainless steel or hot-dip galvanized steel according to ASTM A 153/A 153M or ASTM F 2329.
- C. Sealant Tape: Pressure-sensitive, 100 percent solids, polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch wide and 1/8 inch thick.

- D. Elastomeric Sealant: ASTM C 920, elastomeric polyurethane polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.
- E. Butyl Sealant: ASTM C 1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for hooked-type expansion joints with limited movement.

2.4 FABRICATION, GENERAL

- A. General: Custom fabricate sheet metal flashing and trim to comply with details shown and recommendations in cited sheet metal standard that apply to design, dimensions, geometry, metal thickness, and other characteristics of item required. Fabricate sheet metal flashing and trim in shop to greatest extent possible.
 - 1. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.
 - 2. Obtain field measurements for accurate fit before shop fabrication.
 - 3. Form sheet metal flashing and trim to fit substrates without excessive oil canning, buckling, and tool marks; true to line, levels, and slopes; and with exposed edges folded back to form hems.
 - 4. Conceal fasteners and expansion provisions where possible. Do not use exposed fasteners on faces exposed to view.
- B. Fabrication Tolerances: Fabricate sheet metal flashing and trim that is capable of installation to a tolerance of 1/4 inch in 20 feet on slope and location lines indicated on Drawings and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.
- C. Fabrication Tolerances: Fabricate sheet metal flashing and trim that is capable of installation to tolerances specified in MCA's Guide.
- D. Expansion Provisions: Form metal for thermal expansion of exposed flashing and trim.
 - 1. Form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with butyl sealant concealed within joints.
 - 2. Use lapped expansion joints only where indicated on Drawings.
- E. Sealant Joints: Where movable, nonexpansion-type joints are required, form metal to provide for proper installation of elastomeric sealant according to cited sheet metal standard.
- F. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.
- G. Seams: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with elastomeric sealant unless otherwise recommended by sealant manufacturer for intended use. Rivet joints where necessary for strength.

- H. Do not use graphite pencils to mark metal surfaces.

2.5 WALL SHEET METAL FABRICATIONS

- A. Through-Wall Flashing: Fabricate continuous flashings in minimum 96-inch- long, but not exceeding 12-foot- long, sections, under copings, and at shelf angles. Fabricate discontinuous lintel, sill, and similar flashings to extend 6 inches beyond each side of wall openings; and form with 2-inch- high, end dams. Fabricate from the following materials:
 - 1. Zinc: 0.039 inch thick.
- B. Opening Flashings in Frame Construction: Fabricate head, sill, jamb, and similar flashings to extend beyond wall openings. Form head and sill flashing with 2-inch- high, end dams. Fabricate from the following materials:
 - 1. Galvanized Steel: 0.022 inch thick.

2.6 MISCELLANEOUS SHEET METAL FABRICATIONS

- A. Equipment Support Flashing: Fabricate from the following materials:
 - 1. Galvanized Steel: 0.028 inch thick.
 - a. Drip edges, counterflashing, fascia, and other work as indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, substrate, and other conditions affecting performance of the Work.
 - 1. Verify compliance with requirements for installation tolerances of substrates.
 - 2. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.
 - 3. Verify that air- or water-resistant barriers have been installed over sheathing or backing substrate to prevent air infiltration or water penetration.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. General: Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement. Use fasteners, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.
 - 1. Install sheet metal flashing and trim true to line, levels, and slopes. Provide uniform, neat seams with minimum exposure of solder, welds, and sealant.
 - 2. Install sheet metal flashing and trim to fit substrates and to result in watertight performance. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.
 - 3. Space cleats not more than 12 inches apart. Attach each cleat with at least two fasteners. Bend tabs over fasteners.
 - 4. Install exposed sheet metal flashing and trim with limited oil canning, and free of buckling and tool marks.
 - 5. Torch cutting of sheet metal flashing and trim is not permitted.
 - 6. Do not use graphite pencils to mark metal surfaces.
- B. Metal Protection: Where dissimilar metals contact each other, or where metal contacts pressure-treated wood or other corrosive substrates, protect against galvanic action or corrosion by painting contact surfaces with bituminous coating or by other permanent separation as recommended by sheet metal manufacturer or cited sheet metal standard.
 - 1. Coat concealed side of stainless-steel sheet metal flashing and trim with bituminous coating where flashing and trim contact wood, ferrous metal, or cementitious construction.
- C. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at maximum of 10 feet with no joints within 24 inches of corner or intersection.
 - 1. Form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with sealant concealed within joints.
- D. Fasteners: Use fastener sizes that penetrate substrate not less than recommended by fastener manufacturer to achieve maximum pull-out resistance.
- E. Conceal fasteners and expansion provisions where possible in exposed work and locate to minimize possibility of leakage. Cover and seal fasteners and anchors as required for a tight installation.
- F. Seal joints as required for watertight construction.
 - 1. Use sealant-filled joints unless otherwise indicated. Embed hooked flanges of joint members not less than 1 inch into sealant. Form joints to completely conceal sealant. When ambient temperature at time of installation is between 40 and 70 deg F, set joint members for 50 percent movement each way. Adjust setting

proportionately for installation at higher ambient temperatures. Do not install sealant-type joints at temperatures below 40 deg F.

2. Prepare joints and apply sealants to comply with requirements in Section 07 9200 "Joint Sealants."

3.3 ROOF FLASHING INSTALLATION

- A. General: Install sheet metal flashing and trim to comply with performance requirements, sheet metal manufacturer's written installation instructions, and cited sheet metal standard. Provide concealed fasteners where possible, and set units true to line, levels, and slopes. Install work with laps, joints, and seams that are permanently watertight and weather resistant.
- B. Pipe or Post Counterflashing: Install counterflashing umbrella with close-fitting collar with top edge flared for elastomeric sealant, extending minimum of 4 inches over base flashing. Install stainless-steel draw band and tighten.
- C. Counterflashing: Coordinate installation of counterflashing with installation of base flashing. Insert counterflashing in reglets or receivers and fit tightly to base flashing. Extend counterflashing 4 inches over base flashing. Lap counterflashing joints minimum of 4 inches. Secure in waterproof manner by means of snap-in installation and sealant or lead wedges and sealant unless otherwise indicated.
- D. Roof-Penetration Flashing: Coordinate installation of roof-penetration flashing with installation of roofing and other items penetrating roof. Seal with elastomeric sealant and clamp flashing to pipes that penetrate roof.

3.4 WALL FLASHING INSTALLATION

- A. General: Install sheet metal wall flashing to intercept and exclude penetrating moisture according to cited sheet metal standard unless otherwise indicated. Coordinate installation of wall flashing with installation of wall-opening components such as windows, doors, and louvers.
- B. Opening Flashings in Frame Construction: Install continuous head, sill, jamb, and similar flashings to extend 4 inches beyond wall openings.

3.5 MISCELLANEOUS FLASHING INSTALLATION

- A. Equipment Support, Drip Edges, Counterflashing, Fascia, Flashing and Other Work as Indicated: Coordinate installation of equipment support flashing with installation of roofing and equipment. Weld or seal flashing with elastomeric sealant to equipment support member.

3.6 ERECTION TOLERANCES

- A. Installation Tolerances: Shim and align sheet metal flashing and trim within installed tolerance of 1/4 inch in 40 feet on slope and location lines indicated on Drawings and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.

3.7 CLEANING AND PROTECTION

- A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.
- B. Clean and neutralize flux materials. Clean off excess solder.
- C. Clean off excess sealants.
- D. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed unless otherwise indicated in manufacturer's written installation instructions. On completion of sheet metal flashing and trim installation, remove unused materials and clean finished surfaces as recommended by sheet metal flashing and trim manufacturer. Maintain sheet metal flashing and trim in clean condition during construction.
- E. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 07 6200

SECTION 07 9200

JOINT SEALANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Joint sealants.
 - 2. Closed-cell spray polyurethane foam.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

- A. Product Data: For each joint-sealant product.
- B. Joint-Sealant Schedule: Include the following information:
 - 1. Joint-sealant application, joint location, and designation.
 - 2. Joint-sealant manufacturer and product name.
 - 3. Joint-sealant formulation.
 - 4. Joint-sealant color.

1.5 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: For each kind of joint sealant, for tests performed by manufacturer and witnessed by a qualified testing agency.
- B. Preconstruction Laboratory Test Schedule: Include the following information for each joint sealant and substrate material to be tested:
 - 1. Joint-sealant location and designation.
 - 2. Manufacturer and product name.
 - 3. Type of substrate material.
 - 4. Proposed test.
 - 5. Number of samples required.

- C. Preconstruction Laboratory Test Reports: From sealant manufacturer, indicating the following:
 - 1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility and adhesion with joint sealants.
 - 2. Interpretation of test results and written recommendations for primers and substrate preparation are needed for adhesion.
- D. Preconstruction Field-Adhesion-Test Reports: Indicate which sealants and joint preparation methods resulted in optimum adhesion to joint substrates based on testing specified in "Preconstruction Testing" Article.
- E. Field-Adhesion-Test Reports: For each sealant application tested.
- F. Sample Warranties: For special warranties.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
- B. Product Testing: Test joint sealants using a qualified testing agency.
 - 1. Testing Agency Qualifications: Qualified according to ASTM C 1021 to conduct the testing indicated.

1.7 PRECONSTRUCTION TESTING

- A. Preconstruction Laboratory Testing: Submit to joint-sealant manufacturers, for testing indicated below, samples of materials that will contact or affect joint sealants.
 - 1. Adhesion Testing: Use ASTM C 794 to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.
 - 2. Compatibility Testing: Use ASTM C 1087 to determine sealant compatibility when in contact with glazing and gasket materials.
 - 3. Stain Testing: Use ASTM C 1248 to determine stain potential of sealant when in contact with masonry substrates.
 - 4. Submit manufacturer's recommended number of pieces of each type of material, including joint substrates, joint-sealant backings, and miscellaneous materials.
 - 5. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
 - 6. For materials failing tests, obtain joint-sealant manufacturer's written instructions for corrective measures, including use of specially formulated primers.
 - 7. Testing will not be required if joint-sealant manufacturers submit data that are based on previous testing, not older than 24 months, of sealant products for adhesion to, staining of, and compatibility with joint substrates and other materials matching those submitted.

- B. Preconstruction Field-Adhesion Testing: Before installing sealants, field test their adhesion to Project joint substrates as follows:
1. Locate test joints where indicated on Project or, if not indicated, as directed by Architect.
 2. Conduct field tests for each kind of sealant and joint substrate.
 3. Notify Architect seven days in advance of dates and times when test joints will be erected.
 4. Arrange for tests to take place with joint-sealant manufacturer's technical representative present.
 - a. Test Method: Test joint sealants according to Method A, Field-Applied Sealant Joint Hand Pull Tab, in Appendix X1.1 in ASTM C 1193 or Method A, Tail Procedure, in ASTM C 1521.
 - 1) For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.
 5. Report whether sealant failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. For sealants that fail adhesively, retest until satisfactory adhesion is obtained.
 6. Evaluation of Preconstruction Field-Adhesion-Test Results: Sealants not evidencing adhesive failure from testing, in absence of other indications of noncompliance with requirements, will be considered satisfactory. Do not use sealants that fail to adhere to joint substrates during testing.

1.8 FIELD CONDITIONS

- A. Do not proceed with installation of joint sealants under the following conditions:
1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F.
 2. When joint substrates are wet.
 3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
 4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

1.9 WARRANTY

- A. Special Installer's Warranty: Installer agrees to repair or replace joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 JOINT SEALANTS, GENERAL

- A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.
- B. VOC Content of Interior Sealants: Sealants and sealant primers used inside the weatherproofing system shall comply with the following:
 - 1. Architectural sealants shall have a VOC content of 250 g/L or less.
 - 2. Sealants and sealant primers for nonporous substrates shall have a VOC content of 250 g/L or less.
 - 3. Sealants and sealant primers for nonporous substrates shall have a VOC content of 775 g/L or less.
- C. Low-Emitting Interior Sealants: Sealants and sealant primers shall comply with the testing and product requirements of the California Department of Health's (formerly, the California Department of Health Services) "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." And comply with 2013 California Green Building Standard Code.

2.2 SEALANTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Dow Corning Corporation.
 - 2. Sika Corporation.
 - 3. Tremco.
 - 4. As Architect/Engineer approved equal.
- B. S-1:
 - 1. ASTM C920, polyurethane or polysulfide.
 - 2. Color: To match adjacent area color.
- C. S-3:
 - 1. ASTM C920, polyurethane or polysulfide.
 - 2. Type S.
 - 3. Class 25, joint movement range of plus or minus 50 percent.
 - 4. Grade NS.
 - 5. Shore A hardness of 15-25.
 - 6. Minimum elongation of 700 percent.

7. Color: To match adjacent area color.

D. S-4:

1. ASTM C920 polyurethane or polysulfide.
2. Type S.
3. Class 25.
4. Grade NS.
5. Shore A hardness of 25-40.
6. Color: To match adjacent area color.

E. S-6:

1. ASTM C920, silicone, neutral cure.
2. Type S.
3. Class: Joint movement range of plus 100 percent to minus 50 percent.
4. Grade NS.
5. Shore A hardness of 15-20
6. Minimum elongation of 1200 percent.
7. Color: To match adjacent area color.

F. S-9:

1. ASTM C920 silicone.
2. Type S
3. Class 25.
4. Grade NS.
5. Shore A hardness of 25-30.
6. Non-yellowing, mildew resistant.
7. Color: To match adjacent area color.

G. C-1: ASTM C834, acrylic latex.

1. Color: To match adjacent area color.

H. C-2: One component acoustical caulking, non drying, non hardening, synthetic rubber.

1. Color: To match adjacent area color.

I. C-3: ASTM C570, oil and resin.

1. Color: To match adjacent area color.

2.3 JOINT-SEALANT BACKING

- A. Sealant Backing Material, General: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.

- B. Cylindrical Sealant Backings: ASTM C 1330, Type C (closed-cell material with a surface skin), Type B (bicellular material with a surface skin) or any of the preceding types, as approved in writing by joint-sealant manufacturer for joint application indicated, and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.
- C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint. Provide self-adhesive tape where applicable.

2.4 MISCELLANEOUS MATERIALS

- A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.
- B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.

2.5 CLOSED-CELL SPRAY POLYURETHANE FOAM

- A. Closed-Cell Spray Polyurethane Foam: ASTM C 1029, Type II, minimum density of 1.5 lb/cu. ft. and minimum aged R-value at 1-inch thickness of 6.2 deg F x h x sq. ft./Btu at 75 deg F.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation.
 - b. Fomo Products.
 - c. Johns Manville; a Berkshire Hathaway company.
 - d. As Architect/Engineer approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:
 - 1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
 - 2. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:
 - 3. Remove laitance and form-release agents from concrete.
 - 4. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants. Nonporous joint substrates include the following:
- B. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
- C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.3 INSTALLATION OF JOINT SEALANTS

- A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.
- B. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- C. Install sealant backings of kind indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 - 1. Do not leave gaps between ends of sealant backings.
 - 2. Do not stretch, twist, puncture, or tear sealant backings.
 - 3. Remove absorbent sealant backings that have become wet before sealant application, and replace them with dry materials.

- D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.
- E. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
 - 1. Place sealants so they directly contact and fully wet joint substrates.
 - 2. Completely fill recesses in each joint configuration.
 - 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- F. Installation of Foam Insulation:
 - 1. Spray insulation to envelop entire area to be insulated and fill voids.
 - 2. Apply in multiple passes to not exceed maximum thicknesses recommended by manufacturer. Do not spray into rising foam.
 - 3. Comply with manufacturer's written instructions.

3.4 LOCATIONS

- A. Exterior Building Joints, Horizontal and Vertical:
 - 1. Metal to Metal: Type S-1, S-2.
 - 2. Metal to Masonry: Type S-1.
 - 3. Masonry to Masonry: Type S-1.
 - 4. Threshold Setting Bed: Type S-1, S-3, S-4.
 - 5. Expansion and Control Joints: Type S-6.
- B. Metal Reglets and Flashings:
 - 1. Flashings to Wall: Type S-6.
 - 2. Metal to Metal: Type S-6.
- C. Sanitary Joints:
 - 1. Walls to Plumbing Fixtures: Type S-9.
 - 2. Counter Tops to Walls: Type S-9.
 - 3. Pipe Penetrations: Type S-9.
- D. Interior Joints:
 - 1. Typical Narrow Joint 1/4 inch or less at Walls and Adjacent Components: Type C-1, C-2, C-3.
 - 2. Perimeter of Doors, Windows, Access Panels which Adjoin Concrete or Masonry Surfaces: Type C-1, C-2, C-3.
 - 3. Joints at Masonry Walls and Columns, Piers, Concrete Walls or Exterior Walls: Type C-1, C-2, C-3.
 - 4. Exposed Isolation Joints at Top of Full Height Walls: Type C-1, C-2, C-3.
 - 5. Exposed Acoustical Joint at Sound Rated Partitions Type C-2.

- 6. Concealed Acoustic Sealant Type S-4, C-1, C-2, and C-3.
- E. Conduit Penetrations: Type S-9 and S-6.

3.5 FIELD QUALITY CONTROL

- A. Field-Adhesion Testing: Field test joint-sealant adhesion to joint substrates as follows:
 - 1. Test Method: Test joint sealants according to Method A, Field-Applied Sealant Joint Hand Pull Tab, in Appendix X1 in ASTM C 1193 or Method A, Tail Procedure, in ASTM C 1521.
 - a. For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.
 - 2. Inspect tested joints and report on the following:
 - a. Whether sealants filled joint cavities and are free of voids.
 - b. Whether sealant dimensions and configurations comply with specified requirements.
 - c. Whether sealants in joints connected to pulled-out portion failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. Compare these results to determine if adhesion complies with sealant manufacturer's field-adhesion hand-pull test criteria.
 - 3. Record test results in a field-adhesion-test log. Include dates when sealants were installed, names of persons who installed sealants, test dates, test locations, whether joints were primed, adhesion results and percent elongations, sealant material, sealant configuration, and sealant dimensions.
 - 4. Repair sealants pulled from test area by applying new sealants following same procedures used originally to seal joints. Ensure that original sealant surfaces are clean and that new sealant contacts original sealant.
- B. Evaluation of Field-Adhesion-Test Results: Sealants not evidencing adhesive failure from testing or noncompliance with other indicated requirements will be considered satisfactory. Remove sealants that fail to adhere to joint substrates during testing or to comply with other requirements. Retest failed applications until test results prove sealants comply with indicated requirements.

3.6 CLEANING

- A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.7 PROTECTION

- A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out, remove, and repair damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

END OF SECTION 07 9200

SECTION 09 9123

INTERIOR PAINTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes surface preparation and the application of paint systems on the following interior substrates:
 - 1. Wood.
 - 2. Steel.
 - 3. Gypsum board.
- B. Related Requirements:
 - 1. Section 05 1200 – Structural Steel Framing.
 - 2. Section 07 6200 – Sheet Metal Flashing and Trim.

1.3 DEFINITIONS

- A. Gloss Level 1: Not more than 5 units at 60 degrees and 10 units at 85 degrees, according to ASTM D 523.
- B. Gloss Level 2: Not more than 10 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523.
- C. Gloss Level 3: 10 to 25 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523.
- D. Gloss Level 4: 20 to 35 units at 60 degrees and not less than 35 units at 85 degrees, according to ASTM D 523.
- E. Gloss Level 5: 35 to 70 units at 60 degrees, according to ASTM D 523.
- F. Gloss Level 6: 70 to 85 units at 60 degrees, according to ASTM D 523.
- G. Gloss Level 7: More than 85 units at 60 degrees, according to ASTM D 523.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include preparation requirements and application instructions.
- B. Samples for Initial Selection: For each type of topcoat product.
- C. Product List: For each product indicated, include the following:
 - 1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.
 - 2. Printout of current "MPI Approved Products List" for each product category specified in Part 2, with the proposed product highlighted.
 - 3. VOC content.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Paint: 5 percent, but not less than 1 gal. of each material and color applied.
- B. Coating Maintenance Manual: Upon conclusion of the project, the Contractor or paint manufacturer/supplier shall furnish a coating maintenance manual, such as Sherwin-Williams Custodian Project Color and Product Information" report or equal. Manual shall include an Area Summary with finish schedule, Area Detail designating where each product/color/finish was used, product data pages, Material Safety Data Sheets, care and cleaning instructions, touch-up procedures, and color samples of each color and finish used.

1.6 QUALITY ASSURANCE

- A. Mockups: Provide mock-ups of interior paint systems applied to wall surfaces at the jobsite in each interior wall color and finish specified. Mock-ups shall be a minimum of 4 feet by 4 feet in size, provided in locations as direct by the Owner's Representative. Simulate finished lighting conditions for review of in-place Work. Approved mock-ups may remain as part of the Work.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F.
 - 1. Maintain containers in clean condition, free of foreign materials and residue.
 - 2. Remove rags and waste from storage areas daily.

1.8 FIELD CONDITIONS

- A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F.
- B. Do not apply paints when relative humidity exceeds 85 percent; at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Furnish the products of only one paint manufacturer unless otherwise specified or required. Primers, intermediate and finish coats of each painting system must all be the products of the same manufacturer, including thinners and coloring agents, except for materials furnished with shop prime coat by other trades.
- B. Factory mix paint materials to correct color, gloss, and consistency for installation to the maximum extent feasible.
- C. All paint materials to be minimum "Architectural Grade".
- D. Gloss degree standards shall be as follows:
 - 1. HIGH GLOSS 70 and above EGGSHELL, Graded for Wet location.
 - 2. SEMI – GLOSS 48 to 69 SATIN, 15 to 29
- E. Basis-of-Design Product: Subject to compliance with requirements, provide Sherwin-Williams Company (The); Builders Solution® Interior Latex Eg-Shel, or a comparable product by one of the following:
 - 1. Behr Process Corporation.
 - 2. Benjamin Moore & Co.
 - 3. As Architect/Engineer approved equal.

2.2 PAINT, GENERAL

- A. MPI Standards: Provide products that comply with MPI standards indicated and that are listed in its "MPI Approved Products List."
- B. Material Compatibility:
 - 1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
 - 2. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.

- C. Low-Emitting Materials: Interior paints and coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers.", and comply with 2013 California Green Building Standards Code.
- D. Colors: To be selected by Architect from manufacturer's color chart.

2.3 SOURCE QUALITY CONTROL

- A. Testing of Paint Materials: Owner reserves the right to invoke the following procedure:
 - 1. Engage the services of a qualified testing agency to sample paint materials. Contractor will be notified in advance and may be present when samples are taken. If paint materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
 - 2. Testing agency will perform tests for compliance with product requirements.
 - 3. Owner may direct Contractor to stop applying coatings if test results show materials being used do not comply with product requirements. Contractor shall remove noncomplying paint materials from Project site, pay for testing, and repaint surfaces painted with rejected materials. Contractor will be required to remove rejected materials from previously painted surfaces if, on repainting with complying materials, the two paints are incompatible.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
- B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
 - 1. Concrete: 12 percent.
 - 2. Gypsum Board: 12 percent.
 - 3. Plaster: 12 percent.
- C. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.
- D. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers.
- E. Proceed with coating application only after unsatisfactory conditions have been corrected.

1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

- A. Comply with manufacturer's written instructions and recommendations in "MPI Manual" applicable to substrates indicated.
- B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
 1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.
- C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
 1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.
- D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces to be painted exceeds that permitted in manufacturer's written instructions.
- E. Masonry Substrates: Remove efflorescence and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces or mortar joints exceed that permitted in manufacturer's written instructions.
- F. Steel Substrates: Remove rust, loose mill scale, and shop primer, if any. Clean using methods recommended in writing by paint manufacturer but not less than the following:
 1. SSPC-SP 2, "Hand Tool Cleaning."
 2. SSPC-SP 3, "Power Tool Cleaning."
 3. SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
 4. SSPC-SP 11, "Power Tool Cleaning to Bare Metal."
- G. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.
- H. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal fabricated from coil stock by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.
- I. Aluminum Substrates: Remove loose surface oxidation.

3.3 APPLICATION

- A. Apply paints according to manufacturer's written instructions and to recommendations in "MPI Manual."
 - 1. Use applicators and techniques suited for paint and substrate indicated.
 - 2. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
 - 3. Paint front and backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
 - 4. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
 - 5. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.
- B. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Tint undercoats to match color of topcoat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.
- C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.
- D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

3.4 CLEANING AND PROTECTION

- A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.
- B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.
- C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.
- D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.5 INTERIOR PAINTING SCHEDULE

- A. Concrete Substrates, Traffic Surfaces:
 - 1. Clear Sealer System:

- a. First Coat: Sealer, water based, for concrete floors; basis-of-design: Monolhem 21.
- b. Topcoat: Sealer, water based, for concrete floors; basis-of-design: Permashield 200.

B. Steel Substrates:

1. Latex over Alkyd Primer System:

- a. Prime Coat: Metal primer.
- b. Intermediate Coat: Same as top coat.
- c. Topcoat: Interior high gloss enamel, as indicated on Section 2.1 D

C. Gypsum Board Substrates:

1. Alkyd over Latex Primer System:

- a. Prime Coat: Drywall sealer.
- b. Intermediate Coat: Enamel undercoat.
- c. Topcoat: Alkyd, interior, semi-gloss (Gloss Level 5).

END OF SECTION 09 9123

SECTION 23 0500

MECHANICAL GENERAL PROVISIONS

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. This Section supplements all Sections of this Division and applies to all Work specified and indicated on the Contract Drawings. Provide for complete installation of mechanical systems.

1.2 SUBMITTALS

- A. Refer to individual mechanical Sections for submittals required.
- B. If the equipment submitted under Division 23 requires changes in material or labor from that required in the Contract Drawings and Specifications, such changes shall be submitted as shop drawings.
- C. Operating and Maintenance Manual.
- D. Copy of the Test and Balance Report.

1.3 REFERENCE STANDARDS

- A. The following abbreviations apply to all sections of Division 23:
 - 1. AWG: American Wire Gauge.
 - 2. HEPA: High Efficiency Particulate Air.
 - 3. PSI: Pounds per square inch.
 - 4. PSIG: Pounds per square inch gage.
 - 5. PVC: Polyvinyl chloride.
 - 6. WG: Water gage.

1.4 SERVICE MANUALS

- A. Upon completion of the installation, and as a condition of its acceptance, prepare and submit an Operating and Maintenance Manual to Owner's Representative for approval. Compile the manual from information supplied by equipment manufacturers and from test and balance data furnished. Each manual shall include the following:
 - 1. Complete instructions on the operation of all mechanical equipment including all control settings, switch positions, timer operation, set points, throttling range.
 - 2. Complete instructions regarding the maintenance of all mechanical equipment including periods and frequencies of all inspections, lubrications and filter replacement, etc.; type of lubricants required; and exact description of performance of such maintenance and full description of inspections and corrections on a step-by-step basis. Furnish a chart listing each lubricated piece of equipment, the type

- of oil or grease required, and recommended frequency of lubrication.
 - 3. Copy of all As-Built controls and As-Built wiring diagrams.
 - 4. Complete nomenclature of all replaceable parts, their part numbers, and the name and address of the nearest vendor.
 - 5. Copy of all guarantees and warranties issued for components of the systems, showing all dates of expiration. Such dates shall not be sooner than the expiration of the completed installation guarantee specified herein.
 - 6. Copy of Valve Chart:
 - a. Format: Arrange format of valve charts by rooms and sequence all valve numbers starting with mechanical equipment rooms and finishing with "occupied spaces".
 - b. Information: Furnish the following information typed on valve charts for each valve specified.
 - 1) Room numbers and name where valve is located, i.e., "ZG Boiler Room".
 - 2) Valve number assigned by Contractor and stamped on brass plate, i.e., "147".
 - 3) Service medium using designation assigned to Drawings on mechanical symbols, i.e., "heating hot water supply" or "plumbing cold water".
 - 4) Valve types as specified in Section 23 20 00, VALVES, i.e., "eccentric plug valve" or "gas cock".
 - 5) Function valve serves, i.e., "strainer shut-off" or "balancing valve".
 - 6) Zone identification, i.e., "AHU-2" or "auxiliary heating".
 - 7. A complete index at the front furnishing immediate information as to location in the manual of all data regarding the installation. Numbered tab sheets shall be used.
 - 8. Name, address and telephone number of Contractor and each subcontractor employed for work under this Division.
- B. All material shall be neatly typed or shall be printed material. Instructions specified shall be in continuous narrative form not fragmented sections as prepared by individual equipment manufacturers.

- C. Submit four (4) copies of manuals in binders along with two (2) digital copies with identification readable from the outside stating "HVAC Upgrades for the Brenda Villa Aquatic Center, City of Commerce."
 - 1. Submit in separate, multiples of two, 3-ring loose leaf binders, 2-inch size, with chrome-plated piano hinges and black hard-coated covers.
 - 2. Small or large literature not easily inserted in binders shall each be put in heavy manila envelopes.
 - 3. Furnish each binder with plastic enclosed tabs on reinforced paper neatly arranged. Type each of the following on a separate tab:
 - a. Operating instructions.
 - b. Maintenance instructions.
 - c. As-built controls & as-built wiring diagrams.
 - d. Parts.
 - e. Guarantees and warranties.
 - f. Valve chart.
 - g. Test & balance report.
 - h. Index.
 - i. List of contractors and subcontractors.
 - 4. File under correct tabs. Clearly identify each piece of literature and envelope with equipment name and numbers.

1.5 MANUFACTURER'S DIRECTIONS

- A. In all cases where manufacturers of articles used in this Contract furnish printed directions covering points not shown on Drawings or specified, such printed directions shall be followed.

1.6 DRAWINGS

- A. Diagrammatic Drawings: For purposes of clarity and legibility, the Drawings are essentially diagrammatic and, although size and location of equipment is drawn to scale, Contractor shall make use of all data in all the Contract Documents and verify this information at Project site.
- B. Routing of Ducts and Piping:
 - 1. Drawings indicate required size and termination of pipes and ducts and suggest correct routes of piping and duct to conform to the structure, to prevent obstructions and to preserve clearance.
 - 2. It is not the intent to indicate all necessary offsets and it shall be Contractor's responsibility to install ductwork and piping in such a manner as to conform to structure, prevent obstructions, preserve headroom, keep openings and passageways clear, and make all equipment requiring inspection, maintenance and repair, accessible without further instructions or extra cost to the Owner.

C. Interferences:

1. No interferences shall occur which prevent grade lines from being established for the work.
2. Installed work which interferes with the work specified in other Sections of the Specifications shall be removed and rerouted at the discretion of Owner's Representative.

1.7 SPARE PARTS AND SPECIAL TOOLS

- A. Spare parts shall be furnished to the Owner as follows and receipts obtained and included with Service Manuals.
1. Complete set of belts for each piece of equipment requiring same.
 2. Spare pilot light lamps of each type used on the project, in quantity of ten%, but not less than two.
 3. One year's supply of all expendable parts.
- B. Special Tools: If any part of equipment furnished requires a special tool for assembly, adjustment, setting or maintenance thereof and such tool is not readily available on the commercial tool market, it shall be furnished with equipment as a standard accessory.

1.8 PRELIMINARY OPERATION AND EMERGENCY REPAIRS

- A. The Owner reserves the right to operate portions of the mechanical system on a preliminary basis or make emergency repairs without voiding the guarantee or relieving Contractor of its responsibilities.

1.9 INSTRUCTIONS IN OPERATION

- A. After all tests and adjustments have been made and the service manual has been completed and submitted for approval, furnish one or more full-time qualified personnel as necessary to put the mechanical work in continuous operation for a period of not less than five (5) days, during which time the designated personnel's only purpose shall be to give complete operating and maintenance instructions to University's operating personnel. Furnish all service necessary for the operation and protection of the mechanical systems. Fuel, power, and other supplies required during this period will be furnished by the Owner.

2. PRODUCTS

2.1 MATERIALS

A. Electrical:

1. All motor starters, relays, other electrical components, and related Work specified in Division 23, shall be in compliance with Division 26, ELECTRICAL.

2. All motors shall be single phase or three-phase as indicated on the Drawings. Motor starters shall be as scheduled on the Drawings and specified. If motors, appliances or apparatus are furnished varying in horsepower and characteristics from those specified, make all required changes at no additional cost to the Owner.

2.2 MATERIALS AND EQUIPMENT

- A. Wherever possible, all materials and equipment used in the installation of this Work will be of the same brand of manufacture for each class of material or equipment.

3. EXECUTION

3.1 EXCAVATION AND BACKFILL

- A. General:
 1. Do all excavation and backfill required to install the work of this Division.
 2. Perform all excavation and backfill outside of building perimeter.
- B. Excavation: Bury piping outside the building to a depth of not less than 2'-6" below finish grade unless noted otherwise.
- C. Backfilling: Do not backfill until final inspection and approval for the piping installation by Owner's Representative. Backfill material shall be as specified under pertinent sections.

3.2 DEMOLITION

- A. General:
 1. The work involves demolition of existing ductwork, piping and equipment.
 2. Mechanical drawings show demolition, relocation, removal or re-routing of existing ducts, pipes and equipment.
 3. All demolished or removed materials become the property of Contractor and it shall be its responsibility to remove such materials from the Project site.
- B. Equipment: All the existing equipment to be removed from building shall be disassembled or cut into pieces to allow removal through available existing openings.
- C. Ductwork:
 1. Ductwork shall be capped as follows:
 - a. Where existing ductwork is demolished, opening shall be capped.

- b. Where existing duct is to be replaced by new, temporarily cap existing duct opening until new ductwork connected.
- D. Piping:
 - 1. Piping shall be capped as follows:
 - a. When part of existing piping is removed.
 - b. When part of existing piping is to be replaced pipe shall be capped temporarily until new piping is connected.
- E. Insulation: All damaged insulation on existing or new ductwork, piping or equipment shall be replaced by Contractor at no additional cost to the Owner.

3.3 SERVICE CONTINUITY

- A. All facility utilities and equipment shut-down shall be coordinated with the Owner's Representative.

3.4 PROTECTION AND CLEANING

- A. Protection: Fully protect all finished parts of the materials and equipment against physical damage from whatever cause during the progress of this work and until completion.
- B. During construction, cap all lines and equipment nozzles so as to prevent the entrance of sand and dirt. Protect equipment by covering it with polyethylene sheets.
- C. Cleaning: After installation has been completed, clean all systems as follows:
 - 1. Ductwork, Piping and Equipment to be Insulated: Clean exterior thoroughly to remove rust, plaster, cement and dirt before insulation is applied.
 - 2. Ductwork, Piping and Equipment to be Painted: Clean exterior of piping and equipment exposed in completed structure, removing rust, plaster, cement and dirt by wire brushing. Remove grease, oil and similar materials by wiping with clean rags and solvents.
 - 3. Motors, Pumps, and Other Items with Factory Finish: Remove grease and oil. Leave surfaces clean and polished.

3.5 LUBRICATION

- A. Upon completion of the work and before turning over to the Owner, clean and lubricate all bearings except sealed and permanently lubricated bearings.
- B. Use only lubricant recommended by the manufacturer and as listed in the Service Manual.

- C. Maintain lubrication of all mechanical equipment until work is accepted.

3.6 CUTTING AND PATCHING

- A. Sleeves and Inserts: Provide all sleeves, inserts, and openings necessary for the installation of the mechanical work.
- B. Openings:
 - 1. Special forming, recesses, chases, and curbs, as necessary for the correct reception and installation of the mechanical equipment, as shown on the Drawings, are specified in other Divisions.
 - 2. Examine all Drawings to ascertain that correct provisions have been made for the work. If such provisions are not made in time, Contractor shall bear all extra costs incurred in later cutting and patching to accommodate this work.

3.7 CONCRETE WORK

- A. Housekeeping Pads and Isolation Bases:
 - 1. Furnish all required dimensional drawings for bases and pads and location thereof.
 - 2. Furnish all embedded anchor bolts and sleeving and ensure installation of same.

3.8 OPERATIONAL TESTS

- A. General:
 - 1. Before acceptance tests are performed, demonstrate to Owner's Representative that all systems and components are complete and fully charged with operating fluid and lubricants.
 - 2. Perform operational tests on all machinery and devices to determine compliance with Specifications. Equipment shall function quietly and efficiently. Before acceptance, repair or correct piping and equipment causing noise or vibration.
 - 3. Systems shall be operable and capable of maintaining continuous uninterrupted operational service during the operating and demonstration periods of operation.
 - 4. All control systems shall be completely operable with calibration and setting correctly set and adjusted.
 - 5. All rotating equipment shall be in dynamic balance and alignment.
- B. Test and Balance:
 - 1. Pressure tests shall be performed as specified in Section 23 91 00, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

2. General:
 - a. Notify Owner's Representative when any test is ready to be performed. Owner's Representative is to be present for all tests.
 - b. Furnish all equipment required for testing including fittings for additional openings and all openings required inside and outside the building.
 - c. After the inspection has been approved, or portions thereof, certify in writing the time, date, name and title of the person approving the test. This shall also include the description and what portion of the system has been approved. The person making the inspection shall sign the certification.
 - d. A complete record shall be maintained of all testing that has been approved. It shall be made available at the Project site to all authorities concerned.
 - e. Upon completion of the work, all records and certifications approving testing requirements shall be submitted to Owner's Representative.
 - f. Defective work or material shall be replaced or repaired as necessary at no additional cost to the Owner and the inspection and test repeated. Repairs shall be made with new materials. No caulking of screwed joints or holes will be acceptable.
 - g. Isolate all equipment subject to damage from test pressure. Make no test against a service valve or meter.
3. Timing of Tests: Two weeks before expected completion date, put all systems and equipment into operation and continue operation of same during each working day, but not less than five 8-hour periods, until demonstration of all adjusting, balancing and testing has been approved.
4. Functional Tests: Any installed item not meeting the schedule or specified performance shall be removed and replaced with items whose performance is in accordance with the Drawings and Specifications at no additional cost to the Owner.
5. After all systems have been completely installed, connections made, and tests completed, make arrangements with Owner's Representative to operate the systems for a period of ten (10) working days during the hours of a normal working day.
6. Notify Owner's Representative in writing when the operational period may start. The time for this period shall be scheduled by mutual agreement.

7. During this operation period, instruct Owner's operating personnel in accordance with written instructions of the Service Manual specified.
8. Perform tests as specified and as requested by Owner's Representative to prove installation is in accordance with Contract requirements. Perform tests in presence of Owner's Representative, and furnish test equipment, facilities, and technical personnel required to perform tests.

3.9 SERVICES

- A. General: Perform service on all mechanical Work until acceptance of the Work including oiling and greasing, adjustments, cleaning, packing of seals, and other items as recommended by equipment manufacturer in the maintenance manual hereinbefore specified.
- B. Air Filters:
 1. Do not operate air moving equipment having air filters unless temporary filters, of equal rating to specified, are in place to protect the mechanical Work.
 2. Replace these temporary filters with specified filters before final test and balance work is begun as necessary for accurate readings. After completing the testing and balancing work, replace filters with new filter media as specified.
- C. Strainers: Remove, clean and reinstall each strainer screen as specified below after systems have been flushed as specified in Section 23 05 29, HYDRONIC PIPING, FITTINGS, SUPPORTS AND CLEANING.
 1. Clean each strainer screen after all adjustments have been made and system has operated a minimum of 24 hours, but before final test and balancing operation is started.
 2. Clean each strainer screen again, after final test and balancing operation and before completion of the Project.
- D. Purge all air from water systems after each servicing. Protect all furnishings and finishes during each servicing operation and repair or replace to original condition those damaged as a result of servicing at no additional cost to the Owner.
- E. Replace insulation removed or damaged after each operation. Use insulation as specified in Section 23 07 00, MECHANICAL INSULATION.
- F. Put system in full operating condition.

END OF SECTION 23 0500

SECTION 23 0516

BASIC MECHANICAL MATERIALS AND METHODS

1. GENERAL

1.1 DESCRIPTION

A. Work:

1. Construction, installation, materials and equipment described herein are generally common to the various sections of this Division.
2. Refer to individual mechanical section for piping schedule required for each particular piping system.
3. Requirements of this Section are in addition to any similar or more comprehensive requirements in other sections of this Division.
4. Requirements of this Section apply to all sections in this Division, except as may be specifically modified in those sections.

1.2 SUBMITTALS

A. Descriptive Data:

1. Electric motors.
2. Starters and disconnects.
3. Flow switches.
4. Pressure switches.
5. Lists of material manufacturers.
6. Flexible couplings.
7. Belt drives.
8. Coupling guards.

B. Shop Drawings:

1. Pre-wired control panels.
2. Belt guards.
3. Miscellaneous equipment supports.

C. Welding: Submit proposed welding procedures and list of proposed qualified welders. Refer to paragraph 3.3 D below.

1.3 SPECIFIC ELECTRICAL REQUIREMENTS

- A. General: Except where modified by the specific requirements of an individual Section of Division 23, the electrical work required is specified in Division 26.

