CENTRAL DNR FACILITIES BUILDING IMPROVEMENTS
SAUK, COLUMBIA & JUNEAU COUNTIES
DEPARTMENT OF NATURAL RESOURCES
STATEWIDE, WISCONSIN

TECHNICAL SPECIFICATIONS VOLUME 3 of 3
BID DOCUMENT

Division Project No. **24B2B**

OCTOBER 7, 2025

FOR
THE STATE OF WISCONSIN
DEPARTMENT OF ADMINISTRATION
DIVISION OF FACILITIES DEVELOPMENT
STATE OF WISCONSIN ADMINISTRATION BUILDING - 7TH FLOOR
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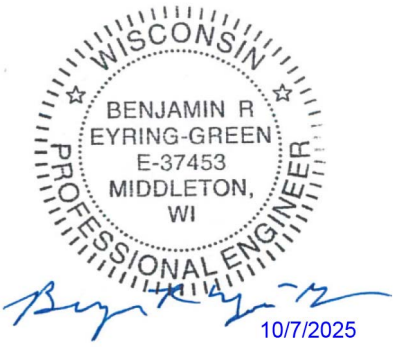

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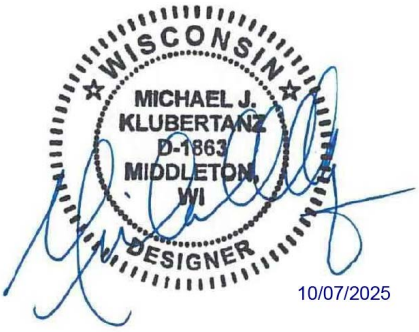

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SECTION 22 05 00
COMMON WORK RESULTS FOR PLUMBING
BASED ON DFD MASTER SPECIFICATION DATED 01/10/25

P A R T 1 - G E N E R A L

SCOPE

This section includes information common to two or more technical plumbing specification sections or items that are of a general nature, not conveniently fitting into other technical sections. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Lead Free Requirements
- Quality Assurance
- Continuity of Existing Services
- Protection of Finished Surfaces
- Sleeves and Openings
- Sealing and Fire Stopping
- Submittals
- Off Site Storage
- Codes
- Certificates and Inspections
- Operating and Maintenance Data
- Training of Owner Personnel
- Record Drawings

PART 2 - PRODUCTS
- Access Panels and Doors
- Identification
- Bedding and Backfill
- Sealing and Fire Stopping

PART 3 - EXECUTION
- Demolition
- Cutting and Patching
- Building Access
- Equipment Access
- Coordination
- Identification
- Lubrication
- Sleeves and Openings
- Agency Training

RELATED WORK

Section 01 91 01– Commissioning Process
Section 01 33 00 – Electronic Submittal Procedures

Section 07 84 00 – Fire Stopping

REFERENCE

Applicable provisions of Division 1 govern work under this section.

This section applies to all Division 22 sections of plumbing.

REFERENCE STANDARDS

Abbreviations of standards organizations referenced in this and other sections are as follows:

ABMA American Boiler Manufacturers Association
ACPA American Concrete Pipe Association
AGA American Gas Association
AMCA Air Movement and Control Association
ANSI American National Standards Institute
APWA American Public Works Association
ASHRAE American Society of Heating, Air Conditioning and Refrigeration Engineers
ASME American Society of Mechanical Engineers
ASPE American Society of Plumbing Engineers
ASSE American Society of Sanitary Engineering
ASTM American Society for Testing and Materials
AWWA American Water Works Association
AWS American Welding Society
CISPI Cast Iron Soil Pipe Institute
CGA Compressed Gas Association
CS Commercial Standards, Products Standards Sections, Office of Eng. Standards Service, NBS
DSPS State of Wisconsin Dept. of Safety and Professional Services, State Plumbing Code
EPA Environmental Protection Agency
FS Federal Specifications, Superintendent of Documents, U.S. Government Printing Office
GAMA Gas Appliance Manufacturers Association
IAPMO International Association of Plumbing & Mechanical Officials
IEEE Institute of Electrical and Electronics Engineers
ISA Instrument Society of America
MCA Mechanical Contractors Association
MICA Midwest Insulation Contractors Association
MSS Manufacturer's Standardization Society of the Valve & Fitting Industry, Inc.
NBS National Bureau of Standards
NEC National Electric Code
NEMA National Electrical Manufacturers Association
NFPA National Fire Protection Association
NSF National Sanitation Foundation
PDI Plumbing and Drainage Institute
STI Steel Tank Institute
UL Underwriters Laboratories Inc.

Standards referenced in this section:

ACI 614	Recommended Practice for Measuring, Mixing and Placing of Concrete
ANSI/ ASHRAE 188	Legionellosis: Risk Management for Building Water Systems
ASTM D1557	Standard Test Method for Moisture-Density Relations of Soils
ASTM E814	Standard Test Method for Fire Tests of Through-Penetration Fire Stops
ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials
UL1479	Fire Tests of Through-Penetration Firestops

UL723 Surface Burning Characteristics of Building Materials

LEAD FREE REQUIREMENTS

All materials that contact potable water shall be lead free and in compliance with the Federal Safe Drinking Water Act 40 CFR 143.10-143.20.

This requirement applies to all the subsequent Plumbing Specification Sections and Plumbing Drawings and supersedes any part or model number that may conflict with this requirement.

QUALITY ASSURANCE

Refer to Division 1, General Conditions, Equals and Substitutions.

Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or engineering parameters from those indicated on the contract documents, the contractor is responsible for all costs involved in integrating the equipment or accessories into the system and for obtaining the intended performance from the system into which these items are placed.

All products and materials used are to be new, undamaged, clean and in good condition. Existing products and materials are not to be reused unless specifically indicated.

CONTINUITY OF EXISTING SERVICES

Do not interrupt or change existing services without prior written approval from the Owner's Project Representative. When interruption is required, coordinate scheduling of down-time with the Owner to minimize disruption to their activities. Unless specifically stated, all work involved in interrupting or changing existing services is to be done during normal working hours.

PROTECTION OF FINISHED SURFACES

Refer to Division 1, General Requirements, Protection of Finished Surfaces.

SLEEVES AND OPENINGS

Refer to Division 1, General Requirements, Sleeves and Openings.

SEALING AND FIRE STOPPING

Sealing and firestopping of sleeves/openings between piping, etc. and the sleeve or structural opening shall be the responsibility of the contractor whose work penetrates the opening. The contractor responsible shall hire individuals skilled in such work to do the sealing and fireproofing.

SUBMITTALS

Refer to Division 1, General Conditions, Submittals and 01 33 00 Electronic Submittal Procedures.

Submittals are to contain a cover page with the project manual cover page information, table of contents, product data sheets, product schedules, shop drawings and fabrication drawings. Submit for all equipment and systems as indicated in the respective specification sections, marking each submittal with that specification section number. Mark general catalog sheets and drawings to indicate specific items being submitted and identification of equipment by name, number or designation, as indicated in the contract documents. Include wiring diagrams of electrically powered equipment.

Before submitting electrically powered equipment, verify that the electrical power and control requirements for the equipment are in agreement with the motor starter schedule on the electrical drawings. Include a statement on the submittal transmittal to the architect/engineer that the equipment submitted and the motor starter schedules are in agreement or indicate any discrepancies. See related comments in Section 22 05 13 in Part 1 under Electrical Coordination.

The specific items that will be required for submittals shall be coordinated with the DFD Project Representative, the A/E, and the General Prime Contractor for inclusion in the project submittal log.

Provide sufficient quantities of submittals to allow the following distribution:

- Operating and Maintenance Manuals 2 copies
- Division of Facilities Development 1 copy
- Architect/Engineer 1 copy

OFF SITE STORAGE

Prior approval by DFD and the A/E will be needed. The contractor shall submit Storage Agreement Form AD-BDC-74 to DFD for consideration of off site materials storage. Generally, sleeves, pipe/pipe fittings and similar rough-in material will not be accepted for off site storage. No material will be accepted for off site storage unless shop drawings for the material have been approved.

CODES

Comply with requirements of Wisconsin Administrative Code.

CERTIFICATES AND INSPECTIONS

Refer also to Division 1, General Conditions, Permits, Regulations, Utilities and Taxes.

Obtain and pay for all required State installation inspections except those provided by the Architect/Engineer. Deliver the originals of inspection certificates and test records to the Owner's Project Representative. Include copies of the certificates and test records in the Operating and Maintenance Instructions.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under Division 01, General Requirements.

In addition to the general content specified under General Requirements, supply the following additional documentation:

1. Records of tests performed to certify compliance with system requirements
2. Manufacturer's wiring diagrams for electrically powered equipment
3. Certificates of inspection by regulatory agencies
4. Valve schedules
5. Lubrication instructions, including list/frequency of lubrication
6. Parts lists for fixtures, equipment, valves and specialties.
7. Manufacturers installation, operation and maintenance recommendations for fixtures, equipment, valves and specialties.
8. Additional information as indicated in the technical specification sections

TRAINING OF OWNER PERSONNEL

Instruct user agency personnel in the proper operation and maintenance of systems, fixtures and equipment provided as part of this project. A factory authorized representative shall be present during the training session for any newly installed plumbing equipment. Include not less than 2 hours of instruction, using the Operating and Maintenance manuals during this instruction. Demonstrate startup, operation and shutdown procedures for all equipment. All training to be during normal working hours. Video record all instructions and provide Owner with copy.

RECORD DRAWINGS

Refer to Division 1, General Requirements, Record Drawings.

PART 2 - PRODUCTS

ACCESS PANELS AND DOORS

PLASTER WALLS AND CEILINGS:

16 gauge frame with not less than a 20 gauge hinged door panel, prime coated steel for general applications, stainless steel for use in toilets, showers, and similar wet areas, concealed hinges, screwdriver operated cam latch for general applications, key lock for use in public or secured areas. Newly installed access panels shall be keyed alike whenever possible, coordinate with Agency and all other applicable disciplines. UL listed for use in fire rated partitions if required by the application. Use the largest size access opening possible, consistent with the space and the item needing service; minimum size is 12" by 12".

IDENTIFICATION

Manufacturers: Brady, Carlton, Emedco, Marking Services Inc., Seton

Stencils:

Not less than 1 inch high letters/numbers for marking pipe and equipment.

Engraved Name Plates:

White letters on a black background, 1/16 inch thick plastic laminate, beveled edges, screw mounting.

Adhesive Markers:

Pressure-sensitive, adhesive backed, vinyl pipe markers with applicable labeling, ¾" min. size for lettering and surrounding tape on both ends. With flow arrows on piping. Color coded per ANSI/ASME 13.1.

Snap-Around Pipe Markers:

One-piece, preformed, vinyl construction, snap-around or strap-around pipe markers with applicable labeling and flow direction arrows, ¾" min. size for lettering. Color coded per ANSI/ASME 13.1.

Valve Tags:

Round brass tags with 1/2 inch numbers, 1/4 inch system identification abbreviation, 1-1/4 inch minimum diameter, with brass jack chains, brass "S" hooks or one piece nylon ties around the valve stem..

Underground Warning Tape:

Detectable underground warning tape, 5.0 mil overall thickness, 6" width, .0035" thick aluminum foil core with polyethylene jacket bonded to both sides. APWA approved color code with caution along with name of buried service printed in bold letters on face of tape.

Ceiling and Access Door Labels:

Clear polyester tape ¾" width with black printing.

Underground Tracer Wire:

All underground non-metallic gas piping, water piping and sewer laterals shall be provided with tracer wire installations. Tracer wire installations shall conform with Section 182.0715(2r) of Wisconsin Statutes. Open trench tracer wire shall be solid copper or copper clad steel with 30 mil HDPE/HMWPE insulation and minimum 280 lb. break load. Directional drilling/boring tracer wire shall be copper clad steel with minimum 1,100 lb. break load and 45 mil HDPE/HMWPE insulation. Color code insulation for service per APWA: Yellow - Gas, Blue - Potable Water, Purple - Non-Potable Water, Green - Sanitary Sewer, Brown - Storm Sewer. Connectors to be dielectric silicon filled designed for underground tracer wire application. Use grade level and at buildings above ground tracer wire access boxes with appropriate “sewer”, “water”

or “gas” service cast into cap at wire termination points, with the exception of terminations at gas meter risers. Provide grounding anode and wire connected to each access box.

SEALING AND FIRE STOPPING

NON-RATED PENETRATIONS:

At pipe penetrations of non-rated interior partitions, floors and exterior walls, use urethane caulk in annular space between pipe insulation and sleeve. For non-rated drywall, plaster or wood partitions where sleeve is not required use urethane caulk in annular space between pipe insulation and wall material

P A R T 3 - E X E C U T I O N

DEMOLITION

Perform all demolition as indicated on the drawings to accomplish new work. Where demolition work is to be performed adjacent to existing work that remains in an occupied area, construct temporary dust partition to minimize the amount of contamination of the occupied space. Where pipe is removed and not reconnected with new work, cap ends of existing services as if they were new work. Coordinate work with the Owner to minimize disruption to the existing building occupants.

All pipe, fixtures, equipment, wiring and associated conduit, insulation and similar items demolished, abandoned, or deactivated are to be removed from the site by the Contractor except as specifically noted otherwise. All designated equipment is to be turned over to the user agency for their use at a place and time so designated. Maintain the condition of material and/or equipment that is indicated to be reused equal to that existing before work began.

CUTTING AND PATCHING

Refer to Division 1, General Requirements, Cutting and Patching.

BUILDING ACCESS

Arrange for the necessary openings in the building to allow for admittance or removal of all apparatus. When the building access was not previously arranged and must be provided by this contractor, restore any opening to its original condition after the apparatus has been brought into the building.

EQUIPMENT ACCESS

Install all piping, conduit and accessories to permit access to equipment for maintenance and service. Coordinate the exact location of wall and ceiling access panels and doors with the General Prime Contractor, making sure that access is available for all equipment and specialties. Access doors in general construction are to be furnished by the Plumbing Contractor and installed by the General Prime Contractor.

COORDINATION

Coordinate all work with other contractors prior to installation. Any work that is not coordinated and that interferes with other contractor's work shall be removed or relocated at the installing contractor's expense.

Verify that all devices are compatible for the type of construction and surfaces on which they will be used.

IDENTIFICATION

Clean and dry substrate prior to applying identification.

Identify equipment in mechanical equipment rooms by stenciling equipment number and service with one coat of black enamel against a light background or white enamel against a dark background. Use a primer where necessary for proper paint adhesion.

Where stenciling is not appropriate for equipment identification, engraved name plates may be used.

Identify interior piping not less than once every 30 feet, not less than once in each room, adjacent to each access door or panel, and on both side of the partition where accessible piping passes through walls or floors. Place flow directional arrows at each pipe identification location and over each end of adhesive labels. For stenciling, use one coat of black enamel against a light background or white enamel against a dark background. Labeling of any exposed piping located in public or common areas shall be coordinated with architect and general prime contractor prior to installation.

For hospital, community-based residential facilities, hospice and nursing home facilities, label hot water piping within water heater mechanical room and interior of mechanical room doors with hot water distribution piping disinfection method per SPS 382.50(3)(b)(12).

Identify all exterior buried piping for entire length with underground warning tape except for sewer piping which is routed in straight lines between manholes or cleanouts. Place tape 6"-12" below finished grade along entire length of pipe. Extend tape to surface at building entrances, meters, hydrants and valves. Where existing underground warning tape is broken during excavation, replace with new tape identifying appropriate service and securely spliced to ends of existing tape.

Install tracer wire on all underground non-metallic gas piping, water piping and sewer laterals. Secure with cable zip ties or insulated tie wire to pipe at 5’ intervals. Connect lateral wires to main wires or existing tracer wires with dielectric silicone filled connectors. Damaged or bare wire may not be taped or coated and must be replaced. Terminate with 2’ of excess wire loop within an access box placed above utility where piping enters buildings or connects to existing mains. Locate in roadway right of ways where connecting points occur under roadways. Provide buried magnesium grounding rod at each access box with grounding wire connected to access box grounding terminal with 2’ excess wire loop. After backfilling, test with low frequency 512 Hz line tracing witnessed by Owner’s representative and record GPS data per SPS 382.30(11)(h).

Identify valves with brass tags bearing a system identification and a valve sequence number. Identify medical gas and vacuum valves with brass tags and wall or cabinet mounted color coded engraved nameplate with the following "(Type of Gas) Shutoff Valve for (Location or Zone)". Valve tags are not required at a terminal device unless the valves are greater than ten feet from the device, located in another room or not visible from device. Provide a typewritten valve schedule and pipe identification schedule indicating the valve number and the equipment or areas supplied by each valve and the symbols used for pipe identification; locate schedules in mechanical room and in each Operating and Maintenance manual. Schedule in mechanical room to be framed under clear plastic.

LUBRICATION

Lubricate all bearings with lubricant as recommended by the manufacturer before the equipment is operated for any reason. Once the equipment has been run, maintain lubrication in accordance with the manufacturer's instructions until the work is accepted by the Owner. Maintain a log of all lubricants used and frequency of lubrication; include this information in the Operating and Maintenance Manuals at the completion of the project.

SLEEVES AND OPENINGS

Pipe penetrations in new poured concrete horizontal construction requiring F and T rating: Form opening using hole form or core drill opening. Alternatively provide cast in place fire stopping devices/sleeves.

Pipe penetrations in new poured concrete horizontal construction requiring F rating but no T rating: Same as pipe penetrations in new poured concrete construction requiring F and T ratings except that schedule 40 steel sleeves may also be used.

Pipe penetrations in new poured concrete horizontal construction that do not require F or T ratings: Provide schedule 40 steel pipe sleeve, form opening using hole form or core drill opening.

Where penetrating pipe or conduit weight is supported by floor, provide manufactured product or structural bearing collar designed to carry load.

SEALING AND FIRE STOPPING

NON-RATED PARTITIONS:

At all interior partitions and exterior walls, pipe penetrations are required to be sealed. Apply sealant to both sides of the penetration in such a manner that the annular space between the pipe sleeve or cored opening and the pipe or insulation is completely blocked.

AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01.

END OF SECTION

SECTION 22 05 13
COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT
BASED ON DFD MASTER SPECIFICATION DATED 01/10/25

P A R T 1 - G E N E R A L

SCOPE
This section includes requirements for single and three phase motors that are used with equipment specified in other sections. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Submittals
- Operating and Maintenance Data
- Electrical Coordination
- Product Criteria

PART 2 - PRODUCTS
- Single Phase, Single Speed Motors

PART 3 - EXECUTION
- Installation

RELATED WORK
Section 01 91 01– Commissioning Process
Section 22 05 00 – Common Work Results for Plumbing
Section 22 42 00 - Commercial Plumbing Fixtures.
Section 22 30 00 - Plumbing Equipment for equipment requiring motors.
Division 26 00 00 - Electrical - Electrical for power wiring, starters, and other electrical devices

REFERENCE
Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

ANSI/IEEE 112	Test Procedure for Polyphase Induction Motors and Generators
ANSI/NEMA MG-1	Motors and Generators
ANSI/NFPA 70	National Electrical Code

SUBMITTALS
Include with the equipment which the motor drives the following motor information: motor manufacturer, voltage, phase, hertz, rpm, full load efficiency, full load power factor, service factor, NEMA design designation, insulation class, and frame type.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

ELECTRICAL COORDINATION
All starters, disconnects, relays, wire, conduit, pushbuttons, pilot lights, and other devices required for the control of motors or electrical equipment are provided by the Electrical Contractor, except as specifically noted elsewhere in this division of specifications.

Electrical drawings and/or specifications show number and horsepower rating of all motors furnished by this Contractor, together with their actuating devices if these devices are furnished by the Electrical Contractor. Should any discrepancy in size, horsepower rating, electrical characteristics or means of control be made to any motor or other electrical equipment after contracts are awarded, Contractor is to immediately notify the architect/engineer of such discrepancy. Costs involved in any changes required due to equipment substitutions initiated by this contractor will be the responsibility of this contractor.

Furnish project specific wiring diagrams to Electrical Contractor for all equipment and devices furnished by this Contractor and indicated to be wired by the Electrical Contractor.

PRODUCT CRITERIA

Motors to conform to all applicable requirements of NEMA, IEEE, ANSI, and NEC standards and shall be listed by U.L. for the service specified.

Select motors for conditions in which they will be required to perform; i.e., general purpose, splashproof, explosion proof, standard duty, high torque or any other special type as required by the equipment or motor manufacturer's recommendations.

Furnish motors for starting in accordance with utility requirements and compatible with starters as specified.

P A R T 2 - P R O D U C T S

SINGLE PHASE, SINGLE SPEED MOTORS

Use NEMA rated 115 volt, single phase, 60 hertz motors for all motors 1/3 HP and smaller.

Use permanent split capacitor or capacitor start, induction run motors equipped with permanently lubricated and sealed ball or sleeve bearings and Class A insulation. Service factor to be not less than 1.35.

P A R T 3 - E X E C U T I O N

INSTALLATION

When motor will be flexible coupled to the driven device, mount coupling to the shafts in accordance with the coupling manufacturer's recommendations. Using a dial indicator, check angular misalignment of the two shafts; adjust motor position as necessary so that the angular misalignment of the shafts does not exceed 0.002 inches per inch diameter of the coupling hub. Again using the dial indicator, check the shaft for run-out to assure concentricity of the shafts; adjust as necessary so that run-out does not exceed 0.002 inch.

Lubricate all motors requiring lubrication.

END OF SECTION

SECTION 22 05 14
PLUMBING SPECIALTIES
BASED ON DFD MASTER SPECIFICATION DATED 01/10/25

P A R T 1 - G E N E R A L

SCOPE
This section includes specifications for floor drains, roof drains, cleanouts, backflow preventers, water hammer arrestors and other miscellaneous plumbing specialties.

RELATED DOCUMENTS
Section 01 91 01– Commissioning Process
Section 22 05 00 – Common Work Results for Plumbing
Section 22 05 23 - General-Duty Valves for Plumbing Piping
Section 22 08 00 – Commissioning of Plumbing
Section22 11 00-FacilityWaterDistribution
Section22 13 00-FacilitySanitarySewerage

REFERENCE
Applicable provisions of Division 1 shall govern work under this section.

REFERENCE STANDARDS
ANSI A112.14.3 – Hydromechanical Grease Interceptors
ANSI A112.21.1 - Floor Drains
ANSI A112.26.1/PDI WH-201 - Water Hammer Arrestors
ASSE 1001 - Pipe Applied Atmospheric Type Vacuum Breakers
ASSE 1010 - Water Hammer Arrestors
ASSE 1011 - Hose Connection Vacuum Breakers
ASSE 1019 - Wall Hydrants, Frost Proof Automatic Draining, Anti-Backflow Type

QUALITY ASSURANCE
Substitution of Materials: Refer to Section GC - General Conditions of the Contract, Equals and Substitutions..

Plumbing products requiring approval by the State of Wisconsin Dept. of Safety and Professional Services must be approved or have pending approval at the time of shop drawing submission.

SUBMITTALS
Include data concerning dimensions, capacities, materials of construction, ratings, certifications, weights, avolon toyotamanufacturer's installation requirements, manufacturer's performance limitations, and appropriate identification.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

P A R T 2 - P R O D U C T S

FLOOR DRAINS
Manufacturer: Josam, Mifab, Sioux Chief, Smith, Wade, Watts, Zurn.

FD-1: 3" min. (2" min. for single shower drains) Enameled cast-iron, two-piece body with double drainage flange, weep holes, reversible clamping adjustable collar, adjustable 6" round polished nickel bronze strainer with threaded collar, bottom outlet. Zurn ZN-415- B.

WATER HAMMER ARRESTORS
Manufacturer: PPP Industries, Sioux Chief, Wade, Watts.

ANSI A112.26.1, ASSE 1010; sized in accordance with PDI WH-201, precharged piston type constructed of hard drawn Type K copper, threaded brass adapter, brass piston with o-ring seals, FDA approved silicone lubricant, suitable for operation in temperature range 35 to 150 degrees F, maximum 250 psig working pressure, 1500 psig surge pressure. Watts series 15.

HOSE BIBBS
HB-1: Anti-Siphon hose bibb in flush mounted cast brass wall box with locking door, 3/4" inlet, 3/4" hose thread ASSE 1011 backflow preventer outlet, loose key tee handle, chrome finish. Woodford model B24 series.

SAFINGS
Safing to be installed by others. Refer to 09 30 00 – Tiling.

P A R T 3 - E X E C U T I O N

INSTALLATION
Coordinate location and setting of plumbing specialties with adjacent construction. Install in accordance with manufacturers recommendations.

Install water hammer arrestors where indicated and at all quick closing valve installations.

Mount hose bibbs securely fastened to wall where indicated. Provide water hammer arrestor in line to hose bibb.

Safing to be installed by others, refer to 09 30 00 – Tiling. Standing water leak test report to be performed by plumbing contractor. Plumbing contractor to coordinate with tile installer and GPC.

CONSTRUCTION VERIFICATION ITEMS
Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 22 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

AGENCY TRAINING
All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01.

STANDING WATER LEAK TEST REPORT

State of Wisconsin
Department of Administration
Division of Facilities Development **Date Submitted:** _____

Project Name: _____

Location: _____ **DFD Project No:** _____

Contractor: _____

Test performed per specification section No. _____

Specified Test Duration _____ Hours

System Identification: _____
Describe Location: ___

_____

Tested By: ____ **Witnessed By:** _
Title: __ **Title:** __
Signed: **Signed:**
Date: __ **Date:** __
Comments: ____

END OF SECTION

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SECTION 22 05 15
PIPING SPECIALTIES
BASED ON DFD MASTER SPECIFICATION DATED 01/10/2025

P A R T 1 - G E N E R A L

SCOPE

This section contains specifications for plumbing piping specialties for all piping systems. Included are the following topics:

RELATED WORK

Section 01 91 01– Commissioning Process
Section 22 05 00 – Common Work Results for Plumbing
Section 22 05 23 - General-Duty Valves for Plumbing Piping
Section 22 07 00 - Plumbing Insulation
Section 22 11 00 - Facility Water Distribution
Section 22 13 00 - Facility Sanitary Sewerage
Section 22 30 00 - Plumbing Equipment

REFERENCE

Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

ASTM B650 Electrodeposited Engineering Chromium Coatings on Ferrous Substrates

QUALITY ASSURANCE

Substitution of Materials: Refer to Section GC – General Conditions of the Contract, Equals and Substitutions.

SUBMITTALS

Required for all items in this section. Include materials of construction, dimensional data, ratings/capacities/ranges, approvals, test data, pressure drop data where appropriate, and identification as referenced in this section and/or on the drawings.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

DESIGN CRITERIA
All piping specialties are to be rated for the highest pressures and temperatures in the respective system in accordance with ANSI B31, but not less than 125 psig unless specifically indicated otherwise.

P A R T 2 - P R O D U C T S

THERMOMETERS
Ashcroft, Marsh, Taylor, H. O. Trerice, Ametek/U. S. Gauge, Weiss, Wika, Weksler.

Stem Type: Cast aluminum case, nine inch scale, clear acrylic window. adjustable angle brass stem with stem of sufficient length so the end of the stem is near the middle of a pipe without reducing the thickness of any insulation, red indicating fluid, black lettering against a white background, with scale ranges as follows:

Service	**Hot Water**
Scale Range, °F	30 - 180
Increment, °F	2

THERMOMETER SOCKETS
Lead free brass or stainless steel with threaded connections suitable for thermometer stems and temperature control sensing elements in pipeline. Furnish with extension necks for insulated piping systems.