1. Wiring Diagrams:
 - a. Furnish all wiring diagrams and information needed to complete installation of electrical work.
 - b. Wiring diagrams shall correctly indicate conditions of this specific job and shall be free from confusing optional methods that do not apply.
 - c. All wiring diagrams shall be submitted for approval.
 2. Pre-wired Control Panels:
 - a. Where pre-wired control panels or equipment is furnished, internal wiring shall extend neatly to a terminal strip which shall have the same designations for terminals that are shown on the wiring diagram.
 - b. Pre-wired panels shall be UL labeled.
 3. Field Wiring: Where work includes field wiring, materials and workmanship shall conform to requirements of Division 26, of these Specifications, and to all Applicable Code Requirements
- B. Power Supply:
1. Power supply for the project is listed as 120 volts, single phase, 480/277 volts, 3 phase or as noted on drawings.
 2. Verify the power requirements before ordering equipment.

2. PRODUCTS

2.1 HEATING HOT WATER PIPING

- A. Typical Service: Heating hot water.
- B. Pipe: 2" and smaller shall be copper type K. Fittings shall be ASME B16.22, solder wrought copper. Joints shall be ASTM B32, solder, Grade 95TA lead free.
- C. Pipe: 2-1/2" and larger shall be steel pipe, ASTM A53, standard weight, Grade B seamless. ERW ASTM A53 pipe is an acceptable alternative to seamless pipe. Fitting shall be steel fittings, ASME B16.9, butt-welding type, or ASME B16.5, flanged type, or convoluted steel flanges conforming to ASME BPVC SEC VIII D1.
- D. Ball Valves:
 1. 400 lb. wog, bronze body, screwed stainless steel ball and handle, teflon seats, packing and gasket. NIBCO or equal.
- E. Check Valves:
 1. Swing Checks: 150 lb. SWP bronze screwed with re-grinding bronze disc and screw-in cap. NIBCO or equal.

F. Strainers:

1. 250 lb. Y-pattern bronze, screwed, with machined gasketed strainer screen retainer cap. NIBCO or equal.
2. Strainer screen shall be Monel with 3/64" perforations (225 per sq. inch).

G. Automatic Air Vents: 150 lb. cast iron or bronze body with stainless steel and float. NIBCO or equal.

2.2 EQUIPMENT DRAIN PIPING, DOMESTIC COLD WATER PIPING

- A. Pipe: Copper Tubing, ASTM B88, Type L, hard drawn. Fittings shall be ANSI/ASME B16.22 solder wrought copper. Joints: ASTM B32, solder, Grade 95TA lead free.

2.3 DISSIMILAR METAL PIPING JOINTS

- A. Use non-conductive fittings whenever ferrous and non-ferrous piping material are joined together.
1. HVAC Systems: Cast iron fitting.
 2. Domestic or Industrial Water: Threaded M.P.S. minimum 3-inches long electro-zinc plated steel casing with inert NSF/FDA listed lining. ASTM F-492 rated at 225°F, 300 PSI.

2.4 INSTRUMENTS

A. General:

1. Thermometers, duct thermometers, pressure gages and draft gages shall be as scheduled herein.
2. Thermometers and pressure gages for temperature control shall be as specified in Section 23 09 00, CONTROLS AND INSTRUMENTATION.
3. Where panel mounted instruments are scheduled they need not be duplicated by pipe mounted instruments.

B. Pressure Gages:

1. Gages shall be of the Bourdon tube type, DWYER or equal.
2. Gages shall have 4-1/2" dial face, white with black numbers and graduations, steel case with double strength glass and nickel plated ring.
3. Movement shall be of the phosphor bronze seamless Bourdon tube type with recalibrating bushed rotary gear movement and link fitted with a black aluminum pointer.
4. Accuracy shall be + 1% of total dial range.

5. Ranges shall be such that gage shall operate in midrange during normal operation of the system.
6. Every gage shall be provided with a 1/4" needle-type valve and an impulse dampener.

2.5 HANGERS AND SUPPORTS

A. General:

1. Hangers and supports shall be factory fabricated units with published load limits.
2. Manufacturer: Hangers and supports shall be TOLCO or equal.
3. Hangers and supports for fire protection installation shall be in accordance with NFPA Standard No. 13.

B. Horizontal Piping: Hangers shall be of the following types:

1. For piping 4" and smaller adjustable malleable iron split ring type, TOLCO or equal.
2. For piping larger than 4" adjustable steel clevis type, TOLCO or equal.
3. Rod lengths shall be adjustable.
4. Trapeze hangers may be used for parallel piping arrangements. Submit detail drawings for review.
5. Hang hanger rods for both single and trapeze hangers from clips, beam clamps or joist "U" brackets manufactured for the purpose.

C. Vertical Piping: Clamps shall be TOLCO or equal.

D. Rods: Minimum size shall be as required by SMACNA guidelines.

E. Sway Bracing of Non-Resiliently Supported Pipe: Restraints shall be malleable iron bracket and pipe end assembly, TOLCO or equal.

F. Trapeze or Framing:

1. For four or less 2" pipes shall be TOLCO or equal. Select to support five times the weight or thrust.
2. Submit details of other trapeze or framing for approval.

G. Protection Shield and Insert Sections:

1. Shields shall be 16 gauge galvanized steel for all piping and shall be preformed to specified radius.
2. Insert sections shall be as specified in Section 23 07 00, MECHANICAL INSULATION.

H. Vibration Isolation:

1. Vibration isolation and restraints shall be as specified in Section 23 05 48, VIBRATION AND SEISMIC CONTROL.
2. Where isolation elements are required on hangers, provide 2-piece rods.
3. Install metal back felt isolators under hangers of all uninsulated water piping. M.W. SAUSSE or equal.

2.6 SLEEVES, CORE DRILLING AND ESCUTCHEONS

A. General:

1. Sleeves shall be permanently installed type where waterproofing is required and cast-in-place or drypacked in core drilled hole.
2. Escutcheons shall be prime coated steel type unless otherwise specified.

B. Sleeves:

1. Exterior Walls and Floor Slabs Below Grade: Concrete pipe dry-packed in place with annular space caulked watertight.
2. Roof Slab: Cast iron sleeve with integral flashing clamp. DANCO or equal.

C. Escutcheons shall be as follows:

1. 6" and Smaller: Prime coated steel with set screw. DANCO or equal.
2. Larger than 6": Prime coated brass with set screw. M.W. SAUSSE or equal.

D. Caulking:

1. Watertight: M.W. SAUSSE or equal.
2. Fireproofing Sound Attenuating: Caulk with a compressible polyurethane foam strip.

2.7 FLASHING

- A. Flashing shall be 4 lb. seamless lead flashing assembly with 10" skirt, steel reinforcing boot and caulk type counterflashing sleeve.
- B. Manufacturer: Flashing assembly shall be MAYCO or equal.

2.8 ACCESS PANELS

- A. Sizes: As required for complete access; minimum size 12".
- B. Doors:

1. No. 13 USSG steel door and trim.
2. No. 16 USSG steel frame.
3. Metal wings for keying into construction.
4. Concealed hinges, screwdriver operated stainless steel cam lock.
5. In Plaster Ceilings: ACUDOR or equal.
6. In Wallboard: ACUDOR or equal.

- C. Access Tile Identification: Buttons, tabs and markers to identify location of concealed work. Submit for review.

2.9 ELECTRIC MOTORS

A. General:

1. All fan and pump motors, except fire pumps, smoke exhaust fans and two-speed motors five (5) HP and larger, shall be of the high efficiency type. Provide BALDOR or equal. Guaranteed minimum full load efficiencies shall be certified in accordance with IEEE Standard 112 Test Method B, NEMA MG-1-12.53a and shall meet or exceed the following minimum criteria:
2. Electric motors shall be open drip-proof, continuous duty, 40°C rise type with Class "B" insulation, NEMA design B unless specified otherwise. Motors shall be of high efficiency type, and 1.15 service factor.
3. Three phase motors shall have re-greasable ball bearings.

- B. Motors installed in outdoor locations shall be totally enclosed, fan cooled and continuous duty rating at 55°C., and 1.00 service factor.

- C. Where motor is an integral part of equipment, motor manufacturer shall be as recommended by the equipment manufacturer.

- D. Motors shall in all cases have adequate starting torque to bring driven equipment up to rated speed in a time interval acceptable to University's Representative.

- E. Motors 1/2 HP and larger shall be 460 volt, 3 phase, 60 Hertz, ball bearing, of NEMA design B, NEC Code F or lower in-rush.

- F. Motors smaller than 1/2 HP shall be 120 volt, single phase, 60 Hertz of NEMA design B, NEC Code F or lower with internal thermal protection.

- G. Control Panels: Where specified, panels shall be a NEMA 12 enclosure prewired for one point feeder supply connection and shall include the following.

1. Across-the-line magnetic type starter with overload protection and HOA switches.
2. Fused switches with dual element fuses.

3. Control transformer with fused primary and fused secondary protection.

2.10 BELT DRIVES

A. General:

1. Belt drives shall be V-belt type with sheaves manufactured for the purpose.
2. Minimum of two belts per drive.
3. Motors 10 HP and smaller shall be provided with variable pitch sheaves and installed on motor slide rails.
4. Motors 15 HP and larger shall have non-adjustable drive sheave and installed on motor slide rails.
5. After air balance is complete and air balance has been accepted by University's Representative, change each variable pitch sheave to fixed pitch sheave.
6. Manufacturer: Sheaves and belts shall be BALDOR or equal.

B. Sheaves:

1. Sheaves shall be cast iron, machined and balanced.
2. Variable pitch sheaves shall be selected for mid-point of equipment operating capacity.
3. Sheaves shall be keyed and located on shafts, with Allen head set screws. On fractional horsepower motors NEMA frame size 48, smaller sheaves may be secured to shaft with set screws only.

C. Ratings:

1. All Other Belt Drives: On each two-belt drive, each belt shall be rated for motor nameplate horsepower rating. On three belt or greater, drive shall be rated for 150% of motor nameplate horsepower rating.

2.11 GUARDS

- ##### A. General:
- All rotating elements on equipment shall have protective devices in accordance with the CCR Title 8, Division of Industrial Safety and General Industry Safety Orders, and OSHA requirements.

- ##### B. Coupling guards shall completely enclose the rotating coupling and shall be constructed of heavy gauge steel in accordance with OSHA requirements.

C. Belt Guards:

1. Guards shall totally enclose the belts and sheaves. Guards shall be fabricated of galvanized expanded metal sides, solid galvanized steel band and adequately sized galvanized angle iron frame.

2. Adequate room for belt adjustments shall be furnished.

3. EXECUTION

3.1 GENERAL

- A. Rough-in Work: Proceed as rapidly as the building construction will permit; complete, test and have approval before enclosing.
- B. Conceal all piping within finished rooms unless otherwise noted on Drawings.
- C. Cleaning: Thoroughly clean piping before installation. Cap all pipe openings to exclude dirt until fixtures are installed and final connections made.
- D. Cut pipe accurately to measurements established at the building; work into place without springing or forcing; clear all windows, doors and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted.
- E. Pipe Damage: Show no tool marks or threads on exposed plated, polished or enameled connections from fixtures. Tape finished surfaces to prevent damage during plastering.
- F. Make all changes in direction with fittings and changes in main sizes through eccentric reducing fittings. Unless otherwise noted, install water supply and return piping with straight side of eccentric fittings at top of pipe.
- G. Pitch pipe lines as required for drainage and elimination of air as follows:
 1. Heating Hot Water: Upwards in direction of flow.
 2. Waste: 1/4" per foot downwards toward mains.
 3. Vents: 1/3" per foot upwards away from fixture trap.
- H. Provide swing joints, ball joints, expansion loops, and devices necessary for a flexible piping system.
- I. Securely bolt in place to building structures all equipment, isolators, hangers, etc.
- J. Provide union and shut-off valves located to facilitate maintenance and removal of all equipment or apparatus.
- K. Equipment Specified in Other Sections: For rough-ins and final connections to equipment specified in other Sections, ascertain exact sizes, services and locations before starting work. Ensure accuracy of work shown on Drawings before starting work. Furnish correct installation.
- L. Dissimilar Metals: Provide cast iron fittings or flanges between all ferrous and non-ferrous materials.

- M. All piping connections to equipment shall be made with screwed or flanged unions to permit dismantling. Unions shall also be installed in the piping systems to permit disassembly consistent with good installation practice and as required for removal of connected equipment from place of installation.
- N. Sleeves, frames, and wall pipes shall be provided for all pipes and ducts passing through concrete floors and walls. Special sleeves through floors and walls shall be installed in accordance with manufacturer's printed instructions and as detailed.
 - 1. All sleeves and frames through exterior floors and walls above ground and all interior floors and walls shall be black iron pipe unless otherwise noted. Sleeves and frames shall be of a size to accommodate the pipe or duct and insulation. Sleeves and frames shall be grouted in place with installation left smooth and finished to match surrounding surfaces.
 - 2. Pipes penetrating fire rated walls, partitions or floors shall have the opening between the pipe and the building construction material, or between the pipe and the sleeve, sealed with an intumescent fire barrier material produced by PARAGON or equal. Thickness of fire barrier shall be appropriate for fire rating of building component.
 - 3. Pipes passing through exterior floors and walls below ground, 2-1/2-inches and smaller, shall utilize black iron pipe sleeves as specified for above-ground in conjunction with a modular mechanical-type seal as hereinafter specified.
 - a. The modular mechanical-type seal shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall sleeve. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut. Tightening of the bolts shall cause the rubber sealing elements to expand, providing a watertight seal between the pipe and wall sleeve.
 - b. The required inside diameter of the sleeve and the installation of the seal shall provide a watertight joint. Seals shall be "Link Seal" manufactured by LINK SEAL or equal. Provide a seal consisting of a combination of a sleeve and a pressure clamping system manufactured by LINK SEAL or equal.
 - 4. Cutting of openings and installation of sleeves and frames through exterior floors and walls above grade, and interior floors and walls shall be done in a neat, workmanlike manner. Openings shall be cut only as large as required for the installation.

- 5. Escutcheons for exposed pipe through floors and walls where exposed to view shall be provided and shall be chromium plated except where special escutcheons are required under plumbing fixtures. Escutcheons shall be sized to conceal the floor or wall opening and sleeve.
- O. Interference: Wherever piping runs above or below ceilings, arrange the run of the piping in such a manner that it does not interfere with grilles, light outlets or light fixtures.
- P. Valves: Valves shall be provided on all piping wherever indicated or specified using adapters where required. All removable or replaceable equipment shall be valved. All valves shall have a securely fastened stamped brass metal plate, each bearing a different number identified in the maintenance manual.
- Q. Openings in Pipes: All openings in pipes shall be kept closed during the progress of the Work.
- R. Lubrication: Furnish all lubrication for the operation of all equipment until completion. Run in all bearings, and after they are run in, drain and flush bearings and refill with a new oil change. Refer to maintenance manual specification for lubrication chart. Bearings that require greasing shall be greased in accordance with the maintenance manual procedure.

3.2 HANGER AND SUPPORTS

- A. Refer to Section 23 05 29, HYDRONIC PIPING, FITTINGS, SUPPORTS AND CLEANING.

3.3 PIPE JOINTS

- A. Copper Piping:
 - 1. Cut square, remove burrs and clean inside of female fitting to a bright finish with steel wool, wire brush, sandpaper or emery cloth. Apply solder flux with brush to tubing. Remove internal parts of solder-end valves prior to soldering.
 - 2. Provide cast iron fittings at points of connection of all copper tubing and any ferrous end equipment.
 - 3. All soldered or brazed joints shall be made by a brazer currently certified for 2-inch pipe. Certifying individual or agency shall in turn be certified by AWS.
 - 4. All soldered or brazed joints shall be acceptable only if 100% full joint penetration of the soldering or brazing alloy is achieved.
 - 5. All soldered or brazed joints shall comply with Section IX of ASME Boiler and Pressure Vessel Code.
 - 6. Joints for copper tube shall be as follows:

- a. Systems Operating at Below 100°F: 95-5 tin-antimony solder.
 - b. Systems Operating at 100°F and Above: Sil-Fos brazing.
- B. Screwed Piping:
 - 1. Cut with machine cutter, hand pipe cutter or carborundum pipe wheel. Deburr with file or scraper or pipe reamer. Do not ream to exceed I.D. of pipe and thread to ANSI B2.1 requirements.
 - 2. Use teflon tape on male thread prior to joining other services. No more than two full threads shall remain exposed after joinings.
 - 3. Use litharge and glycerin on joint prior to joining for air piping.
- C. Brass Screwed Pipe:
 - 1. Cut threads, remove burrs, and apply red lead or approved pipe dope as specified for steel screwed pipe.
 - 2. Make up pipe with surface of chrome plated pipe and fittings.
 - 3. Do not mark surface of chrome plated pipe and fittings.
- D. Welding:
 - 1. Before proceeding, submit for approval:
 - a. Proposed procedures conforming to:
 - 1) ANSI B31.1, Code for pressure Piping, Chapter V.
 - 2) ANSI A49.0, Safety in Welding and Cutting.
 - b. List of Welders: Qualified per Section IX of ASME, Boiler and Pressure Vessel Code.
 - 2. Field Procedures:
 - a. Pipe cleaned free from rust, scale and oxide.
 - b. Pipe Beveled Each End: Per approved procedures.
 - c. Backing rings: Hot water over 100 psi.
- E. Leaky Joints:
 - 1. Remake leaky joints with new material.
 - 2. Remove leaking section and fittings as requested by Owner's Representative and replace as approved and at Contractor's expense.
 - 3. Do not use thread cement or caulking to make joint tight.

3.4 ACCESS TO EQUIPMENT

A. General:

1. All piping, equipment and accessories shall be installed to permit access for maintenance.
2. Any relocation of piping, equipment and accessories required to provide maintenance access shall be accomplished by Contractor at no additional cost to the Owner.

B. Access:

1. Supply access doors where any valves, fire dampers, motors, and equipment requiring access for servicing, repairs, or maintenance are located in walls, chases, above ceilings, or in ductwork.
2. Arrange for the necessary openings in the building to allow for admittance of all apparatus.

3.5 INSTRUMENTS

A. Installation of Pressure Gages:

1. Pressure gages installed on insulated pipe or equipment shall be installed with extension nipples.
2. Locate gages for ease of reading and removing.
3. Install all gages with shut-off cocks.
4. Install one gage between the suction and discharge lines of pumps with shut-off cock on each side and interconnecting piping made up with flexibility.

3.6 SLEEVES, CORE DRILLING AND ESCUTCHEONS

A. Sleeves:

1. Provide sleeving for all pipes that penetrate walls and floors.
2. Cast Iron Sleeves: Secure waterproofing membrane under flashing clamp. Caulk annular space watertight.
3. Sleeves in floors shall extend 2" above finish floor with annular space caulked watertight.

B. Core Drilling:

1. Core drilled holes shall be sized to allow for dry packing sleeves in place; to allow for insulation to extend through holes; to allow for fireproof caulking or clearance around pipes to prevent direct contact between pipes and structures.
2. Locations of core drilling shall be approved by Owner's Representative prior to drilling.

- C. Escutcheons: Provide escutcheons on all piping that penetrates floors, walls and ceilings where exposed to view.

3.7 VALVES

- A. General:
 - 1. All valves shall be first quality of approved manufacture, shall allow for necessary clearances, and shall be tight at the specified test pressure.
 - 2. Each valve shall have the maker's name or brand, the figure or list number and the guaranteed working pressure cast on the body and cast or stamped on the bonnet, or shall be provided with other means of easy identification.
 - 3. Valves shall be minimum working pressure and materials as fittings specified for the service except as herein modified.
 - 4. All gate and globe valves shall be repackable under pressure. Regardless of service, valves shall not be designed for less than 125 lbs. per square inch steam working pressure.
- B. Arrangement: Valves shall be installed in the systems so located, arranged and operated as to give complete regulation of all apparatus, equipment and fixtures.
- C. Installation: Valves shall be installed in the following locations:
 - 1. In all branches and headers of water pipe serving a group of fixtures.
 - 2. On both sides of all apparatus and equipment.
 - 3. For shutoff of risers and branch mains.
 - 4. For flushing and sterilizing the systems.
 - 5. Where shown on the Drawings.
 - 6. Valves shall be installed for accessibility and easy maintenance.

3.8 STRAINERS

- A. General:
 - 1. Bronze bodied strainers shall be installed in copper piping systems.
 - 2. Blow-out connection shall be valved with valve sized same as the blow-out connection.
- B. Valves: Valves shall be gate or ball type.

3.9 FLASHING

- A. Piping: Provide flashing assembly with counter-flashing on each pipe passing through roof.
- B. Ducts: Provide necessary counter-flashing.

3.10 EQUIPMENT SUPPORTS

- A. General:
 - 1. Provide all necessary steel framing supports for piping and equipment for a complete and correct installation.
- B. Approval: Submit drawings of miscellaneous supports for approval.

3.11 INSTALLATION OF ELECTRIC MOTORS

- A. Electric motors which are not part of packaged assemblies shall be delivered to the location of installation.
- B. Mounting and Hook-Up: Refer to Division 26.

3.12 INSTALLATION OF PREWIRED CONTROL PANELS

- A. General:
 - 1. Prewired electrical control panels shall be delivered to the location of installation.
 - 2. Installation and Hook-Up: Refer to Division 26.
- B. Coupling guards shall completely enclose the rotating coupling and shall be constructed of heavy gauge steel in accordance with OSHA requirements.
- C. Belt Guards:
 - 1. Guards shall be supported from equipment bases or equipment with galvanized steel brackets.
 - 2. Guards shall be rigidly held in place without excessive vibration.

3.13 FAN DRIVES

- A. Static pressures indicated show estimated conditions which may vary under actual condition.
- B. Necessary fan speed adjustments and drive changes to obtain specified air volume shall be made by Contractor at no additional cost to the Owner.

3.14 LUBRICATION

- A. Furnish means of lubricating all rotating pieces of equipment.
- B. Extend all inaccessible oil fitting and grease fittings to a readily accessible location.
- C. All rotating pieces of equipment shall be lubricated before start-up and before final acceptance by the Owner.
- D. A record of all equipment requiring lubrication shall be submitted to Owner's Representative.

END OF SECTION 23 0516

SECTION 23 0519

PIPING SPECIALTIES

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide piping specialties as indicated on the Drawings and as specified, complete.

1.2 SUBMITTALS

- A. Shop Drawings and Product Data:
 - 1. The following list includes the required shop drawings that shall be submitted:
 - a. Vents
 - b. Vacuum breakers
 - c. Pressure gages
 - d. Thermometers

2. PRODUCTS

2.1 MATERIALS

- A. Pressure Gauges:
 - 1. Manufacturers:
 - a. H.O. Trerice Co., Model 450 LFSS.
 - b. AMETEK, U.S. Gauge Div.
 - c. Ashcroft by Dresser Industries.
 - d. Marsh Instrument Co.
 - e. Weiss Instruments Inc.
 - f. Or equal.
 - 2. Gauge: ASME B40.1.
 - a. Liquid filled.
 - b. Dial Size: 4-1/2-inch diameter.
 - c. Scale: Both psi and kPa.
 - d. Bourdon Tube: 316 Stainless Steel.
 - e. Socket: 316 Stainless Steel.
 - f. Movement: Stainless Steel.
 - g. Case: Aluminum, solid front with blow-out back.
 - h. Ring: Threaded fiberglass reinforced polypropylene.
 - i. Window: Acrylic.
 - j. Pointer: Micro adjustable, black finished, front adjustable.
 - k. Dialface: Aluminum, white background with black graduation and markings.
 - l. Accuracy: 0.5 percent of scale range, ASME B40.100 Grade 2A.

- m. Options Required:
 - aa. Red Set Hand.
 - bb. Maximum Registering Pointer.
- 3. Snubber Screw. Provide on all gauges on suction and discharge sides of pumps.
- 4. Select dial range of each gauge for normal operating point at mid-span and full range not to exceed 50% of test pressure.
- B. Pressure Gauge Taps
 - 1. Manufacturers:
 - a. H.O. Trerice Co.
 - b. Or equal.
 - 2. Needle Valve: ¼ inch NPT for minimum 125 psi.
 - 3. Ball Valve: Brass ¼ inch NPT for 125 psi.
 - 4. Pressure Snubber:
 - a. Series 872 Brass.
 - b. ¼ inch NPT connections.
 - 5. Coil Siphon:
 - a. Series 885.
 - b. 40 Brass.
 - c. ¼ inch NPT.
- C. Dial Thermometers
 - 1. Manufacturers:
 - a. H.O. Trerice Co.
 - b. AMETEK, U.S. Gauge Div.
 - c. Ashcroft by Dresser Industries.
 - d. Marsh Instrument Co.
 - e. Weiss Instruments Inc.
 - f. Or equal.
 - 2. Thermometer: ASTM E1.
 - a. Bimetallic type.
 - b. Dial Size: 5 inch diameter.
 - c. Scale: Dual Scale Fahrenheit and Celsius.
 - d. Case: Stainless Steel.
 - e. Window: Glass.
 - f. Pointer: Black finished.
 - g. Dialface: Aluminum, white background with black and blue graduations and markings.
 - h. Accuracy: +/- 1% Full Scale.

- i. Options Required:
 - aa. Maximum Registering Pointer.
 - bb. Silicone Dampened Movement.
 - 3. Select dial range of each gauge for normal operating point at mid-span and full range not to exceed 50% of maximum design.
 - 4. Connection: ½" brass union with copper bulb for hydronic service. Provide and select bulbs suitable for steam service. Select bulb length to extend into 2/3 of pipe diameter.
 - 5. Provide thermowells for each thermometer. The thermowells shall be selected for each gauge bulb and shall be ½" NPT. Provide brass thermowells.
- D. Test Plugs
- 1. Manufacturer:
 - a. Peterson Equipment Company Inc, Pete's Plugs, or equal.
 - 2. ¼ inch NPT or ½ inch NPT brass fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with:
 - a. Neoprene core for temperatures up to 250 degrees F at 125 PSIG.
 - b. Nordel core for temperatures up to 250 degrees F at 125 PSIG.
- E. Air Vents:
- 1. Air vents shall be installed on all coils, and other points required for efficient operation of system.
 - a. Automatic Vents:
 - 1) Vents shall be:
 - a) BELL AND GOSSETT or equal for operating pressures to 200 psig.
 - 2) On high points in piping and where exposed to view, install automatic vents specified above.
 - b. Manual Vents: For vents on radiation, unit heaters, coils, and other mechanical equipment, BELL & GOSSETT or equal.
 - 1) Provide air chambers at all high points in piping with air vent cocks fully accessible. Provide air chambers with diameters same size as pipe and a minimum of 2 inches long except furnish same length as diameter for pipes larger than 2 inches. When air

vent cocks on air chambers are not fully accessible, extend cocks with ¼-inch copper water tube ASTM B 88, Type K.

- F. Vacuum Breakers: Vacuum breakers shall be WATTS or equal with bronze body chrome plated in finished areas.

3. EXECUTION

3.1 ADJUSTMENT AND CLEANING

- A. Valves and Specialties:
 - 1. All valves and specialties shall be adjusted to operate smoothly and without binding or leaking. All vents shall be tested and proven to open freely for the passage of air.
 - 2. Locate strainers as necessary to allow easy cleaning.

END OF SECTION 23 0519

SECTION 23 0529

HYDRONIC PIPING, FITTINGS, SUPPORTS AND CLEANING

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide all piping and pipe fittings necessary for complete installation as indicated on the Drawings and as specified, complete.
- B. Provide piping supports, hangers, guides, and anchors as indicated on the Drawings and as specified, complete.
- C. Provide heating hot water piping for the air conditioning system as indicated on the Drawings and as specified, complete.

1.2 SUBMITTALS

- A. Shop Drawings and Product Data:
 - 1. The following list includes the required shop drawings and product data that shall be submitted:
 - a. Manufacturer's technical product data, installation instructions, and dimensioned drawings for each type of pipe and pipe fitting.
 - b. Piping schedule showing manufacturer, pipe weight, fitting type, and joint type for each piping system.
 - c. All pipe supports, hangers, guides, and anchors shall be submitted as shop drawings.
 - d. Hydronic Piping:
 - 1. Gages.
 - 2. Flow indicators.
- B. Pressure Tests:
 - 1. All pressure tests shall be performed with the use of a bristol recording gage, and a record of all tests kept for hand-over to the Owner's Representative.

2. PRODUCTS

2.1 MATERIALS

- A. Copper Tube and Fittings for Copper Tube.
 - 1. Copper Water Tube and Fittings.
 - a. Provide seamless copper water tube conforming to the requirements of ASTM Specification B88 in weight K, and

temper annealed or drawn as specified. Comply with FS WW-T-799, for refrigeration service.

b. Fittings for Copper Water Tube.

- 1) Wrought Copper Fittings. Provide wrought pressure solder joint fittings, pressure fittings conforming in all respects to ANSI B16.22.
- 2) Cast Bronze Fittings. Provide cast bronze solder joints pressure fittings conforming in all respects to ANSI B16.18 and same weight as pipe.
- 3) Brazolets shall be high silicon bronze conforming to ASTM B283 in sizes 2 inches and smaller, and conforming to MIL B-16541 in sizes 2-1/2 inches and larger.
- 4) All solder or brazed joint fittings shall have integral factory formed pipe stops on each inlet or outlet.
- 5) All joints shall be made with approved factory formed fittings. Mechanical formed tee outlets utilizing mechanically extracted collars shall not be used.

B. All hangers, supports, anchors, and guides for pressure piping shall be in accordance with ANSI B-31.

C. Horizontal Piping Hangers:

1. Provide one of the following types of hangers for horizontal piping manufactured by TOLCO or equal.
 - a. All Pipes Except Copper:
 - 1) Except as otherwise specified, provide clevis type, TOLCO or equal. Provide clevis hanger for insulated lines up to 12 inches, TOLCO or equal to keep the clevis nut outside the insulation.
 - 2) Where the pipe exceeds the maximum loading recommended for clevis type hangers, provide steel pipe clamp, TOLCO or equal.
2. Copper Tubing Support:
 - a. Hangers in direct contact with pipe. TOLCO or equal.
 - b. Hangers on Outside of Insulation. TOLCO or equal.
3. Provide trapeze hangers where several pipes can be installed parallel and at the same level, and fabricate from structural steel shapes.

4. Floor Supports: Provide one of the following means of supporting horizontal piping from floor.
 - a. Where bottom of piping is less than 1 foot-6 inches above finish floor for 0 to 8 inches diameter, provide cast-iron pipe rests, TOLCO or equal, with pipe nipples to suit. Fasten to floor.
 - b. Where bottom of pipe is higher than 1 foot-6 inches above finish floor and where provision for expansion is required provide pipe-roll stands, TOLCO or equal, without vertical adjustment, or TOLCO or equal, with vertical adjustment as required. Provide concrete piers and fasten stands to piers.
5. Wall Supports: Provide the following means of supporting horizontal piping from wall.
 - a. Provide steel J-hook for pipe located close to wall, up to 3-inch pipe, TOLCO or equal.
 - b. For hanger suspension with 750 pound maximum loading, provide light welded-steel bracket with hole for one rod, 3/4-inch diameter, TOLCO or equal.
 - c. For pipe-roll stand support, provide welded-steel bracket, light for 700 pound maximum loading, TOLCO or equal, medium for 1500 pound maximum loading TOLCO or equal, heavy for 3000 pound maximum loading, TOLCO Or equal.
- D. Vertical Piping Supports:
 1. All Pipes except Copper: Vertical pipe supports shall be steel extension pipe-clamps, TOLCO or equal. Maximum loading for each size pipe: 3/4"-2"/255 lbs.; 2-1/2"/390 lbs.; 3"/530 lbs.; 4"/810 lbs.; 6"/1570 lbs.; 8"/2500. Bolt clamp securely to pipe, reset clamp-end extension on building structure.
 2. Copper Tubing Support: For uninsulated vertical lines, provide plastic coated riser clamp, TOLCO or equal, with isolation fitting.
- E. Beam clamps shall be malleable iron, TOLCO or equal, for 3/8-inch hanger rods. Forged-steel beam clamp, TOLCO or equal, for hanger rod up to 1-1/2 inches.
- F. Inserts:
 1. Furnish and set inserts in concrete forms. Provide reinforcing rods for pipe sizes over 3 inches.
 2. Concrete inserts shall be black malleable iron universal type for threaded connections with lateral adjustment, TOLCO or equal, for pipe sizes up to 8 inches.

- 3. For pipes 8 inches and over or equivalent group of pipes on trapeze, use two or more inserts to prevent exceeding maximum loading in accordance with manufacturer's printed instructions.
- G. Anchors and Guides: Provide anchors and guides where indicated on the Drawings. Guides shall be TOLCO or equal.
- H. Hydronic Piping:
 - 1. Heating Hot Water Piping: Refer to Section 23 05 16, BASIC MECHANICAL MATERIALS AND METHODS, Paragraph 2.2, Hot Water Piping.

3. EXECUTION

3.1 PREPARATION

- A. Piping and Fittings. Ream all pipe to full inside diameter after cutting and clean before erection.

3.2 INSTALLATION

A. General.

- 1. Run all piping as direct as possible and conceal piping in finished rooms unless shown or specified otherwise. Arrange pipe lines to give ample room for the pipe insulation specified in Section 23 07 00, MECHANICAL INSULATION.
- 2. Make tee connections with standard tee fittings for full size branches. For reduction branches, when branch line is a minimum of 2 pipe sizes smaller than main line, use reducing tees or weldolets and threadolets for steel pipe and brazolets for copper pipe.
- 3. Screwed joints shall be made with teflon tape or a pipe joint compound recommended by the pipe manufacturer, applied to the male threads only. Welded joints shall be welded as set forth in the standard manual of Pipe Welding of the Heating, Piping, and Air Conditioning Contractors Association.
- 4. Joints in copper pipework shall be made with silver solder for systems operating at 100°F or above, and with 95-5 tin-antimony solder for systems operating at below 100°F.

B. Installation.

- 1. Condensate Drainage System Pipe Joints.
 - a. Joints in copper drainage tube shall be soldered using ASTM B 32, Grade 50A solder and fittings recommended by the tube manufacturer. Surfaces to be soldered shall be cleaned bright. The joints shall be fluxed and made with solder.

2. Hangers.

- a. Provide hangers to support the required loads. Supports shall permit movement due to expansion and contraction. Where Drawings indicate details of supports and anchors, conform to details shown. Where details are not shown, conform to requirements of this Section.
- b. Support piping with hangers in direct contact with the pipe for insulated piping not requiring a vapor barrier except on pipes where pipe saddles are specified. Size hangers to fit on the outside of insulation requiring a vapor barrier and on pipes having pipe saddles. Refer to Section 23 07 00, MECHANICAL INSULATION.
- c. Hang pipe from primary building structure. Piping shall not be hung from other piping. All rigid hangers shall provide a means of vertical adjustment after erection. Do not suspend pipe from metal roof deck.
- d. Where non-insulated pipes, in which vibration may occur, pass through walls, floors, or partitions, encase pipe in acoustical wall sleeves.

3. Hydronic Piping.

- a. Water Piping:
 1. Piping shall be run as indicated on the Drawings.
 2. Allowance for expansion shall be made in the installation of all piping so that the usual variation in temperature will not cause undue stress at any point. Pipes shall be securely anchored where necessary to correctly distribute expansion stresses.
 3. Eccentric fittings shall be used for all changes in pipe sizes of supply and return lines arranged to prevent trappage of air, except where reducing tees are used.
 4. Flanged elbows shall be installed for water connections to equipment with heat exchangers to allow easy removal of tube bundles. No obstruction shall be placed in space required for tube removal.
 5. Concealed high points shall have air chambers with 1/4-inch copper tube vent line and stop cock carried to accessible point.

b. Valves and Strainers:

1. General: Provide valves at each piece of equipment to provide isolation of the equipment from its connected system. Locate strainers and valves as necessary to provide easy isolation and cleaning of strainers.
2. Unless shown otherwise, provide a check valve, a balancing valve and gate valve, in the discharge line and a strainer and gate valve in the suction line of each circulating pump.
3. Equipment with automatic control valves shall have gate valves installed either ahead or behind the control valve, to permit removal of the control valve from the line without draining the system.
4. Provide "eccentric plug valves" for balancing valves.
5. Provide gate valve or butterfly valves for isolation.

3.3 ADJUSTMENT AND CLEANING

- A. After piping is erected, flush all piping.
- B. Each system shall be cleaned by passing cleaning fluids through pipework. Equipment that has been previously cleaned shall be isolated from the system and not be subjected to cleaning fluids.
- C. Systems shall be completely flushed after cleaning. Furnish a separate pump for cleaning. Do not use pumps that are furnished as a part of this Contract.
- D. Perform cleaning and boil-out after completion of piping and pressure testing and before the system is put into operation. All piping system cleaning and water treatment must be coordinated with and witnessed by the Owner's operating staff. It is imperative that before any system is filled with water, the operating staff verify that cleaning has been properly completed and proper chemical treatment is in place and maintained. Operating staff should be requested to monitor chemical treatment after the system is filled until the project is completed and turned over to them. The Inspector shall witness the cleaning procedure.
- E. Do not circulate cleaning solution through heating coils. Provide temporary bypasses.
- F. The entire cleaning procedure shall be performed by a contractor furnished independent chemical cleaning company approved by the Owner's Representative.

- G. Flush out entire system for a period of not less than 4 hours to clear it of all loose material. Provide necessary cross-connections to loop system and circulate water for 24 hours. During this period, install 80-mesh screen in strainers and periodically clean. Drain entire system. Refill system. Meter water when refilling to determine amount of chemical required in next procedure. Add trisodium phosphate (TSP) to provide a uniform residual concentration of 10ppm. Circulate water for 48 hours. During circulation, periodically clean screens as required. Flush system for approximately 4 hours or until all traces of chemicals are removed. Remove 80-mesh screens.
- H. For space heating hot water system, provide injection fitting and required connection piping to a 55-gallon chemical drum. Drum shall have provision for wall straps to safely secure to the wall. Chemical pump, controls and interval timer shall be provided. Coordinate with electrical to provide required power for the pump. Coordinate to provide sink and emergency shower/eyewash in location where water treatment will be performed. Run ¼" copper tubing from the water piping system to the sink with appropriate labels and service valves for collecting samples.
- I. Provide water treatment and a 30-day advanced notice to the Owner's Representative prior to treatment. The piping system shall be complete, pressure tested, and cleaned. If water treatment has to be redone due to Contractor's incomplete work, extra services will be at Contractor's expense.

3.4 HORIZONTAL PIPING SUPPORT SCHEDULE

- A. Support horizontal piping on threaded hot rolled steel rod. Threaded rod shall not be reduced to sizes smaller than provided for in support thread sizes.
- B. Maximum spacing between single supports for steel pipe and copper tubing shall be in accordance with table attached at the end of this Section.
- C. The spacing specified herein is included to limit deflection in the pipe to an acceptable minimum. Shorten intervals as necessary so the support manufacturer's maximum recommended safe load values in accordance with ANSI B 31.1 are not exceeded.
- D. Trapeze Hanger. Spacing shall not be farther than the closest interval for any size pipe supported thereby, or as necessary to prevent damage or failure to the structure. Provide additional framing as required to transfer loads to structure.
- E. Supporting rods shall be attached to concrete by inserts placed before concrete is poured.
- F. Supporting rods over 18 inches long shall be braced at every fourth hanger with diagonal bracing attached to the structure by inserts placed before concrete is poured.

3.5 VERTICAL PIPING SUPPORT

- A. Support vertical piping with wrought steel riser clamps.
- B. Support steel pipe at every floor to relieve joint stresses.
- C. Where pipe sleeves extend above floor, place pipe clamps at ceiling below, support clamp-end extension from inserts.

3.6 FIELD QUALITY CONTROL (HYDRONIC PIPING)

- A. Piping System Leak Tests:
 - 1. Make pressure tests in the presence of Owner's Representative.
 - 2. Piping: Pressure test at 125 psig (860 kPa) or 150% of the operating pressure, whichever is greater. If found that any portion of the system does not function correctly, Contractor shall make corrections as approved at no additional cost to the Owner.

END OF SECTION 23 0529

SECTION 23 0548

VIBRATION AND SEISMIC CONTROL

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide all vibration isolators for mechanical equipment to prevent the transmission of vibration and mechanically transmitted sound to the building structure as indicated on the Drawings and as specified, complete. Include adjustments of each mounting system, and the measurement of isolator system performance. Specific mounting arrangements for each item of mechanical equipment shall be as described herein, and as indicated by schedules and details on the Drawings.
- B. Provide seismic restraints on equipment as required by CCR, Title 24, Part 2, Table 20-23J, including motors, air handling units, and control panels.

1.2 SUBMITTALS

- A. Shop Drawings, Product Data and Calculations:
 - 1. The following list includes the required shop drawings that shall be submitted:
 - a. Manufacturer's model number for each isolator, the machine or pipeline to which it is to be applied, and the number of isolators to be furnished for each machine or pipeline.
 - b. For steel spring mounts or hangers - free height, deflected height, solid height, isolator loading, and diameter of spring coil.
 - c. For neoprene isolators - free height, deflected height, and isolator loading.
 - d. Dimensional and weight data for concrete inertia bases, steel and rail bases, and details of isolator attachment.
 - e. For seismic slack cables - indicated method to achieve vertical restraint.
 - f. Furnish seismic calculations per CBC 2016 for all mechanical equipment, isolated or non-isolated, piping and ductwork. Calculations shall be certified by a registered engineer with experience in the design of restraints for flexibly mounted equipment. Seismic restraint design and anchorage design are part of this certification requirement.
- B. Submit written certification from isolation manufacturer that isolation is installed correctly.