P A R T 3 - E X E C U T I O N

THERMOMETERS
Stem Type: Install in piping systems as indicated on the drawings and/or details using a separable socket in each location.

THERMOMETER SOCKETS
Install at each point where a thermometer or temperature control sensing element is located in a pipeline.

END OF SECTION

SECTION 22 05 23
GENERAL DUTY VALVES FOR PLUMBING PIPING
BASED ON DFD MASTER SPECIFICATION DATED 01/10/2025

PART 1 - GENERAL

SCOPE

This section includes valve specifications for all Plumbing systems except where indicated under Related Work. Included are the following topics:

RELATED WORK

Section 01 91 01– Commissioning Process
Section 22 05 00 Common Work Results for Plumbing
Section 22 05 14 - Plumbing Specialties
Section 22 30 00 - Plumbing Equipment

REFERENCE

Applicable provisions of Division 1 govern work under this section.

LEAD FREE REQUIREMENTS
All materials that contact potable water shall be lead free and in compliance with the Federal Safe Drinking Water Act 40 CFR 143.10-143.20.

QUALITY ASSURANCE
Substitution of Materials: Refer to Section GC - General Conditions of the Contract, Equals and Substitutions.

SUBMITTALS
Schedule of all valves indicating type of service, dimensions, materials of construction, and pressure/temperature ratings for all valves to be used on the project. Temperature ratings specified are for continuous operation.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

DESIGN CRITERIA
ANSI Z21.22 - Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems.
ASSE 1003 - Water Pressure Reducing Valves for Domestic Water Supply Systems.

Where valve types (ball, butterfly, etc.) are specified for individual plumbing services (i.e. domestic water, gas, etc.), each valve type shall be of the same manufacturer unless prior written approval is obtained from the Owner.

Valves to be line size unless specifically noted otherwise.

PART 2 - PRODUCTS

WATER SYSTEM VALVES
All water system valves to be rated at not less than 125 psig water working pressure at 240 degrees F unless noted otherwise.

BALL VALVES:
3" and smaller: Two piece bronze body; sweat, threaded or ASTM F1960 joint connection ends, full port stainless steel ball and stem; glass filled teflon seat; teflon packing and threaded packing nut; blowout-proof stem; 600 psig WOG. Provide valve stem extensions for valves installed in all piping with insulation. Nibco 585-66 LF or equal by Apollo, Hammond, Milwaukee, Watts.

SWING CHECK VALVES:
3" and smaller: Bronze body, sweat or threaded ends, bronze seat, renewable bronze disc, Class 125, suitable for installation in a horizontal or vertical line with flow upward. Apollo 161-LF, Hammond UP904, Milwaukee UP509, Nibco 413-Y-LF.

SPRING LOADED CHECK VALVES:
2" and smaller: Bronze body, sweat or threaded ends, bronze trim, stainless steel spring, stainless steel center guide pin, Class 125, teflon seat unless only bronze available. Apollo 61LF-100 series, Hammond UP943, Milwaukee UP548T, Nibco S480-Y-LF, Watts LF600 or equal.

BALANCE VALVES:
2" and smaller: Brass body, 304 stainless steel ball, sweat or threaded ends, glass filled teflon seat, brass readout valves with EPT checks, with adjustable memory stop position indicator and extended handle stem, rated for 300 psig water working pressure at 200 degrees F. B&G Xylem Circuit Setter Plus CB-LF, or equal by Nibco or Watts.

DRAIN VALVES:
3/4 inch ball valve with integral threaded hose adapter, chrome plated brass ball, sweat or threaded inlet connections, with pressure rated threaded cap and chain on hose threads, rated for 200 psig and 200 degrees F. Apollo 70LF-200-HC, Milwaukee UPBA100H/UPBA150H, Hammond UP8501H/UP8511H,or equal.

SPECIALTY VALVES AND VALVE ACCESSORIES

GAUGE VALVES:
Use 1/4" ball valves. Needle valves and gauge cocks will not be accepted.

SAFETY RELIEF VALVES:
Lead free bronze body, self-closing temperature and pressure actuated, stainless steel stem and spring, thermostat with non-metallic coating, test lever, suitable for 125 psig water working pressure at 240 degrees F, sized for full BTUH input and operating pressure of equipment, with valve capacity on metal label. For equipment less than or equal to 200,000 BTUH input, provide AGA, UL or ASME listed and labeled valve. Provide ASME listed and labeled valve for larger equipment. Bell & Gossett, A. W. Cash, Conbraco, Watts, Wilkins. Temperature and pressure relief valve shall be sized per AGA rating for BTUH input, Re: SPS 382.40(5)(d).

PART 3 - EXECUTION

GENERAL

Properly align piping before installation of valves. Install and test valves in strict accordance with valve manufacturer's installation recommendations. Do not support weight of piping system on valve ends.

Mount valves in locations which allow ready access for operation, servicing and replacement.

Provide valve handle extensions for all valves installed in insulated piping sized to clear insulation.

Install all valves with the stem in the upright or horizontal position. If possible, install butterfly valves with the stem in the horizontal position. Valves installed with the stems down will not be accepted.

Prior to flushing of piping systems, place all valves in the full-open position.

Solvent weld valves shall be disassembled prior to initial installation per manufacturer requirements.

SHUT-OFF VALVES

Install shut-off valves at each piece of equipment, at each branch take-off from mains for isolation or repair and elsewhere as indicated.

BALANCING VALVES

Install where indicated on the drawings and details for balancing of flow in pumped hot water recirculation piping systems. Include check valve and shutoff valves on inlet and outlet of each balance indicated.Upon project completion, adjust each valve and set position stop. Balance system to minimum flow in return piping branches needed to maintain even supply water temperature throughout building.

Engineer of record shall provide flow rates and settings for each balance valve per design within contract documents. Contractor shall document valve settings, flow rates and water temperatures in a report included in FPT checklists,and operation & maintenance manual at project closeout.
Include ball valve on inlet and outlet of each balance valve assembly installed.

DRAIN VALVES

Provide drain valves for complete drainage of all systems. Locations of drain valves include low points of piping systems, downstream of riser isolation valves, equipment locations specified or detailed, other locations required for drainage of systems and elsewhere as indicated.

All piping shall be fully drainable for winterization of buildings.

SPRING LOADED CHECK VALVES

Install a spring-loaded check valve in each circulating pump discharge line, each clearwater sump pump discharge line and elsewhere as indicated.

SWING CHECK VALVES

Install swing check valves in recirculation branch lines and elsewhere as indicated. Provide weighted swing check valves at sanitary sump pump discharges.

SAFETY RELIEF VALVES

Install relief valves on all pressure vessels and elsewhere as indicated. Inlet and outlet piping connecting to valves must be the same size as valve connections or larger. Pipe discharge to drain where indicated or to floor.

END OF SECTION

SECTION 22 05 29
HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
BASED ON DFD MASTER SPECIFICATION DATED 01/10/2025

P A R T 1 - G E N E R A L

SCOPE
This section includes specifications for supports of all plumbing equipment and materials as well as piping system anchors. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Quality Assurance
- Description
- Submittals
- Design Criteria

PART 2 - PRODUCTS
- Manufacturers
- Structural Supports
- Pipe Hangers and Supports
- Pipe Hanger Rods
- Strut Channels
- Beam Clamps
- Concrete Inserts
- Anchors

PART 3 - EXECUTION
- Installation
- Hanger and Support Spacing
- Anchors

RELATED WORK
Section 01 91 01– Commissioning Process
Section 03 30 00 - Concrete formwork and cast-in-place concrete for equipment pads.
Section 22 05 00 – Common Work Results for Plumbing
Section 22 07 00 - Plumbing Insulation for insulation protection at support devices.

REFERENCE
Applicable provisions of Division 1 shall govern work under this section.

REFERENCE STANDARDS
MSS SP-58 Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application and Installation

QUALITY ASSURANCE
Refer to Division 1, General Conditions, Equals and Substitutions.

DESCRIPTION

Provide all supporting devices as required for the installation of plumbing equipment and materials. All support and installation procedures are to conform to the latest requirements of the ANSI Code for building piping.

Support apparatus and material under all conditions of operation, variations in installed and operating weight of equipment and piping, to prevent excess stress, and allow for proper expansion and contraction.

Protect insulation at all hanger points; see Related Work above.

SUBMITTALS

Refer to Division 1, General Conditions, Submittals.

Schedule of all hanger and support devices indicating attachment methods and type of device for each pipe size and type of service.

All submittals are to comply with submission and content requirements specified with in specification section 01 91 01 or 01 91 02.

DESIGN CRITERIA

Materials and application of pipe hangers and supports shall be in accordance with MSS Standard Practice SP-58 unless noted otherwise.

Piping connected to pumps, compressors, or other rotating or reciprocating equipment is to have vibration isolation supports for a distance of one hundred pipe diameters or three supports away from the equipment, whichever is greater. Standard pipe hangers/supports as specified in this section are required beyond the 100 pipe diameter/3 support distance.

Piping supported by laying on the bottom chord of trusses will not be accepted.
Fasteners depending on soft lead for holding power or requiring powder actuation will not be accepted.

Provide nonmetallic separation between dissimilar metals such as copper piping and steel clamps/supports.

Use materials in air plenums that have a flame spread rating of 25 or less and smoke developed rating of 50 or less.

Allow sufficient space between adjacent pipes and ducts for insulation, valve operation, servicing and maintenance.

P A R T 2 - P R O D U C T S

MANUFACTURERS

Anvil, B-Line, FNW, HoldRite, Hydra-Zorb, nVent, Pate, Piping Technology, Roof Products & Systems or approved equal. Anvil and B-Line figure numbers are listed below, equivalent products by other manufacturers are acceptable.

STRUCTURAL SUPPORTS

Provide all supporting steel required for the installation of plumbing equipment and materials, whether or not it is specifically indicated or sized, including angles, channels, beams, etc. to suspend or floor support tanks and equipment. For equipment supports; clean and prime with one coat of Sherwin Williams Epo-Phen or approved equal. Finish coat with one coat of gray, low odor, high solids, water-based epoxy

coating equal to TNEMEC typoxy Series 27WB. Where exposed to weather, treat with corrosive atmosphere coatings.

PIPE HANGERS AND SUPPORTS

HANGERS FOR PIPE SIZES 1/2" THROUGH 2":
Carbon steel, adjustable swivel ring, MSS Type-10. B-Line B3170NF, Anvil 69 or 70.
Carbon steel, adjustable clevis, MSS Type-1. B-Line B3100, Anvil 65 or 260.
Carbon steel, adjustable vee clevis for continuous plastic piping support. B-Line 200V.

HANGERS FOR PIPE SIZES 2-1/2" AND LARGER:
Carbon steel, adjustable clevis, MSS Type-1. B-Line B3100, Anvil 260.

MULTIPLE OR TRAPEZE HANGERS:
Steel struts, channels, angles or beams with clamps, straps and guides as required to secure pipe and control movement.

WALL SUPPORT:
Carbon steel welded bracket with hanger, MSS Type-31. B-Line 3068 Anvil 194.

Threaded rod and hinged extension split pipe clamp, MSS Type-12. B-Line B-3198H, Anvil 138R.

Strut channels securely anchored to wall structure, with interlocking, split-type, bolt secured, galvanized pipe/tubing clamps. B-Line B-2000, Anvil AS 1200. When copper piping is being supported, B-Line BVT, Anvil AS 0080DN thru AS 0480D.

VERTICAL RISER SUPPORT:
Carbon steel riser clamp, copper plated or plastic coated when used with copper pipe, MSS Type-8. B-Line B3373/B3373CT/B3373CTC, Anvil 261/CT-121.

FIXURE SUPPLY SUPPORT:
Copper bonded steel brackets or galvanized steel brackets with nylon clamps. HoldRite, nVent.

COPPER PIPE SUPPORTS:
All supports, fasteners, clamps, etc. directly connected to copper piping shall be copper plated or polyvinylchloride coated. Where steel channels are used, provide isolation collar between supports/clamps/fasteners and copper piping.

PIPE HANGER RODS

STEEL HANGER RODS:
Threaded both ends, threaded one end, or continuous threaded, complete with adjusting and lock nuts.

Size rods for individual hangers and trapeze support as indicated in the following schedule.

Total weight of equipment, including valves, fittings, pipe, pipe content, and insulation, are not to exceed the limits indicated.

Maximum Load (Lbs.) (650°F Maximum Temp.)	Rod Diameter (inches)
730	3/8
1350	1/2
2160	5/8
3230	3/4

STRUT CHANNELS
12-gauge ASTM A1011 steel strut channels, fittings and hardware with electrodeposition epoxy or ASTM B633 pre-galvanized finish unless noted otherwise. Anvil-Strut, B-Line Strut, Fastenal, G Strut, Hilti, nVent Caddy, Unistrut.

BEAM CLAMPS
Malleable black iron clamp for attachment to beam flange to 0.62 inches thick with a retaining ring and threaded rod, hardened steel cup point set screw, MSS Type-19 & 23. B-Line B3036L/B3034, Anvil 86/92.

Forged steel jaw type clamp with a tie rod to lock clamp in place, MSS-Type 28 & 29. B-Line B3054, Anvil 228.

CONCRETE INSERTS
DRILLED FASTENERS:
Carbon steel drop-in type expansion anchors, screw anchors, vibration resistant, with ASTM B633 zinc plating. Use drill bit of same manufacturer as anchor. Fastenal, Hilti, Powers, Redhead.

Screw anchors may only be utilized for 3/8" steel hanger rods and below.