1.3 JOB CONDITIONS

- A. Existing Conditions: Notify Owner's Representative of any Project conditions which adversely affect vibration isolation system installation or performance. Do not proceed until approval is received.

2. PRODUCTS

2.1 MATERIALS

A. General:

1. Vibration isolators shall be provided in accordance with the weight distribution to produce uniform deflection. Furnish deflections indicated.
2. Where indicated, scheduled, or specified, provide specific vibration isolation equipment manufactured by M.W. SAUSSE or equal. Where specific type of vibration isolation equipment is not shown or specified, provide isolators recommended by the isolation manufacturer compatible with equipment arrangements shown. A single manufacturer for all vibration isolation equipment is required, unless specifically approved in writing by Owner's Representative.

B. Bases:

1. Base Type A. Provide steel base where shown on the Drawings. Bases shall be one of the following types:
 - a. Integral Structural Steel Base. Base shall be rectangular in shape for all equipment other than centrifugal refrigeration machines and pump bases which may be tee shaped. Pump bases for split case pumps shall include supports for suction and discharge base ells. All perimeter members shall be beams with a minimum depth equal to 1/10 of the longest dimension of the base. Beam depth shall not exceed 14 inches provided that the deflection and misalignment is kept within the limits as recommended by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of 1 inch. Bases shall be M.W. SAUSSE or equal.
 - b. Steel Rail Base. Base shall be for equipment having legs or bases that do not require a complete supplementary base. Members shall be rigid to prevent stress in the equipment and shall be cross braced to prevent twisting under seismic loads.
 - 1) Bases with Spring Isolators. Base shall be constructed of steel wide flange members welded to height saving brackets. Base shall be M.W. SAUSSE or equal with cross braces.

- 2) Bases with Neoprene Isolators. Base shall be constructed of steel channel rails. Bases shall be M.W. SAUSSE or equal with cross bracing.
 2. Base Type B. Provide floating concrete base where shown on the Drawings. Provide rectangular structural channel concrete forms for floating foundations. Bases for split case pumps shall be large enough to provide support for suction and discharge base ells. Channel depth shall be a minimum of 1/12 of the longest dimension of the base, but not less than 6 inches. The base depth shall not exceed 12 inches unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include 1/2-inch diameter reinforcing bars welded in place on 6 inch centers running both ways in a layer 1-1/2 inches above the bottom and drilled steel members with sleeves welded below the holes to receive the equipment anchor bolts. Height saving brackets shall be employed in all mounting locations to maintain a 1-inch clearance below the base. Bases shall be M.W. SAUSSE or equal.
- C. Isolators:
1. General. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid, equal to 50% of the rated deflection.
 2. Isolator Type 1, Neoprene Mounting. Double deflection neoprene mounting shall have a minimum static deflection of 0.35 inch. All metal surfaces shall be neoprene covered to prevent corrosion and have friction pads both top and bottom so they need not be bolted to the floor. Bolt holes shall be furnished for those areas where bolting is required. Isolators shall be M.W. SAUSSE or equal.
 3. Isolator Type 2, Free Standing Springs. Spring isolators shall be free standing and laterally stable without any housing and complete with 1/4-inch neoprene acoustical friction pads between the baseplate and the support. All mountings shall have leveling bolts, rigidly bolted to the equipment. Isolators shall be M.W. SAUSSE or equal.
 4. Isolator Type 3, Housed Spring Mounting with Limit Stop. Springs in housings shall be as specified for Isolator Type 2. Housing shall include vertical resilient limit stops to prevent spring extension when weight is removed, as when equipment is drained. The housing shall serve as blocking during erection and the installed and operating heights shall be the same. A minimum clearance of 1/2 inch shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operation. Mountings used outside shall be hot dipped galvanized. Isolators shall be M.W. SAUSSE or equal.

5. Isolator Type 4, Vibration Hanger. Vibration hanger shall contain a steel spring and 0.3-inch deflection neoprene element in series. The neoprene element shall be molded with a rod isolation bushing that passes through the hanger box. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 degree arc before contacting the hole and short circuiting the spring. Isolators shall be M.W. SAUSSE or equal.
6. Isolator Type 5, Vibration Hanger. Vibration hanger shall be as specified for Type 4, but shall be pre-compressed to the rated deflection so as to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a measuring device. Isolators shall be M.W. SAUSSE or equal.
7. Isolator Type 6, Vibration Hanger. Vibration hanger shall contain a steel spring located in a neoprene cup manufactured with a grommet to prevent short circuiting of the hanger rod. The cup shall contain a steel washer designed to distribute the load on the neoprene and prevent its extrusion. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 degree arc before contacting the hole and short circuiting the spring. Hangers shall be provided with an eye bolt on the spring end and provision to attach the housing to the flat iron duct straps. Hangers shall be M.W. SAUSSE or equal.
8. Isolator Type 7, Vibration Hanger. Hanger shall be a double deflection neoprene-in-shear, Type 2, having a maximum static deflection of 0.35 inch. Isolators shall be M.W. SAUSSE or equal.

D. Isolation of Piping Systems.

1. All metal piping which connects to resiliently mounted equipment shall be suspended with resilient hangers or supported by floor mounted isolators. The first three supports from the connected machine shall have the same static deflection as indicated for the machine. The next two supports shall have static deflection at least equal to one-half of the static deflection indicated for the machine mounting, and the remaining pipe supports shall provide static deflection of 0.35 inches minimum.
2. Where static deflection in excess of 0.35 inches is required, floor isolators shall be Type 3 and isolation hangers shall be Type 5. Where deflection of less than 0.35 inches is required, floor isolators shall be Type 1 and isolation hangers shall be Type 7.

3. Flexible Connections:
 - a. Flexible neoprene connectors shall be used to connect all piping to all isolated equipment, except equipment for which flexible connectors are not permitted by codes. For this application provide swing connections, changing direction a minimum of 3 times before joining isolated equipment. Swing connections shall be made within 6 feet of the isolated equipment.
 - b. Connectors shall be manufactured of multiple plies of nylon tire cord fabric and neoprene, both molded and cured in hydraulic presses. No steel wire or rings shall be used as pressure reinforcement. Connectors up to, and including, 2-inch diameter may have threaded ends. Connectors 2-1/2 inches and larger shall be manufactured with floating steel flanges. All connections shall be rated a minimum of 150 psi at 220°F. All flanged equipment shall be directly connected to neoprene elbows in the size range 2-1/2 through 6 inches or any larger available size if the piping makes a 90 degree turn at the equipment. All straight through connections shall be made with either flanged or screwed connectors pre-extended as recommended by the manufacturer to prevent additional elongation under pressure. Sizes 12 inches and larger operating at pressures above 100 psi shall employ control cables with end fittings isolated from the anchoring plates by means of 1/2-inch-thick bridge bearing, neoprene washer busings designed for a maximum of 1000 psi.
 4. Drain connections from isolated equipment to floor drains shall have at least 1-inch air gap above from drain.
 5. Acoustical Sleeves. Where piping passes through equipment walls, floors or ceilings, provide a split seal consisting of two bolted pipe halves with 3/4 inch or thicker neoprene sponge bonded to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete shall be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum of 1-inch past either face of the wall. Where temperatures exceed 240°F, 10 lb. density fiberglass shall be used in lieu of the sponge.
- E. Isolation of Fractional Horsepower Equipment: All fractional horsepower fans, pumps, and equipment which are mounted on or suspended from floors that are not on-grade shall be isolated with neoprene-in-shear isolators as specified except where such isolators are furnished as an integral part of the machine.

- F. Electrical Connections to Resiliently Mounted Equipment: Electrical connections to equipment which is supported or suspended by vibration isolators shall be made with long lengths of flexible steel conduit or flexible armored cable. These flexible connections shall be located so as to prevent rigid connections between the resiliently mounted equipment and the building structure.
- G. Seismic Restraints.
 - 1. Floor mounted equipment, piping and ductwork.
 - a. Type S. Similar to Type 3 as specified in Paragraph 2.1 C, Isolators, designed for earthquake loads. Restraints shall be TOLCO or equal.
 - b. Type SL. All directional seismic restraints shall consist of interlocking steel members restrained by a one-piece molded bushing or bridge-bearing neoprene. Bushing shall be replaceable and shall have a minimum thickness of 1/4-inch. A minimum air gap of 1/8-inch shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. Snubber ends shall be removable to allow inspection of internal clearances. Neoprene bushing shall be rotated to ensure no short circuits exist. Restraints shall be TOLCO or equal seismic snubbers.
 - 2. Suspended Equipment, Piping and Ductwork: Type SC, Seismic Slack Cables. Cables shall be arranged to achieve the specified all-directional restraints and sized to resist seismic loads. Cables shall be installed with sufficient slack to prevent short circuiting the vibration isolators. Restraints shall be TOLCO or equal type seismic slack cables.

3. EXECUTION

3.1 INSTALLATION

- A. Vibration Isolation Hangers.
 - 1. Resilient hangers shall be installed as near as possible to the supporting overhead structure. The machine suspension points shall be located in a rigid and heavy portion of the building structure. Suspension of machines from lightweight floor slabs is not allowed.
 - 2. Suspension rods shall be attached to rigid members of the machine structure. When such attachment points do not exist, a heavy steel framework shall be provided to support the machine with suspension rods attached to this framework.

3.2 FIELD QUALITY CONTROL

A. General:

1. Install all vibration isolators in accordance with manufacturer's printed recommendations.
2. Replace isolators which do not produce the required deflection, are incorrectly loaded above or below their correct operating height, or which do not produce the required isolation as approved and at no extra cost to the Owner.

END OF SECTION 23 0548

SECTION 23 0553

HVAC PIPING & EQUIPMENT IDENTIFICATION

1. GENERAL

1.1 DESCRIPTION

- A. Provide pipe identification labels as specified herein complete.

1.2 WORK SPECIFIED IN OTHER SECTIONS

- A. Section 23 05 54, MECHANICAL IDENTIFICATION.

1.3 REFERENCES

- A. ANSI A13.1-1981, Scheme for the Identification of Piping Systems.

1.4 SUBMITTALS

- A. Submit full size samples, representing different sizes and colors.

2. PRODUCTS

2.1 GENERAL

- A. Use ANSI 13.1-1981 for specified standard identification for background color, letter color, length of color and letter height of marker required to identify piping systems. Marker shall include flow direction arrows.

2.2 MATERIALS

- A. Markers for pipe of less than 3/4" diameter - 1-1/2" diameter brass tags using meter seals with copper wire.
- B. Markers for pipe sizes 3/4" through 5-7/8" diameter shall be pre-coiled to snap around pipe.
- C. Markers for pipe sizes greater than 5-7/8" diameter shall be strap-on type, using either nylon ties or spring fasteners to secure to pipe.
- D. Markers for Valves: See Paragraph 2.2.A above.

2.3 MANUFACTURERS

- A. Seton Name Plate Co., Telephone No. - (800) 243-6624.
- B. D & G Sign and Label, Telephone No. - (800) 356-9269.
- C. Or equal.

3. EXECUTION

3.1 INSTALLATION/APPLICATION

- A. Install pipe identification markers in accordance with manufacturer's instructions.

3.2 LOCATION

- A. On exposed piping, markers shall be located, installed and easily observable in locations adjacent to valves or flanges and adjacent to changes in direction, branches and where pipe pass through walls and floors. On straight runs pipes shall be identified every 20 feet.
- B. On concealed pipe lines which are accessible by access doors, ceiling removal etc., markers shall be located at each point of entry, junction and exit to the concealed space and spaced every 20 feet on straight runs, except in vertical shafts where it should be identified at every floor near the ceiling.

END OF SECTION 23 0553

SECTION 23 0554

MECHANICAL IDENTIFICATION

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide a complete identification system as specified, complete.

1.2 SUBMITTALS

- A. Submit full size nameplates and tags samples. Samples will be returned to Contractor after approval.

2. PRODUCTS

2.1 APPARATUS IDENTIFICATION

- A. Apparatus nameplates shall be black Lamacoid plates with white lettering engraved through the black layer.
- B. Equipment identification shall be embossed aluminum or engraved plastic plate securely attached to equipment.

2.2 PIPE IDENTIFICATION

- A. Refer to Section 23 05 53, HVAC PIPING & EQUIPMENT IDENTIFICATION.

2.3 DUCTWORK IDENTIFICATION

- A. Ductwork stencils shall be 2" high lettering.

3. EXECUTION

3.1 GENERAL

- A. All valves shall have a 1-1/2" diameter brass identification tag identifying valve number and service.
- B. Secure tags to valves using metal seals with copper wire.
- C. Valves that are equipped with chain operators shall have an additional tag secured to the hook or clip that supports the swagged chain.

3.2 EQUIPMENT IDENTIFICATION

- A. Identification shall be provided for the following types of equipment:
 - 1. Damper motors.
 - 2. Automatic valves.
 - 3. Flow switches.
 - 4. Pressure switches.
 - 5. Variable air volume devices.
 - 6. Valves.

- 7. VFDs.
- 8. Sound Traps.
- 9. Air Handling Units.
- 10. Flow measuring and flow control devices.

- B. Equipment out of view behind access doors in unfinished rooms shall also be identified on the face of the access door.

3.3 DUCTWORK IDENTIFICATION

- A. Provide identification of toilet exhaust, supply air and return air ducts by means of stenciled lettering identifying equipment designation it is connected to, contents and direction of flow.
- B. Colors: Black lettering on white background.
- C. Locations: Stencil identification in ducts coming out of shaft at each floor and in equipment rooms. Straight runs of fume hood exhaust ducts shall be identified every 20 feet, except in vertical shafts where it should be identified at every floor near the ceiling.
- D. Application: Apply to clean surfaces free of dust, grease, oil or any other material which will prevent paint adhesion.

END OF SECTION 23 0554

SECTION 23 0700

MECHANICAL INSULATION

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide all mechanical insulation as indicated on the Drawings and as specified, complete.

1.2 QUALITY ASSURANCE

- A. All insulation shall have composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to the insulation) fire and smoke hazard ratings as tested by procedure ASTM E 84, NFPA 255, and UL 723 not exceeding:
 - a. Flamespread, 25
 - b. Smoke Developed, 50
- 2. Accessories such as adhesives, mastics, cements, tapes and fiberglass cloth for fittings shall have the same component rating as listed above.
- 3. Insulation shall comply with FS HH-I-552, HH-I-562, ASTM C 547-67 and MIL-I-22344B.

1.3 PRODUCT DELIVERY

- A. Delivery of Materials: Material shall be furnished to the Project site bearing the manufacturer's label.

1.4 SUBMITTALS

- A. Shop Drawings and Product Data:
 - 1. The following list includes the required shop drawings that shall be submitted:
 - a. All insulation materials.

2. PRODUCTS

2.1 MATERIALS

- A. Tape: Wherever tape is used for sealing purposes, it shall be of type and applied as recommended by the non-conductive covering manufacturer. Where recommendation is lacking, the tape used shall be sealed with MANVILLE LINACOUSTIC or equal.
- B. Insulating Cement: Insulating cement shall be all-purpose cement. Where insulating cement is applied to pipe fittings in concealed locations, it shall be "one-coat" cement.

- C. Pipe Insulation: Pipe insulation shall be multiservice-type suitable for all lines operating from -20°F to 500°F. Insulation shall be one-piece consisting of glass fibers bonded with phenolic resin and molded into a hollow cylinder covered with a factory applied vapor barrier jacket. Thermal conductivity (Btu/hr square foot degrees F./IN) shall not exceed:
 - a. At 75°F. mean temperature 0.22
 - b. At 100°F. mean temperature 0.23
 - c. At 200°F. mean temperature 0.25
- D. Duct Insulation: All duct insulation shall be glass fiber blanket with a vapor barrier facing as specified. Thermal conductivity (Btu/hr square foot degrees F./IN) shall not exceed 0.25°F at 75°F. Density shall be .75 lbs. cubic foot. Vapor barrier jacket shall be heavy duty ASJ consisting of laminated aluminum foil, glass reinforcing and white building paper. Perm rating shall be 0.01.
- E. Flexible Duct Insulation:
 - 1. Flexible duct insulation shall be factory applied or field applied as follows:
 - a. Insulation shall be adhered to the duct with adhesive applied in 6-inch strips around the duct on 12-inch centers. Tying cord or twine shall be used to secure the insulation. Vapor barrier at butted joints shall be sealed with vapor barrier tape. Where insulation is furnished with vapor barrier flange, flanged joint shall be sealed with vapor barrier mastic.

3. EXECUTION

3.1 INSTALLATION/APPLICATION

- A. The insulation and materials shall be applied only by mechanics skilled at such Work. The appearance of the finished Work shall be of equal importance with its mechanical correctness and efficiency. Insulation for heating surfaces and piping shall not be applied until such times as those surfaces have been heated to dry out the insulation. Insulation shall not be applied until the system is tested as required. Refer to Section 23 91 00, TESTING, ADJUSTING, AND BALANCING FOR HVAC, for tests.
- B. Installation:
 - 1. Wherever vapor barriers are specified, all portions of the covering at joints and fittings shall be vapor sealed.
 - 2. Insulation shall be continuous through all walls, floors, and ceilings unless otherwise specified, or shown.
 - 3. Insulate unions, flanges, and valve bodies but not operating handwheels or levers.

4. Insulation in crawl spaces having dirt floors shall have a vapor barrier jacket.
5. Application of all materials shall be in accordance with the manufacturer's printed instructions.
6. The insulation shall be handled in a manner that will not adversely affect its structural or insulating properties.
7. Support shall be provided for the insulation on vertical lines to prevent the insulation from slipping downward.
8. Do not place insulation over vent and drain inlets and outlets.
9. Self-sealing laps shall have an additional field applied coat of adhesive applied to the opposite mating surface. Both hot and cold pipe self-sealing jacket laps on longitudinal and butt joints shall be stapled at 6 inches maximum spacing for both exposed and concealed. On cold pipe insulation, the staples and the longitudinal and butt edges shall be sealed with mastic as indicated in the jacket manufacturer's printed recommendations.
10. Where pipe hanger rods penetrate vapor barrier, vapor barrier shall be carried up and sealed around rod for a distance of 12 inches away from the outside of the pipe insulation.
11. Fittings and Valves:
 - a. Hot Pipelines (above 60°F.):
 - 1) Flanges, couplings, valves, anchors, and fittings shall be insulated with factory premolded, prefabricated or field fabricated sections of insulation of the same material and thickness as the adjoining pipe insulation.
 - 2) When segments of insulation are used, elbows shall be provided with not less than three segments. When nesting size sections of insulation are used, all voids shall be filled with insulating cement or mineral fiber. Sections of insulation shall be secured in place with wire or by joining the sections with adhesive. Adhesive shall be applied over the insulation in two coats with glass cloth or tape embedded between coats. Cloth or tape shall overlap itself 1 inch (25 mm) and adjoining insulation jacket 2 inches. In lieu of above finish, factory-premolded one-piece PVC fitting covers shall be used. If used, PVC fitting covers shall be secured by stapling, tack fastening, banding, or taping. When PVC fitting covers are used, factory pre-cut blanket inserts furnished by the fitting cover manufacturer may be used. Inserts shall be

installed in accordance with the fitting manufacturer's printed recommendations. Insulated flanges, couplings, valves, anchors, and fittings shall be covered with preformed or field-fabricated sections of aluminum jacket secured with bands in lieu of finishes specified above.

- 3) When pipe insulation with factory-applied aluminum jacket is provided, flanges, valves and fittings may be insulated with factory- or field-fabricated sections of the same material and thickness as adjoining pipe insulation and jacket. Sections shall be secured with bands. Unless otherwise shown, unions will not be insulated and pipe insulation and jacket shall terminate neatly at the ends of unions.
- 4) All termination points shall be finished with a brush coat of adhesive.

b. Cold Pipelines (-30°F to 60°F.):

- 1) Flanges, couplings, unions, valves, anchors and fittings unless otherwise shown shall be insulated with factory premolded, prefabricated or field fabricated sections of insulation of the same material and thickness as the adjoining pipe insulation. Insulation on valve packages in room-fan-coil units may be omitted where the units are furnished with auxiliary drain or drip pans.
- 2) Anchors, when secured directly to the pipe shall be insulated for the necessary distance to prevent condensation, but not less than 6 inches from the surface of the pipe insulation. Insulation and vapor barrier shall be extended to cover glands and stem completely. When segments of insulation are used, elbows shall be provided with not less than three segments.
- 3) When nesting size sections of insulation are used, all voids shall be filled with insulating cement or mineral fiber.
- 4) Sections of insulation shall be secured in place with wire or by joining the sections with adhesive.

- c. Vapor barrier coating shall be applied over the insulation in two coats with glass tape or cloth embedded between coats. Cloth or tape shall overlap itself 1 inch and adjoining insulation jacket 2 inches. The coating shall be applied to a total dry film thickness of not less than 1/16 inch. In lieu of the above vapor barrier coating, factory-remolded one-piece

PVC fitting covers may be used. If used, PVC fitting covers shall be secured by stapling, tack fastening, banding, or taping with vapor barrier tape. Staples or tacks and fitting cover edges shall be sealed with vapor barrier coating, in accordance with the fitting cover manufacturer's printed recommendations. When PVC fitting covers are used, factory pre-cut blanket inserts furnished by the fitting cover manufacturer may be used. Insert shall be installed in accordance with the fitting cover manufacturer's printed recommendations. When required by the Drawings, insulated flanges, couplings, unions, valves, anchors, and fittings shall be covered with preformed or field-fabricated sections of aluminum jacket applied over the vapor barrier and secured bands.

- d. Where unions are shown to be not insulated, the pipe insulation and jacket shall terminate neatly at the ends of the unions. Ends of pipe insulation shall be sealed to the pipe with a brush coat of vapor barrier coating at termination points, valves, flanges, and fittings.

END OF SECTION 23 0700

SECTION 23 0800

MECHANICAL SYSTEMS COMMISSIONING

1. GENERAL

1.1 DESCRIPTION

- A. The purpose of this section is to specify the Contractor's responsibilities and participation in the commissioning process relative to Division 23.
- B. Commissioning testing shall be performed by the Owner's Commissioning Authority (CxA) with assistance from the Contractor and appropriate subcontractors. Commissioning is primarily the responsibility of the Owner's CxA, with start-up, testing and support for commissioning the responsibility of the Contractor. The commissioning process does not relieve the Contractor from participation in the process or diminish the role and obligations to complete all portions of work in a satisfactory and fully operational manner.
- C. Work of Division 23 includes:
 - 1. Testing and start-up of the HVAC equipment.
 - 2. Furnish qualified personnel to assist with commissioning/functional tests, including seasonal testing, to verify equipment/system performance.
 - 3. Completion and endorsement of Pre-functional Test Forms provided by the CxA to assure that Division 23 equipment and systems are fully operational and ready for functional testing.
 - 4. Furnish equipment, materials and labor necessary to correct deficiencies found during the commissioning process which fulfill contract and warranty requirements.
 - 5. Furnish operation and maintenance information and as-built drawings to the CxA for review, verification and organization, prior to distribution.
 - 6. Furnish assistance to the CxA to develop, edit and document system operation descriptions.
 - 7. Furnish training for the systems specified in this Division with coordination of Owner's Representative by the CxA.
 - 8. Commissioning in accordance with SECTION 23 96 00 SEQUENCES OF OPERATIONS.
 - 9. Commissioning using the building automation system, as described in SECTION 23 95 00 BUILDING AUTOMATION SYSTEM.
- D. Various sections in Division 23 outline the specific commissioning responsibilities of applicable subcontractors and Contractor to coordinate and manage the commissioning responsibilities of those subcontractors. Reference to work performed by subcontractor shall not relieve Contractor from sole responsibility for all work of the project.

1.2 RELATED WORK

- A. All installation, testing and start-up procedures and documentation requirements specified within Division 23.
- B. Commissioning Functional Test Procedures that required participation of the Division 23 subcontractors.
- C. Cooperate with the CxA in the following manner:
 - 1. All testing and start-up procedures and documentation requirements specified within Division 1 and Division 23 and related portions of this project.
 - 2. Allow sufficient time before final completion dates so mechanical systems start-up, test and balance and commissioning can be accomplished.
 - 3. Provide labor and material to make corrections when required without undue delay.
 - 4. Put all heating, ventilation and air conditioning systems and equipment into full operation and continue the operation of the same during each working day of the testing, balancing and commissioning.
 - 5. Include the costs of the dampers, replacement sheaves and belts, as required, to obtain satisfactory system performance as requested by the test and balance subcontractor or the CxA.
 - 6. Provide test holes in ducts and plenums where directed or necessary for pitot tubes for taking air measurements and to balance the air systems. Test holes shall be provided with an approved removable plug or seal. At each location where ducts or plenums are insulated, test holes shall be provided with an approved extension with plug fitting.
 - 7. Provide pressure/temperature taps where directed or necessary for taking measurements to test and balance hydronic systems.

2. PRODUCTS

2.1 TEST EQUIPMENT

- A. Standard test equipment for commissioning will be provided by the Contractor.
- B. Contractor shall provide standard and specialized test equipment as necessary to test and start up the HVAC systems.
- C. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment through the installing subcontractor. Have manufacturer provide the test equipment, demonstrate its use and assist the CxA in the commissioning process.

- D. The Contractor shall provide all equipment, software and all test programming support as necessary to start up, calibrate, debug and verify proper function of the control/facility management system. This equipment and software shall be provided for use by both the test and balance subcontractor and the CxA.

3. EXECUTION

3.1 WORK PRIOR TO COMMISSIONING

- A. Complete all phases of work so the systems can be energized, started, tested and otherwise commissioned. Division 23 has primary start-up responsibilities with obligations to compete systems, including all sub-systems, so they are functional. This includes the complete installation of all equipment materials, raceways, wire, terminations, controls, etc., per the Contract Documents and related directives, clarifications, change orders, etc.
- B. A Commissioning Plan will be developed by the CxA. Upon request of the CxA, the Contractor shall furnish assistance and consultation. The Commissioning Plan will be developed prior to completion of the installation. The Contractor is obligated to assist the CxA in preparing the Commissioning Plan by furnishing all necessary information pertaining to the actual equipment and installation. If Contractor-initiated system changes have been made that alter the commissioning process, the CxA will notify the Owner's Representative and the Contractor may be obligated to compensate the CxA to test the revised product or confirm the suitability/unsuitability of the substitution or revision.
- C. Specific pre-commissioning responsibilities of Division 23 are as follows:
 - 1. Normal start-up services required bringing each system into a fully operational state. This includes motor rotational check cleaning, lug tightening, control sequences of operation, etc. The CxA will not begin the commissioning process until each system is complete, including normal contractor start-up and debugging.
 - 2. The Contractor shall complete the Pre-functional Test Forms on the systems to be commissioned to verify that all aspects of the work are complete in compliance with the plans and Specifications. Contractor start-up forms may be substituted for the Pre-functional Test Forms with prior approval by the CxA.
 - 3. Factory start-up services will be provided for key equipment and systems specified in Division 23. Factory start-up activities shall be documented and submitted. The Contractor shall coordinate this work with the manufacturer and the CxA.
 - 4. Notify Owner's Representative and CxA when systems are ready for functional testing.

- D. Commissioning is intended to begin upon completion of a system. Commissioning may proceed prior to the completion of systems and/or sub-systems, if expediting this work is in the best interests of the Owner. Commissioning activities and schedule will be coordinated with the Contractor. Start of commissioning before system completion will not relieve the Contractor from completing those systems as per the schedule.

3.2 PARTICIPATION IN COMMISSIONING

- A. Commissioning testing shall be performed by the CxA with assistance from the responsible Contractor and subcontractors. Provide skilled technicians to start up and debug all systems within this division of work. These same technicians shall be made available to assist the CxA in completing the commissioning program as it relates to each system and their technical specialty. Work schedules, time required for testing, etc., will be requested by the CxA and coordinated by the Contractor. Contractor will ensure the qualified technician(s) are available and present during the agreed-upon schedules and of sufficient duration to complete the necessary tests, adjustments and/or problem resolutions.
- B. System problems and discrepancies may require additional technician time, CxA time, redesign and/or reconstruction of systems and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained.
- C. The CxA reserves the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment, system and/or sub-system. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment and an attitude/willingness to work with the CxA to get the job done. A liaison or intermediary between the CxA and qualified factory representatives does not constitute the availability of a qualified technician for purpose of this work.
- D. Furnish a draft report with final test measurements to the CxA and shall provide qualified technicians and instruments needed for balancing to demonstrate a sample of up to 100% of measurements until specified results are achieved.

3.3 WORK TO RESOLVE DEFICIENCIES

- A. In some systems, maladjustments, misapplied equipment, and/or deficient performance under varying loads will result in a system that does not meet the original design intent. Correction of work will be completed as approved by the Owner's Representative, with input from the Contractor, equipment supplier and CxA. Whereas all members will have input and the opportunity to discuss, debate and work out problems,

the CxA will have final jurisdiction on the necessary work to be done to achieve performance.

- B. Corrective work shall be completed in a timely fashion to permit the timely completion of the commissioning process. Experimentation to render system performance will be permitted. If the CxA deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the CxA will notify the Owner's Representative indicating the nature of the problem, expected steps to be taken and the deadline for completion of activities. If the deadline(s) pass without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Installing subcontractor's responsibility except where they are a result of design issues.

3.4 ADDITIONAL COMMISSIONING

- A. Additional commissioning activities may be required after system adjustments, replacements, etc., are completed. The Contractor, suppliers and CxA shall include a reasonable reserve to complete this work as part of their standard contractual obligations.
- B. The cost of compensation of the CxA for repeat testing or troubleshooting due to systems that do not meet specified performance shall be borne by the Contractor.

3.5 SEASONAL COMMISSIONING AND OCCUPANCY VARIATIONS

- A. Seasonal commissioning pertains to testing under full-load conditions during peak heating and peak cooling seasons, as well as part-load conditions in the spring and fall. Initial commissioning will be done as soon as contract work is completed, regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.
- B. All equipment and systems will be tested and commissioned in a peak season to observe full-load performance. Heating equipment will be tested during winter design extremes. Cooling equipment will be tested during summer design extremes, with a fully occupied building. Contractor, subcontractor and supplier will be responsible to participate in the initial and the alternate peak season test of the systems required to demonstrate performance.
- C. Subsequent commissioning may be required under conditions of minimum and/or maximum occupancy or use. All equipment and systems affected by occupancy variations will be tested and commissioned at the minimum and peak loads to observe system performance. Contractor, subcontractor and supplier will be responsible to participate in the

occupancy sensitive testing of systems to provide verification of adequate performance.

3.6 SYSTEMS THAT SHALL BE COMMISSIONED

- A. Systems that shall be commissioned include:
1. Heating, Ventilation, Air Conditioning (HVAC) Systems and Controls (RTU-1, its VAV boxes, EF-1, and EF-2)
 2. Control and monitoring systems (Building Automation System)

3.7 POST-OCCUPANCY REVIEW

- A. Subsequent commissioning will be required approximately 10 months after substantial completion of the project. The facility operation will be reviewed using BAS trend data, limited functional testing and interviews with the O&M staff and occupants. The Contractor shall assist the post-occupancy review by setting up BAS data trends, downloading those trends and assisting with functional testing as needed. The commissioning activities may identify items for correction by the Contractor.

3.8 TRAINING

- A. The Contractor shall be required to participate in the training of the Owner's engineering and maintenance staff for each system and the related components. Training may be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids, or in the field with the specific equipment. The type of training will be per the Owner's option.
- B. The Contractor will be responsible for the generic training as well as instructing the Owner's staff on the system peculiarities specific to this project.

3.9 SYSTEMS DOCUMENTATION

- A. In addition to the requirements of Division 1, update Contract Documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. All drawings shall be red-lined on two (2) sets. Division 23 as-built drawings shall include updated architectural floor plans and the individual electrical systems in relation to actual building layout.
- B. Maintain as-built red-lines on the job site as required in Division 1. Given the size and complexity of this project, red-lining of the drawings at completion of construction based on memory of key personnel is not satisfactory. Continuous and regular red-lining and/or posting of drawings is considered essential and mandatory.

**BRENDA VILLA AQUATIC CENTER HVAC UPGRADES
CITY OF COMMERCE**

- C. In addition to the stated requirements for operation and maintenance data, submit one (1) copy of equipment technical literature, operation and maintenance literature and shop drawings to the CxA as soon as they are available. This requirement is for review of these documents prior to distribution of multiple copies for the Owner's final use.

END OF SECTION 23 0800

SECTION 23 0900

CONTROLS AND INSTRUMENTATION

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Furnish all labor and provide all materials and equipment for the complete automatic control systems as indicated on the Drawings and as specified, complete. The systems shall provide accurate and stable control of the Project equipment with the sequences indicated.
- B. Provide direct digital controls (DDC) instrumentation devices and interconnect them to the existing building automation system (BAS) or energy management system (EMS). BAS and EMS are used interchangeably in the specifications, but are intended to mean the same thing.
- C. DDC instrumentation devices include:
 - 1. Actuators for control valves and dampers
 - 2. Occupancy sensors
 - 3. Room temperature sensors
 - 4. Pipeline water temperature sensors
 - 5. Air temperature sensors for duct or plenum mounting
 - 6. Air pressure sensors for duct or plenum mounting
 - 7. Air static pressure sensors
 - 8. Building static pressure sensors
 - 9. Differential air pressure sensors for duct or plenum mounting
- D. Control systems for these instrumentation devices shall be complete, including all equipment and appurtenances, and ready for operation. They shall be integrated, programmed, and tested based on the sequence of operations specified below. Control systems shall be furnished, installed, tested, calibrated, programmed, and started up by, or under the supervision of trained technicians certified as qualified representatives or employees of the BAS manufacturer.
- E. The Contractor shall integrate, program, and test controls using specifications and guidelines presented in:
 - 1. Section 23 95 00 – Building Automation System
 - 2. Section 23 96 00 - Sequences of Operations

- F. The controls installer shall assist and be present during the testing by balancing personnel. Adjusting control devices during testing, adjusting, and balancing to override controls for simulating situations necessary for testing, adjusting and balancing the HVAC system.

1.2 SUBMITTALS

- A. Shop Drawings and Product Data:
 - 1. The following list includes the required shop drawings and manuals that shall be submitted:
 - a. Furnish diagrammatic layouts of the automatic control systems specified. Layouts shall show all control equipment, and the function of each item shall be indicated for the different seasons.
 - b. Diagrams shall show, in addition to the automatic control system, installation with the major wiring included with the self-contained equipment and the motor control center circuitry, all of which interface with this system. Data shall be derived from and submitted with diagrams from the manufacturer.
 - c. All shop drawings shall be accompanied with a complete description of sequence of operation. Each control element mentioned in the sequence description shall be identified with same mark as shown on the control diagrams.
 - d. Shop drawings shall be prepared in AutoCAD and shall be presented in a manner to facilitate easy visualization of the system operation.
 - 2. The following list includes Contractor's responsibility for training and instructing Owner's personnel.
 - a. Owner's Instructions. At the completion of the Work and on the day of final acceptance by the Owner, factory representatives under direct employment of Contractor shall furnish six 4-hour periods of instruction to Owner's operating personnel who have responsibility for the mechanical system.
 - b. Control Manual and Documentation. The following information shall be furnished at Project completion. Furnish one set for each operating manual.
 - 1) Shop drawings of control system showing all devices, all interconnections between devices, and all connections to items provided by others. Furnish a sequence of operation and a complete Input/output (I/O) summary indicating input and output devices and their connection point.

- 2) Specification data sheets on each device.
 - 3) An operator's manual which shall include detailed machine interface.
 - 4) An operator's reference table listing the addresses of all connected input points and output points. Setting shall be shown where applicable.
3. Furnish a 41" x 30" Mylar reproducible of each control diagram and equipment schedule, which shall reflect the "as-built" condition.

1.3 SYSTEM STARTUP AND COMMISSIONING

- A. Each point in the system shall be tested for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BAS or EMS shall be tested against the appropriate sequence of operation. Successful completion of the system test shall constitute the beginning of the warranty period. A written report shall be submitted to the Owner's Representative indicating that the installed system functions in accordance with the plans and specifications.
- B. The Controls Contractor shall commission and set in proper operating condition all major equipment and air handling systems, such as air handling units and mixing boxes, in the presence of the Owner's Representative.
- C. The Controls Contractor shall provide all manpower and engineering services required to assist the Mechanical Contractor and Balancing Contractor in testing, adjusting, and balancing the HVAC systems in the building. The Controls Contractor shall have a trained technician available on request during the balancing of the systems. The Controls Contractor shall coordinate all requirements to provide a complete air balance with the Balancing Contractor and shall include all labor and materials in his contract.

1.4 TRAINING

- A. The Controls Contractor shall provide both on-site and classroom training to the Owner's Representative and maintenance personnel per the following description:
 1. On-site training shall consist of a minimum of 4 hours of hands-on instruction geared at the operation and maintenance of the systems. The curriculum shall include:
 - a. System Overview
 - b. System Software and Operation
 - 1) System access
 - 2) Software features overview

- 3) Changing set points and other attributes
- 4) Scheduling
- 5) Editing programmed variables
- 6) Displaying color graphics
- 7) Running reports
- 8) Application programming
- c. Operational sequences.
- d. Equipment maintenance.

1.5 OPERATING AND MAINTENANCE MANUALS

- A. The operation and maintenance manuals shall contain all information necessary for the operation, maintenance, replacement, installation, and parts procurement for the instrumentation devices and their connection to the existing BAS. This documentation shall include specific part numbers and software versions and dates. A complete list of recommended spare parts shall be included with the lead time and expected frequency of use of each part clearly identified.
- B. Following project completion and testing, the Controls Contractor shall submit as-built drawings reflecting the exact installation of the instrumentation devices and their connection to the BAS. The as-built documentation shall also include a copy of all application software both in written form and in electronic form.

1.6 WARRANTY

- A. The Controls Contractor shall warrant the controls installation for 12 months after system acceptance and beneficial use by the Owner. During the warranty period, the Controls Contractor shall be responsible for all necessary revisions to the hardware and software as required to provide a complete and workable system consistent with the letter and intent of the sequences of operations specifications sections.
- B. Updates to the manufacturer's software shall be provided at no charge during the warranty period.

2. PRODUCTS

2.1 MATERIALS

- A. The controls, sensors, and devices shall be compatible for use with the BAS's identified in paragraph 1.1 B of this specification section.
- B. Direct Digital Control (DDC) and BAS: Direct digital controllers, sensors, controlled devices or transducers shall be used for electronic monitoring and control of devices.

1. Direct digital controllers shall be field programmable controllers, microprocessor based, which incorporate direct digital control, all necessary energy management functions and also incorporates digital display and local adjustments of desired variables at the controller cabinet.
 - a. The digital system controller shall perform its assigned control and energy management functions as a stand-alone unit. It shall be incorporated into a trunk for communication with or management by the BAS. The digital system controller shall perform its full control and energy management functions, regardless of condition of communications link with the BAS. These stand-alone capabilities shall include:
 - 1) All closed loop control functions (P, PI, PID, incremental floating, etc.). Control algorithms shall be available and resident in the digital system controller to permit Proportional, Integral and Derivative control modes in any combination to meet the needs of the application. Other control modes such as incremental, floating or two-position shall be available to adapt to job needs.
 - 2) All energy management functions including the following:
 - a) Economizer Control/Enthalpy Control, Unoccupied Period Programs.
 - 3) System start-up and stop from signal initiating from the building control station. Start signal shall override all fire/smoke status alarm signals and cause the system to operate under normal temperature control conditions. The building control station switch shall be manually reset to the auto position before normal control (with full alarm protection) can be re-established.
 - b. Communication between controllers shall be RS422, 600 BAUD, or RS232C. Standard twisted 18 to 22 AWG shall be utilized for input/outputs or communication line.
 - c. Transmission line shall be electrically isolated from the digital controller to prevent induced voltages in the transmission lines from damaging any of the electronic circuits.

C. Electric Wiring:

1. All automatic control wiring shall be color coded and run in a conduit system furnished and installed according to provisions of Division

26. All wire shall be copper, 600V, rated insulation in all respects. Control wiring is the wiring from a piece of control equipment to points of connection on all other control equipment or controlled equipment.

2. Electrical interlocking shall be provided. Provide for interlocking by the digital controller or by hard wire with auxiliary contacts as appropriate for the application. Digital interlocking shall include proof of operation.
3. Interlinking from digital controllers to the BAS, between digital controllers, and from digital controllers to controlled equipment and sensing devices shall utilize No. 18 AWG twisted, shielded pair cables with braid shield and overall PVC jacket.