ANCHORS
Use welding steel shapes, plates, and bars to secure piping to the structure.

P A R T 3 - E X E C U T I O N

INSTALLATION
Size, apply and install supports and anchors in compliance with manufacturers recommendations.

Install supports to provide for free expansion of the piping system. Support all piping from the structure using concrete inserts, beam clamps, ceiling plates, wall brackets, or floor stands. Fasten ceiling plates and wall brackets securely to the structure and test to demonstrate the adequacy of the fastening.

Select and size hangers, supports and building attachments in accordance with MSS Standards and manufacturer's published load rating information.

Coordinate hanger and support installation to properly group piping of all trades.

Trim steel hanger rods to within one inch of the final lock nut position. Hanger and support cutoff burrs shall be removed and sharp edges ground smooth.

Where piping can be conveniently grouped to allow the use of trapeze type supports, use standard structural shapes for the supporting steel.

Size and install hangers and supports, except for riser clamps, for installation on the exterior of piping insulation. Where a vapor barrier is not required, hangers may be installed either on the exterior of pipe insulation or directly on piping.

Perform welding in accordance with standards of the American Welding Society. Clean surfaces of loose scale, rust, paint or other foreign matter and properly align before welding. Use wire brush on welds after welding. Welds shall show uniform section, smoothness of weld metal and freedom from porosity and clinkers. Where necessary to achieve smooth connections, joints shall be dressed smooth.

HANGER AND SUPPORT SPACING

Place a hanger within 12 inches of each horizontal elbow, valve, strainer, or similar piping specialty item. Where several pipes can be installed in parallel and at the same elevation, provide multiple or trapeze hangers.

Support riser piping independently of connected horizontal piping.

Adjust hangers to obtain the slope specified in the piping section of these specifications.

Space hangers for pipe as follows:

Pipe Material	Pipe Size	Max. Horiz. Spacing	Max. Vert. Spacing
Cast Iron	2" and larger	5'-0"	15'-0"
Copper	1/2" through 3/4"	5'-0"	10'-0"
Copper	1" through 1-1/4"	6'-0"	10'-0"
Copper	1-1/2" through 2-1/2"	8'-0"	10'-0"
Steel	1/2" through 1-1/4"	7'-0"	15'-0"
Steel	1-1/2" through 6"	10'-0"	15'-0"
Plastic	Drain and Vent	4'-0"	10'-0"
PEXa*	Tubing* 1/2" through 3/4”	6’-0”	4’-0”
PEXa*	Tubing* 1” through 1-1/2”	8’-0”	4’-0”

*PEXa Tubing shall be supported by PEXa metallic continuous pipe support channels with 50 LB cable ties directly around PEX-a tubing. PEXa tubing without continuous channel (at fittings) shall be supported no less than every 32”. Insulate over the continuous support channels and cable ties. Comply with manufacturers metallic continuous pipe support channel instructions.

ANCHORS

Install where indicated on the drawings and details. Where not specifically indicated, install anchors at ends of principal pipe runs and at intermediate points in pipe runs between expansion loops. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

END OF SECTION

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SECTION 22 07 00
PLUMBING INSULATION
BASED ON DFD MASTER SPECIFICATION DATED 01/10/25

PART 1 - GENERAL

SCOPE

This section includes insulation specifications for plumbing piping and equipment. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference Standards
- Quality Assurance
- Description
- Definitions
- Submittals
- Operation and Maintenance Data
- Environmental Requirements

PART 2 - PRODUCTS
- Materials
- Insulation
- Adhesives, Mastic, Sealants and Reinforcing Materials
- Jackets
- Insulation Inserts and Pipe Shields
- Accessories

PART 3 - EXECUTION
- Installation
- Protective Jacket Installation
- Piping, Valve and Fitting Insulation
- Pipe Insulation Schedule
- Construction Verification Items

RELATED WORK

Section 01 91 01– Commissioning Process
Section 22 05 00 – Common Work Results for Plumbing
Section 22 08 00 – Commissioning of Plumbing
Section 22 05 00 - Common Work Results for Plumbing
Section 22 11 00 – Facility Water Distribution
Section 22 13 00 - Facility Sanitary Sewerage
Section 22 05 29 - Hangers and Supports for Plumbing Piping and Equipment
Section 22 30 00 - Plumbing Equipment

REFERENCE

Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

ASTM B209 Aluminum and Aluminum Alloy Sheet and Plate

ASTM C165	Test Method for Compressive Properties of Thermal Insulations
ASTM C177	Heat Flux and Thermal Transmission Properties
ASTM C195	Mineral Fiber Thermal Insulation Cement
ASTM C302	Density of Preformed Pipe Insulation
ASTM C303	Density of Preformed Block Insulation
ASTM C449	Mineral Fiber Hydraulic Setting Thermal Insulation Cement
ASTM C518	Heat Flux and Thermal Transmission Properties
ASTM C534	Preformed Flexible Elastomeric Thermal Insulation
ASTM C547	Mineral Fiber Preformed Pipe Insulation
ASTM C553	Mineral Fiber Blanket and Felt Insulation
ASTM C591	Preformed Rigid Cellular Polyurethane Thermal Insulation
ASTM C612	Mineral Fiber Block and Board Thermal Insulation
ASTM C921	Properties of Jacketing Materials for Thermal Insulation
ASTM C1136	Flexible Low Permeance Vapor Retarders for Thermal Insulation
ASTM E84	Surface Burning Characteristics of Building Materials
MICA	National Commercial & Industrial Insulation Standards
NFPA 225	Surface Burning Characteristics of Building Materials
UL 723	Surface Burning Characteristics of Building Materials

QUALITY ASSURANCE

Substitution of Materials: Refer to Section GC - General Conditions of the Contract, Equals and Substitutions.

Label all insulating products delivered to the construction site with the manufacturer's name and description of materials.

Insulation systems shall be applied by experienced contractors. Within the past five (5) years, the contractor shall be able to document the successful completion of a minimum of three (3) projects of at least 50% of the size and similar scope of the work specified in this section.

DESCRIPTION

Furnish and install all insulating materials and accessories as specified or as required for a complete installation. The following types of insulation are specified in this section:

- Pipe Insulation
- Equipment Insulation

Install all insulation in accordance with the latest edition of MICA (Midwest Insulation Contractors Association) Standard and manufacturer's installation instructions. Exceptions to these standards will only be accepted where specifically modified in these specifications, or where prior written approval has been obtained from the DFD Project Representative.

DEFINITIONS

Concealed: shafts, furred spaces, space above finished ceilings, utility tunnels and crawl spaces. All other areas, including walk-through tunnels, shall be considered as exposed.

SUBMITTALS

Refer to Division 1, General Conditions, Submittals.

Submit a schedule of all insulating materials to be used on the project, including adhesives, fastening methods, fitting materials along with material safety data sheets and intended use of each material. Include manufacturer's technical data sheets indicating density, thermal characteristics, jacket type, and manufacturer's installation instructions. Include copies of MICA plates that are applicable to this project.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

ENVIRONMENTAL REQUIREMENTS
Do not store insulation materials on grade or where they are at risk of becoming wet. Do not install insulation products that have been exposed to water.

Protect installed insulation work with plastic sheeting to prevent water damage.

PART 2 – PRODUCTS

MATERIALS
Manufacturers: Armacell, Certainteed, Manson, Childers, Dow, Extol, Fibrex, Foster, Halstead, H.B. Fuller, Knauf, Owens-Corning, Rubatex, Johns-Manville, 3M VentureClad, Unifrax or approved equal.

Materials or accessories containing asbestos will not be accepted.

Use composite insulation systems (insulation, jackets, sealants, mastics, and adhesives) that have a flame spread rating of 25 or less and smoke developed rating of 50 or less, with the following exceptions:

Insulation which is not located in an air plenum may have a flame spread rating not over 25 and a smoke developed rating no higher than 450.

INSULATION
Insulating materials shall be fire retardant, moisture and mildew resistant, and vermin proof. Insulation shall be suitable to receive jackets, adhesives and coatings as indicated.

RIGID FIBERGLASS INSULATION:
Minimum nominal density of 3 lbs. per cu. ft., and thermal conductivity of not more than 0.23 at 75 degrees F, minimum compressive strength of 25 PSF at 10% deformation, rated for service to 450 degrees F.

SEMI-RIGID FIBERGLASS INSULATION:
Minimum nominal density of 3 lbs. per cu. ft., thermal conductivity of not more than 0.28 at 75 degrees F, minimum compressive strength of 125 PSF at 10% deformation, rated for service to 450 degrees F. Insulation fibers perpendicular to jacket and scored for wrapping cylindrical surfaces.

Jacket material shall be the same as jacket for adjacent insulation.

ADHESIVES, MASTIC, SEALANTS AND REINFORCING MATERIALS
Products shall be compatible with surfaces and materials on which they are applied and shall be suitable for use at operating temperatures of systems to which they are applied.

FIBERGLASS INSULATION ADHESIVE:
Must comply with ASTM C916, Type II: Foster 85-60, Childers CP-127, Duro Dyne SSG.

VAPOR RETARDING MASTIC:
For below ambient equipment/piping use water based, anti-fungal mastic that meets ASTM D 5590 with a 0 growth rating (AF) and a water vapor permeance that is less than 0.013 perms at 43 mils dry film thickness per ASTM E 96 Procedure B: Foster 30-80AF Vapor Safe Mastic or equal.

Anti-fungal mastic to be used in the following locations;
All locations

WEATHER BARRIER BREATHER MASTIC:
For above ambient equipment/piping use water-based mastic with a permeance greater than 1.0 perms at 1/16" dry film thickness per ASTM E96. Foster 46-50 Weatherite, Childers Vi-Cryl CP-10/CP-11, Vimasco WC-5, Knauf Insulation KI-700 or KI-705.

LAGGING ADHESIVE / COATINGS:
For all indoor applications used in conjunction with canvas/glass cloth: the coating must be anti-fungal and shall meet ASTM D 5590 with 0 growth rating (AF): Foster 30-36 AF Seal Fas, Childers CP-137 AF Chil-Seal.

Anti-fungal adhesive/coating to be used in the following locations;
All locations

REINFORCING MESH:
Use Foster 42-24 Mast A Fab, Childers Chil Glas #10 or Pittsburgh Corning PC 79.

INSULATION JOINT SEALANT:
Joint sealants to be non-shrinking and permanently flexible.
Used on all below ambient piping to prevent moisture ingress.
For Elastomeric use Armaflex 520 or equal.

JACKETS
PVC FITTING COVERS AND JACKETS (PFJ):
White PVC film, gloss finish one side, semi-gloss other side, FS LP-535D, Composition A, Type II, Grade GU. Ultraviolet inhibited indoor/outdoor grade to be used where exposed to high humidity, ultraviolet radiation, in kitchens or food processing areas or installed outdoors. Jacket thickness to be minimum .02" indoors/.03" outdoors for piping 12" and smaller, .03" indoors/.04" outdoors for piping 15" and larger.

ALL SERVICE JACKETS (ASJ):
Heavy-duty, fire-retardant material with polymer coated white kraft reinforced foil vapor retarding jacket, factory applied to insulation with a self-sealing pressure sensitive adhesive lap, maximum permeance of .02 perms and minimum beach puncture resistance of 50 units.

PROTECTIVE METAL JACKETS (PMJ):
0.016 inch thick aluminum or 0.010 inch thick stainless steel with safety edge for indoor installations and 0.024 inch thick aluminum or 0.016 inch thick stainless steel with safety edge for outdoor installations.

SELF-ADHERING JACKETS (SAJ):
5-ply, self-adhering multiple laminated waterproofing material with reflective aluminum foil, high density polymer films and cold weather acrylic adhesive providing zero (0.0) permeance vapor retarding jacket. Minimum 6 mils material thickness, 25lb puncture resistance when tested in accordance with ASTM D1000 and flame spread/smoke developed rating of 10/20 when tested in accordance with UL 723.

Vapor retarding tape shall be specifically designed and manufactured for use with the self-adhering jacket specified above. Tape shall be provided by the same manufacturer that provides jacketing. Vapor retarding tapes used with self-adhering jackets shall have a maximum permeance of 0.0 perms.

FABRIC REINFORCED MASTIC JACKETS (FMJ):
Glass fiber reinforcing fabric imbedded in weather barrier mastic as per manufacturer's recommended procedure for 2 coat application.

VAPOR RETARDING JACKETS (VRJ):
Polyvinylidene chloride (PVDC) vapor retarding jacket material with minimum 6 mils material thickness and maximum permeance of 0.01 perms. Material shall not support the growth of mold or mildew. Dow Saran or equivalent.

Vapor retarding tape shall be specifically designed and manufactured for use with the vapor retarding jacket specified above. Tape shall be provided by the same manufacturer that provides jacketing. Vapor retarding tapes used with vapor retarding jackets shall have a maximum permeance of 0.01 perms.

INSULATION INSERTS AND PIPE SHIELDS

Manufacturers: Anvil, Armacell, B-Line, Buckaroo, ICA Hamfab, Pipe Shields, KB Enterprises SnapITZ, Value Engineered Products

Construct pre-engineered manufactured inserts with high compressive strength polyisocyanurate, phenolic or calcium silicate insulation. Use polyisocyanurate or phenolic on low temperature systems. Provide galvanized steel or premanufactured polypropylene shield. Design for applied load in compliance with MSS SP-58. Insert and shield to be minimum 180-degree coverage on bottom of supported piping and full 360 degree coverage on clamped piping. On roller mounted piping and piping designed to slide on support, provide additional load distribution steel plate. Buckaroos Tru-Balance, KB Enterprises SnapITZ, Value Engineered Products.

Premanufactured polypropylene shields, strut/trapeze/clevis mount, UV resistant, paintable, UL-723 classified, rated for -40 to 178 degrees F. Anvil Shield, Armacell Insuguard, B-Line Snap N Shield.