D. Input Devices:

1. Temperature Sensors. Temperature sensors shall be of the type indicated and be accurate to within $\pm 1\%$ (or better, if specified below) of the temperature range of their intended use (not supplied sensor range). Sensors shall be resistance type (RTDs), nickel, 1000 ohm (Ω) at 70°F, or platinum, 100 or 1000 Ω at 0°C, or thermistor 10,000 ohm at 77°F, and factory calibrated and certified to the specified accuracy. As manufactured by Mamac, Building Automation Products Inc. (BAPI), Hycal, PreCon or equal. All non-tamperproof temperature sensors shall be located at not more than 48 inches above floor level.
2. Duct sensors shall protrude into the air stream a minimum of 6 " or to the far quarter of the duct width, whichever is greater. To accomplish this, multiple sensors or an averaging element may be used.
3. Mixed air sensors shall utilize averaging elements if mixed air plenum is 36" wide or greater. Averaging sensors shall include a minimum of 3 sensors.
4. Heating hot water temperature sensors shall be accurate to within $\pm 1.0^\circ\text{F}$ over the range of their application (80-220°F); as manufactured by PreCon ST-W3, or equal.
5. Room temperature sensors shall be accurate to within $\pm 0.5^\circ\text{F}$ in the range of 65°F to 85°F. Room sensors for office areas are not to be provided with a set point adjustment (set point adjustment shall be by BAS operator only). Sensors for public areas shall be mounted in the return air plenum where possible.
6. Sensors for water shall be installed in new immersion wells. All thermowells shall be one-piece, machined from solid stainless-steel barstock. Process mounting thread to be male $\frac{1}{2}$ " or $\frac{3}{4}$ " NPT. Sensor mounting thread shall be female $\frac{1}{2}$ " NPT. Inside of sensor bore shall be .26" as manufactured by Rosemount,

PreCon WS or equal. All wells shall be filled with temperature conductive material to minimize any temperature change sensing delay.

7. Pressure sensors for air pressure measurements in the range of 0 to 10 inches water column shall be accurate to $\pm 1.0\%$ and utilize a solid-state sensing element. As manufactured by Modus Instruments, Setra, or equal.
8. Differential pressure sensors and pressure sensors (analog) shall have a 4-20mA proportional output signal. Sensors shall withstand up to 150% of rated pressure without calibration shift or damage to the device, and shall be accurate to within $\pm 0.5\%$ of full scale. Duct monitor static pressure sensor shall be installed into a static pressure pitot tube that provides velocity pressure compensation so as to read static pressure only and not total pressure. For static pressure sensing in plenums over 48 inches in height or width, multiple pitot tubes or an averaging multi-port tube shall be used.
9. Static pressure sensors shall be Modus Model T30-030 by Kele & Associates, or equal.
 - a. They shall be a two-wire pressure transmitter with 4-20 ma output. They shall operate on the capacitance principle and shall be capable of sensing very low positive, negative, or differential pressures.
 - b. Accuracy shall be $\pm 1\%$ of range (including non-linearity and hysteresis. Zero and span adjustments (non-interactive adjustments) shall be by manufacture.
 - c. Operating voltage shall be 10 to 35 vdc, protected against reversal of polarity. Output shall be 4-20 ma, limited to approximately 3.85 ma at the low end of the span and approximately 26 ma at the upper end of the span.
 - d. Pressure range shall be 0 to 3.0 inches w.c. Maximum safe momentary overpressure shall be 8 times the pressure range.
 - e. Port connections shall be 3/16-inch diameter suitable for 1/8-inch or 5/32-inch inner diameter Tygon or polyurethane tubing, or 1/4-inch outer diameter polyethylene tubing. There shall be integral filters at both ports.
 - f. The case shall be flame retardant, glass reinforced NORYL.
 - g. The static pressure sensors shall be capable of operating in the following environmental conditions:

Operating temperature range: 32 °F to 125 °F
Storage temperature range: -20 °F to 160 °F
Effect of temperature: $\pm 0.05\%/^{\circ}\text{C}$
Operating humidity range: 20% to 90% RH
noncondensing
Shock resistance: 10 g
Vibration resistance: 5 G to 50 Hz

- h. Static pressure sensors shall be located in the hot and cold ducts, two-thirds of the way down the trunk ducts.
- i. Static pressure sensors shall be tested and calibrated, following installation, to assure their proper measurement, transmission, and operation through their full range.

13. Occupancy Sensors:

- a. Occupancy sensors shall be the ceiling-mounted, dual technology, infrared-ultrasonic type, capable of detecting presence in floor area to be controlled, by detecting Doppler shifts in transmitted ultrasound and infrared technology.
- b. Detection shall be maintained when a person moves only within a maximum distance of 12 inches, in either a horizontal or vertical manner, at approximate speed of 12 inches per second. Associated mixing box (or lights if connected) shall not shut down when a person is reading or writing while seated at a desk.
- c. Each sensor shall be furnished with a convenient shunt provision, which will enable a person to by-pass sensor in event of failure.
- d. Sensitivity shall not change more than 10 percent in a temperature range of 0 degrees F to 120 degrees F, and in a humidity range of 10 percent to 80 percent. Sensitivity adjustment shall be provided for each technology.
- e. Time delay range shall be adjustable from 15 seconds to 15 minutes.
- f. Sensors shall operate on DC power (12 volts to 24 volts). Power supply shall be provided by power pack, consisting of a transformer and contact closure relay in one package. Power output of transformer shall be capable of operating a minimum of 2 sensors.
- g. Additional power packs (auxiliary relays) shall be provided to allow for control of both mixing boxes and lights.
- h. Occupancy sensors shall be provided in every room served by a VAV terminal reheat air terminal unit.

Incorporate the role of the occupancy sensors into the sequence of operations for the VAV terminal reheat air terminal units. An occupancy sensor shall close its associated VAV terminal reheat air terminal unit if it senses that no person is present for a set period of time. However, if the zone temperature gets above or below certain set points within a wide deadband, and the air handling unit is on, the associated VAV terminal reheat air terminal unit damper shall position to minimum air flow.

- i. Manufacturers: Watt Stopper No. DT-200, Novitas, model 01-300-BAS or equal by Leviton, Sensor Switch, or Unenco.

14. Air Flow Measuring Station:

- a. Provide air flow measuring stations of the sizes and capacities scheduled on the Drawings.
 - 1) Each air flow measuring station shall measure air flow by the pitot tube traverse method and shall consist of a network of static and total pressure sensors factory positioned and connected in parallel to produce an equalized velocity pressure. The measured velocity pressure converted to air flow (CFM) shall have an accuracy within 2% of the full scale throughout the velocity range from 700 to 4000 fpm.
 - 2) Each air flow measuring station shall not amplify the sound level within the duct and shall not exceed the air pressure drop scheduled. The unit shall be manufactured for continuous operation up to a temperature of 250°F.
 - 3) Construction. Each air flow measuring station shall consist of a minimum of 16 gauge sheet metal casing, an aluminum air velocity treatment and air straightening section with an open face area of not less than 97%, and a copper total and static pressure sensing manifold. Each station shall contain non-combustible sensors, which shall be incapable of producing toxic gases or fumes in the event of elevated duct temperatures. All interconnecting tubing shall be internal to the unit with the exception of one total pressure and one static pressured meter connection.
 - 4) A network of total and static pressure sensors shall be positioned on the equal area traverse principle, with a maximum of 16 square inches per total

pressure sensor and 48 square inches per static pressure sensor on units four (4) square feet or smaller, and with a maximum of 36 square inches per total pressure sensor and 144 square inches per static pressure sensor on units in excess of four (4) square feet. Interconnecting sensor manifolds shall average and relate each type of sensor measurement into one (1) total pressure and one (1) static pressure metering port. The manifold mounting hardware shall not penetrate the manifold tubes and shall be so constructed as to eliminate any possible violation of the integrity of the total or static pressure measurements. The meter tubing for the averaged total and static pressures shall not be exposed to internal duct conditions.

- 5) Each air flow measuring station shall have a permanent name plate attached to the exterior of the casing and the meter, with the following information clearly visible from the installed position:
 - a) Unit Number as indicated on the Drawings
 - b) Unit size
 - c) Companion meter designation
 - d) Design air volume - CFM
 - e) Design air velocity - fpm
 - f) Direction of air flow

2. Provide a local thermometer and well or pressure gage as applicable, at all sensor locations. Wells in steel pipes shall be stainless steel.

E. Output Devices:

1. Control Valves
 - a. All control valves shall be as scheduled in the Drawings.
2. Dampers
 - a. See air handling unit specification sections for dampers.
3. Actuators
 - a. Low and high torque electronic actuators shall be as manufactured, brand labeled, or distributed by Belimo (800-543-9038).
 - b. Warranty all actuators for a period of five years from the date of final project acceptance.
 - c. Low torque electronic actuators, less than 600 in-lb. of rated torque, shall have ISO 9001 and CE certification and

- be UL listed under standard 873, CSA C22.2 No. 24 or 4812 02.
- d. All actuators shall have end switches for two position actuators. These position indicators shall be wired to input points in the same controller as the output point that controls that actuator.
 - e. Actuators shall have visual position indicators and shall operate in sequence with other devices if required. Actuator auxiliary switches shall be installed on all actuators.
 - f. For power-failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Spring return actuators shall be capable of CW or CCW rotation. Models > 60 in-lbs. shall be capable of mounting on shafts up to 1.05 inches in diameter.
 - g. Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required. Valves and dampers requiring greater torque or higher close off may be assembled with multiple low torque actuators.
 - h. Enclosure shall be designed to meet outdoor applications, using factory weather shields (if applicable for outdoor applications).
 - i. Actuator shall be suitable for operation in ambient temperatures ranging from -22°F to +150°F [-30°C to +65°C].
 - j. The motor shall be fractional horsepower; permanent split capacitor type designed to operate on either a 24 or 120 VAC, 1 pH, 60 Hz supply as required by the application. A self-resetting thermal switch shall be imbedded in the motor for overload protection.
 - k. A 6-foot wiring harness shall be provided for ease in field wiring (above 1500 in-lbs).
 - l. 2 SPDT auxiliary switches, rated at 250 VAC shall be included.
 - m. Actuators above 1500 in-lbs torque shall be equipped with a hand wheel. Actuators below 1500 in-lbs torque shall have either a hand wheel or shaft for manual override to permit operation of the valve in the event of electrical power failure or system malfunction.

- n. Damper sections shall be sized so that no more than one actuator will be required per section.
- o. Triac outputs on controllers can only control pilot relays.

3. EXECUTION

3.1 ADJUSTMENT AND CLEANING

- A. After completion of the installation, regulate and adjust all thermostats, temperature sensors, control valves, other devices and sensors, motors, and other equipment, and place them in complete operating condition. Testing and adjusting of temperature control systems shall be coordinated with all testing, balancing, and adjusting specified.

3.2 SEQUENCES OF OPERATIONS

- A. Provide all automatic control work necessary to accomplish the sequences of operations. Some items of equipment are furnished with integral control equipment. Verify degree and extent of integral control and coordinate with manufacturer to provide for all additional automatic control required to incorporate the equipment into the system in accordance with these sequences.
- B. Refer to the following for sequences of operations:
 - 1. Section 23 96 00 – Sequences of Operations

3.3 INSTALLATION

- A. General. Install systems and materials in accordance with manufacturer's printed instructions and roughing-in Drawings, and details on Drawings. Install electrical components and use electrical products complying with requirements of applicable Division 26 of these Specifications. Mount controllers at convenient locations and heights.
- B. Install control wiring without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with NEC requirements.

3.4 WIRING, CONDUIT, AND CABLE

- A. All wire shall be copper and meet the minimum wire size and insulation class listed below:

Wire Class	Wire Size	Isolation Class
Power	12 Gauge	600 Volt
Class One	14 Gauge Std.	600 Volt
Class Two	18 Gauge Std.	300 Volt
Class Three	18 Gauge Std.	300 volt
Communications	Per Mfr.	Per Mfr.

- B. Power and Class One wiring may be run in the same conduit. Class Two and Three wiring and communications wiring may be run in the same conduit.
- C. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.
- D. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum ½-inch galvanized EMT. Set screw fittings are acceptable for dry interior locations. Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture. Provide conduit sealoff fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.
- E. Flexible metallic conduit (max. 3 feet) shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment. Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.
- F. Junction boxes shall be provided at all cable splices, equipment termination, and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.
- G. In the space above the ceiling, the wiring shall be plenum rated. Wiring can be run without conduit above ceilings, using approved hanger system. EXCEPTIONS: 1) All wiring in exposed areas or mechanical rooms shall be in EMT conduit.
- H. Coaxial cable shall conform to RG62 or RG59 rating. Provide plenum rated coaxial cable when running in return air plenums.
- I. Fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140.
- J. Only glass fiber is acceptable, no plastic.

3.5 HARDWARE INSTALLATION

- A. Installation Practices for Wiring:
 - 1. All controllers shall be mounted vertically and per the manufacturer's installation documentation.
 - 2. The 120VAC power wiring to each controller shall be a dedicated run, with a separate breaker. Each run shall include a separate hot, neutral and ground wire. The ground wire shall terminate at the breaker panel ground. This circuit shall not feed any other circuit or device.
 - 3. A true earth ground shall be available in the building. Do not use a corroded or galvanized pipe, or structural steel.

4. Wires shall be attached to the building proper with approved hanger system, at regular intervals such that wiring does not droop. Wires shall not be affixed to or supported by pipes, conduit, etc.
5. Conduit in finished areas shall be concealed in ceiling cavity spaces, plenums, furred spaces and wall construction. Exception: Metallic surface raceway may be used in finished areas on masonry walls. All surface raceway in finished areas shall be color matched to the existing finish within the limitations of standard manufactured colors.
6. Conduit in non-finished areas where possible, shall be concealed in ceiling cavity spaces, plenums, furred spaces, and wall construction. Exposed conduit shall run parallel to or at right angles to the building structure.
7. Wires shall be kept a minimum of three inches from hot water, steam, or condensate piping.
8. Where sensor wires leave the conduit system, they shall be protected by a plastic insert.
9. Wire shall not be allowed to run across telephone equipment areas.

B. Installation Practices for Field Devices:

1. Well-mounted sensors shall include thermal conducting compound within the well to ensure good heat transfer to the sensor.
2. Actuators shall be firmly mounted to give positive movement and linkage shall be adjusted to give smooth continuous movement throughout 100 percent of the stroke.
3. Relay outputs shall include transient suppression across all coils. Suppression devices shall limit transients to 150% of the rated coil voltage.
4. Water line mounted sensors shall be removable without shutting down the system in which they are installed.
5. For duct static pressure sensors, the high pressure port shall be connected to a metal static pressure probe inserted into the duct pointing upstream. The low pressure port shall be left open to the plenum area at the point that the high pressure port is tapped into the ductwork.
6. For building static pressure sensors, the high pressure port shall be inserted into the space via a metal tube. Pipe the low pressure port to the outside of building.

7. For wall sensors, cavity behind sensor shall be filled with insulation to prevent drafts from affecting sensor.

C. Enclosures:

1. For all I/O requiring field interface devices, these devices where practical shall be mounted in a field interface panel (FIP). The Contractor shall provide an enclosure which protects the device(s) from dust, moisture, conceals integral wiring and moving parts.
2. FIPs shall contain power supplies for sensors, interface relays and contactors, safety circuits, and I/P transducers.
3. The FIP enclosure shall be of steel construction with baked enamel finish, NEMA 1 rated with a hinged door and keyed lock. The enclosure shall be sized for twenty percent spare mounting space. All locks shall be keyed identically.
4. All wiring to and from the FIP shall be to screw type terminals. Analog or communications wiring may use the FIP as a raceway without terminating. The use of wire nuts within the FIP is prohibited.
5. All outside mounted enclosures shall meet the NEMA 4 rating.
6. The wiring within all enclosures shall be run in plastic track. Wiring within controllers shall be wrapped and secured.

D. Identification:

1. Identify all control wires with labeling tape or sleeves, using words, letters, or numbers that can be exactly cross-referenced with as-built drawings.
2. All field enclosures, other than controllers, shall be identified with a Bakelite nameplate. The lettering shall be in white against a black or blue background.
3. Junction box covers shall be marked to indicate that they are a part of the BAS system.
4. All I/O field devices (except space sensors) that are not mounted within FIP's shall be identified with nameplates.
5. All I/O field devices inside FIP's shall be labeled.

E. Location:

1. Space temperature sensors shall be mounted away from machinery generating heat, direct light and diffuser air streams.
2. Occupancy sensors shall be mounted where they have coverage of the entire space they are designed to serve.

3. Field enclosures shall be located immediately adjacent to the controller panel(s) to which it is being interfaced.

3.6 SOFTWARE INSTALLATION

A. General:

1. The Contractor shall provide all labor necessary to install, initialize, start-up and debug all software necessary for successful operation of the system.

B. Documentation:

1. As built software documentation shall include the following:
 - a. Descriptive point lists
 - b. Application program listing
 - c. Application programs with comments.
 - d. Printouts of all reports.
 - e. Alarm list.
 - f. Printouts of all graphics.

3.7 COMMISSIONING AND SYSTEM STARTUP

A. Point-to-Point Checkout:

1. Each I/O device (both field-mounted as well as those located in FIPs) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated and approved by the Project Manager, for submission to the Owner's Representative.

B. Controller Checkout:

1. A field checkout of all new and existing controllers involved in this project shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the Owner's Representative by the completion of the project.

C. System Acceptance Testing:

1. All application software shall be verified and compared against the sequences of operation. Control loops shall be exercised by inducing a set point shift of at least 10% and observing whether the system successfully returns the process variable to set point. Record all test results and attach to the Test Results Sheet.

2. Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations or printers), and that any other related actions occur as defined (i.e. graphic panels are invoked, reports are generated, etc.). Submit a Test Results Sheet to the Owner's Representative.

END OF SECTION 23 0900

SECTION 23 2000

VALVES

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide all valves within the building as indicated on the Drawings and as specified, complete.

1.2 SUBMITTALS

- A. Shop Drawings and Product Data:
 - 1. The following list includes the required shop drawings and samples that shall be submitted:
 - a. All valves.

2. PRODUCTS

2.1 MATERIALS

- A. General. Unless otherwise indicated, all valves of all types installed in connection with mechanical piping shall comply with the following:
 - 1. All plumbing valves shall be lead-free.
 - 2. Furnish one make throughout the Project manufactured by NIBCO or equal, unless otherwise indicated.
 - 3. Pack all stems in conformance to ANSI B16.34.
 - 4. All valves 2 inches and smaller shall be threaded and have bronze bodies.
 - 5. All valves 2-1/2 inches and larger shall be iron body bronze mounted (IBBM) type and shall be flanged.
 - 6. Wheel handles shall be non-heating style cast from malleable iron ASTM A 197.
 - 7. All valves 4 inches and larger, mounted higher than 7 feet above the floor in mechanical rooms, shall be equipped with chain operators and guides. Extend chains to within 6 feet-6 inches of floor.
 - 8. Mark each valve at the factory with the following minimum information, engraved, stamped, or cast on each valve or metal tag permanently attached to the valve.
 - a. Manufacturer's name.
 - b. Catalog or figure number.

- c. Size and pressure class.
 - d. Arrows to indicate direction of flow on check, globe, angle, non-return, and eccentric plug valves.
 - e. UL approved valves shall bear the UL label.
- 9. Each valve shall be the same size as the pipe in which it is installed.
- B. Gate Valves.
 - 1. General. Provide wedge disc pattern with non-rising stem, repackable under full operating pressure when wide open.
 - 2. 125 psig Gate Valves.
 - a. General. Provide valves designed for 125 psig steam and 200 psig non-shock water, oil, and gas working pressures.
 - b. Size, 2 inches and smaller (screwed).
 - 1) Materials. Provide bodies, bonnets, and discs made from bronze conforming to ASTM B 62. Stems shall be copper silicon alloy.
 - 2) Manufacturer. Provide NIBCO or equal.
 - c. Size, 2-1/2 inches and larger (flanged).
 - 1) General. Provide bolted bonnets, renewable ring seats, and matching machined guides in body and disc to accurately position disc in the seat.
 - 2) Materials. Provide body and bonnet made from cast iron conforming to ASTM A 126, Class B. Disc and seat rings shall be made from bronze conforming to ASTM B 62. Stem shall be copper silicon alloy.
 - 3) Manufacturers. Provide NIBCO or equal.
- C. Ball Valves.
 - 1. Bronze or stainless steel body.
 - 2. Threaded ends.
 - 3. Full port.
 - 4. Stainless steel ball.
- D. Globe and Angle Valves.
 - 1. General. Stems shall be repackable under full operating pressure when wide open.
 - 2. Size, 2 inches and smaller.

- a. General. Provide valves designed for 300 psig steam and 400 psig non-shock water, oil, and gas working pressures. Valves shall permit seat, disc, and union bonnet replacement without removing valves from piping.
 - b. Materials. Provide bodies and bonnets, made from bronze conforming to ASTM B 61. Stems shall be a copper silicon alloy. Provide discs and seats made from industry standard, type 500 Grinnell, hardened stainless steel.
 - c. Manufacturers.
 - 1) Globe Pattern. NIBCO or equal.
 - 2) Angle Pattern. NIBCO or equal.
- 3. Size, 2-1/2 inches and larger.
 - a. General. Provide valves designed for 125 psig steam and 200 psig water, oil, and gas working pressures. Valves shall have bolted bonnets, outside screw and yoke, and bottom guided stems. Seats shall be replaceable without removing valves from the line.
 - b. Materials. Provide body and bonnet made from cast iron conforming to ASTM A 126, Class B. Disc and seat shall be made from bronze conforming to ASTM B 62. Stem shall be copper silicon alloy.
 - c. Manufacturers.
 - 1) Globe Valves. NIBCO or equal.
 - 2) Angle Valves. NIBCO or equal.
- E. Check Valves.
 - 1. Size, 2 inches and smaller.
 - a. General. Provide swing check valves designed for 400 psig non-shock water, oil, and gas working pressures. Regrinding valve seats shall not require removal of valve from line. Provide screwed caps, renewable side plugs, hinges, and bronze discs. Valves shall operate equally well in the vertical or horizontal position.
 - b. Materials. Body shall be made from bronze conforming to ASTM B 61. Cap, disc, and hinge shall be made from bronze conforming to ASTM B 61 or B 62.
 - c. Manufacturer. NIBCO or equal.

2. Size, 2-1/2 inches and larger.
 - a. General. Provide silent check valves in water piping.
 - b. Water Check Valves.
 - 1) General. Silent type, spring loaded check valves for either vertical or horizontal installation. Valves shall be designed for 175 psig non-shock water working pressure at 250°F.; spring shall be designed to close valve before reverse flow can occur.
 - 2) Materials. Cast iron body conforming to ASTM A 126 Class B, bronze disc and trim or double plates conforming to ASTM B 148 or ASTM B 62, 316 stainless steel pin and spring, and ANSI B2.1 type seal, for installation between 125 lb. flanges.
 - 3) Manufacturer. NIBCO or equal.

F. Eccentric Plug Valves (Balancing Valve).

1. General. Valves shall be non-lubricated eccentric plug style designed for minimum pressure loss in the wide open position. All valves shall be equipped with adjustable opening stops for balancing. Resilient plug facing shall be capable of continuous bubble tight service in water at 250°F.
 - a. Provide valves, sizes 5 inches and smaller designed for 150 psig and valves 6 inches and larger for 125 psig, non-shock water working pressures at 250°F.
 - b. Valves shall have permanently lubricated corrosion resistant bushings in top and bottom bearings.
 - c. Bodies shall be tapped with a pipe connection on downstream side of seat for pressure gage connection. Equip valves 4 inches and larger with gear actuators. All gearing shall be enclosed, manufactured for running in oil, and the actuator shall be submersible with seals provided on all shafts to prevent entry of water into the actuator. All shaft bearings shall be furnished with permanently lubricated bronze bearing busings. Actuator shall clearly indicate valve position and an adjustable stop shall be provided to set closing torque. Valve packing and adjustment shall be accessible without disassembly of the actuator.
2. Manufacturer - General.
 - a. NIBCO or equal.

3. Manufacturer - By Size.
 - a. Sizes, 2 inches and smaller. NIBCO or equal.
 - b. Sizes, 2-1/2 inches through 3 inches. NIBCO or equal.
- G. UL Approved Valves.
 1. General. Valves shall be designed for a minimum of 175 psig non-shock cold water working pressure, UL approved.
 2. Gate Valves.
 - a. General. Provide OS and Y pattern, guided wedge disc, with stem repackable under full operating pressure.
 - b. Size, 2 inches and smaller.
 - 1) Materials. Provide bodies, bonnets and discs made from bronze conforming to ASTM B 61 or B 62, with bronze alloy stems.
 - 2) Manufacturers. NIBCO or equal.
 - c. Size, 2-1/2 inches and larger.
 - 1) Materials. Provide body and bonnet made from cast iron conforming to ASTM A 126, Class B. Renewable seat rings and disc shall be made of bronze conforming to ASTM B 61 or B 62. Stem shall be bronze alloy.
 - 2) Manufacturers. NIBCO or equal.
- H. Butterfly Valve.
 1. General. Provide valves designed for 175 psig 2 through 12 inches, 150 psig 14-20 inches and 250°F water service.
 2. Manufacturer. NIBCO or equal, butterfly valves, as follows:
 - a. Valves shall be lug type drilled and tapped for dead end service.
 - b. Valves shall be bi-directional for drop tight shut-off at full rated pressure with flow in either direction. Valves shall be hydrostatically tested at the factory simulating dead end service at 100 psi.
 - c. Materials of construction shall be:
 - 1) Body: Cast or Ductile Iron.
 - 2) Disc: Stainless Steel.

- 3) Stem: 300 series stainless steel if exposed to flowing media, 400 series stainless or alloy steel phosphate coated, if not exposed to flowing media.
- 4) Seat: Ethylene Propylene Diene Monomer.
- d. Operator shall be a 10-position lever lock for sizes 2-6 inches with a totally enclosed weatherproof acme screw gear actuator for 8 inches and larger infinite adjustment; memory stop options shall be provided where called for.
- e. Disc shall be stainless steel.

3. EXECUTION

3.1 INSTALLATION

- A. Install all valves in accordance with manufacturer's printed instructions and as indicated on Drawings.

3.2 ADJUSTMENT AND CLEANING

- A. Valves and stops shall be adjusted, packed, and repacked as may be required to eliminate leaks and to meet flow requirements of ASME B31.

END OF SECTION 23 2000

SECTION 23 3100

DUCTWORK

1. GENERAL

1.1 DESCRIPTION OF WORK

A. Provide ductwork as indicated on the drawings and as specified to include the following:

1. All sheet metal for the complete heating, air conditioning, exhaust, and ventilating systems.
2. All flexible ductwork.

1.2 QUALITY ASSURANCE

A. Material Testing: Pay for testing. Pay for retesting of nonconforming work. Provide access for material testing agency. Notify Owner's Representative and testing agency in advance of performance of Work requiring testing. Contractor shall provide labor and material required for testing.

B. Reference Standards:

1. NFPA: NFPA No 90-A, "Air Conditioning and Ventilating Systems."
2. SMACNA, 8224 Old Court House Rd., Vienna Virginia 22180. HVAC Duct Construction Standards, First Edition, 1985.
3. CAC Title 24 Part 4, California Mechanical Code.
4. California State Fire Marshal.
5. Factory Mutual Standard 7-78.
6. NFPA 91.
7. NBS Voluntary Product Standard 15-69.

C. Refer to Section 23 05 48, VIBRATION AND SEISMIC CONTROL.

1.3 SUBMITTALS

A. Shop Drawings and Product Data:

1. The following list includes the required shop drawings and product data that shall be submitted:
 - a. Ductwork fabrication drawings.
 - b. Schedule of duct systems, SMACNA construction details for joints, gauges and reinforcements.
 - c. Detailed drawings of built-up plenums with all accessories.

- d. Hangers and support systems.
 - e. Vibration isolation equipment.
- B. Test Report:
 - 1. A test report shall be submitted for the flamespread of the resins.
 - 2. A test report shall be submitted for air leakage tests.
 - 3. Test for light gauge round/oval duct indicating that the rigidity and performance is equivalent to SMACNA standard gauge ducts.

1.4 DEFINITION

- A. SMACNA Duct Pressure Classification:
 - 1. Low Pressure: Static pressure Class up to 3" water gauge (wg). Ductwork downstream from air volume controllers. Supply ductwork for heating and ventilating unit, exhaust and return ductwork.
 - 2. Medium Pressure: Static pressure Class over 3" up to 6" (wg). Ductwork between air handling units or built-up unit and air volume controllers.
 - 3. High Pressure: Static pressure Class over 6" wg.
- B. Seal or Sealing: Use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams and connections to acceptable minimum.
- C. Exposed Duct: Exposed to view in a finished room.

1.5 DUCT MATERIALS AND SEALANTS

- A. General: Except for system specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel per SMACNA 1985 Duct Construction Standard (DCS).
- B. Joint Sealing: Refer to SMACNA DCS, Table 1-2, Duct Sealing Requirements.
 - 1. Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) compounded specifically for sealing ductwork. Use products as recommended by manufacturer for low, medium or high pressure systems. Provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable.

2. Tape: Use only tape specifically designated by the sealant manufacturer. SMACNA recommends that foil tape not be used, and that pressure sensitive tape not be used on bare metal surface or on dry sealant.

3. Gaskets in Flanged Joints: Soft neoprene.

- C. Factory made joints are acceptable.

1.6 LOW PRESSURE DUCTWORK

- A. Gauges, Reinforcement, Joints, Seams, Sealing, Fitting, Support and Other Details: Construct ducts not shown otherwise for SMACNA DCS 3" wg static pressure rating.
- B. Sealing: Class C (2-inches wg static) in accordance with SMACNA DCS, Table 1-2.

1.7 MEDIUM PRESSURE DUCTWORK

- A. Gauges, Reinforcement, Joints, Seams, Sealing, Fitting, Support and Other Details: Construct ducts not shown otherwise for SMACNA DCS 6" wg static pressure rating. Round ducts, gauge according to SMACNA DCS Table 3-2, with the size converted on the basis of equal pressure drop, may be furnished in lieu of rectangular ducts shown on the drawings.
- B. Sealing: Class A in accordance with SMACNA DCS, Table 1-2. Refer to EXECUTION for required pressure tests for installed duct systems.
- C. Rectangular Ducts and Casings: In accordance with SMACNA DCS. Submit details of proposed joints/sealing system. Provide bolted construction and tie-rod reinforcement where required.
- D. Round Ducts: Furnish duct and fittings made by the same manufacturer to ensure good fit of slip joints.
 1. Elbows: Factory fabricated elbows, stamped or segmented standing seam per SMACNA DCS Figure 3-3. Coat galvanized areas of fittings damaged by welding with a corrosion-resistant aluminum paint or galvanized repair compound.
 2. Provide conical tees, laterals, reducers, and other low loss fittings as shown in SMACNA Standards.

1.8 FLEXIBLE AIR DUCT CONNECTORS

- A. General: Factory fabricated, complying with NFPA 90A for connectors up to 7' maximum length and not passing through the floors of buildings. Flexible ducts shall not penetrate any fire or smoke barrier.
- B. Flexible ducts shall be listed by Underwriters Laboratories, Inc., complying with UL 181 and shall have a flame spread rating and a smoke developed rating not exceeding 25 and 50 respectively. Operating temperature range shall be 0 to 200°F. Operating pressure shall be 10" positive water gauge.

- C. Factory made including 1" thick mineral fiber insulation with maximum C factor of 0.25 at 75°F mean temperature, encased with a low permeability moisture barrier outer jacket, having a puncture resistance of not less than 50 Beach Units. Flexible ducts shall have a minimum R-8 insulating value.
- D. Interior insulation covering shall be spun nylon or similar sound transparent material.
- E. Fittings: All takeoffs for diffuser connection from low velocity duct mains provided with conical twist-lock fittings, with a manual balancing damper having continuous rod. Damper provided with a lever position indicator and a positive locking device.

1.9 VIBRATION ISOLATION EQUIPMENT

- A. Isolation hangers as described in Section 23 05 48, VIBRATION AND SEISMIC CONTROL.

1.10 PLENUMS

- A. Construct with 18 gauge galvanized sheet metal with galvanized angle bracing as required, rivet or bolted to sheet metal. Refer to SMACNA plenum construction standards for detail and construction requirement.
 - 1. Seams: Standing seam spaced at 24" on center, staggered at adjacent panels.
 - 2. Reinforcing: Consists of galvanized angles riveted or bolted to back of sheet metal, perpendicular to standing seams. Angles run at floor, wall, and ceilings, at all corners, and round all openings at 3'-0" on center.
 - 3. Panels: Cross broken.
 - 4. Fasten plenums to concrete floors, ceilings and walls with expansion shields and sealed with mastic. All seams and joints sealed and made airtight.

3. EXECUTION

3.1 INSTALLATION

- A. General:
 - 1. Adhere to Drawings: Contractor may vary run and shape of ducts and make offsets during progress of work, if required to meet structural or other interferences, as approved.
 - 2. Install ductwork in adherence to ceiling height schedules indicated. Establish necessary space requirements so as to maintain required clearances around all equipment.

3. Reinforce all ducts to prevent buckling, breathing, vibrations or noise, such reinforcing shall be as recommended in the reference specified herein.

B. Ductwork Installation:

1. Ducts shall be constructed and supported per SMACNA 1985 DCS with exceptions as noted in these specifications. Fittings, joints, branches, dampers, and fasteners shall be per SMACNA Standards, except as noted herein.
2. The size of the ducts indicated on the drawings shall be net inside dimensions.
3. All uninsulated ducts over 18" shall be cross broken.
4. Ducts shall be braced and reinforced with galvanized steel angles.
5. Seams and Joints: Longitudinal seams shall be Pittsburgh lock with 3/8" minimum pocket. Button punch snap lock per Figure 1-5 of SMACNA Standards will be unacceptable.
6. Radius elbows shall have centerline radius not less than 1-1/2 times duct width. Short radius elbows will be unacceptable. Square elbows or where radius is less than 1-1/2 width of duct shall be provided with hollow double radius type duct turns. Single vanes will be unacceptable. Duct turns shall be secured to the duct with spot weld, screws or rivets. Friction type attachment will be unacceptable.
7. Branch connections per Figure 2-8 of SMACNA Standards shall be 45° entry clinch lock type. Straight tap, butt flange and dovetail joints will not be acceptable.
8. Air volume control on parallel flow branches shall be by branch dampers. Splitter type dampers will not be acceptable.
9. Duct access doors shall be provided with continuous piano hinge. Butt hinge will not be acceptable (Figure 2-12). Access doors insulated or lined ducts shall be insulated double wall construction.
10. Rods on volume dampers shall be continuous, regardless of pressure class. Split rods will be unacceptable. The end of the rod shall be slotted with the slot parallel with the blade. For any arrangement having more than two blades, use the multi-blade volume damper per Figure 2-15 of SMACNA Standards.
11. Air extractor volume damper will be accessible at the guide and register connections per Figure 2-16 of SMACNA Standards.
12. On transverse joints on round ducts, use beaded sleeve joint or draw band joint. Swedge bell, crimp or outside sleeve type per Figure 3-2 of SMACNA Standards will be unacceptable.

13. Pleated or adjustable round duct elbows per Figure 3-3 of SMACNA Standards will be unacceptable.
14. 90° tees and laterals or round ducts shall be 45° lateral or 90° tee with oval to round tap, per Figure 3-4 of SMACNA Standards 90° tee fitting or 90° tap will be unacceptable. Conical tees per Figure 3-5 will be acceptable.
15. Powder actuated fasteners, or friction clamps attached to steel members per Figures 4-1 and 4-2 of SMACNA Standards, will be unacceptable.
16. On hanger attachments per Figure 4-4 of SMACNA Standards, no screws will be allowed into the duct proper. Bands with single hanger will be unacceptable on ducts greater than 24" diameter.
17. Pipe penetration of casings shall be sealed with a continuous weld per Figure 6-10 of SMACNA Standards. Mastic sealant will be unacceptable.
18. All ductwork shall be supported and anchored to the structure so that horizontal ducts are without sag or sway, vertical ducts are without buckle, and all ducts are free from deformations, collapse or vibration.

C. Duct Liner/Return Air Plenum:

1. Air handling unit RETURN PLENUM ONLY. Provide 2" elastomeric, closed cell fiber-free R-8 thermal and acoustical insulation. K-Flex Duct Liner Gray or equal.
2. All joints tightly butted and adequately sized to assure continuity of surface.
3. Use metal nose to protect leading edges of liner insulation. Caulk all joints with a fire retardant mastic to keep moving air from getting behind the insulation.
4. The sizes of the lined plenum indicated on Drawings are net inside dimension.

D. Flexible Ductwork:

1. Insulated flexible ducts continuous, single pieces not over seven feet in length and adequately supported. Centerline radius of bends shall be not less than one and one-half times duct diameter. Provide 4" wide sheet metal protection saddles under ductwork at each hanger.
2. Where flexible ducts join other ductwork, air control boxes, and air terminals, apply duct sealer to outside surface of collar, secure duct to collar with sheet metal screws or clamps, and finish with three wraps of pressure sensitive vapor seal adhesive tape.

3. Flexible ducts installed in as straight a manner as possible. Cut ducts to lengths required rather than create bends to take up excess lengths.
- E. Vibration Isolation: Isolate ductwork from structure/equipment as follows:
 1. Ductwork to Air Handling Units (AHUs):
 - a. All duct connections to AHUs shall be via flexible sleeves (Type FPC).
 2. All initial duct penetrations through building exterior or mechanical room walls shall be resilient.

3.2 FIELD QUALITY CONTROL - LEAKAGE TEST

- A. TEST ALL DUCTS in accordance with SMACNA Air Duct Leakage Test Manual (ADLTM). Leakage class shall be per SMACNA ADLTM Table 4-1, Seal Class A.
 1. Field Test Procedures:
 - a. Seal all openings in duct section to be tested.
 - b. Connect test apparatus to test section of duct, using a flexible duct connection or hose.
 - c. Close damper or blower suction side to prevent excessive build up of pressure.
 - d. Start blower and gradually open damper on suction side of blower.
 - e. Build up pressure in duct test section to 6 inches wg.
 - f. Read the flow meter and compare the leakage in cfm per square foot with the allowable rate. If it meets the allowable rate, proceed to step specified in Paragraph 3.2.A.1.j below. If it does not meet the allowable rate, follow steps specified in Paragraphs 3.2.A.1.g, 3.2.A.1.h, and 3.2.A.1.i below.
 - g. Inspect the pressurized duct for all sensible leaks. Mark location for each leak.
 - h. Depressurize and repair all visual and audible leaks.
 - i. Upon completion of repairs, retest until leakage rate is acceptable.
 - j. Complete test reports. Remove temporary blankouts and seals.

- B. Engage the testing agency specified in Section 23 05 93, TESTING, ADJUSTING AND BALANCING to verify the leakage tests of all medium and high pressure duct and submit a certification attesting to the results obtained. Make arrangements to field test installed sections of ductwork. Tested sections of ductwork shall be visually marked by agency with certification sticker and initials of field test inspector. Tests shall be made before duct sections are concealed.

3.3 CLEANING

- A. Clean all duct interiors of all debris.

END OF SECTION 23 3100

SECTION 23 3300

DUCTWORK ACCESSORIES

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide ductwork accessories complete for the air distribution system, as indicated on the Drawings and as specified, complete.

1.2 SUBMITTALS

- A. Shop Drawings and Product Data:
1. The following list includes the required shop drawings that shall be submitted:
 - a. Flexible connections.
 - b. Volume dampers.
 - c. Fire dampers.
 - d. Combination fire/smoke dampers.
 - e. Draft gages.
 - f. Sound attenuators.
 - g. Grilles, registers, diffusers.
 - h. Variable air volume air terminal units (VAV boxes).
 - i. Air duct thermometers.

2. PRODUCTS

2.1 MATERIALS

- A. Flexible Connections: Six-inch flexible connections shall be installed between all rigid ductwork or casing and all air handling equipment. Connections shall be of fireproof material and manufactured for temperatures and pressures involved. At least 1-inch slack shall be allowed in these connections to insure that no vibration is transmitted from fan to ductwork. The fabric shall either be folded in with the metal or attached with metal collar frames at each end to prevent air leakage. Material shall be THERMAFLEX or equal.
- B. Turning Vanes: Turning vanes shall be installed in all mitered duct elbows and where shown on the Drawings. All turning vanes shall be double thickness.
- C. Volume Dampers, Low Pressure:
1. Volume dampers shall be provided at each branch duct and as indicated on Drawings for supply air duct systems, return air duct systems, and exhaust air duct systems.
 2. Comply with SMACNA Fig 2-11B, 2-11D, "Side Elevation Fig 2-11B" and Text on Volume Dampers" for all details except as specified herein on single blade and two bladed dampers for 2" WG

class duct. Each damper shall be provided with a closed end bearing.

3. Use 3/8" continuous square rod and 18 gauge galvanized stiffened blade for damper blade sizes 18" wide by 18" high and smaller, or 12" diameter and smaller.
4. Use 1/2" continuous square rod and 16 gauge galvanized stiffened blade for damper blade sizes 19" to 48" wide by 10" high. Maximum blade size is 48" by 10" high. Maximum diameter is 16".
5. Maximum of Two Blades Without a Frame: Over two blades, use a manufactured 16 gauge galvanized, stiffened, opposed blade damper in a 14 gauge galvanized steel frame. All hardware shall be galvanized except use brass trunions and bronze oilite bearing.
6. Provide closed end bearing.
7. Cut slot in end of damper rod (Quadrant End) to indicate blade position.
8. Provide galvanized sheet metal "hat section" on ducts with exterior insulation so that quadrant will be exposed.
9. Each square rod shall be installed vertical or horizontal so that quadrant will be accessible for adjusting.
10. Provide 24" x 24" access door for each volume damper that is not accessible as approved by the Owner's Representative.

D. Fire Dampers:

1. Fire dampers shall be provided in all duct openings through all respective fire-rated partitions, floors and roofs as indicated on the Drawings. Dampers shall be installed in conformance with NFPA Standard 90A and shall be California Fire Marshal listed. Airtight, hinged access doors with catches shall be installed adjacent to all dampers and shall be sized for easy inspection or maintenance of the dampers. Contractor shall not obstruct access doors with piping, etc. Provide required ceiling access doors in areas with other than removable type ceiling. All fire dampers shall be UL listed.
 - a. Dampers shall be factory manufactured items, and performance tested prior to shipment to the Project site.
 - b. Each damper shall be placed into a steel sleeve (approved with the damper) which in turn shall be placed into the partition, floor or roof. Each sleeve shall extend through the partition, floor or roof far enough on either side for a correct breakaway duct connection in accordance with SMACNA recommendations. No sheet metal duct shall pass through a fire-rated enclosure. Dampers shall be type B or C.

- c. Fire dampers shall be so arranged that the fusible link/clip assembly or firestat controller shall be accessible.
 - d. Each damper shall have a free area equal to the duct to which they are installed. Provide applicable transitions.
 - e. Dampers shall be suitable for vertical or horizontal installation as indicated on the Drawings. Fire dampers shall employ gravity or spring and latch closure principle.
 - f. Fire dampers shall use fusible links having an activation temperature of 165°F unless noted otherwise. All links shall be UL listed. All firestats shall be UL classified.
 - g. All fire dampers shall comply with UL Test Standard 555.
 - h. All fire dampers used for protection of openings in assemblies shall carry a minimum 1-1/2-hour UL rating.
 - 2. Fire dampers shall be interlocking blade, curtain type GREENHECK or equal.
- E. Combination Fire Smoke Dampers:
- 1. Ratings:
 - a. Fire Resistance:

Dampers shall have a UL 555 fire resistance rating of 3 hours.
 - b. Fire Closure Temperature:

Each combination fire smoke damper shall be equipped with a factory installed heat responsive device rated to close the damper when the temperature at the damper reaches: 350 degrees F.
 - c. Elevated Operational Temperature:

Dampers shall have a UL 555S elevated temperature rating of 350 degrees F.
 - d. Leakage:

Damper shall have a UL555S leakage rating of Leakage Class I.
 - e. Differential Pressure:

Dampers shall have a minimum UL 555S differential pressure rating of 4 in. wg.

f. Velocity:

Dampers shall have a minimum UL 555S velocity rating of 3000 fpm.

2. Construction:

a. Frame:

Damper frame shall be 16 ga. galvanized steel formed into a 5" x 1" structural hat channel. Top and bottom frame members on dampers less than 17" high shall be low profile design to maximize the free area of these smaller dampers. Frame shall be 4-piece construction with 1 ½" (minimum) integral overlapping gusset reinforcements in each corner to assure square corners and provide maximum resistance to racking.

b. Blades:

Blades: Damper blades shall be 16 ga. galvanized steel with full length structural reinforcement and a double skin airfoil shape. Each blade shall be symmetrical relative to its axle pivot point, presenting identical performance characteristics with air flowing in either direction through the damper. Provide symmetrical blades of varying size as required to completely fill the damper opening.

c. Blade Stops:

Each blade stop (at top and bottom of damper frame) shall occupy no more than ½" of the damper opening area to allow for maximum free area and to minimize pressure loss across the damper.

d. Seals:

Blade Edge: Blade seals shall be extruded silicone rubber permanently bonded to the appropriate blade edges.

Jamb: Flexible stainless steel compression type.

e. Linkage: Concealed in jamb.

f. Retaining Angles: Damper shall be supplied with factory retaining angles sized to provide installation overlap in accordance with the manufacturer's UL listing.

g. Axles: Minimum ½ inch dia. plated steel.

h. Bearings: Axle bearings shall be sintered bronze sleeve type rotating in polished extruded holes in the damper frame.

- i. Sleeve: Damper shall be supplied as a single assembly with a factory sleeve.
 - 4. Actuators
 - a. Type:
 - i. Electric, 120V AC, 2-position
 - b. Mounting
 - i. External
 - 5. Switch
 - a. 20 amps rated one pole toggle switch.
 - 6. Model: Greenheck FSD-300 series or equal.
- F. Draft Gages: Provide draft gages across all filter banks to show differential pressure across filters. Draft gages shall be mounted on same panel as provided for remote thermometers, where possible, or on separate panels of the same type. Gages shall be of the remote type connected to tapings on both sides of the filters and connected to reading points with 1/4 inch copper tubing, shut-off cocks shall be provided on each side of gage. Gage shall be DWYER or equal.
- G. Sound Attenuators: Provide sound attenuators, as shown, manufactured by I.A.C. or equal. Furnish the sound attenuator factory constructed and rated by an independent testing company to meet ASTM E 477-73 requirements. Gauge of metal and joints in the outer liner shall be as specified for high velocity ductwork. Units shall have the sound reduction characteristics, dynamic insertion loss, DB, and shall not exceed the pressure drop indicated on the schedule.
- H. Diffusers, Registers and Grilles:
 - 1. General: Provide all diffusers, registers and grilles to match the performance and size requirements as scheduled on the Drawings. They shall be located as indicated on the reflected ceiling plan Drawings and shall be for installation in suspended ceiling systems or surface mounted in plaster ceilings as scheduled. Units shall have been tested in accordance with the ADC Code and ASHRAE Standard 36-72, with ratings certified by the ADC. The perforated face, on units so specified, shall be hinged for easy access to pattern control and duct accessories. Units shall be manufactured from heavy gauge steel or aluminum and have a factory-applied finish. Provide diffusers, registers and grilles as manufactured by KREUGER, TITUS, or equal.
 - 2. Diffusers: Provide square face, round neck diffusers with opposed blade dampers. The damper shall be capable of adjustment from the face of the diffuser.

3. Linear Diffusers: Provide extruded aluminum 3-slot diffusers of the length indicated on the Drawings. Vane design shall permit full 180° adjustable air pattern and complete flow rate control, including blank-off.
 4. Registers (R): Provide surface mounted registers with opposed blade dampers. Adjustment of damper shall be accessible from the face of the register. Louvers shall be adjustable and run parallel with the horizontal or longest face. Furnish a sponge rubber gasket between the border and surface to prevent streaking.
 5. Grilles (G): Provide grilles of similar specification to diffusers and registers, but omit air volume dampers.
 6. Flow bar: Provide extruded aluminum, continuous flow bar as indicated on the drawings. KREUGER, TITUS, or equal.
- I. Variable Air Volume (VAV) Air Terminal Units (VAV Boxes):
1. General:
 - a. Each VAV box shall be a completely factory assembled and calibrated unit consisting of an acoustically lined plenum section, air inlet collar, air volume damper, air volume regulator for limiting flow both maximum and minimum, damper shaft extension, electronic operator, and DDC controls. Control actuator shall be electric type, factory mounted with appropriate linkages in accordance with box requirements. Box shall also contain a duct pressure compensator to ensure that box is pressure independent.
 - b. The VAV box shall automatically regulate the air volume flow rate from maximum to minimum values scheduled on the Drawings. The box shall maintain air delivery as called for by the wall-mounted thermostat over an inlet pressure range of 3/4 to 3 inches WG.
 - c. The maximum leakage permissible at shut-off shall not exceed 4% of the nominal CFM at 3-inch WG.
 - d. Electric/DDC operator shall be factory installed.
 - e. Provide heating hot water reheat coils with two-way modulating heating hot water control valves for all VAV boxes as scheduled on the Drawings. Coils shall have capacities as scheduled.
 2. Casings:
 - a. Minimum No. 22 Ga., galvanized steel with round inlet collar and rectangular discharge with slip and drive connection.

- b. Acoustic lining:
 - 1) ½-inch thick coated lining, fiberglass-free, 1.5 PCF density.
 - 2) Meet erosion test method described in UL Publication No. 181.
 - 3) Meet smoke developed and flame spread rating requirements of NFPA-90A.
 - 4) All exposed insulation edges shall be coated with an NFPA 90A approved sealant to prevent the entrainment of fibers into the airstream.
 - c. With gasketed access door, or removable regulator if actuators are mounted externally.
 - d. ARI Certified Catalog Data.
- 3. Control motors:
 - a. Factory-installed on units by unit manufacturer.
 - b. Motors supplied by approved automatic control system manufacturer.
 - 1) Belimo floating actuator.
- 4. Variable air volume controller:
 - a. For DDC control, each terminal air unit shall be equipped with existing DDC controller and 120/24 VAC transformer.
- 5. Noise level at noted capacities:
 - a. Not to exceed criteria specified:
- 6. Sound attenuators:
 - a. Provide for each unit.
- 7. Depth of units not to exceed allowable space allocation.
- 8. Moving parts suitable for minimum of 300,000 cycles.
- 9. VAV boxes shall be TITUS DESV, KRUEGER, or equal.
- J. Air Duct Thermometers: Provide thermometers of the rigid stem type 6-1/2-inch scale, case, adjustable angle, 12-inch insertion length, DWYER or equal. Thermometer shall have a range of 0°F to 160°F, and shall be mounted for convenient reading. Provide perforated aluminum bulb guard.

3. EXECUTION

3.1 INSTALLATION

- A. Install ductwork accessories in accordance with the manufacturer's printed instructions.

END OF SECTION 23 3300

SECTION 23 3400

DUCT CLEANING

1. GENERAL

1.1 DESCRIPTION

- A. This section specifies the labor, services, equipment, and materials necessary to clean supply, return, and outside air ducts.

1.2 QUALITY ASSURANCE

A. REFERENCES:

1. The firm shall provide references for at least five projects of a similar size and complexity in the last two years.

B. STAFF QUALIFICATIONS:

1. Assigned supervisors shall have a minimum five years experience, and shall be 40 hour OSHA trained. Foremen shall have as a minimum 2 years experience.

C. EQUIPMENT REQUIREMENTS: The duct cleaning contractor shall have the following equipment available for negative pressure duct cleaning use on this project:

1. Low pressure fan unit - 15,000 cfm @ 10 inches of water column, 95% efficiency at 1.0 micron. This fan unit shall exhaust to the outside of the building.
2. Mechanical agitation equipment - variable speed, constant torque, 25 foot minimum cleaning distance from each penetration, various rotary brushes appropriate to the interior configuration of the ductwork.
3. Pneumatic agitation equipment - 75 cfm @110 psi, 50 foot minimum cleaning distance from each penetration, various ends appropriate to the interior configuration of the ductwork.
4. Pressure washing equipment - 3,000 psi @ 6 gpm @ 180 degrees F.

2. PRODUCTS

2.1 PROJECT REPORTS

- A. **PRE-PROJECT REPORT:** The Contractor shall prepare and submit a pre-project report prior to commencing the cleaning. The report shall consist of the following:
1. **Contents:** As a minimum, the pre-project report shall contain the following:
 - a. A general overview of the systems conditions before cleaning.
 - b. Findings and recommendations.
 - c. Sample results.
 - d. Photographic or video documentation to support recommendations.
 2. **Sampling and Testing:** As a minimum, the Contractor shall take one mold and fungi sample for each ductwork system.
 3. **Photographic and/or Video Documentation:** As a minimum, the Contractor shall take photographs of the inside of each ductwork system.
 4. In addition to the above photographs, documentation in support of findings and recommendations shall be submitted.
- B. **POST-PROJECT REPORT:** The Contractor shall prepare and submit a post-project report within 30 days of completion of the project. The report shall consist of the following:
1. **Contents:** As a minimum, the post-project report shall contain the following:
 - a. A complete overview of the systems conditions after cleaning.
 - b. Corrective actions taken.
 - c. Sample results.
 - d. Photographic or video documentation to support corrective actions taken.
 2. **Sampling and Testing:** As a minimum, the Contractor shall take mold and fungi samples for each ductwork system.
 3. As a minimum, the Contractor shall take NADCA vacuum test samples for each ductwork system per NADCA specifications.
 4. **Photographic and/or Video Documentation:** As a minimum, the Contractor shall take photographs of the inside of each ductwork system after the completion of the cleaning (they shall correspond to the pre-project photograph locations):

5. In addition to the above photographs, documentation in support of major corrective actions shall be submitted.

3. EXECUTION

3.1 GENERAL - DUCTWORK AND APPURTENANCE CLEANING

- A. All cleaning work done on the ductwork shall be done while the associated air handling unit is turned off and while the ductwork system is under negative pressure so that the possibility of cross contamination (contamination from one area of the system migrating to another part of the system or into the occupied spaces of the building) is reduced. All ductwork shall be cleaned with the direction of airflow going from the interior of the building to the exterior of the building. To accomplish this, the negative pressure fan unit shall be attached to the ductwork in order to create negative pressure and airflow inside the ductwork to carry the particulates entrained in the agitation process out of the building. This exhaust shall be filtered to 80 percent particulate removal in accordance with the ASHRAE filtration standard.

3.2 SPECIFIC COMPONENTS - DUCTWORK AND APPURTENANCE CLEANING

A. DUCTWORK CLEANING:

1. Starting at the blank end of each run of ductwork, cut openings large enough, and so configured, as to facilitate the introduction of mechanical or pneumatic agitation devices as appropriate to the ductwork. As a general rule, these openings should not need to be closer together than 40 feet, and should not be farther apart than 80 feet. Inspection points shall be spaced at not more than 15 foot intervals in between the openings made for cleaning. Cut outs shall be patched with sheet metal 2 gauges heavier than existing.
2. Starting at the blank end of each run of ductwork, insert mechanical or pneumatic agitation devices, and clean the interior of the ductwork. After each section of ductwork has been cleaned, inspect the interior of the ductwork, and repeat as necessary until ductwork is cleaned.
3. Seal all inspection points and cleaning points using 2 piece access ports or insulated, fire rated access doors that conform to SMACNA standards, fastened with caulk and self tapping screws.
4. All penetrations in the ductwork shall be noted on the record drawings.

B. DUCT INSULATION INSPECTION:

1. The Contractor shall carefully inspect all external duct insulation for rips, tears, missing wires, and sagging sections. Such observed

duct insulation problems shall be notated and reported to the Owner's Representative.

C. JOINTS:

1. The Contractor shall inspect all joints for leaks. Any observed mechanical defects shall be notated and reported to the Owner's Representative.

D. TURNING VANES:

1. The Contractor shall clean all surfaces with mechanical or pneumatic agitation equipment. Any observed mechanical defects shall be notated and reported to the Owner's Representative.

E. SENSORS:

1. Special care shall be taken to ensure that the ductwork's internal sensors are not damaged during the cleaning process. The Contractor shall inspect all sensors for proper mounting. Any observed mechanical defects shall be notated and reported to the Owner's Representative.

F. ACCESS DOORS:

1. The Contractor shall inspect all existing access doors for proper opening and closing, and for leaks. Any observed mechanical defects shall be notated and reported to the Owner's Representative.

G. FIRE DAMPERS:

1. The Contractor shall clean all surfaces with mechanical or pneumatic agitation equipment. The Contractor shall inspect all linkages for proper operation, and shall lubricate linkages with Dry Moly Grease or approved equivalent. The Contractor shall ensure that fusible links are in place and the dampers are open. Any observed mechanical defects shall be notated and reported to the Owner's Representative.

H. REGISTERS, GRILLES, AND LOUVERS

1. The Contractor shall wash all registers, grilles, and louvers that can be easily removed in an environmentally safe detergent that will not harm the finish. These registers, grilles, and louvers shall then be dried and reinstalled. All registers, grilles, and louvers that cannot be easily removed shall be washed and dried in place.

I. LINKAGES:

1. The Contractor shall inspect all linkages for proper operation, and shall lubricate linkages with Dry Moly Grease or approved equivalent. Any observed mechanical defects shall be notated and reported to the Owner.

J. SANITIZATION:

1. The Contractor shall sanitize all interior surfaces of the ductwork using an EPA registered biocide. All sanitization shall comply with EPA guidelines and manufacturer's recommendation.

3.3 DUCTWORK, TO BE CLEANED

A. The following shall be cleaned:

1. Any existing ductwork, registers, and grilles that are connected to the RTU-1 air handling system. Ductwork to be cleaned shall be subject to inspection by the Owner's Representative at any given time during the project. The Contractor shall provide openings for inspection as required.

END OF SECTION 23 3400

SECTION 23 8300

SEMI-CUSTOM PACKAGED ROOFTOP UNIT

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide a semi-custom packaged rooftop unit, RTU-1, as indicated on the Drawings and as specified, complete.
- B. RTU (sections and/or components) shall include supply fans, return fans, motors, variable frequency drives, economizer dampers, return air plenums, DX coil, filter, housing, and vibration isolation.
- C. Ancillary equipment, appurtenances, and devices shall be provided as specified in this section.
- D. The RTU shall be provided with all sensors shall be capable of stand-alone operations. The RTU shall also be interconnected to the building automation system (BAS) or energy management system (EMS). BAS and EMS are used interchangeably in the specifications, but are intended to mean the same thing.

1.2 SUBMITTALS

- A. Submit in accordance with SECTION 01 33 00 - SUBMITTAL PROCEDURES.
- B. Submit shop drawings. Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, electrical characteristics, and connection requirements.
- C. Submit product data.
 - 1. Provide literature that indicates dimensions, weights, capacities, ratings, and electrical characteristics and connection requirements.
 - 2. Provide data on filter media, filter performance, filter assembly, and filter frames.
 - 3. Provide computer generated fan curves with specified operating point clearly plotted.

1.3 OPERATION AND MAINTANENCE DATA

- A. Maintenance Data: Provide instructions for installation, maintenance, and service.

1.4 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience, who issues complete catalog data on total product.
- B. Startup shall be done by trained personnel experienced with rooftop equipment.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver the products to site.
- B. Handle carefully to avoid damage to components, enclosures, and finish.
- C. Store in a clean, dry place, and protect from weather and construction traffic.
- D. Comply with manufacturer's installation instructions for rigging, unloading, and transporting air handling unit.

1.6 START-UP AND OPERATING REQUIREMENTS

- A. Do not operate air handling unit for any purpose, temporary or permanent, until bearings are lubricated (if applicable), belts are aligned and tensioned, all shipping braces are removed, bearing set screws are torqued, ductwork is clean, filters and remote controls are in place, bearings lubricated, and manufacturer's installation instructions have been followed.

1.7 WARRANTY

- A. The equipment manufacturer shall provide, at no additional cost, a standard parts warranty that covers a period of one year from unit start-up or 18 months from shipment, whichever occurs first. This warrants that all products are free from defects in material and workmanship and shall meet the capacities and ratings set forth in the equipment manufacturer's catalog and bulletins.

2. PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Provide semi-custom packaged rooftop unit as manufactured by Daikin Applied (as the basis-of-design), or equal.
- B. Any mechanical equipment manufacturer and model, other than the basis of design product, shall comply with all the physical, operational, and performance constraints, parameters, and requirements identified in the drawings and specifications. Any redesign, plan check, and construction efforts and costs to comply with those physical, operational, and performance constraints, parameters, and requirements for equipment other than the basis of design manufacturer and model listed shall be borne by the Contractor.

- C. Other manufacturers that will be considered, providing that they comply with contract documents, are Mammoth, Gouvernaire, Seasons 4, Engineered Air, Energy Labs, and Trane. Alternate manufacturers must be approved prior to submitting bid.

2.2 GENERAL DESCRIPTION

- A. Provide as shown on plans, a rooftop packaged unit, single zone, variable air volume (VAV), heating and cooling unit. Unit performance and electrical characteristics shall be per the New Roof Top Packaged DX Unit Schedule on Drawing M-1.10.
- B. Configuration: Fabricate as detailed on the Drawings.
- C. The complete unit shall be ETL listed.
- D. The unit shall be specifically designed for outdoor rooftop application and shall include a weatherproof cabinet. Unit shall be of a modular design with factory installed access sections available to provide maximum design flexibility.
- E. Unit shall be completely factory assembled and shipped in one piece.
- F. Unit to be shipped fully charged with R410A.
- G. The unit shall undergo a complete factory run test prior to shipment. The factory test shall include final balancing of all fan assemblies, a refrigeration circuit runtest, a unit control system operations checkout, a unit refrigerant leak test, and a final unit inspection. Provide factory test reports to the Owner's Representative.
- H. The unit shall have decals and tags to indicate caution areas and aid unit service. Unit nameplates shall be fixed to the main control panel door. Electrical wiring diagrams shall be attached to the inside of the control panel doors. Installation, operating and maintenance bulletins and start-up forms shall be supplied with the unit.

2.3 CABINET

- A. Unit cabinet shall be designed to operate at total static pressures up to 6.5 inches w.g.
- B. Unit shall be constructed for a maximum leakage rate of 1% at 6" w.g.
- C. Unit shall have heavy gauge solid galvanized steel liners provided throughout, allowing no exposed insulation within the air stream. All cabinet insulation, except floor panels, shall be a nominal 2" thick, 1 ½ lb. density, R6.5, glass fiber. Floor panels shall include 1" thick, 3 lb. density, R4.2, glass fiber insulation.
- D. All interior galvanized solid steel liners shall be coated with PPG Amerlock Primer and PSX700 coating.

- E. Exterior surfaces shall be constructed of pre-painted galvanized steel for aesthetics and long-term durability. Paint finish shall include a base primer with a high quality, polyester resin topcoat of a neutral beige color. Finished surface shall withstand a minimum 750-hour salt spray test in accordance with ASTM B117 standard for salt spray resistance.
- F. Service doors shall be provided on both sides of each section in order to provide user access to all unit components. Service doors shall be constructed of heavy gauge galvanized steel with galvanized steel interior liners. All service doors shall be mounted on multiple, stainless steel hinges and shall be secured by a stainless steel latch with a single handle. Doors 36" and greater in height shall have minimum two latches. The latch system shall feature a staggered engagement for ease of operation and a safety catch shall protect the user from injury in case a positive pressure door is opened while the fan is operating. Removable panels, or doors secured by multiple, mechanical fasteners are not acceptable.
- G. The unit base frame shall be constructed of 13 gauge pre-painted galvanized steel.
- H. The unit base shall overhang the roof curb for positive water runoff and shall have a formed recess that seats on the roof curb gasket to provide a positive, weathertight seal, suitable for structural anchorage per the structural design. Lifting brackets shall be provided on the unit base with lifting holes to accept cable or chain hooks.

2.4 FANS

- A. All fan assemblies shall be statically and dynamically balanced at the factory, including a final trim balance, prior to shipment. All fan assemblies shall employ solid steel fan shafts. Heavy-duty pillow block type, self-aligning, grease lubricated ball bearings shall be used. Bearings shall be sized to provide an L-50 life at 200,000 hours. The entire fan assembly shall be isolated from the fan bulkhead and mounted on rubber-in-shear isolators. Pitch V-belt drives with matching belts shall be provided. V-belt drives shall be selected at the manufacturers standard service factor.
- B. Fan motors shall be heavy-duty, 1800 rpm premium efficiency, inverter-duty rated. Fan motors shall have grease lubricated ball bearings. Motors shall be mounted on an adjustable base that provides for proper alignment and belt tension adjustment.
- C. Motor shall be Open Dripproof, premium efficiency.
- D. Airfoil supply fans.
 - 1. Supply fan shall be a double width, double inlet (DWDI) airfoil centrifugal fan. All fans shall be mounted using shafts and hubs with mating keyways. Fans shall be Class II type and fabricated

from heavy-gauge aluminum. Fan blades shall be continuously welded to the back plate and end rim.

E. Airfoil return fans.

1. A single width, single inlet (SWSI) airfoil centrifugal return air fan shall be provided. The fan shall be Class II construction. The fan wheel shall be Class II construction and fabricated from heavy-gauge aluminum with fan blades continuously welded to the back plate and end rim. The fan shall be mounted using shafts and hubs with mating keyways. Exhaust fans are not acceptable.

2.5 VARIABLE AIR VOLUME CONTROL

- A. Separate electronic variable frequency drives (VFDs) shall be provided for each fan. VFDs shall be independent. VFDs shall be cooled by the filtered mixed air stream. The completed unit assembly shall be listed by a recognized safety agency, such as ETL. VFDs shall be accessible through a hinged door assembly complete with a single handle latch mechanism. Mounting arrangements that expose VFDs to high temperature, unfiltered ambient air are not acceptable. The unit manufacturer shall install all power and control wiring.
- B. The VFD output shall be controlled by the factory installed main unit control system and VFD status and operating speed shall be monitored and displayed at the main unit control panel. The supply and return/exhaust fan VFD outputs shall be independently controlled in order to provide the control needed to maintain building pressure control. Supply and return air fan VFDs that are slaved off a common control output are not acceptable.
- C. Each VFD shall be provided with a factory-installed 2-contactor bypass system with a service switch that shall allow the motor to be safely transferred from the VFD output to the AC line, or from the AC line to the VFD output, while the motor is de-energized.
- D. All VFDs shall be factory run tested prior to unit shipment.

2.6 ELECTRICAL

- A. Unit wiring shall comply with NEC requirements and with all applicable UL standards. All electrical components shall be UL recognized where applicable. All wiring and electrical components provided with unit shall be number and color coded and labeled according to the electrical diagram provided for easy identification.
- B. The unit shall be provided with a factory-wired weatherproof control panel. Unit shall have a power terminal block for main power connection. A terminal board shall be provided for low voltage control wiring. Branch circuit short circuit protection, 115 volt control circuit transformer and fuse, system switches, and a high temperature sensor. Each compressor and condenser fan motor shall be furnished with contactors and inherent

thermal overload protection. Supply and return fan motors shall have contactors and external overload protection. Knockouts shall be provided in the of the main control panels for field wiring entrance.

- C. All 115-600 volt internal and external wiring between control boxes and components shall be protected from damage by raceways or liquid tight conduit.
- D. The unit shall be provided with a 15 amp GFCI convenience outlet mounted by the light switch. The electrical contractor shall provide a separate 120/60/1 power service to operate the GFCI convenience outlet and lighting circuit.
- E. Single terminal block shall be provided for connecting electrical power at the unit.
- F. Unit shall have a Short Circuit Capacity Rating (SCCR) of 10 kAIC.
- G. Each panel shall include an externally operated non-fused main disconnect wiring shall be clearly labeled to allow for ease of final field connections.
- H. Provide a factory-mounted $\frac{3}{4}$ " empty conduit for controls wiring with internally mounted J-box in each section and an external J-Box at each end of the unit.
- I. Lights: Provide factory-mounted, weatherproof, marine type lights in each unit section wired to a single 60-minute timer switch located on the unit exterior at the supply fan section door.

2.7 COOLING SECTION

- A. The cooling coil section shall be installed in a draw through configuration, upstream of the supply air fan. The coil section shall be complete with factory piped cooling coil and sloped drain pan. Hinged access doors on both sides of the section shall provide convenient access to the cooling coil and drain pan for inspection and cleaning.
- B. Submittals shall demonstrate that scheduled unit leaving air temperature (LAT) is met, that fan and motor heat temperature rise (TR) have been considered, and scheduled entering air temperature (EAT) equals mixed air temperature (MAT). Draw-thru cooling - Scheduled EAT equals cooling coil EAT and scheduled unit LAT equals cooling coil LAT plus TR.
- C. Direct expansion (DX) cooling coils shall be fabricated of seamless 1/2" diameter high efficiency copper tubing that is mechanically expanded into high efficiency aluminum plate fins. Coils shall be a multi-row, staggered tube design. The unit shall have two independent refrigerant circuits and shall use an interlaced coil circuiting that keeps the full coil face active at all load conditions.
- D. All coils shall be factory leak tested with high pressure air under water.

- E. A stainless steel, positively sloped drain pan shall be provided with the cooling coil. The drain pan shall extend beyond the leaving side of the coil and underneath the cooling coil connections. The drain pan shall have a minimum slope of 1/8" per foot to provide positive draining. The drain pan shall be connected to a threaded drain connection extending through the unit base. Units with stacked cooling coils shall be provided with a secondary drain pan piped to the primary drain pan.

2.8 FILTERS

- A. Unit shall be provided with a draw-through filter section. The filter section shall be supplied complete with the filter rack as an integral part of the unit.
- B. The filter rack shall be side access and hold 2" MERV-8 pre-filters and 4" MERV-13 final filters. Provide Type-8 filter frame with spring loaded clips.
- C. Provide factory-mounted differential pressure gauges across each filter.

2.9 OUTDOOR/RETURN AIR SECTION

- A. Unit shall be provided with an outdoor air economizer section. The 0 to 100% outside air economizer section shall include outdoor, return, and exhaust air dampers. Outdoor air shall enter from both sides of the economizer section through horizontal, louvered intake panels complete with rain lip and bird screen. The floor of the outdoor air intakes shall provide for water drainage. The economizer section shall allow return air to enter from the bottom of the unit. The outside and return air dampers shall be sized to handle 100% of the supply air volume. The dampers shall be opposed sets of parallel blades, arranged vertically to converge the return air and outdoor air streams in multiple, circular mixing patterns.
- B. Daikin Applied UltraSeal low leak dampers shall be provided on outdoor air and return air dampers. Damper blades shall be fully gasketed and side-sealed and arranged horizontally in the hood. Damper leakage shall be less than 1.5 CFM/Sq. Ft. of damper area at 1.0 inch static pressure differential. Leakage rate shall be tested in accordance with AMCA Standard 500. Damper blades shall be operated from multiple sets of linkages mounted on the leaving face of the dampers.
- C. A barometric exhaust damper shall be provided to exhaust air out of the back of the unit. A bird screen shall be provided to prevent infiltration of foreign materials. Exhaust damper blades shall be lined with urethane gasketing on contact edges.
- D. Control of the outdoor or return dampers shall be by a factory-installed actuator. Damper actuator shall be of the modulating, spring return type. If outdoor air is suitable for "free" cooling, the outdoor air dampers shall modulate in response to the unit's temperature control system. An adjustable enthalpy control shall be provided to sense the dry-bulb

temperature and relative humidity of the outdoor air stream to determine if outdoor air is suitable for “free” cooling.

- E. Economizer assembly shall be California Title 24 compliant. MicroTech III controls shall display a warning and write a warning to the energy management system (EMS), if the economizer malfunctions in accordance with Title 24 specifications.

2.10 DISCHARGE AND RETURN PLENUMS

- A. Provide a supply air discharge plenum section with a main down discharge opening with walk-on grate at floor opening. Additionally, provide a branch duct connection on the right side (Air in your face) on the discharge plenum with reinforced flange duct connection, per the plans.
- B. Provide a down discharge return plenum with walk-on grate at floor opening. Additionally, provide a branch duct connection on the rear on the return section with reinforced flange duct connection, per the plans.

2.11 CONDENSING SECTION

- A. Air-Cooled Condenser.
 - 1. The condensing section shall be open on the sides and bottom to provide access and to allow airflow through the coils. Condenser coils shall be multi-row and fabricated from cast aluminum micro-channel coils. Each condenser coil shall be factory leak tested with high-pressure air under water. Coils shall be recessed so that the cabinet provides built in hail protection.
 - 2. Condenser fans shall be direct drive, propeller type designed for low tip speed, vertical air discharge, and include service guards. Fan blades shall be constructed of steel and riveted to a steel center hub. Condenser fan motors shall be heavy-duty, inherently protected, three-phase, non-reversing type with permanently lubricated ball bearing and integral rain shield.
 - 3. The unit shall have at least one condenser fan controlled to maintain positive head pressure.
- B. Scroll Compressors.
 - 1. The unit shall have multiple, heavy-duty Copeland scroll compressors.
 - 2. Each compressor shall be complete with gauge ports, crankcase heater, sight-glass, anti-slug protection, motor overload protection, and a 5-minute time anti-cycling time delay.
 - 3. Compressors shall be isolated with resilient rubber isolators to decrease noise transmission.

C. Refrigeration Circuit.

1. The unit shall have two independent refrigeration circuits. Each circuit shall be complete with low pressure control, pumpdown switch, liquid line solenoid valve, filter drier, liquid moisture indicator/sight-glass, thermal expansion valve, liquid line charging valve with a 3/8" charging port, a manual reset high pressure safety switch. The thermal expansion valve shall be capable of modulation from 100% to 25% of its rated capacity. Sight-glasses shall be accessible for viewing without disrupting unit operation. Each circuit shall be dehydrated and factory charged with 410-A refrigerant and oil.
2. Each compressor shall be complete with gauge, ports, crankcase heater, sight - glass, anti-slug protection, motor overload protection and a 5-minute time anti-cycling time delay.

2.12 ROOF CURB

- A. A prefabricated 12-gauge galvanized steel, mounting curb, designed and manufactured by the unit manufacturer, shall be provided for field assembly on the roof decking prior to unit shipment. The roof curb shall be a full perimeter type with complete perimeter support of the air handling section and rail support of the condensing section. Supply and return opening duct frames shall be provided as part of the curb structure allowing duct connections to be made directly to the curb prior to unit arrival. The curb shall be a minimum of 16" high and include a nominal 2" x 4" wood nailing strip. Gasket shall be provided for field mounting between the unit base and roof curb.

2.13 CONTROLS

- A. The unit and its sensors shall be capable of stand-alone operations. The unit and its sensors shall also be interconnected to the building automation system (BAS) or energy management system (EMS). BAS and EMS are used interchangeably in the specifications, but are intended to mean the same thing. See the following specification sections:
1. SECTION 23 09 00 - CONTROLS AND INSTRUMENTATION
 2. SECTION 23 95 00 – BUILDING AUTOMATION SYSTEM
 3. SECTION 23 96 00 – SEQUENCES OF OPERATION
- B. The unit shall be equipped with a complete MicroTech® III microprocessor based control system. The unit control system shall include all required temperature and pressure sensors, input/output boards, main microprocessor and operator interface. All boards shall be individually replaceable for ease of service. All microprocessors, boards, and sensors shall be factory mounted, wired and tested.

- C. The supply air fan shall be controlled by duct static pressure from a factory-furnished and factory-mounted supply air discharge duct static pressure sensor. The return fan shall be controlled via fan tracking.
- D. The microprocessor shall be a stand-alone DDC controller not dependent on communications with any on-site or remote PC or master control panel. The microprocessor shall maintain existing set points and operate stand-alone if the unit loses either direct connect or network communications. The microprocessor memory shall be protected from voltage fluctuations as well as any extended power failures. All factory and user set schedules and control points shall be maintained in nonvolatile memory. No settings shall be lost, even during extended power shutdowns.
- E. The main microprocessor shall support an RS-232 direct connection to a product service tool or a modem. A BACnet® MSTP communications module shall be provided for direct communication into the BAS network.
- F. All digital inputs and outputs shall be protected against damage from transients or wrong voltages. Each digital input and digital output shall be equipped with an LED for ease of service. All field wiring shall be terminated at a separate, clearly marked terminal strip.
- G. The microprocessor memory shall be protected from all voltage fluctuations as well as any extended power failures. The microprocessor shall support an RS-232 direct connect from an IBM PC or 100% true compatible using MicroTech software. The microprocessor shall maintain existing set points and operate stand-alone if the rooftop unit loses either direct connect or network communications.
- H. The microprocessor shall have a built-in time schedule. The schedule shall be programmable from the unit keypad interface. The schedule shall be maintained in nonvolatile memory to ensure that it is not lost during a power failure. There shall be one start/stop per day and a separate holiday schedule. The controller shall accept up to sixteen holidays each with up to a 5-day duration. The unit shall also have the ability to accept a time schedule via BAS network communications.
- I. If the unit is to be programmed with a night setback or setup function, an optional space sensor shall be provided. Space sensors shall be available to support field selectable features. Sensor options shall include Zone sensor with tenant override switch, or Zone sensor with tenant override switch and heating/cooling set point adjustment.
- J. User Interface (UI)
 - 1. The keypad/display character format shall be 20 characters x 4 lines. The character font shall be a 5 x 8 dot matrix. The display shall be a super twist liquid crystal display (LCD) with black characters on yellow background providing high visibility. The display form shall be in plain English coded formats. Lookup tables are not acceptable.

2. The keypad shall be equipped with 8 individual touch-sensitive membrane key switches. All control settings shall be password protected from changes by unauthorized personnel.
 3. Both a unit-mounted and remote-mounted UI shall be provided. One remote UI shall communicate with up to 8 separate units. Both the unit-mounted and remote-mounted UI shall be always active. The controls contractor shall be responsible for wiring between the unit and the remote UI. The maximum wiring distance to the remote UI is 2100 feet. The remote UI shall have an 8 line x 30 character display. The remote UI shall be provided with the same "push and roll" navigational tool and have identical functionality to the unit-mounted UI.
- K. The display shall provide the following information:
1. Supply, return, outdoor, and space air temperature.
 2. Duct and building static pressure. The controls contractor shall be responsible for providing and installing sensing tubes.
 3. Fan status and airflow verification.
 4. Fan VFD speed.
 5. Outside air damper position and economizer mode.
 6. Cooling, heating, and changeover status.
 7. Occupied, unoccupied, and dirty filter status.
 8. Date and time schedules.
 9. Up to 4 current alarms and 8 previous alarms with time and date.
- L. The keypad shall provide the following set points as a minimum:
1. Six control modes, including off manual, auto, heat/cool, cool only, heat only and fan only.
 2. Four occupancy modes, including auto, occupied, unoccupied and bypass (tenant override with adjustable duration).
 3. Control changeover based on return air temperature, outdoor air temperature, or space temperature.
 4. Primary cooling and heating set point temperature based on supply or space temperature.
 5. Night setback and setup space temperature.
 6. Cooling and heating control differential (or dead band).

7. Cooling and heating supply temperature reset options based on one of the following: Return air temperature, outdoor air temperature, space temperature, Airflow, or external (1-5VDC) signal.
 8. Reset schedule temperature.
 9. High supply, low supply and high return air temperature alarm limits.
 10. Ambient compressor and heat lockout temperatures.
 11. Auto or manual lead lag method on compressors.
 12. Compressor interstage timers duration.
 13. Duct static pressure.
 14. Return fan tracking (VaneTrol) settings that include minimum/maximum VFD speed, with and without remote exhaust operation.
 15. Minimum outdoor airflow reset based on external reset (1-5 VDC), percent of CFM capacity, and fixed outdoor damper position.
 16. Economizer changeover based on enthalpy, dry bulb or network signal.
 17. Current time and date.
 18. Occupied/unoccupied time schedules with allowances for holiday/event dates and duration.
 19. Three types of service modes including timers normal (all time delays,) timers fast (all time delays 20 seconds,) and normal.
- M. Open Communications Protocol. The unit control system shall have the ability to communicate to an independent building automation system (BAS) or energy management system (EMS) through a direct BACnet MSTP. It shall use only standard BACnet objects. Proprietary BACnet objects shall not be allowed. BACnet communications shall conform to the BACnet protocol (ANSI/ASHRAE 135-2001). A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided. Multiple units may be connected in a common communications network.
- N. The independent BAS shall have access to “read only” variables and “read & write” variables. Communications shall not require field mounting of any additional sensors or devices at the unit. The BAS shall be capable of interacting with the individual rooftop controllers in the following ways.
1. Monitor controller inputs, outputs, set points, parameters and alarms.

2. Set controller set points and parameters.
 3. Clear alarms.
 4. Reset the cooling and heating discharge air temperature set point.
 5. Reset the duct static pressure set point.
 6. Set the heat/cool changeover temperature.
 7. Set the representative zone temperature.
- O. The Contractor shall integrate the rooftop unit data into the BAS control logic and interface stations.
- P. Refrigeration capacity control shall be accomplished by staging of the unit's multiple compressors. The unit shall be equipped with a 120V terminal strip for field supplied and installed controls.

3. EXECUTION

3.1 PREPARATION

- A. Provide storage for equipment at the project site. Protect materials and equipment from weather. Provide clearance for inspection, repair, replacement and service.

3.2 INSTALLATION AND FIELD QUALITY CONTROL

- A. Use factory-provided lifting lugs to rig the unit. Spreader bars shall be used to prevent damaging casing.
- B. Verify that pads or bases are level. Provide approved shims if necessary.
- C. Install unit in accordance with the manufacturer's instructions.
- D. Provide operational tests to demonstrate proper operation and adequate capacity of balancing and adjusting.
- E. Supply and install sheaves as necessary for final balancing.
- F. Clean fans, wire-brush and touch up any marred areas with factory supplied matching paint.
- G. The manufacturer shall provide with the unit, a detailed pre-shipping inspection checklist completed at the factory. Provided also will be a pre-start checklist and commissioning record which shall be completed and e-mailed back to the manufacturer within 30 days of start up to validate the factory warranty.
- H. The Contractor shall provide seismic restraint of the unit structural frame, including seismic calculations, to concrete foundation or curb.
- I. The unit manufacturer shall provide factory service for pre-start-up site inspection, start-up and operating instructions to Owner personnel.

- J. Schedule and administer specified tests. Provide personnel, instruments and equipment for such tests. Correct defects and repeat the respective inspection and tests. Give the Owner ample notice of the date and time schedule for tests and trial operations. Conduct inspection and testing in the presence of the Owner's Representative.
- K. Prior to initial operation, inspect equipment installation for conformance with contract documents. Verify shipping restraints have been removed and level spring isolators. Adjust thrust restraints, if necessary. Check belt drives are adjusted for tension and alignment.
- L. Perform an operational test to determine unit will operate correctly (e.g. check fan rotation, shipping restraints removed, vibration isolators operate correctly, etc.). Operate unit for a minimum period as required in Division 01.
- M. Vibration signatures shall be taken on each bearing in the horizontal, vertical and axial directions. The reading as measured at the fan shall not exceed 0.10 inch per second peak with the fan flexibility mounted. The vibration signatures shall be submitted.