Where contractor proposes shop/site fabricated inserts and shields, submit schedule of materials, thicknesses, gauges and lengths for each pipe size to demonstrate equivalency to pre-engineered manufactured product described above.

Precompressed 18# density molded fiberglass blocks, Buckaroo, ICA Hamfab or equal, of same thickness as adjacent insulation may be substituted for polyisocyanurate, phenolic or calcium silicate inserts. Select width, length and number of blocks to support applied load without deformation of insulation. Submit shield schedule to demonstrate equivalency to pre-engineered manufactured product described above.

Wood blocks will not be accepted.

ACCESSORIES

All products shall be compatible with surfaces and materials on which they are applied and be suitable for use at operating temperatures of the systems to which they are applied.

Adhesives, sealants, and protective finishes shall be as recommended by insulation manufacturer for applications specified.

Insulation bands to be 3/4 inch wide, constructed of aluminum or stainless steel. Minimum thickness to be .015 inch for aluminum and .010 inch for stainless steel.

Tack fasteners to be stainless steel ring grooved shank tacks.

Staples to be clinch style.

Insulating cement to be ANSI/ASTM C195, hydraulic setting mineral wool.

Finishing cement to be ASTM C449.

Fibrous glass or canvas fabric reinforcing shall have a minimum untreated weight of 6 oz./sq. yd.

Bedding compounds to be non-shrinking and permanently flexible.

Vapor barrier coatings to be non-flammable, fire resistant, polymeric resin.

Fungicidal water base coating (Foster 40-20 or equal) to be compatible with vapor barrier coating.

PART 3 - EXECUTION

INSTALLATION

Install insulation, jackets and accessories in accordance with manufacturer's instructions and under ambient temperatures and conditions recommended by manufacturer. Surfaces to be insulated must be clean and dry.

Do not insulate systems or equipment which are specified to be pressure tested or inspected, until testing, inspection and any necessary repairs have been successfully completed.

Install insulation with smooth and even surfaces. Poorly fitted joints or use of filler in voids will not be accepted. Cover and seal exposed insulation when insulation is terminated, no raw fiberglass insulation is allowed. Provide neat and coated terminations at all nameplates, uninsulated fittings, or at other locations where insulation terminates. Install with longitudinal joints facing wall or ceiling.

Install fabric reinforcing without wrinkles. Overlap seams a minimum of 2 inches.

Use full-length material (as delivered from manufacturer) wherever possible. Scrap piecing of insulation or pieces cut undersize and stretched to fit will not be accepted.

Insulation shall be continuous through walls, ceiling or floor openings and through sleeves except where firestop or fire safing materials are required. Vapor retarding jacket shall be maintained continuously through all penetrations.

Provide a continuous unbroken moisture vapor retarding jacket on insulation applied to systems noted below. Attachments to cold surfaces shall be insulated and vapor sealed to prevent condensation.

Provide a complete vapor retarding jacket for insulation on the following systems:

- Cold water (potable and non-potable, softened and unsoftened)
- Equipment or piping with a surface temperature below 65 degrees F

PROTECTIVE JACKET INSTALLATION

PVC FITTING COVERS AND JACKETS (PFJ):
Lap seams and joints a minimum of 2 inches and continuously seal PVC with welding solvent recommended by jacket manufacturer. Secure PVC fittings with welding solvent on seams and joints. Lap slip joint ends 4" without fasteners where required to absorb expansion and contraction. For sections where vapor retarding jacket is not required, and jacket requires routine removal, tack fasteners may be used. For systems requiring a vapor retarding jacket, apply a 1-1/2" band of mastic over ends, throat, seams and penetrations.

ALL SERVICE JACKETS (ASJ) and FOIL SCRIM KRAFT JACKETS (FSK):
Install according to manufacturer's recommendations using factory supplied lap seals and butt strip seals. In addition to factory adhesive, secure lap seals and tape with clinch type staples.

PROTECTIVE METAL JACKET (PMJ):
Lap seams a minimum of 2 inches. Secure with metal bands for end to end joints, and rivets or sheet metal screws for longitudinal joints. Rivets, screws, and bands to be constructed of the same material as the jacket. For piping with VRJ jacket, provide metal bands at 12" centers, rivets and screws cannot be used. Locate longitudinal seams on the side (3:00 O'clock) for exterior applications. Seal laps with 1/8" bead of metal jacketing sealant to prevent water entry.

SELF-ADHERING JACKETS (SAJ):
Install according to manufacturer's recommendations. Cut allowing minimum 4" overlap on ends and 6" on longitudinal joints. Align parallel to surface. Remove release paper and press flat to surface to avoid wrinkles. Rub entire surface with plastic squeegee for full adhesion and sealing at joint overlaps. On exterior applications, provide a bead of compatible caulk along exposed edges.

Piping with self-adhering (SAJ) jackets shall have elbows, fittings, valves and butt joints wrapped with 2 layers of vapor retarding tape. Piping with a PVC jacket (PFJ) installed over the self-adhering (SAJ) jacket may be provided with a single, lapped layer of vapor retarding tape for elbows, fittings and valves under the PVC jacket. Vapor retarding tape shall be compatible with the jacket material used.

FABRIC REINFORCED MASTIC JACKETS (FMJ):
Glass fiber fabric shall be fitted without wrinkles. Glass fiber fabric shall be sized immediately upon application with lagging adhesive and shall be capable of drying within 6 hrs. Apply adhesive and coating in accordance with manufacturer's recommendations. All seams shall overlap not less than 2".

VAPOR RETARDING JACKETS (VRJ):
Piping with vapor retarding jackets (VRJ) shall have elbows, fittings, valves and butt joints wrapped with 2 layers of vapor retarding tape. For piping without a (PFJ) jacket, wrap jacket with 1" wide vapor retarding tape at 12" centers with a 25% overlap. Piping with a PVC jacket (PFJ) installed over the vapor retarding jackets (VRJ) may be provided with a single, lapped layer of vapor retarding tape for elbows, fittings and valves under the PVC jacket. Vapor retarding tape shall be compatible with the jacket material used.

PIPING, VALVE, AND FITTING INSULATION

GENERAL:
Install insulation with butt joints and longitudinal seams closed tightly. Provide minimum 2" lap on jacket seams and 3" tape on butt joints, firmly cemented with lap adhesive unless noted otherwise. Additionally secure with clinch style staples along seams and butt joints.

Water supply piping insulation shall be continuous throughout the building and installed adjacent to and within building walls to a point directly behind the fixture that is being supplied.

On systems requiring a vapor retarding jacket, seal off all raw ends of insulation and butt joints with vapor retarding mastic at intervals of not more than 20 feet on piping to create a vapor dam. Also provide a vapor dam on each side of valves, unions, and tees. Coat staples, longitudinal and transverse seams with vapor retarding mastic and on systems requiring vapor retarding jacket, coat insulated elbows, fittings, and valves with vapor retarding mastic.

Install insulation continuous through pipe hangers and supports with hangers and supports on the exterior of insulation. Where a vapor barrier is not required, hangers and supports may be attached directly to piping with insulation completely covering hanger or support and jacket sealed at support rod penetration. Where riser clamps are required to be attached directly to piping requiring vapor retarding jacket, extend insulation and vapor barrier jacketing/coating around riser clamp. Add PEX-a insulation note.

INSULATION INSERTS AND PIPE SHIELDS:
Provide high density insulation inserts between pipe and shield and pipe shields at all hanger and support locations. Quantity and placement of inserts shall be according to the manufacturer's installation instructions; however, the inserts shall be no less than 12" in length. Inserts shall be of equal thickness to the adjacent insulation and shall be vapor sealed as required for system.

Inserts may be omitted on 3/4" and smaller copper piping provided 12" long 22-gauge pipe shields are used.

PIPING PROTECTIVE JACKETS:
In addition to the jackets specified in the pipe insulation schedule below, the following protective jackets are required:

Provide a protective PVC jacket (PFJ) for the following insulated piping:
- Exposed piping in locker/shower rooms/restrooms
- Exposed piping in Mechanical rooms below 7'-0".
- Exterior piping

Provide a protective self-adhering (SAJ) jacket for the following insulated piping:

Provide a protective covering of 2 coats of vapor retarding mastic with fibrous glass or canvas fabric reinforcing (FMJ) for the following insulated piping:

PIPE INSULATION SCHEDULE:

Provide insulation on new and existing remodeled piping as indicated in the following schedule:

SERVICE	INSULATION	JACKET	INSULATION THICKNESS BY PIPE SIZE				
			< 1"	1" to < 1-1/2"	1-1/2" to < 4"	4" to < 8"	8" and Larger
Hot Water Supply and Return, Potable & Non-Potable, Softened & Unsoftened (100-140°F)	Rigid Fiberglass	ASJ	1"	1"	1.5"	1.5"	1.5"
Tempered Water Supply and Return (80-100°F)	Rigid Fiberglass	ASJ	0.5"	0.5"	1"	1"	
Cold Water, Potable & Non-Potable, Softened & Unsoftened	Rigid Fiberglass	ASJ	0.5"	0.5"	1"	1"	1"

The following piping and fittings are not to be insulated:

- Chrome plated exposed supplies and stops (except where specifically noted).
- Water hammer arrestors.
- Piping unions and flanges for systems not requiring a vapor barrier.

EQUIPMENT INSULATION

Do not insulate over equipment access manholes, fittings, nameplates or ASME stamps. Bevel and seal insulation at these locations.

SEMI-RIGID FIBERGLASS:

Apply insulation to equipment shells using weld pins, bonding adhesive, banded and wired in place. Fill all joints, seams and depressions with insulating cement to a smooth, even surface. Cover with reinforcing fabric and 2 coats of mastic. . Use vapor barrier mastic on systems requiring a vapor barrier.

CONSTRUCTION VERIFICATION ITEMS

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 22 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

END OF SECTION

SECTION 22 08 00
COMMISSIONING OF PLUMBING
BASED ON DFD MASTER SPECIFICATION DATED 12/1/16

P A R T 1 - G E N E R A L

SCOPE

This section includes commissioning forms for construction verification and functional performance testing. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Submittals

PART 2 - PRODUCTS
- (Not Used)

PART 3 – EXECUTION
- Commissioning Forms
  - CV-22 07 00 Plumbing Insulation
  - CV-22 11 00 Facility Water Distribution
  - CV-22 13 00 Facility Sanitary Sewerage
  - CV-22 30 00 Expansion Tanks
  - CV-22 30 00 Inline Centrifugal Pumps
  - CV-22 30 00 Storage Tanks
  - CV-22 30 00 Water Heaters (Electric)
  - CV-22 30 00 Water Heaters (Gas)
  - CV-22 42 00 Commercial Plumbing Fixtures
  - FPT-22 30 00 Inline Centrifugal Pump
  - FPT-22 30 00 Water Heaters

RELATED WORK

Section 01 91 01– Commissioning Process

REFERENCE

Applicable provisions of Division 1 shall govern work under this section.

SUBMITTALS

Reference the General Conditions of the Contract for submittal requirements.

Reference Section 01 91 01 Commissioning Process for Construction Verification Checklist and Functional Performance Test submittal requirements.

P A R T 2 – P RO D U C T S

(Not Used)

P A R T 3 – E X E C U T I O N

COMMISSIONING FORMS

Commissioning forms are to be filled in as work progresses by the individuals responsible for installation and shall be completed for each installation phase.

Provide a description of the work completed since the last entry, the percentage of the total work completed for the system for that area and the step of installation or finalization.

Circle Yes or No for each commissioning form item. If the information requested for an item does not apply to the given stage of installation for the system, list it as "N/A". Explain all discrepancies, negative responses or N/A responses in the negative responses section.

Once the work is 100% complete and the responses to each item are complete and resolved for a given commissioning forms group, mark as complete, initial and date in the spaces provided.

Provide copies of the commissioning forms to the commissioning agent 2 days prior to construction progress meetings.