END OF SECTION 23 8300

SECTION 23 8400

EXHAUST FANS

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide new exhaust fans, EF-1 and EF-2, as indicated on the Drawings and as specified, complete.
- B. Exhaust fans shall be aluminum, wall-mounted, centrifugal, direct drive, exhaust fans.
- C. Ancillary equipment, appurtenances, accessories, and devices shall be provided as specified in this section and on the Drawings.

1.2 QUALITY ASSURANCE

- A. The exhaust fans shall be manufactured at an ISO 9001 certified facility.
- B. Exhaust fans shall be listed by Underwriters Laboratories (UL 705) and UL listed for Canada (cUL 705).
- C. Exhaust fans shall bear the AMCA Certified Ratings Seal for Sound and Air Performance.

1.3 SUBMITTALS

- A. Submit in accordance with SECTION 01 33 00 - SUBMITTAL PROCEDURES.
- B. Submit exhaust fan performance including: capacity, nominal and operating performance.
- C. Submit Mechanical Specifications for unit and accessories describing construction, components and options.
- D. Submit shop drawings indicating overall dimensions as well as installation, operation and service clearances. Indicate lift points and recommendations. Indicate installation and operating weights including dimensions.
- E. Provide fan curves with specified operating point clearly plotted.
- F. Submit data on electrical requirements. Include safety and start-up instructions.
- G. Submit certified sound data.

1.4 EXHAUST FAN PERFORMANCE AND OPERATING REQUIREMENTS

- A. The exhaust fan shall deliver the air flow and static pressure specified in the New Exhaust Fan Schedule on Drawing M-1.10. It shall also comply with the other operating requirements stated in that schedule.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting exhaust fan.
- B. The exhaust fan shall ship fully assembled up to practical shipping and rigging limitations. Exhaust fans not shipped fully assembled shall have tags and airflow arrows on each section to indicate location and orientation in direction of airflow. Shipping splits shall be clearly defined on submittal drawings. Costs associated with non-conformance to shop drawings shall be the responsibility of the manufacturer. Each section shall have lifting lugs or shipping skid to allow for field rigging and final placement of section.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.6 START-UP AND OPERATING REQUIREMENTS

- A. Do not operate exhaust fan for any purpose, temporary or permanent, until bearings are lubricated (if applicable), all shipping braces are removed, bearing set screws are torqued, and exhaust fan has been test run under observation.

1.7 WARRANTY

- A. The equipment manufacturer shall provide, at no additional cost, a standard parts warranty that covers a period of one year from unit start-up or 18 months from shipment, whichever occurs first. This warrants that all products are free from defects in material and workmanship and shall meet the capacities and ratings set forth in the equipment manufacturer's catalog and bulletins.

2. PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Provide exhaust fan as manufactured by Loren Cook ACW-D-120W175 (as the basis-of-design), or equal.
- B. Any mechanical equipment manufacturer and model, other than the basis of design product, shall comply with all the physical, operational, and performance constraints, parameters, and requirements identified in the drawings and specifications. Any redesign, plan check, and construction efforts and costs to comply with those physical, operational, and performance constraints, parameters, and requirements for equipment other than the basis of design manufacturer and model listed shall be borne by the Contractor.

2.2 GENERAL

- A. Furnish and install where shown on the plans exhaust fan with construction features as specified below. Exhaust fans shall be spun aluminum, wall-mounted, direct-driven, horizontal centrifugal exhaust ventilators. The exhaust fan shall be provided and installed in strict accordance with the specifications. The exhaust fan shall be complete with all components and accessories as specified. Any exceptions shall be clearly defined. The Contractor shall be responsible for any additional expenses that may occur due to any exception made.
- B. Exhaust fans shall be designed specifically for wall mounting, to discharge contaminated air perpendicular to a wall.

2.3 UNIT DESCRIPTION

- A. Provide factory-fabricated exhaust fan. The exhaust fan shall come completely assembled. All electrical components and assemblies shall comply with NEMA standards.

2.4 CONSTRUCTION

- A. Exhaust fans shall be of bolted and welded construction utilizing corrosion resistant fasteners.
- B. The spun aluminum structural components shall be constructed of minimum 16 gauge marine alloy aluminum, bolted to a rigid aluminum support structure. The spun aluminum wall flange shall have pre-punched keyslot holes and a mounting template with wall opening location for ease of installation.
- C. The windband shall have a rolled bead for added strength.
- D. An integral conduit chase shall be provided into the motor compartment to facilitate wiring connections. The motor shall be enclosed in a weather-tight compartment, separated from the exhaust airstream.
- E. The exhaust fans shall bear an engraved aluminum nameplate. Nameplate shall indicate design CFM and static pressure.
- F. The exhaust fans shall be shipped in ISTA Certified Transit Tested Packaging.

2.5 FAN WHEEL

- A. The fan wheel shall be centrifugal backward inclined, constructed of 100 percent aluminum, including a precision machined cast aluminum hub.
- B. The wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency.
- C. The wheel shall be balanced in accordance with AMCA Standard 204-05, Balance Quality and Vibration Levels for Fans.

2.6 MOTOR

- A. Motor shall be NEMA design B, premium efficiency, with a minimum of Class B insulation, rated for continuous duty and furnished at the specified voltage, phase, and enclosure.
- B. Motor (EC) shall be an electronically commutated motor rated for continuous duty and furnished either with internally mounted potentiometer speed controller with leads for connection to 0-10 VDC external controller.

2.7 EMS CONTROLS AND SEQUENCE OF OPERATIONS

- A. The exhaust fans and all their sensors shall be capable of stand-alone operations. They shall also be interconnected to the energy management system (EMS). See the following specification sections:
 - 1. SECTION 23 09 00 - CONTROLS AND INSTRUMENTATION
 - 2. SECTION 23 95 00 – BUILDING AUTOMATION SYSTEM
 - 3. SECTION 23 96 00 – SEQUENCES OF OPERATION
- B. The new exhaust fans shall be integrated into the rooftop packaged unit and exhaust fan sequences of operations, both as stand-alone operation and using the EMS. See the sequence of operations.
- C. All controls shall be supplied and field-installed by the controls contractor.

3. EXECUTION

3.1 PREPARATION

- A. Provide storage for equipment at the project site. Protect materials and equipment from weather. Provide clearance for inspection, repair, replacement and service.

3.2 INSTALLATION AND FIELD QUALITY CONTROL

- A. Install exhaust fans in accordance with the manufacturer's instructions.
- B. Exhaust fans shall ship fully assembled.
- C. Provide operational tests to demonstrate proper operation and adequate capacity of balancing and adjusting.
- D. Clean fan, wire-brush and touch up any marred areas with factory supplied matching paint.
- E. The manufacturer shall provide with the exhaust fans, a detailed pre-shipping inspection checklist completed at the factory. Provided also will be a pre-start checklist and commissioning record which shall be completed and e-mailed back to the manufacturer within 30 days of start up to validate the factory warranty.

- F. Prior to initial operation, inspect equipment installation for conformance with contract documents. Verify shipping restraints have been removed.
- G. Perform an operational test to determine exhaust fan will operate correctly (e.g. check fan rotation, shipping restraints removed, vibration isolators operate correctly, etc.). Operate exhaust fans for a minimum period as required in Division 01.
- H. Vibration signatures shall be taken on each bearing in the horizontal, vertical and axial directions. The reading as measured at the fan shall not exceed 0.10 inch per second peak with the fan flexibility mounted. The vibration signatures shall be submitted.

END OF SECTION 23 8400

SECTION 23 9100

TESTING, ADJUSTING, AND BALANCING FOR HVAC

1. GENERAL

1.1 SUMMARY

A. SECTION INCLUDES

1. This Section specifies the requirements for test and balance of HVAC and related systems, specifically the RTU-1 air handling system and the EF-1 and EF-2 exhaust air systems. Under this contract, Contractor shall test, adjust, and balance all new and related existing systems and associated equipment.

B. RELATED REQUIREMENTS

1. SECTION 01 1100: SUMMARY OF WORK.
2. SECTION 01 3100: PROJECT MANAGEMENT AND COORDINATION
3. SECTION 01 3250: PROGRESS SCHEDULE.
4. SECTION 01 3300: SUBMITTAL PROCEDURES.
5. SECTION 01 7700: CLOSEOUT PROCEDURES.
6. SECTION 01 7800: CLOSEOUT SUBMITTALS.
7. SECTION 23 0500: MECHANICAL GENERAL PROVISIONS.
8. SECTION 23 0516: BASIC MECHANICAL MATERIALS AND METHODS.
9. SECTION 23 0548: VIBRATION AND SEISMIC CONTROL.
10. SECTION 23 0900: CONTROLS AND INSTRUMENTATION.
11. SECTION 23 3100: DUCTWORK.
12. SECTION 23 3300: DUCTWORK ACCESSORIES.
13. SECTION 23 8300: SEMI-CUSTOM PACKAGED ROOFTOP UNITS.
14. SECTION 23 8400: EXHAUST FANS.
15. SECTION 23 9500: BUILDING AUTOMATION SYSTEM.

16. SECTION 23 9600: SEQUENCES OF OPERATIONS.

2. PRODUCTS (Not used)

3. EXECUTION

3.1 DEFINITIONS AND APPLICABLE PUBLICATIONS

- A. For the purposes of this Section definitions are as indicated in applicable publications of AABC, ASHRAE, ANSI and SMACNA.
 - 1. TAB: Testing, Adjusting and Balancing.
 - 2. AABC: Associated Air Balance Council.
 - 3. ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers.
 - 4. ANSI: American National Standards Institute.
 - 5. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.

3.2 QUALITY ASSURANCE

- A. The General Contractor shall contract directly with the test and balance agency. Tests performed by testing agencies contracted with the system's subcontractor will not be accepted. The qualifications of the agency shall comply with Article 3.2, Quality Assurance. The agency shall be responsible for furnishing labor, instruments, and tools required to test, adjust, and balance the heating, ventilating, and air conditioning (HVAC) systems and related plumbing systems, as described and/or as indicated in the Contract Documents.
- B. The General Contractor shall obtain services of an independent, qualified testing agency acceptable to the Owner's Representative to perform testing and balancing Work as specified and as follows:
 - 1. Agency shall be currently certified by the Associated Air Balance Council (AABC).
 - 2. Work shall be in accordance with the latest edition of the AABC National Standards. If the Contract Documents impose a more stringent standard, then the Contract Documents shall prevail.
- C. Performance Criteria: Work of this Section shall be performed in accordance with approved Testing, Adjusting, and Balancing agenda.

- D. Test Equipment Criteria: Basic instrumentation requirements and accuracy/calibration required by Section Two of the AABC Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.
- E. Verification: The Test and Balance Agency shall recheck 10 percent (minimum 10) of the measurements listed in the report. The locations shall be selected by Owner's Representative. The recheck will be witnessed by the Owner's Representative. If 20 percent of the measurements that are retested differ from the report and are also out of the specified range, an additional 10 percent will be tested. If 20 percent fall outside the specified range, the report will be considered invalid and all test and balance work shall be repeated.

3.3 SUBMITTALS

- A. Submit name of agency to perform the Work. Include in the submittal the certified qualifications of all persons responsible for supervising and performing actual Work of this Section. Agency shall submit a minimum of five commercial or industrial HVAC system TAB projects of similar type, size, and degree of difficulty completed within the last two years. Agency shall provide name and telephone number of contact person for each listed project.
- B. Submit, for approval, 6 copies of the Agenda as indicated in Article 3.6 to test and balance all mechanical and relevant plumbing systems.
- C. Preliminary Report: Review the Contract Documents, examine Work installations and submit a written report to the Owner's Representative indicating deficiencies in Work precluding proper testing and balancing of the Work.
- D. Final TAB Report: Submit the final TAB report for review by the Owner's Representative outlining the conditions and Work completed on each HVAC system. All outlets, devices, HVAC equipment, etc. shall be identified, along with a numbering system corresponding to report unit identification.
- E. Submit an AABC "National Project Performance Guaranty," assuring the Project systems were tested, adjusted, and balanced in accordance with the Specifications and AABC National Standards.
- F. CAD drawings: Submit single line, multi-color CAD drawings indicating outside return and supply air, volume control boxes, each outlet and inlet, room numbers, duct sizes at traverse locations, temperatures and pressures, systems balanced, components changed, and CONTRACTOR installed access points. In addition, drawings shall identify controls, equipment settings, including manual damper quadrant positions, manual valve indicators, fan speed control levers, and similar controls, and devices shall be marked on the drawings to show final settings. CAD files shall be submitted on CD-ROM upon final submittal of

TAB report. Reports shall identify discrepancies between completed Work and the Contract Documents affecting the performance and longevity of the system.

3.4 GENERAL SCOPE OF WORK

- A. The general scope of Work shall include but not be limited to the following:
1. Measure airflow rates of HVAC systems and make adjustments to achieve design airflow rates, tabulate results, and submit reports.
 2. Measure flow velocities, temperatures, static pressures, rotational speed, and electrical power demand of fans and other related HVAC system components, tabulate results, and submit reports.
 3. Measure sound levels in each conditioned space, tabulate results, and submit reports.
 4. Measure ambient sound levels of outdoor HVAC units and system components, tabulate results, and submit reports.
 5. Reports shall contain sufficient data for the system designer to evaluate system performance and solve installation problems such as system pressure profiles and pressure drops across system components.

3.5 SPECIFIC SCOPE OF WORK

- A. The specific scope of Work shall include the following HVAC system components as indicated on the Drawings:
1. Packaged Rooftop Unit.
 2. Cooling Coils.
 3. Outside Air and Return Air Plenums.
 4. Outside Air Intakes.
 5. All Supply and Return Ductwork.
 6. All associated Air Terminal Devices, i.e. Supply Diffusers, Return Registers, etc.
 7. Variable Air Volume (VAV) Boxes and Their Reheat Coils.
 8. Exhaust Fans and Duct Systems.

3.6 TESTING, ADJUSTING, AND BALANCING AGENDA

- A. Provide proposed materials, methods, procedures, forms, diagrams, and reports for test and balance Work.
- B. Agenda shall be completed by the test and balance agency and submitted to the Owner's Representative for review and approval.
- C. Agenda shall include one complete set of AABC publications listed in Sub-paragraph 3.2.B.2, applicable publications, or, in case of other test and balance agencies and or organizations, comparable publications to establish an approved, systematic, and uniform set of procedures.
- D. Agenda shall also include the following detailed narrative procedures, system diagrams, and forms for test results:
 - 1. Specific standard procedures required and proposed for each system of the Work.
 - 2. Specified test forms for recording each procedure and for recording sound and vibration measurements.
 - 3. Systems diagrams for each air system. Diagrams may be single line.
- E. In addition to information recorded for standard AABC procedures, the following information is required:
 - 1. Fan data.
 - 2. System number, location, manufacturer, model, and serial number.
 - 3. Fan wheel type and size.
 - 4. Motor horsepower, type, and rpm.
 - 5. Sheave size, type, number of grooves, and open turns on Variable Pitch Sheave.
 - 6. Number and size of belts, motor and fan shaft sizes, center-to-center of shafts in inches, and adjustment available motor data, including nameplate data, actual amps, rated, and actual motor rpm, volts, phase, hp, kW, starter heater size, and capacity.
 - 7. Fan design airflow and service (supply, return, outdoor air or exhaust).
 - 8. Fan static pressure, suction/discharge, static profile, and static control point.
- F. The following traverse data is required:

1. Traverse location, size of duct (inside dimensions), and area of duct in square feet.
 2. Column for each hole traversed/lines for each reading.
 3. Barometric pressure.
 4. Temperature/Static pressure in the duct.
 5. Actual CFM corrected to SCFM.
 6. Notes.
- G. The following air distribution data is required:
1. Room identification.
 2. Outlet or intake balance sequence number.
 3. Size of outlet or inlet.
 4. AK Factor.
 5. Design and Actual FPM and CFM.
 6. Notes.
- H. The following hydronic coil data is required for HHW reheat coils at VAV boxes:
1. Air flow through the coil in CFM.
 2. Dry bulb and wet bulb temperatures entering/leaving coil.
 3. Enthalpy or total heat differences in BTU/pound.
 4. Capacity in BTU/hour at time of test.
 5. Water temperature and pressure entering/leaving coil.
 6. Flow (in GPM) through coil.
 7. Air pressure drop across coil.
 8. Water head drop across coil.
 9. Notes.
- I. The following DX coil data is required:
1. Air flow through the coil in CFM.

2. Dry bulb and wet bulb temperatures entering/leaving coil.
 3. Enthalpy or total heat differences in BTU/pound.
 4. Capacity in BTU/hour at time of test.
 5. Air pressure drop across coil.
 6. Notes.
- J. The following air-cooled condensing unit data is required:
1. Performance test results for rated capacity.
 2. Unit identification number.
 3. Nameplate data, manufacturer, model, and serial number.
 4. Compressor nameplate and actual amps, volts, phase, and hertz.
 5. RPM of motors, where applicable.
 6. Refrigerant type.
 7. Suction/Discharge pressure when gage installed.
 8. Number of stages.
 9. Low-pressure/High-pressure control setting.
 10. Condenser fan sequence stages.
 11. Crankcase heater watts (nameplate).
 12. Hot gas bypass installed - yes/no.
 13. SCFM Air Flow Measurement vs. Design CFM.
- K. The following mixing damper leakage test data is required:
1. Equipment identification number (unit, box, zone, etc.).
 2. Dry bulb temperature in the cold/hot (or bypass) deck.
 3. Dry bulb temperature in the mixed air stream.
 4. Calculated percent leakage.
 5. Data above taken in the full cool and full heat (or bypass) mode.
 6. Notes.

- L. The following sound test data is required:
 - 1. Area or location.
 - 2. Sound level in dB(A) as specified in Article 3.19.
 - 3. Sound level at the center band frequencies of eight non-weighted octaves with equipment on and off for 5 rooms selected by the Owner's Representative.
 - 4. Plot of corrected sound-level reading on Noise Criteria (NC) curve for the measurements.
- M. The following vibration test data is required:
 - 1. Equipment identification number.
 - 2. Vibration levels at all accessible bearings, motors, fans, pumps, casings, and isolators.
 - 3. Measurements in mils deflection and velocity in inches per second.
 - 4. Each measurement taken in horizontal, vertical, and axial planes as accessible.
- N. The following VAV box test data is required:
 - 1. Equipment identification number (box, zone, etc.).
 - 2. Dry bulb temperature in the supply air to the VAV box.
 - 3. Dry bulb temperature in the discharge air from the VAV box.
 - 4. Calculated percent leakage.
 - 5. Air flow.
 - 6. Data above taken in the full cool and full heat mode.
 - 7. Notes.
- M. The following airflow station data is required:
 - 1. Station identification number.
 - 2. Nameplate data including effective area.
 - 3. Differential test pressure or velocity.
 - 4. Calculated CFM.

5. Actual CFM (from Pitot-tube traverse form).
6. Read out CFM.
7. Notes

3.7 PROCEDURES

- A. Schedule the Work of this Section in order for test and balance activities to be completed prior to the date of Substantial Completion. CONTRACTOR shall place all heating, ventilating, and air conditioning equipment into operation during each day and until all HVAC adjusting, balancing, testing, demonstrations, and instructions on systems are completed. Agency shall prepare and submit reports within ten (10) days from completion of the Work of this Section to allow sufficient time for corrective measures to be completed before Substantial Completion of the Work. When an individual building or portion thereof is ready for occupancy, all equipment relative to such portion of Work shall be put into service, tested, and balanced.
- B. Prior to the date of Substantial Completion, and upon completion of test and balance Work, place all exhaust fans in operation, force all air handling units, and air conditioning units into a 100 percent outdoor air economizer mode with heating and cooling locked out and flush the building continuously for a period of fourteen (14) days.
- C. Coordinate test and balance procedures with any phased Project requirements so test and balance procedures on each phased portion of the Work will be completed prior to completion of said designated phase.

3.8 FIELD EXAMINATION

- A. Before the commencement of test and balance Work, CONTRACTOR shall ascertain that following conditions are fulfilled:
 1. Ensure that all water heating systems have been flushed, cleaned, and filled, and high points vented.
 2. Refrigerant systems are fully charged with specified refrigerant.
 3. Over-voltage and current protection have been provided for motors.
 4. Equipment has been labeled as required.
 5. Curves and descriptive data on each piece of equipment to be tested and adjusted are available as required.
 6. Operations and maintenance manuals have been supplied.

7. Controls manufacturer representative shall be available for consultation and supervision of adjustments during tests.
 8. Verify that heating and cooling coil fins are cleaned, combed and air filters clean, and installed.
 9. Verify that duct systems are clean of debris and leakage is minimized, access doors are closed and duct end caps are in place, and fire and volume dampers are in place and open.
 10. Automatic control systems are completed and operating.
 11. Start up and initial commissioning of all HVAC equipment except fans shall be by the manufacturer.
- B. In addition to the above, CONTRACTOR shall establish a specific, coordinated plan which details how each area of existing building will be balanced during the various phases of the Work. The evaluation shall address, at a minimum, the following concerns:
1. OWNER operations.
 2. Building safety and security policies. Prior to any fire safety or security systems shutdown at any time during the Work, CONTRACTOR shall first advise and coordinate with the Owner's Representative to ensure all concerned parties are notified.
 3. Protecting furniture, computers, photocopiers, and other office equipment.
 4. Protecting room fixtures and equipment.
 5. Concerns specific and unique to building related issues.
 6. Downtime required for each HVAC unit including projected time to return each portion of the building back to its normal occupancy temperature and humidity.
 7. Shutdown and reactivation of the fire alarm system to avoid accidental alarms during test and balance and related Work.

3.9 TEST AND BALANCE

- A. For each heating, ventilating, or air conditioning system the following shall be performed, recorded, and submitted in an approved format for review. Make, type, and model of unit, and location of each piece of equipment shall be included in the report. Readings shall include but not be limited to following:
1. Air Systems:

a. General

- 1) Verify all ductwork, dampers, grilles, registers, and diffusers have been installed per design and set in the full open position. Agency shall perform the following TAB procedures in accordance with AABC National Standards. Where the requirements of the two standards are different, the more stringent requirements shall prevail. Also, if the Contract Documents impose a more stringent standard then the Contract Documents shall prevail.

b. Zone, Branch, and Main Ducts:

- 1) Adjust ducts to within design CFM requirements by means of Pitot-tube duct traverse.

c. Supply Fans:

- 1) Fan Speeds: Test and adjust fan RPM to achieve maximum or design CFM. CONTRACTOR shall provide new belt pulleys when required.
- 2) Current and Voltage: Test and record motor voltage and amperage, and compare data with the nameplate limits. Ensure fan motor is not in or above the service factor as published by the motor manufacturer.
- 3) Pitot-Tube Traverse: Perform a Pitot-tube traverse of main supply and return ducts, record total CFM.
- 4) Outside Air: Test and adjust the outside air using Pitot-tube traverse.
- 5) Static Pressure: Test and record system static profile of each supply fan.
- 6) Current and Voltage: Test and record motor voltage and amperage, and compare data with the nameplate limits. Ensure fan motor is not in or above the service factor as published by the motor manufacturer.

d. Return, Relief, and Exhaust Fans:

- 1) Fan Speeds: Test and adjust fan RPM to achieve maximum or design CFM. CONTRACTOR shall provide new belt pulleys where required.

- 2) Pitot-Tube Traverse: Perform a Pitot-tube traverse of the main return ducts to obtain total CFM.
 - 3) Static Pressure: Test and record system static profile of each fan.
- e. VAV Systems:
 - 1) Set volume regulators on all terminal boxes to meet design maximum and minimum CFM requirements.
 - 2) Identification: Identify the type, location, and size of each terminal box. This information shall be recorded on terminal box data sheets.
- f. Diffusers, Registers and Grilles:
 - 1) Tolerances: Test and balance each diffuser, grille, and register to within 5 percent of design requirements.
 - 2) Identification: Identify the type, location, and size of each grille, diffuser, and register. This information shall be recorded on air outlet data sheets.
- g. Coils: Air Temperature: Once airflow is set to acceptable limits, agency shall take wet bulb and dry bulb air temperatures on the entering and leaving side of each cooling coil. Dry-bulb temperature shall be taken on the entering and leaving side of each heating coil.
- h. Duct Leakage Testing:
 - 1) On existing ductwork, agency shall calculate duct leakage by traversing the unit and reading associated diffusers.
 - 2) On new installations each and every section of the entire air distribution system (all supply, return, exhaust, and relief ductwork) shall be tested at 1.5 times design static pressure. All ducts shall demonstrate 5 percent leakage maximum (per CBC).
- i. RTU Air Handling System:
 - 1) Prepare pressure profile and show design and actual CFM (outside air, return air, and supply air).

- 2) Measure and record each mode (minimum OA and 100 percent OA) where economizer cycle is specified.
 - 3) Record pressure drops of all components (coils, filters, sound attenuators, louvers, dampers, and fans) and compare with design values.
 - 4) Pressure profile and component pressure drops are performance indicators and are not to be used for flow measurements.
- j. System Pressure Profiles:
- 1) Prepare pressure profiles from fan (supply, return, and exhaust) or air handling unit to extremities of system.
 - 2) As a minimum, show pressure at each floor, main branch, and airflow measuring device.
 - 3) Make pitot-tube traverses of all trunk lines and major branch lines where required for analysis of distribution system. Airflow measuring devices installed in ductwork, if available, may be utilized.
 - 4) Record residual pressures at inlets of volume controlled terminals at ends of system.
 - 5) Show actual pressures at all static pressure control points utilized for constant or variable flow systems.
- k. Fan speed adjustments and balancing for optimum acoustical performance:
- 1) As the very first step, the speed of all fans (supply, return, and exhaust) shall be adjusted to deliver the required fan total air quantity with all volume dampers and other flow rate control devices fully open. Adjustments shall be made with the outdoor air intake dampers, return air dampers, and relief air dampers in the minimum outdoor air position. The adjustments shall be made again in the 100 percent outdoor air position in systems with 100 percent outdoor air economizers.
 - 2) The above adjustment shall be done with wet cooling coils, where cooling coils are provided.

- 3) The airflow rates at each branch duct shall be adjusted as the second step with air with all volume dampers and other flow rate control devices fully open.
 - 4) The airflow rates at each air inlet and outlet shall be adjusted as the final step. The volume damper in the branch duct shall be used for balancing. Opposed blade dampers at air inlets and outlets where provided shall only be used for fine adjustments and shall not be closed beyond 60 percent open or when the dampers start to generate audible noise.
 - 5) CONTRACTOR shall provide the labor and materials for all dampers, pulleys, and belt changes required for balancing. The design documents indicate the worst-case scenario with safety factors in fan static pressures for contingency. Properly coordinated and installed air systems may require a lower static pressure and a reduction in fan speed.
- I. Packaged Rooftop Unit: (Start-up and initial commissioning by manufacturer only.)
- 1) Suction pressure and temperature.
 - 2) Discharge pressure and temperature.
 - 3) Amps and volts.
 - 4) Make, type, and model of unit, capacity rating.
 - 5) Ambient temperature: WB, DB.
 - 6) Supply, return, relief, and exhaust fans shall be balanced as indicated paragraphs 3.9 A 1 c and 3.9 A 1 d.
 - 7) Proper operation of controls: Temperature controllers and safety devices shall be tested during operating tests, with all other controls and devices, except one under test, being by-passed.
 - 8) Upon completion of tests, controls and devices shall be returned to their normal operating condition and boiler shall remain in service.

2. Water Systems: CONTRACTOR shall confirm all equipment, piping, and coils have been filled and purged, strainers are clean, and all balancing valves (except bypass valves) are set full open. Agency shall perform the following TAB procedures in accordance with the AABC National Standards:

B. Coils:

1. Tolerances: Test and balance all heating hot water coils within 5 percent of design requirements.
2. Verify the type, location, final pressure drop, and GPM of each coil.

C. System Mains and Branches including heating hot water:

1. Balance water flow in pipes to achieve maximum or design GPM.

3.10 VERIFICATION OF HVAC CONTROLS

- A. Agency shall verify in conjunction with CONTRACTOR all control components are installed in accordance with the intent of the Contract Documents and are functioning according to the design intent, including all electrical interlocks, damper sequences, air and water resets, fire stats, and other safety devices.
- B. CONTRACTOR shall verify all control components are calibrated and set for design operating conditions and intent.

3.11 TEMPERATURE TESTING

- A. To verify system control and operation, agency shall perform a series of three temperature tests taken at approximately two-hour intervals in each separately controlled zone. The resulting temperatures shall not vary more than two degrees Fahrenheit from the thermostat or control set point during the tests. Outside temperature and humidity shall also be recorded during the testing periods.

3.12 FINAL TABULATION

- A. After heating, ventilating, and air conditioning components are satisfactorily tested and balanced, entire system shall be put into operation and all pressures, temperatures, gpm, cfm, velocities, etc., shall be recorded and checked against design schedules. Design requirements shall be listed on reports and final tabulation shall be within a tolerance of plus or minus five percent of design requirements.
- B. Readings at various locations as described herein will be made every hour for four (4) hours, during normal working hours for three (3) days.

3.13 VIBRATION TESTING

- A. Furnish instruments and perform vibration measurements for all systems. Provide measurements for all rotating HVAC equipment half horsepower and larger, including reciprocating/centrifugal/screw/scroll compressors, fans, and motors.
- B. Record initial and final measurements for each unit of equipment on test forms. Where vibration readings exceed allowable tolerance and efforts to make corrections have proved unsuccessful, forward a separate report to the Owner's Representative.

3.14 SOUND TESTING

- A. Perform and record sound measurements as specified in this Section. Take additional readings if required by the Owner's Representative.
- B. Measuring equipment and methods shall comply with the current requirements of AABC and ANSI S12.60. Take measurements with a calibrated Type 1 sound level meter and octave band analyzer.
- C. Sound reference levels, formulae, and coefficients shall be according to ASHRAE Handbook: HVAC Applications, Chapter on Sound and Vibration Control.
- D. Where sound levels are required in dbA, measure sound levels using the A-frequency-weighting of meter. Single value readings will be used instead of octave band analysis.
- E. Measure sound levels at each octave band as NC. Where measured sound levels exceed specified level, CONTRACTOR shall take all remedial action and necessary sound tests shall be repeated. Sound tests after remedial action shall be in octave band in NC for the room and also at each diffuser, grille, or register in occupied areas. Sound levels shall be measured approximately five feet above floor on a line approximately 45 degrees to center of opening, on the A- and C-frequency-weighting of the measuring instrument.
- F. Measure and record sound levels in decibels for each room per current ANSI S12.60.
- G. Report shall include ambient sound levels, taken without air handling equipment operating, of rooms in which above openings are located. A report shall also be made of any noise caused by mechanical vibration.

END OF SECTION

SECTION 23 9500

BUILDING AUTOMATION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

- A. As part of this Brenda Villa Aquatic Center HVAC Upgrades Project, the Owner seeks to connect into its existing energy management system (EMS) or building automation system (BAS), which is a Siemens Apogee EMS.
- B. Specifically, new RTU-1, its new VAV air terminal units, and new exhaust fans EF-1 and EF-2 shall be connected into the existing Siemens Apogee EMS. This requires a new Siemens PXC controller/control panel for new RTU-1, new Application Specific Controllers (ASC) for the VAV boxes, and other items.
- C. BAS and EMS are used interchangeably in the specifications, but are intended to mean the same thing.
- D. These specifications present specifications for the new Siemens PXC controller/control panel for new RTU-1, new Application Specific Controllers (ASC) for the VAV boxes, and other new items.
- E. The Contractor shall provide the new Siemens PXC controller/control panel, new Application Specific Controllers (ASC) for the VAV boxes, and other new items, and connect them into the existing Siemens Apogee EMS as described in the Drawings and these specifications.
- F. The Contractor shall provide all labor, programming, and testing, and provide all materials and equipment for the new interconnections to the energy management system as indicated on the Drawings and as specified, complete. All labor, material, equipment, programming, and software not specifically referred to herein, that are required to meet the functional intent of this specification, shall be provided without additional cost to the Owner. The systems shall provide accurate and stable control of the Project equipment with the sequences indicated.
- G. The documentation contained in this section and other contract documents pertaining to HVAC and other Controls is schematic in nature. The Contractor shall provide the hardware, design, engineering, and software necessary to implement the functions shown or as implied in the contract documents.
- H. Control systems specified herein and the DDC instrumentation devices shall be complete, including all equipment and appurtenances, and ready for operation. They shall be integrated, programmed, and tested based on the sequence of operations specified. Control systems shall be furnished, installed, tested, calibrated, programmed, and started up by, or under the supervision of trained technicians certified as qualified representatives or employees of the EMS manufacturer.

- I. Please see Specification Section 23 09 00 "Controls and Instrumentation" for DDC instrumentation required under this project.
- J. The Contractor shall integrate, program, and test the EMS and controls using specifications and guidelines presented in Section 23 96 00 - Sequences of Operations.
- K. The controls installer shall assist and be present during the testing by balancing personnel. Adjusting control devices during testing, adjusting, and balancing to override controls for simulating situations necessary for testing, adjusting and balancing the HVAC system.
- L. Strict adherence to the System Integrator (SI) qualifications as detailed in paragraph 1.3 shall be enforced to maintain the integrity, reliability, performance, and warranty of the overall EMS.
- M. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s).

1.2 RELATED DOCUMENTS

- A. SECTION 23 96 00 SEQUENCES OF OPERATIONS

1.3 QUALIFICATIONS

- A. System Integrator (SI) Qualifications
 - 1. The SI shall be regularly engaged in the service and installation of Siemens controls and as specified herein. The SI shall have a minimum of 5 years experience in the sales, installation, engineering, programming servicing and commissioning of Siemens controls. The SI shall submit a resume of no less than 5 Siemens EMS projects dating back 5 years.
 - 2. The SI shall be an authorized factory direct representative, and in good standing of the manufacturer of the specified hardware and software components. The SI shall have a minimum of 18 months experience installing, engineering, and programming Siemens EMS hardware and software.
 - 3. The SI shall have an office within 150 miles of the project site that is staffed with a minimum of 2 technicians who have successfully completed the factory authorized training of the specified manufacturer's hardware and software components. The SI capabilities shall include engineering and design of control systems, programming, electrical installation of control systems, troubleshooting and service.
 - 4. All EMS system programming must be performed by an employee of the SI. Programming performed by outside contract services shall not be accepted. Demonstration of SI programming capabilities may be requested by the Owner.
- B. Hardware and Software Component Manufacturer Qualifications

1. The manufacturer of the hardware and software components shall be primarily engaged in the manufacture of Siemens EMS systems as specified herein, and must have been so for a minimum of five (5) years.
2. The manufacturer of the hardware and software components shall have a technical support group accessible via a toll free number that is staffed with qualified personnel, capable of providing instruction and technical support service for networked control systems.
3. Acceptable manufacturers of the hardware and software components as specified herein are as follows: Siemens. No exceptions are allowed since an existing Siemens EMS exists in the building and will be connected into on this project. The Siemens local contact is: Doug Pittard, (714) 227-5140, Douglas.pittard@siemens.com

1.4 SUBMITTALS

A. General

1. Meet all applicable Submittal requirements of Division 1, Division 23, and the following including listed below and in the Submittal check list.
2. Provide to the Engineer and the Owner's Representative all information or data necessary to determine compliance with these specifications.
3. Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures, including specific requirements indicated.
4. All Drawings and Diagrams shall be machine-drafted using AutoCAD 2014 or later. .At project closeout, provide vellum plots and diskette or CD copy of control drawings and layout drawings to the Owner's Representative. In no case shall a proprietary database be used.

B. Hardware - Include a complete list of materials of equipment to be used, including technical data, performance curves, project specification sheets and installation/ maintenance instructions.

C. Control Panel Design – Provide scaled panel design drawings including panel layout, wiring diagram, bill of materials, and electrical rating. All control panels to be constructed as a U.L. 508 listed assembly. All external wiring shall be connected to terminal strips mounted within the panel. Provide engraved phenolic nameplates identifying controlled equipment mounted on the face of control panels. A complete set of 'as-built' control drawings (relating to the controls within that panel) shall be furnished within each control panel. Place drawings in an adhesive back clear plastic document pouch. Permanently fasten pouch to inside of door. See also section 7.6.

D. Control System Diagrams - Provide schematic diagrams for each controlled system. Illustrate the relationship between control system and controlled equipment. Show all control elements. Show all terminations and cable/tube numbers.

1. Provide equipment interface details using actual equipment termination information. Blank terminals or “field verify” is not acceptable.
 2. Provide individual diagrams for each mechanical system. If two systems are identical, then a single diagram may represent multiple mechanical systems. Notations like “this part here only applies to unit’s xxx”, etc. are not acceptable.
 3. The control diagrams and sequence of operation shall be together on the same sheet and shall be suitable for posting.
 4. The sequence of operation shall reference a schematic diagram of the controlled system. The sequence of operation shall describe in words the control strategies utilized, worded in such a way to serve as an informative reference to the maintenance and service personnel who will be responsible for unit operation.
 5. Each component and instrument on the control diagrams shall have a unique tag number such as temperature element “TE-1”. The sequence of operation verbiage shall make specific reference to the individual component tag numbers, such as “Controller (C-1) compares the space temperature sensor (TE-1) to set point, and modulates hot water heating coil valve (V-1) as required”. The mechanical system being controlled shall be schematically drawn and show the measurement and control points, such as “TE-1” and “V-1”.
- E. Graphic Displays - Include draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.
- F. Point List - Provide a point list for each system controller including both inputs and outputs (I/O) point, point number, the controlled device associated with the I/O point and the location of the I/O device. Use naming convention consistent with control diagrams and sequence of operation.
- G. Software manuals - Include software manuals that describe programming, testing, system overview. The manuals shall include a detailed description of each software feature including editing and writing control programs, reading or modifying printout and logs, adding, deleting and modifying user password, creating and modifying graphics. Software manuals may be provided on CD ROM in lieu of paper copy. If submitted as a CD ROM, the vendor shall arrange to review the software manuals with the engineer at the engineer’s office.
- H. Other Items Requiring Submittals
1. Point to point and basic function commissioning forms to be used on site for the start, test and check of network components and systems.
 2. List of specific personnel who will be involved in the system installation and commissioning.
 3. Functional performance test documentation and procedures to be used in commissioning control sequences.

- I. Operation and Maintenance Manuals shall be submitted indicating the correct procedures and processes to operate and maintain the system. O&M's shall be delivered either hard copy or on a CD-ROM developed specifically for the project. Contractor shall submit (3) copies of the Operation and Maintenance Manuals.
- J. Parts List shall be submitted listing: Manufacturer's name, part number, nomenclature, and stock level required for maintenance and repair necessary to ensure continued operation with minimal delay.

1.5 TRAINING

- A. Meet all applicable Training requirements of Division 1 and Division 23.
- B. Provide 4 hours of on-site training to the Owner's designated personnel in the programming and operation of the added EMS items as part of the overall existing Siemens Apogee EMS.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers of the hardware and software components as specified herein, and the basis of design, are as follows: Siemens Apogee. No exceptions are allowed since an existing Siemens EMS exists in the building and will be connected into on this project.
- B. The Siemens local contact is: Doug Pittard, (714) 227-5140, Douglas.pittard@siemens.com

2.2 DDC CONTROLLERS

- A. Provide all necessary hardware for a complete operating system as required. The Building Controller shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation. Communication between DDC Controllers and the main operator's workstation shall be by BACnet/IP.
- B. Basis of design is Siemens PXC Modular and Compact Controllers (PXC).
- C. This controller shall have the BTL listing and meet the BACnet device profile of a Building Controller (B-BC) and shall support the following BACnet BIBBs:
 - 1. The Building Level Controller shall support transmitting and receiving segmented messages.
 - 2. The Building Level Controller shall have the capability to be the BACnet/IP Broadcast Management Device (BBMD) and support foreign devices.
 - 3. The Building Level Controller shall have the capability to act as a gateway between the Primary BACnet/IP network and other devices integrated to via other open protocols on the Secondary Network.

- D. This level of controller shall be used for the following types of systems:
 - 1. Semi-custom packaged rooftop units
 - 2. VAV air terminal units with reheat
 - 3. Exhaust fans
- E. Computing power and memory minimum:
 - 1. A 32-bit, stand-alone, multi-tasking, multi-user, real-time 100MHz digital control microprocessor module.
 - 2. Inputs shall be 16-bit minimum analog-to-digital resolution.
 - 3. Outputs shall be 10-bit minimum digital-to-analog resolution
 - 4. Memory module (24 Megabyte, minimum) to accommodate all Primary Control Panel software requirements, including but not limited to, its own operating system and databases (see Controllers Software section), including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O.
 - 5. Real time clock and battery
 - 6. Data collection/ Data Trend module sized for 10,000 data samples.
 - 7. Flash Memory Firmware: Each Building Level Control Panel shall support firmware upgrades without the need to replace hardware.
- F. Onboard or Modular hardware and connections:
 - 1. Primary Network communication module enabling communication via BACnet/IP.
 - 2. Secondary Network communication module, if needed for secondary network communications.
 - 3. Human to Machine Interface port (HMI)
 - 4. USB Port
- G. Input and Output Points Hardware:
 - 1. Input/output point modules as required including spare capacity.
 - 2. Input/output point modules shall have removable terminal blocks.
 - 3. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.

4. Each primary control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated at the operator workstation.
 5. Optional HOA (hand-off-auto module) with software configurability and LED status indicators.
- H. Accessories:
1. Appropriate NEMA-rated metal enclosure.
 2. Power supplies as required for all associated modules, sensors, actuators, etc.
- I. Each Building Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.
- J. Panel setup, point definitions and sequencing diagrams shall be backed up on EEPROM memory.
- K. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building 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 30 days.
- L. Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.
- M. Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be "future" on drawings and 20% more of each point type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.
- N. Environment.
1. Controller hardware shall be suitable for the anticipated ambient conditions.
 2. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
 3. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
 4. Controller hardware shall be optionally suitable for rooftop environments.

- 2.3 ALL COMPONENTS AND CONTROLLERS supplied under this contract shall be true “peer-to-peer” communicating devices. Components or controllers requiring “polling” by a host to pass data shall not be acceptable.
- 2.4 DDC CONTROLLER SOFTWARE AND CONTROL METHODS
- A. DDC and HVAC Mechanical Equipment Controllers shall provide the following energy management routines for the purpose of optimizing energy consumption while maintaining occupant comfort.
1. 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.
 - a) The SSTO program shall operate in both the heating and cooling seasons.
 - 1) It shall be possible to apply the SSTO program to individual fan systems.
 - 2) The SSTO program shall operate on both outside weather conditions as well as inside zone conditions and empirical factors.
 - b) 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:
 - a) Time, day
 - b) Commands such as on, off, auto, and so forth.
 - c) Time delays between successive commands.
 4. There shall be provisions for manual overriding of each schedule by an appropriate operator.
 5. It shall be possible to schedule events up to one year in advance.
 - a) Scheduling shall be calendar based.

- b) Holidays shall allow for different schedules.
- C. Enthalpy switchover (economizer): The Energy Management Control Software (EMCS) will control the position of the RTU relief, return, and outside air dampers. If the outside air-dry bulb temperature falls below changeover set point the EMS 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.
- D. Temperature-compensated duty cycling.
 - 1. The DCCP (Duty Cycle Control Program) shall periodically stop and start loads according to various patterns.
 - 2. The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.
- E. Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.
- F. Night setback control: The system shall provide the ability to automatically adjust set points for night control.
- G. The Peak Demand Limiting (PDL) program shall limit the consumption of electricity to prevent electrical peak demand charges.
 - 1. 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.
 - 2. PDL shall sample the meter data to continuously forecast the demand likely to be used during successive time intervals.
 - 3. 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.
 - 4. Once the demand peak has passed, loads that have been shed shall be restored and returned to normal control.
- H. DDC Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
 - 1. A single process shall be able to incorporate measured or calculated data from any and all other DDC Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC Controllers on the network. Database shall support 30 characters, English language point names, structured for searching and logs.

2. 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.
 3. DDC Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task-orientated information from the user manual.
 4. DDC Controller shall be capable of comment lines for sequence of operation explanation.
- I. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC 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 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.
1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
 2. 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, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC 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.
 3. 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.
 4. 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.
- J. 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.
1. 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 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 7 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 data samples.

2. 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.
 3. 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.
- K. DDC 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.
- L. DDC Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for user-selected analog and digital pulse input type points as specified in the point I/O summary.
1. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g., KWH, gallons, BTU, tons, etc.).
 2. The totalization routine shall have a sampling resolution of one minute or less.
 3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.
- M. DDC Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis for points as specified in the point I/O summary.
1. The event totalization feature shall be able to store the records associated with a minimum of 9,999.9 events before reset.
 2. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.
- N. The EMS network shall allow the DDC Controllers to access any data from or send control commands and alarm reports directly to any other DDC Controller or combination of controllers. This communication shall be via BACnet/IP only.
- O. The EMS network shall allow the DDC Controllers to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password shall enable the operator to monitor, adjust, and control the points that the operator is authorized for.
- 2.5 MAXIMUM ACCEPTABLE RESPONSE TIME from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces. Maximum acceptable response time from any alarm

occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

2.6 APPLICATION SPECIFIC CONTROLLERS (ASC)

- A. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, and real-time digital control processor.
- B. Each ASC shall communicate to the EMS network and other ASC's via BACnet/IP communication. BACnet MS/TP shall not be an acceptable communication protocol between ASC's.
- C. Each ASC shall communicate, if necessary, with an associated thermostat via a two-wire, open-protocol communication trunk. Communication via telephone cable, traditional I/O wiring, or 5-wire configurations shall not be acceptable.
- D. Provide an ASC for control of each of, but not limited to, the following pieces of equipment as called for in the project documents:
 - 1. Variable Air Volume (VAV) air terminal units with reheat
 - 2. Exhaust Fans
- E. Control sequences. Analog outputs shall be industry standard signals such as 24V floating control, 0-10v, allowing for interface to a variety of modulating actuators.
- F. All controller sequences and operation shall provide closed loop control of the intended application within the ASC. Closed loop control over the EMS network shall not be acceptable.

2.7 ELECTRONIC VALVE ACTUATORS

- A. Manufacturers
 - 1. Siemens
 - 2. Belimo
 - 3. Or equal
- B. Provide all control valves as shown on the drawings and as required to perform function specified in sequence of operation.
- C. Direct mounted, self-calibrating type designed for a minimum 60,000 full stroke cycles at rated force and shall be from the same manufacturer as the pressure independent control valve.

- D. Size for torque required for valve close off at 150 percent of total system (head) pressure for two-way valves; and 100 percent of pressure differential across the valve or 100 percent of total system (pump) head differential pressure for three-way valves.
- E. Actuator shall allow smooth and position operation of devices served and to provide sufficient torque capacity for tight shutoff against system temperature and pressure encountered.
- F. Full proportional actuator use 0-10VDC inputs and zero and span adjustment.
- G. For two-position actuator use 24VAC, 120VAC actuator may be used for hardwire interlock.
- H. Actuator for applications other than terminal units shall be provided with a manual override capability.
- I. Actuator shall be provided with a visible position indicator and shall possess a 2-10V DC position feedback signal allowing the EMCS to read the exact position of the valve and provide information for EMCS algorithm to calculate the exact flow rate through the valve with accuracy +/- 5%.
- J. Actuator shall have automatic reset button compatible with the valve to automatically recalibrate the 0-10 V input/output signal to match the maximum high limit flow set on the valve.
- K. Provide spring-return for application involving moisture protection or specified normally open/close operation.
- L. Valves shall move to their fail positions on loss of power to the actuator.
- M. Provide actuators with linkages and brackets for mounting on device served.
- N. Coupling: Directly couple end mount to stem, shaft, or ISO-style direct-coupled mounting pad.
- O. Overload Protection: Electronic overload or digital rotation-sensing circuitry without the use of end switches to deactivate the actuator at the end of rotation.
- P. Fail-Safe Operation: Electronic fail safe shall incorporate a visual indication of the fail safe status on the face of the actuator. The power fail position shall be field adjustable between 0 to 100% in 10% increments. The electronic fail safe shall have a 2 second operational delay.
- Q. Temperature Rating: -22 to 122 degrees F.
- R. Housing: Minimum requirement NEMA type 2 / IP54 mounted in any orientation.
- S. Agency Listing: ISO 9001, cULus, and CSA C22.2 No. 24-93.

2.8 ELECTRONIC DAMPER ACTUATORS

- A. Manufacturers
 - 1. Siemens.
 - 2. Belimo.
 - 3. Or equal.
- B. Size operators for smooth and positive operation of devices serve, and with sufficient torque capacity to provide tight shutoff against system temperatures and pressure encountered.
- C. Damper actuator shall be located outside of air stream unless otherwise indicated such as on fire damper.
- D. Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle.
- E. Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
- F. Overload Protection: Electronic overload or digital rotation-sensing circuitry without the use of end switches to prevent any damage to the actuator during a stall condition.
- G. Fail-Safe Operation: Mechanical, spring-return mechanism. Electronic fail safe shall incorporate a visual indication of the fail safe status on the face of the actuator. The power fail position shall be field adjustable between 0 to 100% in 10 degree increments. The electronic fail safe shall have a 2 sec operational delay.
- H. Power Requirements (Spring Return): 120 V-ac, maximum 10 VA at 24-V ac or 8 W at 24-V dc.
- I. Full proportional actuator use 0-10VDC inputs and zero and span adjustment.
- J. Proportional Actuators shall be fully programmable. Control input, position feedback and running time shall be factory or field programmable by use of external computer software Diagnostic feedback shall provide indications of hunting or oscillation, mechanical overload and mechanical travel. Programming shall be through an EEPROM without the use of actuator mounted switches.
- K. For two position actuator use 24 VAC, 120 VAC actuator may be used for hardware interlock.
- L. Temperature Rating: -22 to 122 degrees F.
- M. Housing: Minimum requirement NEMA type 2 (4/4X) / IP54 (IP67) mounted in any orientation.
- N. Actuator stroke time shall match the requirements of the DDC controller for proper operation.

- O. All electric actuator will be provided with overload protection to prevent motor from damage when stall application involving fire, moisture protection or specified normally open/close operation.
- P. Provide damper end switch with dry contact where control sequences require damper position indication. End switches shall not contain mercury.
- Q. Provide operators with linkages and brackets for mounting on device served.
- R. Agency Listing: ISO 9001, cULus, and CSA C22.2 No. 24-93.
- S. Actuator to have manual override capability

2.09 CONTROL VALVES

- A. Manufacturer
 - 1. Belimo
 - 2. Bray
 - 3. Or equal.
- B. Pressure independent globe type valve.
- C. Factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
- D. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional (except as noted).
- E. Pressure Independent Temperature Control Valves
 - 1. Factory fabricated pressure independent with internal differential pressure regulator consisting of EPDM diaphragm, stainless steel spring and pressure control disc, which automatically adjusts to normal changes in system pressure providing 100 percent control valve authority at all positions of the valve. Valve shall be globe type to maintain a linear flow characteristic, accurately controlling flow from 0-100 percent full rated flow with an operating pressure differential range of 3 to 60 psi. Valve leakage shall meet FCI 70-2 Class IV leakage rating (0.01 percent of valve Kv). Unless otherwise specified or shown, valves shall be two-way pressure independent globe-style bodies. Hydronic system pressure independent control valve bodies shall meet ASME B16.34 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150 percent of the system design operating pressure.
 - 2. NPS 2 and smaller: Class 150 bronze or brass body with union connections, stainless steel trim, stainless steel rising stem, stainless steel disc, and screwed ends with back seating capacity repackable under pressure.

3. NPS 2-1/2 and larger: Brass or bronze body, stainless steel trim, stainless steel rising stem, stainless steel disc, flanged ends with back seating capacity repackable under pressure.
4. Sizing
 - a) Valve manufacturer shall provide 1/2" to 10" valves. Valves shall be from single manufacturer.
 - b) Two-position: Shall be based of flow and line sized.
5. Close-Off Pressure Rating: 125 psi for valves under NPS 1 1/4 and smaller and 250 psi for NPS 1 1/2 and larger.
6. The actuator shall be the same manufacturer as the valve, integrally mounted to the valve at the factory with a single screw on a four-way DIN mounting-base.
7. Valves NPS 1 1/4 and smaller for individual coil control shall be provided as part of a pipe package including the following. All components shall be factory assembled.
 - a) The supply side of the coil shall contain a strainer/shut-off ball valve/drain, manual air vent with a P/T port.
 - b) The return side of the coil shall contain a union fitting with a P/T port, characterized control valve, an integrated manual balancing valve/union/isolation ball valve/manual air vent with P/T port.
 - c) Shut-off valves as an integrated part of the characterized control valve are prohibited.
 - d) For 3-way installations, supply an integrated 100 percent port isolation valve/manual air vent with a P/T port for field installation in the bypass of the circuit.
 - e) A 24 inches stainless steel flexible hose set shall be provided for each coil supply and return connection for all pipe pack.
8. Valve shall maintain flow accuracy under 5% from 0-100% full rated flow with an operating pressure differential ranging from 5-60 psig for valve sizes NPS 1/2 to NPS 1-1/4, 4-60 psi for size NPS 1-1/2 to NPS 10, and 2.3 to 60 psi for NPS 1/2 low flow valve.

F. Control valve shall have manual override capability.

2.10 FIELD DEVICES

A. General

1. Provide mounting hardware for all devices, including actuator linkages, wells, installation kits for insertion devices, wall boxes and fudge plates, brackets, etc.
2. If a special tool is required to mount a device, provide that tool.

B. Application Specific Controller Space Thermostats

1. Each controller performing space temperature control shall be provided with a matching room temperature sensor. Basis of Design is Siemens QMX3 series.
 - a) Plain Space Temperature Sensors – Wired: Where called for in the sequences or on the drawings, provide sensors with plain covers.
 - b) The sensing element for the space temperature sensor shall be thermistor type providing the following.
 - 1) Element Accuracy: $\pm 1.0^{\circ}\text{F}$
 - 2) Operating Range: 55 to 95°F
 - 3) Set Point Adjustment Range: 55 to 95°F
 - 4) Calibration Adjustments: None required
 - 5) Installation: Up to 100 ft. from controller
 - 6) Auxiliary Communications Port: as required
 - 7) Local LCD Temperature Display: as required
 - 8) Setpoint Adjustment Dial: as required
 - 9) Occupancy Override Switch: as required
2. Digital Display temperature sensor specifications – Wired:
 - a) As called for in the sequences of operations or on the drawings, provide temperature sensors with digital displays.
 - b) The sensing element for the space temperature sensor shall be IC-based and provide the following.
 - c) Digitally communicating with the Application Specific Controller.
3. Mountable to and fully covering a 2 x 4 electrical junction box without the need for an adapter wall plate.
4. IC Element Accuracy: $\pm 0.9^{\circ}\text{F}$
5. Operating Range: 55 to 95°F

6. Setpoint Adjustment Range: User limiting, selectable range between 55 and 95°F
 7. Display of temperature setpoint with numerical temperature values
 8. Display of temperature setpoint graphically, with a visual Hotter/Colder setpoint indication
 9. Calibration: Single point, field adjustable at the space sensor to +/- 5°F
 10. Installation: Up to 100 ft. from controller
 11. Auxiliary Communications Port: included
 12. Local OLED Temperature Display: included
 13. Display of Temperature to one decimal place
 14. Temperature Setpoint Adjustment: included
 15. Occupancy Override Function: included
- C. Provide the following options as they are called for in the sequences or on the drawings:
1. Setpoint Adjustment. The setpoint adjustment function shall allow for modification of the temperature by the building operators. Setpoint adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at any central workstation, Building Controller, room sensor two-line display, or via the portable operator's terminal.
 2. Override Switch. An override button shall initiate override of the night mode to normal (day) operation when activated by the occupant and enabled by building operators. The override shall be limited to two (2) hours (adjustable). The override function may be locked out, overridden, or limited through software by an authorized operator at the operator interface, Building Controller, room sensor two-line display or via the portable operator's terminal.
 3. Space Combination Temperature and Humidity Sensors. Each controller performing space temperature control shall be provided with a matching room temperature sensor, which also includes the ability to measure humidity for either monitoring or control purposes. The combination temperature and humidity sensors shall have the same appearance as the space temperature sensors. Humidity elements shall measure relative humidity with a +/- 2% accuracy over the range of 10 to 90% relative humidity. Humidity element shall be an IC (integrated circuit) sensing element. Humidity sensing elements shall be removable and field replaceable if needed.
- D. Temperature Sensors
1. All temperature sensors shall meet the following specifications:

- a) Accuracy: Plus or minus 0.2 percent at calibration point.
 - b) Wire: Twisted, shielded-pair cable.
 - c) Vibration and corrosion resistant
2. Space temperature sensors shall meet the following specifications:
- a) 10k ohm type 2 thermisters
3. Insertion Elements in Ducts shall meet the following specifications:
- a) Single point 10k ohm thermister
 - b) Use where not affected by temperature stratification
 - c) The sensor shall reach more than 1/3 the distance from the duct wall
 - d) Junction box for wire splices
4. Averaging Elements in Ducts shall meet the following specifications:
- a) 72 inches (183 cm) long
 - b) Flexible
 - c) Use where prone to temperature stratification, in front of coils, or where ducts are larger than 9 sq. ft.
 - d) Junction box for wire splices
5. Insertion Elements for Liquids shall meet the following specifications:
- a) Platinum RTD with 4-20mA transmitter
 - b) Threaded mounting with matching well
 - c) Brass well with minimum insertion length of 2-1/2 inches for pipes up to 4" diameter
 - d) Brass well with insertion length of 6 inches for pipes up to 10" diameter
 - e) Junction box for wire splices
6. Outside-Air Sensors Platinum RTD with 4-20mA transmitter:
- a) Watertight enclosure, shielded from direct sunlight
 - b) Circulation fan
 - c) Watertight conduit fitting

- E. Where called for in the sequences of operations, provide the following feature on space sensors and thermostats:
 - 1. Security Sensors: Stainless-steel cover plate with insulated back and security screws.
 - 2. Space sensors with setpoint adjust: Plain white plastic cover with slide potentiometer to signal a setpoint adjustment to the DDC.
 - 3. Space Sensors with LCD display:
 - a) Operator buttons for adjusting setpoints, setting fans speeds and overriding unit to on/off.
 - b) Graphical LCD icons for signaling heating/cooling mode, fans speed, schedule mode, actual temperature and current setpoint.
- F. Humidity Sensors shall meet the following specifications:
 - 1. Bulk polymer sensor element
 - 2. Accuracy: 2 percent full range with linear output
 - 3. Room Sensors: With locking cover matching room thermostats, span of 0 to 100 percent relative humidity
 - 4. Duct and Outside-Air Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity
- G. Air Static Pressure Transmitter shall meet the following specifications:
 - 1. Non-directional sensor with suitable range for expected input, and temperature compensated.
 - 2. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
 - 3. Output: 4 to 20 mA.
 - 4. Building Static-Pressure Range: 0 to 0.25 inches wg.
 - 5. Duct Static-Pressure Range: 0 to 5 inches wg.
- H. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.
- I. Equipment operation sensors as follows:
 - 1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 inches wg.

2. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psig.
 3. Status Inputs for direct drive electric motors: Current-sensing relay with current transformers, adjustable and sized for 175 percent of rated motor current.
 4. Status inputs for belt drive electric motors: Current sensing transmitter with linear 4-20 mA output
- J. Water-Flow Switches: Pressure-flow switches of bellows-actuated mercury or snap-acting type, with appropriate scale range and differential adjustment, with stainless-steel or bronze paddle.
- K. Air Differential Pressure Switches: Diaphragm type air differential pressure switches with die cast aluminum housing, adjustable setpoint, minimum 5 amp switch rating at 120VAC, SPDT switches, and the switch pressure range shall be suited for the application. Provide Dwyer or equal. These switches shall be utilized for filter status.
- L. Carbon Dioxide Sensors
1. Space or Zone Sensing
 - a) One wall module in each zone shall take of each type of sensing called for in the sequences of operations. Separate wall devices in one zone for temperature, humidity and CO2 shall not be allowed.
 - b) Provide a plain cover, no display, no setpoint change unless called for in the sequences of operations.
 - c) CO2 Sensing Specifications:
 - 1) Range: 0-2000ppm
 - 2) Signal: 4-20mA or digital
 - 3) Sensing element type: NDIR
 - 4) Response: < 3 min full scale
 - 5) CO2 Accuracy: Maximum +/- 50ppm + 2% of reading
 - 6) CO2 drift: Maximum +/- 5% of range over 5 years
 - 7) Power: 24Vac or 24Vdc
 - d) Where called for in the sequences of operation or shown on the drawings, provide a display on the face of the thermostat cover. The display shall normally show the current sensor readings. If more than one sensor is used, then rotate the display between the readings.
 - e) The display shall be an LED, OLED or backlit LCD.

- f) The display shall show the value, units and the occupied /unoccupied status
 - g) Where called for in the sequences of operations, provide setpoint adjustment. If not called for in the sequence, then provide a plain cover or lock out the adjustment through settings.
 - h) Where called for in the sequences of operation, provide an occupancy override button to allow the user to switch the zone from unoccupied to occupied.
 - i) Provide power for the sensor. If a special power module is required, then provide one for each sensor.
 - j) Provide cables to run from the wall sensor to the zone controller
2. Duct or Outside Air Intake Sensing
- a) Provide a duct probe sensing module for sensing CO2 levels. Outside air CO2 shall be sensed at an outside air intake duct so that air movement can be maintained over the sensing element.

PART 3 - EXECUTION

3.1 PROJECT MANAGEMENT

- A. Provide a project manager who will be on site whenever required and shall, as a part of his duties, be responsible for the following activities:
 - 1. Coordination between the contractor and all other trades, owner, local authorities and the design team.
 - 2. Scheduling of manpower, material delivery, equipment installation and checkout.
 - 3. Maintenance of construction records such as project scheduling and manpower planning and AutoCAD or Visio for project co-ordination and as-built drawings.
 - 4. Coordination/Single point of contact.

3.2 START-UP AND COMMISSIONING

- A. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. The manufacturer shall complete all testing, calibrating, adjusting and final field tests. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power.
- B. Provide any recommendations for system modification in writing to the Owner's Representative. Do not make any system modifications, including operating parameters and control settings, without prior approval of the Owner's Representative.

3.3 ELECTRICAL WIRING AND MATERIALS

- A. Install, connect and wire the items included under this Section. This work includes providing required conduit, wire, fittings, and related wiring accessories.
- B. Where wiring is not exposed and above accessible ceilings, plenum rated cable shall be acceptable.
- C. Provide wiring between thermostats and split units.
- D. Provide conduit and control wiring as necessary for devices specified in this Section.
- E. Provide conduit and signal wiring between motor starters in motor control centers and high and/or low temperature relay contacts and remote relays in EMS panels located in the vicinity of motor control centers.
- F. All wiring to be compliant to local building code and the NEC.
- G. Provide electrical wall box and conduit sleeve for all wall-mounted devices.
- H. Ethernet Cabling
 - 1. CAT6, unshielded twisted pair (UTP) cable shall be used for EMS Ethernet.
 - 2. Solid wire shall be used for long runs, between mechanical rooms and between floors. Stranded cable can be used for patch cables and between panels in the same mechanical room up to 50 feet away.
 - 3. When the EMS Ethernet connects to an Owner's network switch, document the port number on the EMS As-builts.

3.4 COMMISSIONING, TESTING AND ACCEPTANCE

- A. Perform a commissioning procedure consisting of field I/O testing and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets, which shall be submitted prior to acceptance testing. Commissioning work, which requires shutdown of system or deviation from normal function, shall be performed when the operation of the system is not required. The commissioning must be coordinated with the owner and construction manager to ensure systems are available when needed. Notify the Owner's Representative in writing of the testing schedule so that authorized personnel from the owner and construction manager are present throughout the commissioning procedure.
 - 1. Prior to system program commissioning, verify that each control panel has been installed according to plans, specifications, and approved shop drawings. Test, calibrate, and bring on line each control sensor and device. Commissioning shall include, but not be limited to:
 - a) Sensor accuracy at 10, 50, and 90% of range.

- b) Sensor range.
 - c) Verify analog limit and binary alarm reporting.
 - d) Point value reporting.
 - e) Binary alarm and switch settings.
 - f) Actuator ranges.
 - g) Fail safe operation on loss of control signal, electric power, and network communications.
- B. After control devices have been commissioned (i.e. tested and signed off), each EMS program shall be put on line and commissioned. The Contractor shall, in the presence of the Owner's Representative, demonstrate each programmed sequence of operation and compare the results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracy's. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and retested.
- C. After all EMS programs have been commissioned; the Contractor shall verify the overall system performance as specified. Tests shall include, but not be limited to:
- 1. Data communication, both normal and failure modes.
 - 2. Fully loaded system response time.
 - 3. Impact of component failures on system performance and system operation.
 - 4. Time/Date changes.
 - 5. End of month/ end of year operation.
 - 6. Season changeover.
 - 7. Global application programs and point sharing.
 - 8. System backup and reloading.
 - 9. System status displays.
 - 10. Diagnostic functions.
 - 11. Power failure routines.
 - 12. Battery backup.
 - 13. Testing of all electrical and HVAC systems with other Divisions of work.

- D. Submit for approval, a detailed acceptance test procedure designed to demonstrate compliance with contractual requirements. This Acceptance test procedure will take place after the commissioning procedure but before final acceptance, to verify that sensors and control devices maintain specified accuracy's and the system performance does not degrade over time.

3.5 TRAINING

- A. The EMS Contractor shall be responsible for coordinating and implementing a formal classroom instruction period. The instruction shall be held at the Owner's site, using either the Owner's equipment or equipment identical in type, application and configuration to the Owner's.
- B. The instruction shall consist of a total of four hours and be performed during normal business hours (7:30am - 4:30pm). Instructions or familiarization sessions given to the Owner informally, during the course of the construction project, shall not count against the formal training period.
- C. The EMS Contractor shall submit to the Owner's Representative, for approval, a proposed training schedule and format. This shall be submitted a minimum of 30 days prior to the schedule construction completion data. The training shall start no later than 30 days prior to the scheduled construction completion date.
- D. The formal training shall, as a minimum, cover the following:
 - 1. System Architecture.
 - 2. System Configuration.
 - 3. Logging On/Logging Off.
 - 4. Password Security Procedures.
 - 5. Adjusting/Changing Set points.
 - 6. Polling Graphics.
 - 7. Making/Changing Graphics.
 - 8. Using the Sequence of Operation.
 - 9. Running 3rd Party Software.
 - 10. Modifying Hardware.
 - 11. Modifying Firmware.
 - 12. Modifying Software.

END OF SECTION

SECTION 23 9600

SEQUENCES OF OPERATIONS

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. This section describes the controls and monitoring sequences of operations for:
 - 1. Packaged rooftop unit (RTU-1), variable air volume (VAV), air handling system.
 - 2. VAV terminal reheat boxes.
 - 3. Exhaust fans, EF-1 and EF-2.
- B. This section and the Drawings specify the points that shall be incorporated into the energy management system (EMS), also referred to as the building automation system (BAS).
- C. The Contractor shall integrate the sequences of operations into existing controls using specifications and guidelines presented in:
 - 1. Section 23 09 00 - Controls and Instrumentation
 - 2. Section 23 83 00 – Semi-Custom Packaged Rooftop Unit
 - 3. Section 23 95 00 – Building Automation System
- D. The Contractor shall retain the services of a certified Siemens Apogee representative to provide the EMS programming modifications necessary to accomplish the sequences of operations and to integrate the new EMS points, as described in this section and the Drawings. Actual setpoints required to establish the specified sequences of operations shall be similar to existing setpoints. The Contractor's certified EMS representatives, serving as the Controls Contractor, shall consult with the Owner's Representative in establishing the actual setpoints.

1.2 SUBMITTALS

- A. Shop Drawings and Product Data
 - 1. Shop drawings of each control loop shall be provided in accordance with Section 01 33 00 - Submittal Procedures. Each drawing shall indicate the piping or wiring required to interconnect control devices, valves, equipment, and other components. Submittal drawings shall also indicate manufacturers' part numbers for all parts provided as well as all existing parts where existing control loops are modified. Ladder diagrams shall be submitted where appropriate. Drawings shall generally conform to

Instrument Society of America Standard ANSI/ISA-S5.1-1975 (R 1981).

2. Each new item of control equipment identified on the drawings submitted shall include a manufacturer's description of the item and its performance.

B. Operation and Maintenance Instructions

1. Operation and Maintenance instructions shall be provided for each operable control device (with moving parts). Data shall include a list of replacement parts, those parts requiring periodic maintenance and any consumable items needed (oil, grease, etc.) to maintain controls in working order.

1.3 SEQUENCES OF OPERATIONS – GENERAL

- A. The paragraphs below describe the operation of the applicable systems. Reference to the drawings is required for a complete understanding of the HVAC controls. Prior to providing submittals, all field wiring connections shall be determined and shown on the submittals for electrical and controls interface.
- B. All proportional (P), integral (I), and derivative (D) values shall be adjustable variables, such that the actual numeric values are not entered into the control loop functions. All setpoint values shall also be adjustable.
- C. Following is the typical sequences of operations for specific HVAC components provided under this project and controlled by the controller. Each control sequence requires appropriate input/output (I/O) points.

1.4 SEQUENCE OF OPERATION – PACKAGED ROOFTOP UNIT (RTU-1), VARIABLE AIR VOLUME (VAV), AIR HANDLING SYSTEM.

- A. Packaged rooftop unit (RTU), RTU-1, is part of a VAV, terminal reheat, air handling system. Under this project, it shall have VAV terminal reheat boxes, and use space temperature sensors for temperature control.
- B. RTU-1 shall be connected to the EMS through a BACnet interface.
- C. See sequences of operation also presented in Section 23 83 00 – Semi-Custom Packaged Rooftop Unit.
- D. Start/Stop Control:
 1. The speed of the supply fan is controlled with a variable frequency drive (VFD). The RTU is considered a system. The supply air fan shall be controlled by duct static pressure from a factory-mounted supply air discharge duct static pressure sensor. The return fan shall be controlled via fan tracking.

2. The RTU is enabled and disabled based on an adjustable time schedule, as set by the building engineer. Actual start and stop times for individual pieces of equipment and systems are determined by the EMS through the scheduled START/STOP control program.
 3. If the RTU is commanded “off” by the controller, EMS, or Fire Alarm System, then the supply fan is stopped, the return air (RA) damper is set to the 100% Open position, and the outside air (OSA) damper is set to the 0% Open position.
- E. Status and Alarms:
1. When the RTU is started, a current switch is used to confirm operation. If run status is not confirmed after an operator defined time delay following the start command, a “no start” alarm is generated. An alarm is also issued if, at any time after the RTU has been running, the current switch input is lost.
 2. A digital input monitors the fan VFD fault output and alarms when the VFD fails.
- F. Programmed Interlock:
1. When there is an existing START/STOP interlock, this interlock shall be left operative unless a new START/STOP data point is installed for the particular piece of equipment.
 2. Smoke detector, high limit, and/or other safeties will remain active and will not be overridden by the EMS.
- G. Mixed Air Temperature:
1. The controller will monitor the mixed air temperature and use it as required for economizer control.
- H. Return Air Temperature:
1. The controller will monitor the return air temperature and use it as required for setpoint control or economizer control.
- I. Electrical Demand Control:
1. Demand limiting mode will be accomplished at the VAV level with 4 levels of temperature reset. Levels to be determined by Building Engineer for each zone.
- J. Filter Status:
1. The controller will monitor the filter status. A differential pressure switch across the RTU filter bank will be used as the input to the controller, which will alarm at setpoint.
 2. Alarms will be provided as follows:
 - a. Filter Change Required: Filter differential pressure exceeds a user definable limit (adj.).

- K. Supply Fans Speed Control:
 - 1. Supply Fans Speed Control:
 - 2. The supply air fan shall be controlled by duct static pressure. The return fan shall be controlled via fan tracking.
 - a. The controller measures duct static pressure and modulates the supply fan VFD speed to maintain duct static pressure setpoint according to the reset schedule. Initial duct static pressure setpoint will be 1.0 in. w.c. (adj.). The supply fan VFD speed will not drop below 10% (adj.). Speed signal shall be scaled in the VFD and the controller to match VFD speed output.
 - b. The supply static pressure reset range is from 0.5"-2.0" w.c. (adj.), and will be reset by return air temperature (RAT) as follows:
 - 1) Supply air setpoint (SASP) will be determined via a PID calculation and reset between 0.5"-2.0" w.c. (adj.) as return air temperature varies between 60°F and 80°F (adj.).
 - c. Alarms will be provided as follows:
 - 1) High Supply Air Static Pressure: If the supply air static pressure is 25% (adj.) greater than setpoint for 1 minute (adj.).
 - 2) Low Supply Air Static Pressure: If the supply air static pressure is 25% (adj.) less than setpoint for 1 minute (adj.).
 - 3) Supply Fan VFD Fault.
- L. Supply Air Temperature Control:
 - 1. Supply air temperature (SAT) setpoint control shall be enabled if the RTU is on. The controller shall continuously monitor supply air temperature.
 - 2. The SAT setpoint range is from 55°F - 70°F (adj), and will be reset based on return air temperature (RAT) as follows:
 - a. SAT setpoint will be determined via a PID calculation and reset between 55° - 70°F (adj) as return air temperature varies between 75°F - 60°F (adj).
 - 3. SAT setpoint will be achieved in accordance with the following table.

SAT SETPOINT CONTROL TABLE

SAT CONTROL	IF	THEN
SAT-1	If economizer (Econo) is on	Modulate RA damper to meet (or approach) SAT setpoint at mixed air temperature (MAT) sensor. If OSA temperature is higher than SAT setpoint, then modulate the DX cooling system in accordance with M below, to meet SAT setpoint.
SAT-2	If economizer is off.	Modulate the DX cooling system in accordance with M below, to meet SAT setpoint.

M. DX Cooling System Control:

1. The controller measures the SAT and modulates the DX cooling system to maintain SAT setpoint.
2. The DX cooling shall be off when the associated supply fan is off.
3. Alarms will be provided as follows:
 - a. High SAT: If SAT is 5°F (adj.) greater than setpoint for 10 minutes (adj.).
 - b. Low SAT: If SAT is 5°F (adj.) lower than setpoint for 10 minutes (adj.).

N. Ventilation Control:

1. The economizer will be on IF:
 - a. The RTU is on,
 - b. AND the RTU is in Occupied mode or cooldown mode,
 - c. AND the outside air temperature is less than the return air temperature,
 - d. AND the SAT control loop is on.
2. The economizer will be off IF:
 - a. The RTU is off,
 - b. OR the outside air temperature is greater than the return air temperature,
 - c. AND the SAT control loop is off.
3. Outside Air Volume Control:
 - a. Continuously monitor all air stream volumes.
 - b. The Minimum and Maximum OSA damper position will be controlled to either minimum position or 100% open when

- the RTU is on, as specified in the sequences below. No modulation.
- c. OSA volume will be controlled by the RA damper. Dampers operate inversely and in unison in accordance with the following sequences.
 - d. OSA volume will be controlled according to the following OSA Mode Control Table.

OSA MODE CONTROL TABLE

MODE ID	MODE CONDITIONS	OSA VOLUME CONTROL
Mode 1: OSA mode (warmup)	On initial startup and before occupancy: If RAT < operator selected value, then warmup is in effect.	Position OSA damper to minimum position. Open RA damper.
MODE 2: Minimum OSA volume mode	If economizer is off.	Position OSA damper to minimum position. Modulate RA damper to meet Minimum OSA setpoint.
MODE 3: Economizer mode	If economizer is on.	Open OSA damper to full open position. Modulate RA damper to meet (or approach) SAT setpoint at mixed air temperature (MAT) sensor. The economizer shall have high limit shutoff control based on Climate Zone 8 per Title 24 Standards Table 140.4-B, and shall lock out when OSA temperature exceeds return air temperature minus 4°F.

- O. Fire Alarm (Not Controlled By Programming):
 - 1. If the fire alarm system determines the presence of smoke, it sends a signal to shut down the RTU (supply fan), closes the OSA damper, and opens the RA damper.
- P. Other Alarms:
 - 1. If the filter differential pressure exceeds the setpoint, an alarm is generated.
 - 2. Supply fan fail to start.
 - 3. Supply fan fail to stop.
 - 4. SAT high temperature (adj.).
 - 5. SAT low temperature (adj.).
 - 6. Supply Fan high static pressure (adj.).

1.5 SEQUENCE OF OPERATION – VARIABLE AIR VOLUME (VAV), TERMINAL REHEAT BOXES

- A. Packaged rooftop unit (RTU), RTU-1, is part of a VAV, terminal reheat, air handling system. Under this project, it shall have VAV terminal reheat boxes, and use space temperature sensors for temperature control. The VAV boxes shall be integrated into the EMS with this sequence of operations.
- B. Run Conditions - Scheduled:
 - 1. The unit will run according to a user definable time schedule in the following modes:
 - a. Occupied Mode: The unit shall maintain:
 - 1) 75°F (adj.) cooling setpoint.
 - 2) 68°F (adj.) heating setpoint.
 - b. Unoccupied Mode: The unit shall maintain:
 - 1) 85°F (adj.) cooling setpoint.
 - 2) 55°F (adj.) heating setpoint.
 - c. Unoccupied Mode: When the zone is unoccupied, the zone damper will control to its minimum unoccupied air flow (adj.) (which, in non-lab spaces, will be 0 cfm (adj.)). The HHW control valve will be fully closed.
 - d. Shutoff Mode: When the associated RTU is “off” or shut down, either by EMS program or Fire Alarm System, and the supply fan is stopped, all associated VAV boxes’ dampers shall be positioned to 100% open (adj.). The HHW control valve will be fully closed.
 - 2. Alarms will be provided at the EMS as follows:
 - a. High Zone Temperature: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
 - b. Low Zone Temperature: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).
- C. Zone optimal start:
 - 1. The unit will use an optimal start algorithm for morning start-up. This algorithm will minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

- D. Variable Air Volume Terminal Reheat Box Supply Air Flow Control:
1. The unit shall maintain zone setpoints by controlling the air flow through one of the following:
 - a. Occupied:
 - 1) When zone temperature is greater than its cooling setpoint, the zone damper shall modulate between the minimum occupied airflow (adj.) and the maximum cooling air flow (adj.) until the zone is satisfied.
 - 2) When the zone temperature is between the cooling setpoint and the heating setpoint, the zone damper will maintain the minimum required zone ventilation (adj.).
 - 3) When zone temperature is less than its heating setpoint, the controller shall enable heating to maintain the zone temperature at its heating setpoint. Specifically, it will first modulate open the heating hot water (HHW) control valve to allow HHW to circulate through the reheat coil to heat the minimum required zone ventilation (adj.) supply air and thereby maintain its heating setpoint. It will heat the minimum required zone ventilation (adj.) supply air up to 90°F as the first stage of heating. If more heat is required, the damper will modulate to increase the airflow rate up to a “heating” maximum airflow setpoint (adj.).
 - b. Unoccupied:
 - 1) When the zone is unoccupied, the zone damper will control to its minimum unoccupied air flow (adj.) (which, in non-lab spaces, will be 0 cfm (adj.)). The HHW control valve will be fully closed.
 - c. Shutoff Mode:
 - 1) When the associated RTU is “off” or shut down, either by EMS program or Fire Alarm System, and the supply fan is stopped, all associated VAV boxes’ dampers shall be positioned to 100% open (adj.). The HHW control valve will be fully closed.
- E. Discharge Air Temperature:
1. The controller will monitor the discharge air temperature.
 2. Alarms will be provided to the EMS as follows:
 - a. High Discharge Air Temperature: If the discharge air temperature is greater than 120°F (adj.).

- b. Low Discharge Air Temperature: If the discharge air temperature is less than 40°F (adj.).

F. Minimum Air Flow Setpoints:

- 1. All variable air volume terminal units have a minimum air flow setpoint, which will be set.

1.6 SEQUENCE OF OPERATION –EXHAUST FANS (EF-1 AND EF-2) CONTROL AND MONITORING

A. General:

- 1. Under this project, there are two new exhaust fans EF-1 and EF-2. These are for the purpose of exhausting air from the pool area of the building.

B. EF-1 and EF-2 Monitoring and Control:

- 1. EF-1 and EF-2 are enabled and disabled based on an adjustable time schedule, as set by the building engineer. Actual start and stop times for individual pieces of equipment and systems are determined by the EMS through the scheduled START/STOP control program.

1.7 OPERATOR TRAINING

- A. The Contractor shall ensure that the controls subcontractor provides a minimum of 4 hours of training on the control systems, specific to the needs of this project. This training shall be provided to designated Owner operating staff.

END OF SECTION 23 9600

SECTION 26 0000

BASIC ELECTRICAL MATERIALS AND METHODS

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. This Section supplements all Sections of this Division and shall apply to all Work specified, indicated in the Drawings, and as required to provide for a complete installation of electrical systems for the Project. Review all sections of the Specifications for related work and coordinate the work of this Section with all other Sections.
- B. Furnish all labor and services, and provide all materials, tools, equipment, appliances, facilities, and transportation necessary for and incidental to performing the Work complete, as shown on the drawings and specified herein. All electrical systems and equipment shall be in proper operating order upon completion of the work. Work includes the following:
 - 1. Perform all incidental work required to provide a complete properly operating system.
 - 2. Provide the following:
 - a. All construction power and lighting and all power for testing of equipment and systems through final acceptance tests.
 - b. A complete system of switchboards, panelboards, conduits, outlet boxes, switches, receptacles, plates and wiring for power and light.
 - c. Outlet, junction and pull boxes, plaster rings, plates, conduit only and pull lines for the telephone / data system.
 - d. All lighting fixtures and lamps, complete.
 - e. Outlet, junction and pull boxes, conduits, wiring and connections of all motors and equipment for all heating, ventilating and cooling equipment.
 - f. A complete grounding system for power system neutrals and equipment. The system shall interconnect including the conduit system, and the equipment grounding bus system.
 - g. Testing, adjusting and cleaning of the completed work.
 - h. All line-voltage (120-volt) control system conduit and wiring and all low-voltage control conduit only, with pull lines, required for the automatic temperature control systems.