CV-22 07 00 – Plumbing Insulation

Equipment Identification/Tag: _____
Location: _____

PIPING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)									
				1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:		_____			DATE:		_____		

Question Details

1) Piping clean, dry, pressure tested and approved prior to application of insulation.
2) Type and thickness of insulation complies with listed specification requirements for given system and pipe size.
3) Insulation installed with smooth and even surfaces, without the use of filler in voids.
4) Butt joints and longitudinal seams closed tightly with a minimum of 2” lap on jacket seams and 2” tape on butt joints.
5) Staples along seams and butt joints provided with vapor barrier mastic provided for staples on systems requiring vapor barrier.
6) **F**ull-length material used as possible, with no scrap piecing or stretching of insulation utilized.
7) Insulation continuous through sleeves and openings with vapor barriers continuous through all penetrations.
8) Complete vapor barrier provided for all cold water, storm water and piping systems with surface temperatures below 65ºF.
9) Exposed fiberglass insulation covered and sealed at all permanent terminations and at end of work day.
10) Piping and direction of flow is labeled per specification requirements.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

B) VALVE, FITTING & EQUIPMENT INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)					
				1)	2)	3)	4)	5)	6)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:		_____		DATE:	_____

Question Details

1) Fittings, valves, unions, flanges, couplings and specialties insulated with factory molded or built up insulation of the same thickness as adjoining insulation.
2) Insulated fittings, valves, unions, flanges, couplings and specialties covered with fabric reinforcing and mastic or where temperatures do not exceed 150°F, PVC fitting covers.
3) PVC fitting covers secured with tack fasteners and 1-1/2” band of mastic over ends, throat, seams or penetrations or for systems requiring vapor barrier, vapor barrier mastic.
4) Equipment access manholes, fittings, nameplates or ASME stamps left uninsulated with insulation beveled and sealed at these locations.
5) Equipment insulation installed with smooth and even surfaces per specifications requirements.
6) No insulation provided at chrome plated exposed supplies and stops (except where specifically noted), water hammer arrestors, and piping unions and flanges for piping systems not requiring a vapor barrier.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

Construction Verification Checklist

22 10 13 – Facility Fuel Piping

CV-22 11 00 – Facility Water Distribution

Equipment Identification/Tag: _____
Location: _____

A) PRE-INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)		
				1)	2)	3)
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:	_____	DATE: _____

Question Details

1) All piping, valves, etc. are clean and free of damage prior to installation.
2) Temporary protective coating is provided on cast iron and steel valves during storage.
3) Temporary end caps are provided on piping and fittings until installation.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

B) GENERAL PIPING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)									
				1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:		_____			DATE:		_____		

Question Details

1) Piping is free to expand and contract without noise or damage to hangers, joints, or the building.
2) Piping is installed in a manner to ensure that insulation will not contact adjacent surfaces.
3) Piping is installed with sufficient pitch and arranged in a manner to ensure drainage of entire system.
4) Changes in pipe sizes are made with the proper size reducing fittings, reducing elbow or reducing tees, and no bushings are utilized.
5) Connections between dissimilar pipe materials are made with dielectric fittings.
6) Pipe hanger spacing complies with specification requirements.
7) All equipment requiring maintenance is accessible (valves, strainers, etc.).
8) Piping allows access to equipment that is part of this system or another system.
9) Water piping not installed within exterior walls.
10) Open pipe ends capped at completion of work day.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

C) UNDERGROUND PIPING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)						
				1)	2)	3)	4)	5)	6)	7)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS: _____					DATE: _____	

Question Details

1) Exterior water piping installed below predicted frost level in accordance with SPS Table 382.30-6, but in no case less than 6' bury depth to top of pipe.
2) Minimum of 8' horizontal distance maintained between 2-1/2" and larger water piping and sanitary sewer piping.
3) Minimum of 30" horizontal and 12" vertical distance, water on top, maintained between 2" and smaller water piping and sanitary sewer piping.
4) Where water piping crosses a sanitary sewer, minimum 18" vertical clearance add waterproof PVC water pipe sleeve (reference sanitary sewer materials) sealed at both ends for distance of 10' from sewer in both directions provided.
5) Thrust restraints provided for 3" and larger exterior water piping joints, hydrants, caps, plugs, fittings and bends of 22-1/2 degrees or more.
6) Excavation and backfill meet specification requirements.
7) Underground warning tape installed 6"-12" below finished grade above all exterior below ground piping.
8) Pipe and fittings encased in a polyethylene wrap per specification.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

D) VALVE & FITTING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)						
				1)	2)	3)	4)	5)	6)	7)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:		_____			DATE:	_____

Question Details

1) All valves are in a horizontal or upright vertical position (not inverted) with handles in an accessible position.
2) Valve handle extensions are provided where needed per the specification.
3) Drainage valves provided at all low points and downstream of riser isolation valves.
4) Isolation valves provided at all equipment connections, main branches and sub-branches, “T” connections, and as necessary for repairing the system as specified in contract documents.
5) Riser shutoff valve and a capped hose thread drain valve at the bottom of each riser provided.
6) All strainers in piping system have ball valves installed at the tapped screen retainer.
7) Yard and wall hydrants installed with discharge above minimum grade clearance requirements noted in specifications.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

E) TESTING CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)							
				1)	2)	3)	4)	5)	6)	7)	8)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:		_____			DATE:		_____

Question Details

1) Piping tested utilizing water at specified pressure and duration as per specification.
2) All leaks identified during testing have been repaired and test re-done until satisfactory conditions are accomplished.
3) Test conducted with all piping of tested system or section visible during testing.
4) Proceeding system chlorination, all outlets flushed for a minimum of 1 minute with clean water until water runs clear.
5) Following initial flush system filled with water and chlorine at 50 PPM and allowed to stand for 24 hours, or system filled and with a water solution containing at least 200 PPM of chlorine and allowed to stand for 3 hours.
6) Following specification prescribed stand times for chlorine treatment system flushed until chlorine levels are at source water levels.
7) 24 hours after final flushing, water samples of the number and location specified by the Engineer taken for lab testing and results show the absence of coliform bacteria.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

F) FINALIZATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)			
				1)	2)	3)	4)
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:		DATE:	

Question Details

1) All exposed piping which passes through a wall, ceiling or floor is provided with escutcheon plates.
2) Piping labels and direction of flow is provided per specification requirements.
3) All penetrations through fire rated wall assemblies have been sealed per specification requirements.
4) All penetrations through non-rated wall assemblies have been sealed per specification requirements for given space type.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

CV-22 13 00 – Facility Sanitary Sewerage

Equipment Identification/Tag: _____
Location: _____

A) PRE-INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)		
				1)	2)	3)
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:	_____	DATE: _____

Question Details

1) All piping meets ASTM standards and specifications.
2) All piping, etc. is clean and free of damage prior to installation.
3) Temporary protective covering is provided on pipe and fittings during storage.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

B) GENERAL PIPING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials		1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
					YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
					YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
					YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
					YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
					YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
					YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
					YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
					YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
					YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
					YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:					

Question Details

1) Piping is free to expand and contract without noise or damage to hangers, joints, or the building.
2) Piping is installed with sufficient pitch and arranged in a manner to ensure drainage of entire system.
3) Interior piping pitched to drain at minimum slope of 1/4" per foot where possible and in no case less than 1/8" per foot for piping 3" and larger.
4) Changes in pipe sizes are made with the proper size reducing fittings, reducing elbow or reducing tees, and no bushings are utilized.
5) Pipe hanger spacing complies with specification requirements.
6) All equipment requiring maintenance is accessible (valves, strainers, etc.).
7) Drains and cleanouts level and plumb to finished floor, roof or finished wall.
8) Minimum clearance of 18” provided for all cleanouts and backwater valves.
9) Open pipe ends capped at completion of work day.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

C) UNDERGROUND PIPING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)					
				1)	2)	3)	4)	5)	6)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:				DATE:	

Question Details

1) Exterior piping installed below predicted frost level, but in no case less than 5' bury depth to top of pipe.
2) Minimum of 8' horizontal distance maintained between 2-1/2" and larger water piping and sanitary sewer piping.
3) Minimum of 30" horizontal and 12" vertical distance, water on top, maintained between 2" and smaller water piping and sanitary sewer piping.
4) Where water piping crosses a sanitary sewer, minimum 18" vertical clearance and waterproof PVC water pipe sleeve (reference sanitary sewer materials) sealed at both ends for distance of 10' from sewer in both directions provided.
5) Excavation and backfill procedures meet specification requirements.
6) Piping bedding and backfill materials meet specification requirements.
7) Underground warning tape installed 6"-12" below finished grade above all exterior below ground piping.
8) Non-metallic piping has tracer wire installed per Wisconsin Administrative Plumbing Codes.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

D) TESTING & FINALIZATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)							
				1)	2)	3)	4)	5)	6)	7)	8)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:		

Question Details

1) Piping tested utilizing water at specified pressure and duration as per specification for given piping system type.
2) All leaks identified during testing have been repaired and test re-done until satisfactory conditions are accomplished.
3) Test conducted with all piping of tested system or section visible during testing.
4) Entire testing procedure witnessed by DFD Representative per the specifications.
5) Piping inlets (floor drains, hub drains, mop basins, fixtures, etc.) flushed with high flow of water at completion of project to demonstrate full flow capacity.
6) Blockages removed and necessary repairs made where flow is found to be impeded during flushing test.
7) Piping identification and direction of flow is provided per specification requirements.
8) All penetrations through fire rated wall assemblies have been sealed per specification requirements.
9) All penetrations through non-rated wall assemblies have been sealed per specification requirements for given space type.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

22 30 00 – Expansion Tanks

Equipment Identification/Tag: _____
Location: _____

Group/Item	Group/Task Description			Submitted	Delivered
A	*MODEL VERIFICATION*				
1	Manufacturer				
2	Model				
3	Serial Number				
4	Capacity (gallons).				
5	Maximum pressure (psi).				
6	Tank suitable for us with potable water.				
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
B	*PHYSICAL CHECKS*				
1	Unit is free from physical damage.			YES	NO
2	Openings are sealed with plastic plugs.			YES	NO
3	All components present.			YES	NO
4	Installation and startup manual provided.			YES	NO
5	Unit tags affixed.			YES	NO
6	Manufacturer's ratings readable/accurate			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
C	*INSTALLATION*				
1	Unit secured as required by manufacturer and specifications.			YES	NO
2	Unit support is independent of adjacent piping.			YES	NO
3	Adequate clearance around unit for service.			YES	NO
4	All components accessible for maintenance.			YES	NO
5	Unit labeled and is easy to see.			YES	NO
6	Unit charged to correct operating pressure per contract documents.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
D	*PIPING*				
1	All piping components have been installed (in the correct order) as required by contract document or manufacturer.			YES	NO
2	Piping arranged for ease of unit removal.			YES	NO
3	Piping supported as required by specifications.			YES	NO
4	Unit connected to water supply and drain piping using unions or flanges and isolation valves.			YES	NO
5	Piping is clean.			YES	NO
6	Dielectric fittings installed to isolate dissimilar pipe materials.			YES	NO
7	Piping and valves properly checked and free of leaks.			YES	NO
8	Piping insulation is complete and installed as per specifications.			YES	NO
9	All valves and test ports are easily accessible.			YES	NO
10	Valve tags attached.			YES	NO
11	Drain valve provided.				
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
E	*MECHANICAL STARTUP*				
1	System flushed, filled, and air purged.			YES	NO
2	Unit has been charged to pressure specified by drawings and application.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

22 30 00 – Inline Centrifugal Pumps

Equipment Identification/Tag: _____
Location: _____

Group/Item	Group/Task Description	Submitted	Delivered
A	*MODEL VERIFICATION*		
1	Manufacturer		
2	Model		
3	Serial Number		
4	Pump Type		
5	Inlet / Outlet Size (in)	/	/
6	Impeller Diameter (in)		
7	Capacity / Head (gpm / ft w.g.)	/	/
8	Motor Speed / Power (rpm / hp)	/	/
9	Voltage / Phase / Frequency (V / - /Hz)	/ /	/ /
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____

Group/Item	Group/Task Description	Response	
B	*PHYSICAL CHECKS*		
1	Unit is free from physical damage.	YES	NO
2	Openings are sealed with plastic.	YES	NO
3	All components present.	YES	NO
4	Installation and startup manual provided.	YES	NO
5	Unit tags affixed.	YES	NO
6	Manufacturer's ratings readable/accurate	YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____
C	*INSTALLATION*		
1	Unit secured as required by manufacturer and specifications.	YES	NO
2	Equipment location coordinated with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances.	YES	NO
3	Adequate clearance around unit for service.	YES	NO
4	All components accessible for maintenance.	YES	NO
5	Unit labeled and is easy to see.	YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____
D	*WATER PIPING*		
1	All piping components have been installed (in the correct order) as required by contract document or manufacturer.	YES	NO
2	Piping arranged for ease of unit removal.	YES	NO
3	Piping supported as required by specifications.	YES	NO
4	Piping is clean.	YES	NO
5	Unit connected to water system return piping using unions or flanges and isolation valves.	YES	NO
6	Dielectric fittings installed to isolate dissimilar pipe materials.	YES	NO
7	Piping and valves properly checked and free of leaks.	YES	NO
8	Thermometers and pressure gauges supplied on supply and return lines.	YES	NO
9	Piping insulation is complete and installed as per specifications.	YES	NO
10	All valves and test ports are easily accessible.	YES	NO
11	Valve tags attached.	YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____
E	*ELECTRICAL*		

Group/Item	Group/Task Description			Response	
1	Local disconnect installed in accessible and visible location.			YES	NO
2	Each motor terminal box is connected with a minimum 12", maximum 36" piece of flexible conduit to a fixed junction box.			YES	NO
3	Motor rotation in the proper direction.			YES	NO
4	All electrical connections are tight.			YES	NO
5	All electrical components are grounded.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
F	*CONTROLS INSTALLATION (if applicable)*				
1	Remote start and stop wiring installed and communication verified.			YES	NO
2	Remote status wiring installed and communication verified.			YES	NO
3	Aqua-stat wiring installed and communication verified.			YES	NO
4	Timer wiring installed.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
G	*MECHANICAL STARTUP*				
1	Unit checked, aligned, and certified prior to startup and report submitted.			YES	NO
2	Unit and motor lubricated before startup.			YES	NO
3	Pump shaft rotates easily with power turned off.			YES	NO
4	System flushed, filled, and air purged.			YES	NO
5	System starts and runs without any unusual noise or vibration.			YES	NO
6	Manufacturer's startup checklist completed and attached.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
H	*CONTROLS STARTUP (if applicable)*				
1	Aqua-stat temperature set point set and verified.			YES	NO
2	Lead/lag sequence verified and acceptable.			YES	NO
3	Timer schedule programmed and operation verified.			YES	NO
4	Control wiring labeled per specification requirements.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-22 30 00 – Water Heaters (Electric)