- i. Access panels, fire rated as required, in the ceilings and walls where necessary for access to electrical equipment, junction boxes, pull boxes, conduit stubs, etc., located in the walls or furred ceiling spaces.
- j. Cutting and patching of the building structure required by Contractor in the performance of the work.
- k. All sleeves, hangers, supports, inserts, anchors, bolts, etc., required for the installation of this work.
- l. Certified report including seismic calculations for anchorage or support of all electrical system equipment (as indicated in appropriate specification section), signed by a structural engineer registered in California.
- m. Shop drawings and technical data; instructions and maintenance manuals.
- n. "As-built" drawings.
- o. Comply with 2016 California Electrical Code (CEC).

1.2 REFERENCE STANDARDS

- A. The following abbreviations apply to all sections of Division 26 00 00:

AC: Alternating Current.
ADA: Americans with Disabilities Act.
AISI: American Iron and Steel Institute.
ANSI: American National Standards Institute.
ASTM: American Society for Testing and Materials.
AWG: American Wire Gauge.
CCR: California Code of Regulations.
CBM: Certified Ballast Manufacturers.
CEC: California Electrical Code.
DC: Direct Current.
ETL: Electrical Testing Laboratory.
FS: Federal Specification.
HID: High Intensity Discharge.
HP: Horsepower.
ICEA: Insulated Cable Engineers Association
IEEE: Institute of Electrical and Electronic Engineers.
NEMA: National Electrical Manufacturers' Association.
NETA: National Electrical Testing Association, Inc.
NFPA: National Fire Protection Association.
OSHA: Occupational Safety and Health Act.
PVC: Polyvinyl chloride.
UBC: Uniform Building Code.
UL: Underwriters Laboratories, Inc.

1.3 QUALITY ASSURANCE

A. General Requirements:

1. Work performed under this Division shall be installed by craftsmen skilled in the trade involved, and apprentices as indicated in the General Conditions.
2. Contractor shall ensure work is performed in accordance with the certification and other requirements of California Labor Code Section 3099.
3. Provide all control equipment for electrically operated equipment except when equipment is furnished with control equipment.
4. Provide all electrical Work required for the service and connection of electrically operated and controlled equipment specified in other Divisions of the Specification.
5. All electrical power, signal, alarm and communication systems shall be complete and ready for use.

B. Requirements of Regulatory Agencies:

1. Codes and Ordinances: All materials shall bear the UL label.

C. Factory Tests:

1. Test reports shall include the following:
 - a. Description of equipment tested.
 - b. Description of tests.
 - c. Test results.
2. The Owner's Representative shall be notified fourteen (14) days in advance of when tests will be performed. The Owner's Representative will witness tests.

D. Electrical Acceptance Tests:

1. General Scope:
 - a. Contractor shall engage the services of a qualified testing laboratory for the purpose of performing inspections and tests of installed Work as herein specified and specified in other Sections of Division 26 00 00, ELECTRICAL, of these Specifications.
 - b. The testing laboratory shall provide all material, equipment, labor and technical supervision to perform such tests and inspections.

- c. All tests shall be performed in compliance with the recommendations and requirements of the NETA and Applicable Code Requirements.
 - d. Upon completion of the tests and inspections noted in these specifications, a label shall be attached to all serviced devices. These labels shall indicate date serviced and the service company responsible.
 - e. The tests and inspections shall determine suitability for continued reliable operation.
 - f. All tests shall be conducted in the presence of the Owner's Representative and the Owner's Electrical Inspector.
2. Qualifications of Testing Agency:
- a. The testing laboratory shall meet the Federal OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907.
 - b. Contractor shall submit proof of the above qualifications.
 - c. All instruments used to evaluate electrical performance shall meet NETA's Specifications for Test Instruments.
3. Test reports shall include the following:
- a. Description of equipment tested.
 - b. Description of test.
 - c. Test results.
 - d. Conclusions and recommendations.
 - e. Appendix, including appropriate test forms.
 - f. List of test equipment used and calibration date.

1.4 SUBMITTALS

A. Shop Drawings and Product Data:

- 1. Submit to the Owner's Representative six (6) certified copies of the following:
 - a. Furnish a System Short Circuit Study based on an infinite bus on primary side of the utility company transformers and on the per unit method or in accordance with the latest IEEE recommendations.
 - 1) Report shall be submitted in copies bound with a stiff cover and shall indicate calculated fault values and equipment ampere interrupting capacities (AIC) for each equipment including downstream panelboards and motor control centers. AIC ratings shall be a minimum of 110% of calculated fault values. Reports shall include actual lengths and materials for each feeder as installed by Contractor. It shall

also include a tabular comparison of equipment withstand and AIC ratings, and calculated fault current at each equipment, and elevators.

- b. Furnish a Coordination Study of all protective devices, including the utility protective device through all feeder devices on the secondary of each transformer. Study to be presented on LOG-LOG paper. Upon approval of the study, Contractor shall set all devices at agreed-upon settings and furnish a data sheet to the Owner's Representative, with a copy to the Owner, indicating final settings for all adjustable devices. Both system studies (short circuit and coordination) shall be signed by California Registered Electrical Engineers. Switchgear and distribution equipment shall comply with calculations and recommendations of studies. Studies shall be submitted prior to or with switchgear submittals.
 - c. Manufacturer's printed instructions for operation and maintenance of electrical equipment, including replacement parts lists. Each set shall be bound in an indexed loose leaf ring binder with permanent cover and permanent identification on edge.
 - d. Service and operating manuals for all equipment.
 - e. Three phase voltage test.
 - f. Report showing test voltage L-N on the secondaries of all transformers.
 - g. Grounding system tests.
 - h. Test reports.
- B. Qualifications of electrical testing laboratory. Refer to Paragraph 1.3 D.2.a above.

1.5 LOCATION AND ROUTING

- A. The Drawings indicate diagrammatically the desired location or arrangement of conduit runs, outlets, equipment, etc., and shall be followed as closely as possible. Execute the Work so as to secure the best possible installation in the available space and overcome local difficulties due to space limitations or interference with structural conditions.
- B. Locations shown on architectural ceiling Drawings or on wall elevations shall take precedence over electrical drawing locations.
- C. Verify dimensions and the correct location of equipment before proceeding with the roughing-in of connections.

- D. Lighting fixtures in mechanical spaces and elevator machine rooms are shown in their approximate locations only. Do not install light outlets or fixtures until mechanical piping and ductwork are installed; then lighting fixtures shall be installed in locations best suited for equipment arrangement and as approved by the Owner's Representative. Verify locations of fixtures in elevator machine rooms before installation.
- E. All scaled and figured dimensions are approximate of typical equipment of the class indicated. Before proceeding with any Work, check and verify all dimensions, sizes, etc., with the Drawings to see that the equipment being installed will fit into the spaces furnished.
- F. Locations of Openings. Locate all chases, shafts and openings required for the installation of the electrical Work during framing of the structure. Do any cutting and patching required due to incorrectly located or omitted openings as approved and at no additional cost to the Owner. Cutting or drilling in any structural member is prohibited without prior written approval of the Owner's Representative.
- G. Access to Equipment. Locate starters, switches, receptacles, and pull boxes to provide easy access for operation, repair, and maintenance and, if concealed, provide access doors.
- H. Rough-in locations for all electrical equipment shall be determined from approved shop drawings or from the equipment itself.

1.6 MATERIAL STANDARDS

- A. All materials and equipment shall be new.
- B. All Work shall meet the requirements of the all Applicable Code Requirements and the requirements of the following:
 - 1. NEMA.
 - 2. ANSI.
 - 3. IEEE.
 - 4. ICEA.
 - 5. CEC.
 - 6. UL.
- C. Items for similar application shall be of the same manufacturer.
- D. The label of listing by UL shall appear on all materials and equipment for which standards have been established by the agency.
- E. Furnish all materials and equipment with either the required labels affixed or the necessary written approval.
- F. Provide the type and quantity of electrical materials and equipment necessary to complete Work and all systems in operation, tested and ready for use.

- G. Provide all incidental items that belong to the Work described and which are required for complete systems.

1.7 TESTING

- A. Upon completion of the work and adjustment of all equipment, conduct an operating test for each system approval. Conduct the test in the presence of the Owner's Representative. Demonstrate all systems and equipment to operate in accordance with all requirements of the Contract Documents and to be free from all electrical and mechanical defects. Provide all systems free from short circuits and incorrect grounds and show an insulation resistance between phase conductors and ground not less than 250,000 ohms. Test all circuits for correct neutral connection.
- B. Conduct resistance to ground tests by journeymen electricians and the required number of apprentices to measure resistance to ground at all grounding electrodes. Make tests before slabs of affected areas are poured in order that corrective measures, if required, may be taken.
- C. Prior to energizing any motors, measure the service voltage for phase balance and report immediately to the Owner's Representative if unbalance exceed 1% from mean.
- D. Measure the three-phase voltage at no load and at maximum load conditions.
- E. Complete all tests prior to final field observation of Project, including corrective Work based on the results of the tests.

1.8 SETTINGS OF PROTECTIVE DEVICES

- A. Prior to final completion of the Project, set all protective device relays and internal settings to provide coordination between upstream and downstream protective devices. Setting shall be based on the accepted coordination study.

1.9 TRAINING

- A. Furnish a period of sixteen (16) hours for the necessary training programs and instructions to the Owner's personnel, unless indicated otherwise in individual specification sections.

2. PRODUCTS

2.1 GENERAL

- A. Whenever possible, all materials and equipment used in the installation of the work shall be of the same brand or manufacturer for each class of material or equipment.

3. EXECUTION

3.1 INSTALLATION

- A. Install electrical equipment as specified in individual specification sections, and in accordance with manufacturers' recommendations.

3.2 DEMOLITION

- A. General:
 - 1. The work involves demolition of existing conduit, conductors and equipment.
 - 2. Electrical drawings show demolition, relocation, removal or rerouting of existing equipment.
 - 3. All demolished or Contractor removed materials become the property of the Contractor, unless otherwise indicated. Contractor shall be responsible for removing such materials from the job site.
- B. Equipment: All the existing equipment to be removed from building shall be disassembled or cut into pieces to allow removal through available existing openings.
- C. Conduits (feeder and branch):
 - 1. Conduit shall be capped for all abandoned installations.

3.3 SERVICE CONTINUITY

- A. Contractor to ascertain, prior to disconnecting items or devices to be removed that any downstream items or devices are properly connected to ensure service continuity.

3.4 PROTECTION AND CLEANING

- A. Protection: Fully protect all finished parts of the materials and equipment against physical damage from whatever cause during the progress of this work and until completion.
- B. During construction, cap all conduits so as to prevent the entrance of sand and dirt.
- C. Cleaning: After installation has been completed, the Contractor shall clean all systems as follows:

1. Equipment with Factory Finish: Clean exterior thoroughly to remove grease, oil, plaster, cement and dirt, and leave surfaces clean and polished.
2. Equipment to be Painted: Clean exterior of piping and equipment exposed in completed structure, removing rust, plaster, cement and dirt by wire brushing. Remove grease, oil and similar materials by wiping with clean rags and solvents.

3.5 PAINTING

- A. Provide painting as required.

3.6 CUTTING AND PATCHING

- A. Sleeves and Inserts: Provide all sleeves, inserts, and openings necessary for the installation of the Electrical Work.
- B. Openings for all electrical equipment shall be field verified:
 1. Special forming, recesses, chases, and curbs, as necessary for the correct reception and installation of the electrical equipment, as shown on the Drawings, are specified in other Divisions.
 2. The Contractor shall examine all Drawings to ascertain that correct provisions have been made for the work. If such provisions are not made in time, the Contractor shall bear all extra costs incurred in later cutting and patching to accommodate this work.

3.7 SEISMIC RESTRAINTS

- A. Provide seismic restraints and supports for equipment and work as shown on drawings. Seismic restraints and supports shall be installed directly after installation of any work requiring them, so as to avoid concealment or difficulty of access. Contractor shall be responsible for any costs and delays associated with gaining access to any installation needing restraints or supports.

END OF SECTION 26 0000

SECTION 26 0519

INSULATED WIRE AND CABLE

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide conductors as shown on the Drawings and as specified, complete.

1.2 QUALITY ASSURANCE

- A. Testing: Contractor shall pay for the services of a qualified testing laboratory to perform the specified tests. Contractor shall furnish all material required for testing.

1.3 SUBMITTALS

- A. Tests and Reports (Test Requirements are detailed in Paragraph 3.1 M below).
1. Testing laboratory shall submit Megger Test Report to the Owner's Representative who will approve or disapprove Contractor's Work.
- B. Shop Drawings and Product Data: The following list includes the required shop drawing information that shall be submitted.
1. Wire and cable.
2. Splice details.
3. Connectors.
- C. Refer to Section 26 00 00 – Basic Electrical Materials and Methods - 1.4 Submittals.

2. PRODUCTS

2.1 MATERIALS

- A. Insulated wire conductors for circuit voltage, 600 volts or less, shall be copper, minimum size #12 AWG. Control wiring may be #14 AWG minimum except where otherwise shown.
- B. Conductors shall have UL approved 600 volt insulation of type specified below or elsewhere in the Specifications.
1. Branch Circuits - Lighting and Power.
- a. #10 AWG and smaller, solid wire type THHN/THWN.
- b. #8 AWG and larger, stranded type THHN/THWN.
2. Feeders: Lighting and power, type THHN/THWN.

3. Connectors for #10 conductor and smaller UL listed for 600 volts, UL approved for use with copper, cone shaped, expandable coil spring insert, insulated with a nylon shell and two wings placed opposite each other to serve as a "built-in" wrench. Shell shall be molded one-piece.
4. Connectors for #8 AWG and larger shall be screw pressure lugs made of high strength structural aluminum alloy and UL approved for use with copper wire.
5. All conductor insulation shall be color coded to indicate phase leg, voltage and use. If color coded wire is unavailable, color banding (minimum 2" wide) shall be required where conductors are visible. This color coding is acceptable only in size AWG #8 and larger.
6. Conductor insulation type, size and UL approval shall be printed with permanent white paint on all conductor insulation continually repeating.
7. Wiring through fluorescent fixtures in continuous rows shall be type THHN.
8. Provide all conductors used for power, lighting, control signal and communications systems, operating at 600 volts and below, with a minimum insulation rating of 600 volts.
9. Minimum Size Conductors: #12 AWG copper, unless otherwise indicated.
10. All conductors shall be new and shall have been manufactured within 12 months of the date of delivery to the Project site and continuously stored where protected from the heat or weather.
11. Vertical cable supports shall be OZ-Gedney, or equal.
12. Deliver all conductors to the Project site on their original cable reels or in their original unbroken packages.
13. Provide all conductor packages and cable reels plainly marked or tagged with UL labels, AWG size, voltage rating, insulation type, type of standing, manufacturer's name, and month and year when manufactured.
14. Insulating Tape - Plastic Self-adhering. 3M or equal.
15. Conductor tags shall be premarked, self-adhesive wrap-around cloth type. Seton, or equal.
16. Conductor ties shall be plastic with cinching holders. U-Line, or equal.
17. Conductor sealant shall be silicone type GE, or equal.

3. EXECUTION

3.1 INSTALLATION

- A. The following color code prevails for all branch circuits and feeders:
 - 1. Neutral: White for 208/120, white for 480/277.
 - 2. Ground: Green.
 - 3. Phase A: Brown.
 - 4. Phase B: Orange.
 - 5. Phase C: Yellow.
 - 6. Three-way travelers: Purple.
 - 7. Switch legs same color as phase leg.
- B. Identify all feeders as to phase or leg in each panelboard with identifying tape a minimum of two inches wide color coded according to Paragraph 3.1.A above.
- C. For conductors installed in areas subjected to temperatures exceeding 140°F, including terminating in incandescent lighting fixtures and installed through or into housing containing ballasts, furnish type THHN.
- D. For conductors installed in exposed conduit outside of buildings and conduit within or just under roofing material, furnish type THHN.
- E. Control Circuits for Mechanical Equipment: Use 600 volt UL type THWN conductors except where subject to abnormally high temperatures such as on or near boilers. Under these conditions, use UL type THHN.
- F. Make all branch circuit and fixture joints for #10 AWG and smaller wire with connectors as specified in Paragraph 2.1 B.3 above.
- G. Make all branch circuit joints of #8 AWG and larger with screw pressure lugs as specified in Paragraph 2.1 B.4 above, and insulate with electrical tape to 150% of the insulating value of the conductor insulation.
- H. Tape all connections made with non-insulated type connectors with insulating tape to 150% of the insulating value of conductor insulation.
- I. Each circuit shall correspond to the branch circuit number indicated on the panel schedule shown on the Drawings unless otherwise approved by the Owner's Representative.
- J. For control wiring, conform to the wiring diagrams shown on the mechanical Drawings and the manufacturer's wiring diagrams to control the equipment in the manner specified in Section 23 05 00 Mechanical General Provisions of the Specifications. Color code all control wiring.
- K. Where conductors in conduit pass through exterior walls, a sealing compound of moisture-resistant material shall be applied in the ends of the conduits to seal around the conductors.

- L. Tag all conductors of power circuits and the various signal and sound systems. Conductors shall be tagged in each junction box, pull box, wireways or auxiliary gutter and at each device, motor outlet, panelboard, switchboard or other conductor termination. Tag shall show feeder number, size, phase and origin.
- M. Megger tests shall be taken on all feeder conductors and on all conductors for motors over 15 HP. Tests shall be made prior to connection of equipment. Conductors testing below manufacturer's standard shall be replaced at Contractor's expense.
- N. Wiring within all equipment enclosures shall be neatly grouped and tied together.
- O. Pigtails shall be extended from branch wiring in outlet boxes for attachment to devices. Loops in through wiring will not be acceptable.
- P. Conductors in outlet boxes shall have a minimum of 8 inches of extra conductors.
- Q. Tag all conductors in junction boxes, pull boxes, and wireways, indicating panel board and circuit number.

END OF SECTION 26 0519

SECTION 26 0536

WIREWAYS AND CABLE TRAYS

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide wireways and cable trays as shown on the Drawings and as specified, complete.

1.2 SUBMITTALS

- A. Shop Drawings and Product Data: The following list includes the required shop drawings and product data that shall be submitted.

- 1. Manufacturer's standard catalog sheets for wireways and cable trays and accessories indicating:

- a. Cross sectional dimensions.
- b. Gauge of metal.
- c. Construction.
- d. Radius of bends.
- e. Finish.
- f. Manufacturer's structural loading chart.
- g. UL label.
- h. Compliance with NEMA Standard VE-1.

- 2. Structural Support System.

- a. Cross sectional dimensions.
- b. Gauge of metal.
- c. Finish.
- d. Details of support assembly.
- e. Structural strength of devices.

2. PRODUCTS

2.1 MATERIALS

- A. Cable tray and wireway shall consist of galvanized sheet metal side rails, galvanized solid sheet metal bottom parts, solid sheet metal cover plate, galvanized sheet metal barriers, straight sections, connectors and elbows as specified. Sizes and lengths as shown on the Drawings. Tray shall be capable of supporting 125 pounds of cable per lineal foot. Products shall be manufactured by PW Industries, or equal.

- B. Supports:

- 1. Beam clamps for 1/2-inch threaded galvanized rod with anchor clips shall be manufactured by Thomas & Betts, or equal.
- 2. One-half inch diameter threaded rod shall be galvanized steel.

- 3. Steel channels shall be 14 gauge 1-1/2 inches by 1-1/2 inches with 17/32-inch diameter holes, 1-1/2 inches on center, manufactured by Unistrut, or equal.

- C. Fire barriers shall be manufactured by 3M, or equal.

3. EXECUTION

3.1 INSTALLATION

- A. Securely fasten wireways and cable trays to structural members.
- B. Provide seismic restraints as required.
- C. Provide fire barriers where cable trays and wireways penetrate fire rated building components.
- D. Furnish and install nameplates every 25 feet of the length of wireways and cable tray.
- E. Furnish and install a #2 AWG insulated copper ground conductor in each cable tray and wireway. Connect each section of cable tray and wireway to the ground connector.

END OF SECTION 26 0536

SECTION 26 0548

VIBRATION CONTROL AND SEISMIC RESTRAINT

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide vibration isolators for electrical equipment as specified complete and as shown on the drawings to prevent transmission of vibration and sound to the building. Refer to equipment listed under Paragraph 3.1.
- B. Provide seismic restraints on electrical equipment as required by California Building Code (CBC), Title 24, Part 2, Table 2-23j, Part B. Refer to the equipment listed under Paragraph 3.1.

1.2 QUALITY ASSURANCE

- A. Testing: Contractor shall furnish the Owner's Representative with a copy of a certified factory test report complying with ANSI and NEMA standards.
- B. Contractor shall pay for the services of a qualified testing laboratory to perform the specified field tests. Contractor shall provide all material required for testing. Testing laboratory shall report results of the tests to the Owner's Representative who will approve or disapprove Contractor's work.

1.3 SUBMITTALS

- A. Shop drawings, product data and calculations:
 - 1. Refer to Section 26 00 00 – Basic Electrical Materials and Methods – 1.4 Submittals.
 - 2. The following includes the minimum required shop drawing data and calculations:
 - a. Manufacturer's model number for each isolator or restraining device and the equipment to which it will be applied.
 - b. Neoprene isolator free height, deflected height, isolator loading and displacement.
 - c. Seismic and anchorage design, including methods to achieve vertical restraint for seismic slack cables.
 - d. Written certification from isolation manufacturer that isolation is installed correctly.
 - 3. Furnish load versus deflection curves from manufacturer; curves shall be linear over a deflection range of not less than 50% above the design deflection.

4. All submittals shall be signed by a structural engineer registered in the State of California.

2. PRODUCTS

2.1 MATERIALS

- A. Provide vibration isolators as specified in Paragraph 2.1.B below. Provide restraining devices as specified in Paragraph 2.1.C below, and as shown on the drawings. The isolators and the seismic restraining devices shall comply with the current seismic requirements of the State of California.
- B. Vibration Isolators:
 1. General Properties:
 - a. All vibration isolators shall have either undeflected heights or calibration markings so that, after adjustment when carrying their load, the deflection under load can be verified, thus determining that the load is within the range of the device and that the correct degree of vibration isolation is being provided according to the design.
 - b. All isolators shall operate in the linear portion of their load versus deflection curve.
 - c. The ratio of lateral to vertical stiffness shall be not less than 0.9, nor greater than 1.5.
 - d. The theoretical vertical natural frequency for each support point based upon the load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment as a whole by more than (+) 10%.
 - e. Wave motion through the Isolator shall be reduced to the following extent: Isolation above the primary vertical system resonance frequency shall follow the theoretically predicted isolation curve for single degree of freedom systems with 10 db to 50 db at all frequencies above 150 Hz.
 - f. All neoprene mountings shall have a shore hardness of 40-65 after minimum aging of thirty (30) days, or corresponding open-aging.
 - g. Vibration isolators shall provide the proper weight distribution to produce uniform deflection.
 2. Isolator Types:
 - a. Type MS shall be spring type without housings or snubbers, equipped with leveling bolts and with two layers of ribbed or waffled neoprene pads, separated by a 1/16" galvanized steel plate under the base plate. Neoprene sleeves and washer shall be installed at all anchor bolts.

- b. Type HS shall be suspension hangers having a steel frame and spring element, in series with a neoprene pad, cup or washer. The isolator shall be designed so that hanger rod may be misaligned 15° in any direction relative to the vertical, without contacting hanger box frame.
 - c. Type MN shall be neoprene isolator support type unit having a minimum static deflection of 1/4".
 - d. Type HN shall be a suspension hanger type employing a neoprene isolator unit having a minimum static deflection of 1/4".
 - e. Manufacturers for type MS, HS, MH, and HN isolators shall be by Mason Industries, or equal.
3. Equipment Frames:
- a. Mounting frames and brackets shall be provided to carry the load of the equipment without causing mechanical distortion or stress to the equipment.
 - b. The mounting frames shall consist of welded, wide flange or channel structural steel, with welder brackets to accept the isolators. The section depth of any frame member shall be not less than 1/10th of the length of the longest frame member, and not less than 1/10th of the greatest span between support points. All frame members shall have the same depth.
- C. Restraining Devices.
- 1. Restraints shall consist of 2" by 1/4" flat iron bars with resilient pads to provide vertical and lateral restraint during seismic shock.
 - 2. Each restraint shall consist of two pieces of flat iron bars bolted together with two 3/8" bolts and serrated washers. The holes in the bars shall be slotted vertically to permit adjustment for required clearance.
 - 3. Steel wire minimum #12 AWG.

3. EXECUTION

3.1 INSTALLATION

- A. All electrical equipment shall be mounted on vibration isolation rails or frames using neoprene isolators.
- B. Provide restraints for floor standing electrical equipment shown on the drawings.
- C. Provide restraints for all suspended transformers and other suspended electrical equipment.

- D. Install restraints after equipment has been set on isolators and after the isolators have been adjusted for required deflection.
- E. All floor supported transformers of 300 KVA and smaller located within the building shall be mounted on vibration isolation rails utilizing Type MN neoprene mounts selected to deflect a minimum of 0.25".
- F. Suspended electrical equipment shall be supported on an appropriate steel frame from Type HS hangers, selected for a minimum static deflection of 0.75".
- G. Provide cable restraints for lighting fixtures, wireways and bus ducts.

3.2 ACCEPTANCE TEST

- A. Inspect the installation of all vibration isolators in accordance with manufacturer's printed recommendations.
- B. Replace, at no extra cost to the Owner, isolators which do not produce the required deflection, are incorrectly loaded above or below their correct operating height, or which do not produce the required isolation as approved.
- C. Inspect whether all electrical equipment has seismic restraints as required under Paragraphs 1.1 and 3.1 above.
- D. Inspect whether all restraining devices have used materials and have been installed as required under Paragraphs 1.1 and 3.1 above.

END OF SECTION 26 0548

SECTION 26 0553

NAMEPLATES AND WARNING SIGNS

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide nameplates and warning signs as shown on the Drawings and as specified, complete.

1.2 SUBMITTALS

- A. Shop Drawings and Product Data: The following list includes the required shop drawings that shall be submitted.
 - 1. Complete data.
- B. Refer to Section 26 00 00 – Basic Electrical Materials and Methods – 1.4 Submittals.

2. PRODUCTS

2.1 MATERIALS

- A. Fabricated nameplates shall clearly state the following:
 - 1. Manufacturer's name and equipment design ratings including current, voltage, KVA, HP, bus bracing rating or as applicable.
 - 2. System usage and purpose, system nominal voltage, equipment rating KVA, amperes, HP and RPM as applicable. Designation data per Drawings or supplied with shop drawings.
 - 3. Panel designation, voltage and phase.
- B. Manufacturer's Device Nameplates: Device usage, purpose, or circuit number; manufacturer and electrical characteristic ratings including the following:
 - 1. Circuit Breakers: Voltage, continuous current, maximum interrupting current and trip current.
 - 2. Switches: Voltage, continuous current, horsepower or maximum current switching. If fused, include nameplate stating "Fuses must be replaced with current limiting type of identical characteristics."
 - 3. Contactors: Voltage, continuous current, horsepower or interrupting current, and whether "mechanically held" or "electrically held."
 - 4. High Voltage Sectionalizing Switches: Voltage, continuous current and maximum current switching, located to be visible after installation.

- 5. Motors: Rated voltage, full load amperes, frequency, phases, speed, horsepower, code letter rating, time rating, type of winding, class and temperature.
- 6. Controllers: Voltage, current, horsepower and trip setting of motor running overcurrent protection.
- C. Equipment nameplate material shall be engraved, laminated, plastic or Micarta type with white letters engraved through the black background, except on emergency systems background shall be red and include the word "EMERGENCY." Letters shall be 3/16" high for devices, and minimum 1/4" high for equipment and enclosures. Adhesives are not acceptable. All plates for receptacles on emergency circuits shall be engraved "Emer. 120V" with 3/8" black filled letters.
- D. All boxes containing conductors of systems 4160 volts and higher shall be provided with nameplates with a red plastic laminated nameplate with 2" high white core letters inscribed "HIGH VOLTAGE" on pullbox covers. In addition, the nameplate shall contain the following information in 1/2" high letters:

Circuit Voltage: _____ (Insert 4160, 4800, or 12,470 as appropriate)

Circuit Number: _____

Circuit Source: _____ (Provide name and location of high voltage switchboard)
- E. Warning signs shall be minimum 18 gauge steel, white porcelain enamel finish with red lettering. Lettering shall read "DANGER - HIGH VOLTAGE," with "DANGER" in 1-1/2" letters and "HIGH VOLTAGE" in 1" letters. Warning signs shall be included on door or immediately above door of all electrical equipment rooms, vaults or closets containing equipment energized above 150 volts to ground.
- F. Other equipment nameplates or warning signs required by the Contract Documents, or added at the equipment manufacturer's or Contractor's discretion, shall be fabricated and installed according to the guidelines specified in this Section.

3. EXECUTION

3.1 INSTALLATION

- A. Nameplates shall be mounted by self-tapping, threaded screws and bolts, or by rivets.
- B. Signs shall be permanently mounted with cadmium plated, steel screws or nickel-plated brass bolts.

END OF SECTION 26 0553

SECTION 26 2416

PANELBOARDS

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide panelboards as shown on the Drawings and as specified, complete.

1.2 SUBMITTALS

- A. Shop Drawings and Product Data: The following list includes the required shop drawing information that shall be submitted.
 - 1. Thickness, gauges, and finish of materials.
 - 2. Types of materials and bus bracing.
 - 3. Circuit breaker ratings, interrupting capacities, and FS compliance.
 - 4. Sheet metal enclosure construction and sizes, and UL approval.
- B. Refer to Section 26 00 00 – Basic Electrical Materials and Methods - 1.4 Submittals.

1.3 FACTORY INSPECTION (NOT REQUIRED)

2. PRODUCTS

2.1 MATERIALS

- A. Provide panelboard cabinets flush or surface mounted as noted on the Drawings, with hinged lockable door, typewritten index card holders under plastic cover, copper busing, and main lugs or main protective device as indicated on the Drawings. Panels shall have concealed hinge, latch and flush locks, keyed to operate from one key, and permanent type plastic or metal numbers on adjacent trim removable only from back of trim, to identify the branch circuit breakers. Busing shall be minimum 225 amperes and, except where feeder breaker protecting panel is less than 100 ampere, the busing may be 100 ampere. Panelboards with a height greater than 3 feet shall have three trim bolts each side.
- B. Lighting, power and distribution panelboards shall be three-phase, four-wire, S/N 208/120 volt or 480/277 volt, as indicated on the Drawings. Panelboards shall be as manufactured by Eaton, Square D or equal. All panelboards shall be equipped with a ground bus and double lugs or main circuit breaker as indicated on Drawings.
- C. All boxes shall be formed of galvanized metal, chemically cleaned, and all breaks in galvanizing shall be painted with metallic aluminum paint. Minimum size shall be 20" wide by 5-3/4" deep unless noted otherwise on the Drawings. All trims and doors shall be chemically cleaned. Front door and trim shall be finished with ANSI #61 light gray paint for surface or semi-

recessed mounting, and shall be finished with a prime coat for flush mounting.

- D. Provide a zinc primer factory finish on the exposed trim of all flush mounted panels in corridors, offices and other public spaces.
- E. Protective devices, main, branch or sub-feed shall be as shown on the Drawings or panel schedules. Circuit breakers in panelboards shall be rated to interrupt the fault current available at panelboards, as shown on the Drawings or otherwise indicated. As a minimum, 208 volt circuit breakers shall be rated 10,000 amperes RMS symmetrical and circuit breakers for the 480/277 voltage ratings shall be minimum 14,000 amperes RMS interrupting rating.
- F. Equip each circuit feeding electrical discharge lamp with NEC lock-off device, unless lamps are within sight of panelboard, or have local switch. Non-switched emergency light circuits, fire alarm and control circuits shall include "lock-on" devices.
- G. Where a contactor, relay, or time switch is indicated to be included with or adjacent to a panelboard, it shall be in a separate box and mounted under a separate hinged lockable door. Where a panelboard or box has more than one door, a barrier and divider bar shall be provided between doors. Relays, time switches and control devices may be grouped under one door, but not with contactor.
- H. Panelboards shown on Drawings with a feed-through gutter shall incorporate an additional side gutter 8-inch minimum width with separate screw-on cover.
- I. For all lighting and power panelboards, circuit breakers shall be 20A minimum except when used as a feeder to one motor with full load current of 5 amperes or less, heavy duty, Eaton, Square D or equal. Circuit breakers for higher voltage rating shall be appropriately rated for voltage and interrupting rating.

3. EXECUTION

3.1 INSTALLATION

- A. Installation of adjacent panelboards shall be such that top trims are level and at the same height, unless specifically noted otherwise. Protection device heights shall be a maximum of 6 feet 6 inches to the handle for panelboards over 29 inches in height, and 5 feet 6 inches in panelboards 29 inches high or less, except where adjacent to taller panelboards.
- B. From each flush mounted panelboard, route 4-3/4-inch empty conduits into accessible ceiling space.
- C. All lighting and power panelboards shall be rigidly supported independently of conduit from concrete floor to concrete floor.

- D. Panelboards located in mechanical areas shall have weatherproof gaskets on trims and doors.
- E. Obtain the Owner's room numbering system and include these room numbers in final typewritten panelboard directories.
- F. Provide nameplates as specified in Section 26 05 53, NAMEPLATES AND WARNING SIGNS.

END OF SECTION 26 2416

SECTION 26 2726

WIRING DEVICES

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide wiring devices as shown on the Drawings and as specified, complete.

1.2 SUBMITTALS

- A. Shop Drawings and Product Data: The following list includes the required shop drawings that shall be submitted.
 - 1. Each device indicating FS number, amperage and voltage rating, materials, color and manufacturer's catalog sheet.
 - 2. Each device plate indicating materials and thickness or gauge of materials, color and manufacturer's catalog sheet.
- B. Refer to Section 26 00 00 – Basic Electrical Materials and Methods – 1.4 Submittals.

2. PRODUCTS

2.1 MATERIALS

- A. All devices shall conform to NEMA standards, shall be UL listed and labeled, and shall be "Hospital Grade," meeting the requirements of FS WC-596-G and switches meeting the requirements of FS WS-896-E.
- B. Switches:
 - 1. Wall switches shall be fully enclosed, quiet type switches rated 20 amperes, 277-volt, Bakelite or composition. Refer to drawings for more information.
 - 2. Single Pole Quiet Switches: Lutron, or equal. Refer to drawings for more information.
 - 3. Double Pole Quiet Switches: Lutron, or equal. Refer to drawings for more information.
 - 4. Three-way Quiet Switches: Lutron, or equal. Refer to drawings for more information.
 - 5. Remote control motor switches shall be standard duty, momentary contact, push button, or selector switches, with pilot lights and jewels. Manufacturer shall be Square D, or equal.

- C. Manual motor control switches for single-phase motors shall be flush or surface mounted, as required, full-voltage type with thermal overload protection and with pilot light and jewel where specified. Manufacturer shall be Eaton, Square D, or equal.
- D. Remote control switches shall be standard duty, momentary contact, push button or selector switches, equipped with pilot light and jewel, where specified. Manufacturer shall be Square D, or equal, and shall be mounted in the NEMA type enclosure most applicable for the location.
- E. Limit switches shall be Square D, or equal.
- F. Door switches shall be Square D, or equal.
- G. Contactors for the control of lighting circuits shall be mechanically held, NEMA Size 2 or larger, with the number of poles as required by the schedules or diagrams. Contactors shall have coil clearing contacts. Manufacturers shall be Square D, or equal.
- H. Dimmers: (Refer to Drawings for additional information).
- I. Receptacles: (Refer to Drawings for additional information).
 - 1. Single and duplex convenience receptacles shall be U-grounded type, 125 volts, side and back wired with binding screws only. Rating 20 amperes as indicated, Hubbell, or equal.
 - 2. The grounding contact shall be internally connected to the frame with ground terminal for external ground.
 - 3. Special receptacles shall be as indicated on Drawings by NEMA configuration.
 - 4. Ground fault receptacles shall be 20 amperes, 125 volt, duplex, three wire grounding with pilot light and test and reset buttons including self-test and self-diagnostic features. Suitable for feed-through wiring, color to be as selected by the Owner's Representative from manufacturer's standard colors, Hubbell, or equal.
 - 5. Corridor Cleaning Receptacles: Hubbell, or equal.
 - 6. Hospital Grade Duplex: Hubbell, or equal.
 - 7. Clock outlets shall be Hubbell, or equal.
 - 8. Wiring devices in exposed weatherproof boxes shall be the devices specified in this Section, and shall be installed in "FS" or "FD" series condulets with weatherproof cast metal covers, and gaskets as required.
 - 9. Receptacle wireway (prewired plugmold) shall be Wiremold, or equal.

J. Floor Outlets:

1. Where floor outlets are shown, boxes shall be Hubbell, or equal. Where 120 on 208 volts are used, standard NEMA receptacles, suitable for the service, shall be used. Receptacles shall be Hubbell, or equal, with ampere and voltage ratings as required.
2. All switch, convenience, telephone and signal outlets, except as otherwise noted or specified, shall be covered with Hubbell, or equal, satin finish, 0.040-inch, type 302 stainless steel plates.

K. Plates:

1. Provide plates for all switches, receptacles, junction boxes, telephone and other outlets.
2. Provide engraved or etched plates for all lock switches, pilot switches, switches from which equipment or circuit controlled cannot be readily seen, three or more switches under a common plate and for switches as indicated.
3. Stainless steel plates shall be AISI Type 302, with beveled edges, 0.040" thick with satin finish. Hubbell, or equal.
4. Where outlets are indicated to be weatherproof, provide a AISI Type 302 stainless with double hinged covers.
5. Galvanized steel plates shall be square or rectangular and hot dipped galvanized or sherardized, beveled edges and 0.040" thick.
6. Provide plates equipped with close fitting openings for the exact device to be used. Provide plates for telephone outlets equipped with bushed openings.
7. Dimmer plates shall be custom type. Lutron or equal.
8. Finish of plates and devices shall be as follows:
 - a. Plates: Plates for emergency lighting and receptacles shall be red.

9. Finish of plates and devices shall be as follows:

Location	Plate	Device Color*
General Interior Finished Areas	TBD	TBD
On Exterior Spring Loaded Cover	TBD	TBD
In Equipment Rooms or Other Generally Unfinished Areas	TBD	TBD

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Janitor and Utility Rooms	TBD	TBD
Toilet (Public)	TBD	TBD
Emergency Circuits	Nylon	Red

* NOTE: Device colors except for emergency (red) may be changed at the Owner's Representative's request if desirable to match building color scheme.

- L. All pilot lights shall be transformer type.
- M. Occupancy Sensors: Lutron or equal. Refer to drawings for additional information.

3. EXECUTION

3.1 INSTALLATION

- A. Mount switches 40" above finished floor and vertically in all locations unless indicated otherwise.
- B. All convenience and telephone outlets mounted 15" above the floor shall be installed vertically. Install receptacle with the grounding terminal up. All 3-wire duplex receptacles mounted more than 15 inches above the floor shall be installed horizontally with the grounding terminal to the left.
- C. NEC sized (#12 minimum) bonding jumper shall connect grounded outlet box to receptacle grounding terminal on all flush mounted units.
- D. Align and plumb all devices and plates. Plates shall fit flat against wall and tight against device surface without strain on plate.
- E. Each class of device shall be furnished by one manufacturer for total Project. Mixing devices of different suppliers will not be permitted.
- F. Ganged switches on 277 volt circuits shall have a barrier between each switch.
- G. Dimmers shall be installed in individual outlet boxes. Do not install in ganged boxes with other devices.

END OF SECTION 26 2726

SECTION 26 2816

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

1. GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide switches, disconnect and safety, as shown on the Drawings and as specified, complete.

1.2 SUBMITTALS

- A. Shop Drawings and Product Data: The following list includes the required shop drawings that shall be submitted.
 - 1. Complete equipment shop drawings.
- B. Refer to Section 26 00 00 – Basic Electrical Materials and Methods – 1.4 Submittals.

2. PRODUCTS

2.1 MATERIALS

- A. All disconnect switches shall be the "Heavy Duty" type and shall meet the latest edition of FS W-S-865.
- B. Provide all disconnect switches with devices enabling the switch to be locked in the open and closed positions.
- C. Manual motor starters shall be motor rated tumbler switches rated 3 HP 208 or 480 volts, three-phase with overload heaters as specified or shown to protect equipment served.
- D. Externally operable safety switches shall have quick-make, quick-break mechanism, capable of switching 10 times the switch rating, and with cover interlocks with defeat mechanism for maintenance. Provide switches with number of poles, ampere, voltage and HP rating, types of enclosures and fusible or nonfusible as indicated and as required for the particular application. Disconnect switches shall be heavy duty type unless otherwise indicated. Provide NEMA I enclosures for interior locations and NEMA 3R enclosures for exterior or wet locations unless otherwise indicated. Switches having a dual rating when used with dual element fuses shall have rating so indicated on the metal plate. Fuses, where required, shall be UL listed current limiting type RK5.
- E. Manufacturers: Eaton, Square D or equal.

3. EXECUTION

3.1 INSTALLATION

- A. Install switches, disconnects and safety, where indicated on the Drawings.

- B. Securely fasten to structural members or channel support.
- C. Install manual motor starters flush mounted for switching motors 3 HP and smaller in finished areas.
- D. Install manual motor starters surface mounted in equipment rooms and non-finished areas. Where installed above ceilings, access panels shall be provided.

END OF SECTION 26 2816