Equipment Identification/Tag: _____
Location: _____

Group/Item	Group/Task Description			Submitted	Delivered
A	*MODEL VERIFICATION*				
1	Manufacturer				
2	Model				
3	Serial Number				
4	Heating Input (kW)				
5	Voltage / Phase / Frequency (V / - / Hz)				
6	Storage Capacity (gal.)				
7	Recovery capacity at 100 deg. F rise (gph)				
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
B	*PHYSICAL CHECKS*				
1	Unit is free from physical damage.			YES	NO
2	Water and gas openings are sealed with plastic plugs.			YES	NO
3	All components present.			YES	NO
4	Installation and startup manual provided.			YES	NO
5	Unit tags affixed.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
C	*INSTALLATION*				
1	Unit secured as required by manufacturer and specifications.			YES	NO
2	Equipment location coordinated with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances.			YES	NO
3	Unit is set on concrete housekeeping pad and is level (commercial units ONLY).			YES	NO
4	Adequate clearance around unit for service.			YES	NO
5	All components accessible for maintenance.			YES	NO
6	Drain pan installed and piped to an adequate drain.			YES	NO
7	Proper clearances from combustible surfaces maintained per manufacturer's instructions and applicable codes.			YES	NO
8	Unit labeled and is easy to see.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
D	*WATER PIPING*				
1	All piping components have been installed (in the correct order) as required by contract document or manufacturer.			YES	NO
2	Piping arranged for ease of unit removal.			YES	NO
3	Piping supported as required by specifications.			YES	NO
4	Piping is clean.			YES	NO
5	Unit connected to water supply and return/make-up piping using unions or flanges and isolation valves.			YES	NO
6	Dielectric fittings installed to isolate dissimilar pipe materials.			YES	NO
7	Piping and valves properly checked and free of leaks.			YES	NO
8	Thermometers and pressure gauges supplied on supply and return lines.			YES	NO
9	Piping insulation is complete and installed as per specifications.			YES	NO
10	All valves and test ports are easily accessible.			YES	NO
11	Valve tags attached.			YES	NO

Group/Item	Group/Task Description			Response	
12	Pressure and temperature relief valve(s) for correct pressure and temperature installed.			YES	NO
13	Pressure and temperature relief valve(s) piped with sufficient pipe diameter to drain designed for boiling water.			YES	NO
14	Drain valve installed.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
E	*ELECTRICAL*				
1	Local disconnect installed in accessible and visible location.			YES	NO
2	All electrical connections are tight.			YES	NO
3	All electrical components are grounded.				
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
F	*MECHANICAL STARTUP*				
1	System flushed, filled, and air purged.			YES	NO
2	Temperature setting adjusted to correct temperature per contract documents.			YES	NO
3	Pressure and temperature relief valve(s) set to proper pressure and temperature and manually checked for functionality.			YES	NO
4	Manufacturer's startup checklist completed and attached.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-22 30 00 – Water Heaters (Gas)

Equipment Identification/Tag: _____
Location: _____

Group/Item	Group/Task Description			Submitted	Delivered
A	*MODEL VERIFICATION*				
1	Manufacturer				
2	Model				
3	Serial Number				
4	Heating Input / Output (MBH / MBH)				
5	Voltage / Phase / Frequency (V / - / Hz)			/ /	/ /
6	Storage Capacity (gal.)				
7	Recovery capacity at 100 deg. F rise (gph)				
8	Fuel Type				
9	Gas Inlet Pressure (psig)				
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
B	*PHYSICAL CHECKS*				
1	Unit is free from physical damage.			YES	NO
2	The water and gas openings are sealed with plastic plugs.			YES	NO
3	All components present.			YES	NO
4	Installation and startup manual provided.			YES	NO
5	Unit tags affixed.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
C	*INSTALLATION*				
1	Unit secured as required by manufacturer and specifications.			YES	NO
2	Equipment location coordinated with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances.			YES	NO
3	Unit is set on concrete housekeeping pad and is level (commercial units ONLY).			YES	NO
4	Adequate clearance around unit for service.			YES	NO
5	All components accessible for maintenance.			YES	NO
6	Drain pan installed and piped to an adequate drain.			YES	NO
7	Proper clearances from combustible surfaces maintained per manufacturer's instructions and applicable codes.			YES	NO
8	Unit labeled and is easy to see.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
D	*VENTILATION AND COMBUSTION AIR SUPPLY*				
1	Sufficient fresh air supply for proper unit operation.			YES	NO
2	Fresh air not taken from areas that contain negative pressure producing devices.			YES	NO
3	Fresh air supply free of corrosive elements and flammable vapors.			YES	NO
4	Fresh air openings located correctly with consideration given to the blocking effect of louvers and grilles.			YES	NO
5	Overall ductwork length and restrictions comply with manufacturer requirements.			YES	NO
6	Ductwork is the same cross-sectional area as openings.			YES	NO
7	All ductwork is properly sealed and sloped per manufacturer specifications.			YES	NO
8	Vertical gas vents terminate with a listed cap or other roof assembly and are installed according to their manufacturer's instructions.			YES	NO

Construction Verification Checklist
22 30 00 – Plumbing Equipment

Group/Item	Group/Task Description			Response	
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
E	*VENT PIPE SYSTEM*				
1	Draft hood for atmospheric burners properly installed.			YES	NO
2	Vent connectors securely fastened with screws and supported properly to maintain 6-inch clearance.			YES	NO
3	Vent connector made of approved material and sloped correctly.			YES	NO
4	Vent pipe system in accordance with "National Fuel Gas Code", NFPA 54, ANSI Z223.1-Latest Edition or prevailing provisions of local codes.			YES	NO
5	Overall ductwork length and restrictions comply with manufacturer requirements.			YES	NO
6	Flue baffle engaged in slots provided in the flue tube.			YES	NO
7	Flue way, draft hood or vent pipe system not obstructed in any way.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
F	*WATER PIPING*				
1	All piping components have been installed (in the correct order) as required by contract document or manufacturer.			YES	NO
2	Piping arranged for ease of unit removal.			YES	NO
3	Piping supported as required by specifications.			YES	NO
4	Piping is clean.			YES	NO
5	Unit connected to water supply and return/make-up piping using unions or flanges and isolation valves.			YES	NO
6	Dielectric fittings installed to isolate dissimilar pipe materials.			YES	NO
7	Piping and valves properly checked and free of leaks.			YES	NO
8	Thermometers and pressure gauges supplied on supply and return lines.			YES	NO
9	Piping insulation is complete and installed as per specifications.			YES	NO
10	All valves and test ports are easily accessible.			YES	NO
11	Valve tags attached.			YES	NO
12	Pressure and temperature relief valve(s) for correct pressure and temperature installed.			YES	NO
13	Pressure and temperature relief valve(s) piped with sufficient pipe diameter to drain designed for boiling water.			YES	NO
14	Drain valve installed.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
G	*GAS PIPING*				
1	Gas supply is the same type as listed on the unit data plate.			YES	NO
2	Pressure reducing valves provide correct pressure to unit.			YES	NO
3	Gas cock / valve and union provided on gas supply.			YES	NO
4	Drip / dirt leg and cap provided on gas supply.			YES	NO
5	Pressure relief valves are piped to outdoors.			YES	NO
6	Piping and valves properly checked and free of leaks.			YES	NO
7	Gas utility company inspected installation (if required).			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
H	*ELECTRICAL (if applicable)*				
1	Local disconnect installed in accessible and visible location.			YES	NO
2	All electrical connections are tight.			YES	NO
3	All electrical components are grounded.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
I	*MECHANICAL STARTUP*				
1	System flushed, filled, and air purged.			YES	NO
2	Pilot lit according to manufacturer instructions.			YES	NO

Group/Item	Group/Task Description			Response	
3	Temperature setting adjusted to correct temperature per contract documents.			YES	NO
4	Pressure and temperature relief valve(s) set to proper pressure and temperature and manually checked for functionality.			YES	NO
5	Manufacturer's startup checklist completed and attached.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-22 42 00 – Commercial Plumbing Fixtures

Equipment Identification/Tag: _____
Location: _____

A) INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)								
				1)	2)	3)	4)	5)	6)	7)	8)	9)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:						DATE:		

Question Details

1) Fixture traps and service stops easily accessible for service.
2) Fixture and carriers secured per manufacturer requirements and level and plumb to finished surface.
3) Pipe penetrations covered with escutcheons.
4) Openings between walls, floors and fixtures sealed with mildew-resistant silicone sealant same color as fixture.
5) Fixtures tested and fully operational.
6) Fixture valves adjusted for intended water flow rate to fixtures to eliminate splashing, noise or overflow
7) Self-closing lavatory faucets adjusted to 15 second cycle.
8) Shower valve temperature limit stops set to 110 degree maximum outlet temperature.
9) Fixtures and trim cleaned using manufacturer's recommended cleaning methods and materials.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

FPT-22 30 00 – Inline Centrifugal Pump

Equipment Identification/Tag: _____
Location: _____

Test Duration

Date: _____ Start Time: _____ End Time _____

Estimated Duration: _____
Cx Provider(s): _____
_____
_____
_____

Applicable Equipment: _____
_____

Objectives

This test is performed to investigate the functionality of inline centrifugal pumps.

Instrumentation

Instrument	Accuracy	Measurement
N/A	N/A	N/A

Stated Sequence

To be defined by A/E and commissioning provider at completion of construction documents.

Sampling Set

All units and all sequences.

Procedure

1. Lead/Lag
    a. Have associated system and/or building automation system start and call for lead pump to run.
    b. Verify that lead pump is energized and that building automation system reflects unit is operational.
    c. De-energize pump via local disconnect switch.
    d. Verify lag pump is energized and building automation system reflects status of each unit.
    e. Return system to normal operation.
2. Aquastat
    a. Record temperature setpoint of aquastat.
    b. Record current temperature of water loop.
    c. Adjust aquastat setpoint to be 10º below current loop temperature.
    d. Verify pump is energized and allow to stabilize for 10 minutes.
    e. Return system to normal operation.
    f. Verify pump de-energizes.
3. Run Schedule
    a. Verify pump is in run mode. If not override system into run mode.
    b. Verify pump energizes.
    c. Change run schedule for current time to be in down mode.
    d. Verify pump de-energizes.
    e. Return schedule to originally programmed values.

Results

Lead/Lag:

Lead pump is energized when associated system commands? YES NO

Lag pump is energized on lead pump failure? YES NO

Aquastat:
Aquastat Temperature Setpoint: _____
Water Temperature: _____

Pump is energized when loop temperature falls below aquastat setpoint? YES NO

Run Schedule:
Pump is energized during scheduled run period? YES NO
Pump is de-energized during scheduled down period? YES NO

Conclusion

Acceptable Criteria: Pump is energized when called upon by its associated system, aquastat or timer, and that lag pump (if applicable) is energized upon loss of power or failure of lead pump.

Comments:

Observations:

Final Status: ❑ Accepted ❑ Not Accepted

Relevant Trend Data

Pump run status

Witnesses

Name	**Signature**

FPT-22 30 00 – Water Heater

Equipment Identification/Tag: _____
Location: _____

Test Duration

Date: _____ Start Time: _____ End Time _____

Estimated Duration: _____
Cx Provider(s): _____
_____
_____
_____

Applicable Equipment: _____
_____

Objectives

This test is performed to investigate the ability of the water heater to provide hot water to the facility.

Instrumentation

Instrument	Accuracy	Measurement
N/A	N/A	N/A

Stated Sequence

To be defined by A/E and commissioning provider at completion of construction documents.

Sampling Set

All units and all sequences.

Procedure

1. Record hot water temperature set point and verify complies with contract documents.
2. Open a single faucet fed by water heater so as to cause water to flow through the hot water supply lines.
3. Record temperature of water exiting water heater.
4. Allow unit to cycle on and off a total of three times.
5. Record temperature of water exiting water heater.
6. Verify no discernable difference between initial and final water temperatures is present.
7. Increase water temperature setpoint by 10°F.
8. Allow unit to cycle on and off a total of three times.
9. Open a single faucet fed by water heater so as to cause water to flow through the hot water supply lines.
10. Record temperature of water exiting water heater and verify temperature is within ±2.0°F.
11. Return system to normal operating temperatures

Results

Initial temperature set point: _____
Temperature setpoint complies with contract documents? **Y / N**
Exiting water temperature #1: _____
Exiting water temperature #2: _____
No discernable difference in exiting water temperatures (±1.0°F) from unit heater under normal operating conditions for single faucet? **Y / N**
Raised temperature set point: _____
Exiting water temperature #3: _____

Exiting water temperature is within ±2.0°F of raised temperature setpoint?	**Y / N**

Conclusion

Acceptable Criteria: Initial hot water temperature setpoint complies with contract documents. No discernable temperature difference of exiting water temperatures observed under normal operating conditions for single faucet. Difference between temperature setting of the water heater and the temperature read by the test instrument is ±2.0°F with raised temperature setpoint.

Comments:

Observations:

Final Status: ❑ Accepted ❑ Not Accepted

Relevant Trend Data

N/A

Witnesses

Name	**Signature**

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SECTION 22 10 13
FACILITY FUEL PIPING
BASED ON DFD MASTER SPECIFICATION DATED 10/1/12

P A R T 1 - G E N E R A L

SCOPE
This section contains specifications for fuel pipe and fuel pipe fittings for this project. Included are the following topics:

PART 1 - GENERAL
- Scope
- Reference
- Reference Standards
- Shop Drawings
- Quality Assurance
- Delivery, Storage, and Handling
- Design Criteria
- Welder Qualifications

PART 2 - PRODUCTS
- Liquid Propane Gas
- Vents and Relief Valves
- Unions and Flanges

PART 3 - EXECUTION
- Preparation
- Erection
- Welded Pipe Joints
- Threaded Pipe Joints
- Liquid Propane Gas
- Vents and Relief Valves
- Unions and Flanges
- Piping System Leak Tests
- Construction Verification Items
- Piping System Test Report

RELATED WORK
Section 01 91 01 – Commissioning Process
Section 22 08 00 – Commissioning of Plumbing
Section 22 05 14 - Plumbing Specialties
Section 22 05 23 - General-Duty Valves for Plumbing Piping
Section 22 05 29 - Hangers and Supports for Plumbing Piping and Equipment
Section 22 07 00 - Plumbing Insulation.

REFERENCE
Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

ANSI B16.3	Malleable Iron Threaded Fittings
ASTM A53	Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless
ASTM A234	Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ANSI B31.9	Pipe Material Requirements

QUALITY ASSURANCE
Substitution of Materials: Refer to Section GC – General Conditions of the Contract, Equals and Substitutions.

SHOP DRAWINGS
Refer to division 1, General Conditions, Submittals.

Contractor shall submit schedule indicating the ASTM specification number of the pipe being proposed along with its type and grade and sufficient information to indicate the type and rating of fittings for each service.

TYPE E OR S STEEL PIPE:
Mill certification papers, also known as material test reports, for the pipe furnished for this project, in English. Heat numbers on these papers to match the heat numbers stenciled on the pipe. Chemical analysis indicated on the mill certification papers to meet or exceed the requirements of the referenced ASTM specification.

QUALITY ASSURANCE
Order all Type E and Type S steel pipe with heat numbers rolled, stamped, or stenciled to each length or each bundle, depending on the size of the pipe, and in accordance with the appropriate ASTM specification.

Any installed material not meeting the specification requirements must be replaced with material that meets these specifications without additional cost to the Owner.

DELIVERY, STORAGE, AND HANDLING
Promptly inspect shipments to insure that the material is undamaged and complies with specifications.

Cover pipe to eliminate rust and corrosion while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade. Protect pipe, tube, and fitting ends so they are not damaged. Where end caps are provided or specified, take precautions so the caps remain in place.

Offsite storage agreements will not relieve the contractor from using proper storage techniques.

Storage and protection methods must allow inspection to verify products.

DESIGN CRITERIA
Use only new material, free of defects, rust and scale, and meeting the latest revision of ASTM specifications as listed in this specification.

Construct all piping for the highest pressures and temperatures in the respective system in accordance with ANSI B31, but not less than 125 psig unless specifically indicated otherwise.

Non-metallic piping will be acceptable only for the services indicated. It will not be acceptable in occupied spaces and ventilation plenum spaces, including plenum ceilings.

Where weld fittings or mechanical grooved fittings are used, use only long radius elbows having a centerline radius of 1.5 pipe diameters.

Where ASTM A53 grade A pipe is specified, ASTM A53 grade B pipe may be substituted at Contractor's option. Where the grade or type is not specified, Contractor may choose from those commercially available.

WELDER QUALIFICATIONS
Before any metallic welding is performed, Contractor to submit his Standard Welding Procedure Specification together with the Procedure Qualification Record as required by Section IX of the ASME Boiler and Pressure Vessel Code and/or the National Certified Pipe Welding Bureau.

Before any polyethylene fusion welding is performed, Contractor to submit certification that the welders to be used on this project have successfully demonstrated proper welding procedures in accordance with the Code of Federal Regulations, Title 49, Part 192, Section 192.285.

The A/E or DFD reserves the right to test the work of any welder employed on the project, at the Contractor's expense. If the work of the welder is found to be unsatisfactory, the welder shall be prevented from doing further welding on the project.

P A R T 2 - P R O D U C T S

LIQUID PROPANE GAS
2" and Smaller: ASTM A53, type E or S, standard weight (schedule 40) black steel pipe with ASTM A197/ANSI B16.3 class 150 black malleable iron threaded fittings or ASTM A234 grade WPB/ANSI B16.9 standard weight, seamless, carbon steel weld fittings.

2-1/2" and Larger: ASTM A53, type E or S, standard weight black steel pipe with ASTM A234 grade WPB/ANSI B16.9 standard weight, seamless, carbon steel weld fittings.

VENTS AND RELIEF VALVES
Use pipe and pipe fittings as specified for the system to which the relief valve or vent is connected.

UNIONS AND FLANGES
2" and Smaller: ASTM A197/ANSI B16.3 malleable iron unions with brass seats. Use black malleable iron on black steel piping and galvanized malleable iron on galvanized steel piping. Use unions of a pressure class equal to or higher than that specified for the fittings of the respective piping service but not less than 250 psi.

2-1/2" and Larger: ASTM A181 or A105, grade 1 hot forged steel flanges of threaded, welding and of a pressure class compatible with that specified for valves, piping specialties and fittings of the respective piping service. Flanges smaller than 2-1/2" may be used as needed for connecting to equipment and piping specialties. Use raised face flanges ANSI B16.5 for mating with other raised face flanges on equipment with flat ring or full face gaskets. Use ANSI B16.1 flat face flanges with full face gaskets for mating with other flat face flanges on equipment.

P A R T 3 - E X E C U T I O N

PREPARATION
Remove all foreign material from interior and exterior of pipe and fittings.

ERECTION
Install all piping parallel to building walls and ceilings and at heights which do not obstruct any portion of a window, doorway, stairway, or passageway. Where interferences develop in the field, offset or reroute piping as required to clear such interferences. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.

Mitered ells, notched tees, and orange peel reducers are not acceptable. On threaded piping, bushings are not acceptable.

"Weldolets" and "Threadolets" may be used for branch takeoffs up to one-half (1/2) the diameter of the main.

Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment

Install all valves, and piping specialties, including items furnished by others, as specified and/or detailed. Make connections to all equipment installed by others where that equipment requires the piping services indicated in this section.

WELDED PIPE JOINTS
Make all welded joints by fusion welding in accordance with ASME Codes, ANSI B31, and State Codes where applicable.

Electrodes shall be Lincoln, or approved equal, with coating and diameter as recommended by the manufacturer for the type and thickness of work being done.

THREADED PIPE JOINTS
Use a Teflon based thread lubricant or Teflon tape when making joints; no hard setting pipe thread cement or caulking will be allowed.

LIQUID PROPANE GAS

Pitch horizontal piping down 1" in 60 feet in the direction of flow. Install a 4" minimum depth dirt leg at the bottom of each vertical run and at each appliance. When installing mains and branches, cap gas tight each tee or pipe end which will not be immediately extended. All branch connections to the main shall be from the top or side of the main. Teflon tape is acceptable for use on liquid propane gas lines.

Do not install gas pipe in a ventilation air plenum.

If an above ground vent terminates in an area subject to snow accumulation, terminate the line at least five feet above grade.

Install a shut off valve at each appliance. Provide a valved connection at the main for equipment and appliances furnished by others.

Piping through a roof shall be run through an approved roof penetration with flashing and counter flashing.

Each gas pressure reducing valve vent and relief valve vent shall be run separately to a point outside of the building, terminated with a screened vent cap, and located according to gas utility regulations.

Clean all welded piping before all regulators and control valves. Test by placing target cloth over piping and blow with compressed air. Clean piping until target cloth is clean and free of debris.

VENTS AND RELIEF VALVES

Install vent and relief valve discharge lines as indicated on the drawings, as detailed, and as specified for each specific valve or piping specialty item. In no event is a termination to occur less than six feet above a roof line.

UNIONS AND FLANGES

Install a union or flange, as required, at each automatic control valve and at each piping specialty or piece of equipment which may require removal for maintenance, repair, or replacement. Where a valve is located at a piece of equipment, locate the flange or union connection on the equipment side of the valve. Concealed unions or flanges are not acceptable.

PIPING SYSTEM LEAK TESTS

Verify that the piping system being tested is fully connected to all components and that all equipment is properly installed, wired, and ready for operation. If required for the additional pressure load under test, provide temporary restraints at expansion joints or isolate them during the test. Verify that hangers can withstand any additional weight load that may be imposed by the test.

Provide all piping, fittings, blind flanges, and equipment to perform the testing.

Conduct pressure test with test medium of air or water unless specifically indicated. Minimum test time is indicated in the table below; additional time may be necessary to conduct an examination for leakage. Each test must be witnessed by the Division's representative. If leaks are found, repair the area with new materials and repeat the test; caulking will not be acceptable.

Do not insulate pipe until it has been successfully tested.

For hydrostatic tests, use clean water and remove all air from the piping being tested by means of air vents or loosening of flanges/unions. Measure and record test pressure at the high point in the system.

For air tests, gradually increase the pressure to not more than one half of the test pressure; then increase the pressure in steps of approximately one-tenth of the test pressure until the required test pressure is reached. Examine all joints and connections with a soap bubble solution or equivalent method. The piping system exclusive of possible localized instances at pump or valve packing shall show no evidence of leaking. After testing is complete, slowly release the pressure in a safe manner.

Measure liquid propane gas system test pressure with a water manometer or an equivalent device calibrated in increments not greater than 0.1 inch water column. System will not be approved until it can be demonstrated that there is no measurable loss of test pressure during the test period.

Conduct fuel oil system test so as not to impose a pressure of more than 10 psig on the tank. Instead of a pressure test, suction lines may be tested under a vacuum of not less than 20 inches of mercury maintained for at least one hour.

System	Pressure	Medium	Duration
Liquid Propane gas	100 psig	Air	24 hr

All pressure tests are to be documented on a Division of Facilities Development form included in this specification.

On piping that can not be tested because of connection to an active line, provide temporary blind flanges and hydrostatically test new section of piping. After completion of test, remove temporary flanges and make final connections to piping. Die penetrate test pass weld or x-ray the piping that was not hydrostatically tested up to the active system.

CONSTRUCTION VERIFICATION ITEMS

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 22 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

END OF SECTION

PIPING SYSTEM TEST REPORT

State of Wisconsin
Department of Administration **Date**
Division of Facilities Development **Submitted:** _____

Project Name: _____

Location: _____ **DFD Project No:** _____

Contractor: _____

☐ **HVAC** ☐ **Refrigeration** ☐ **Controls**

☐ **Power Plant** ☐ **Plumbing** ☐ **Fire Sprinkler**

Test Medium: ☐ **Air** ☐ **Water** ☐ **Other** _____

Test performed per specification section No. _____

Specified Test Duration _____ **Hours** **Specified Test Pressure** _____ **PSIG**

System Identification: _____

Describe Location: _____

_____

Test Date: _____

Start Test Time: _____ **Initial Pressure:** _____ **PSIG**

Stop Test Time: _____ **Final Pressure:** _____ **PSIG**

Tested By: _____ **Witnessed By:** _____

Title: _____ **Title:** _____

Signed: _____ **Signed:** _____

Date: _____ **Date:** _____

Comments: _____

_____

_____

_____

SECTION 22 11 00
FACILITY WATER DISTRIBUTION
BASED ON DFD MASTER SPECIFICATION DATED 09/17/24

P A R T 1 - G E N E R A L

SCOPE

This section contains specifications for plumbing pipe and pipe fittings for this project. Included are the following topics:

PART 1 - GENERAL
- Scope
- Reference
- Reference Standards
- Shop Drawings
- Quality Assurance
- Delivery, Storage, and Handling
- Design Criteria
- Welder Qualifications

PART 2 - PRODUCTS
- Domestic Water
- Dielectric Unions and Flanges
- Unions and Flanges
- Mechanical Grooved Pipe Connections

PART 3 - EXECUTION
- General
- Preparation
- Erection
- Copper Pipe Joints
- Threaded Pipe Joints
- Domestic Water
- Flushing and Disinfection of Potable Water Systems
- Dielectric Unions and Flanges
- Unions and Flanges
- Piping System Leak Tests
- Construction Verification Items

RELATED WORK

Section 01 91 01– Commissioning Process
Section 22 08 00 – Commissioning of Plumbing
22 05 29 - Hangers and Supports for Plumbing Piping and Equipment
22 05 14 - Plumbing Specialties

REFERENCE

Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

ANSI A21.4
ANSI A21.11
ANSI A21.51
ANSI B16.3 Malleable Iron Threaded Fittings
ANSI B16.4 Cast Iron Threaded Fittings

ANSI B16.5	Pipe Flanges and Flanged Fittings
ANSI B16.22	Wrought Copper and Wrought Copper Alloy Solder Joint Pressure Fittings
ANSI B16.29	Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV
ASTM A53	Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless
ASTM A105	Forgings, Carbon Steel, for Piping Components
ASTM A126	Gray Cast Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A234	Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ASTM B32	Solder Metal
ASTM B88	Seamless Copper Water Tube
ASTM B280	Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B813	Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube
ASTM F876	Standard Specification for Crosslinked Polyethylene (PEX) Tubing
ASTM F877	Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems
ASTM F1960	Standard Specification for Cold Expansion Fittings with PEX Reinforcing Rings
AWWA C904	Standard for Crosslinked Polyethylene (PEX) Pressure Pipe, 1/2-inch Through 3-inch, for Water Service
AWS A5.8	Brazing Filler Metal

SHOP DRAWINGS

Schedule from the contractor indicating the ASTM, AWWA or CISPI specification number of the pipe being proposed along with its type and grade if known at the time of submittal, and sufficient information to indicate the type and rating of fittings for each service.

QUALITY ASSURANCE

Substitution of Materials: Refer to Section GC – General Conditions of the Contract, Equals and Substitutions.

Order all copper, cast iron, steel, PVC and polyethylene pipe with each length marked with the name or trademark of the manufacturer and type of pipe; with each shipping unit marked with the purchase order number, metal or alloy designation, temper, size, and name of supplier.

Any installed material not meeting the specification requirements must be replaced with material that meets these specifications without additional cost to the State.

DELIVERY, STORAGE, AND HANDLING

Promptly inspect shipments to ensure that the material is undamaged and complies with specifications.

Cover pipe to prevent corrosion or deterioration while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade. Protect pipe, tube, and fitting ends so they are not damaged. Where end caps are provided or specified, take precautions so the caps remain in place. Protect fittings, flanges, and unions by storage inside or by durable, waterproof, above ground packaging.

Offsite storage agreements will not relieve the contractor from using proper storage techniques.

Storage and protection methods must allow inspection to verify products.

DESIGN CRITERIA

Use only new material, free of defects, rust and scale, and meeting the latest revision of ASTM, and AWWA specifications as listed in this specification.

Construct all piping for the highest pressures and temperatures in the respective system.

Non-metallic piping will be acceptable only for the services indicated. It will not be acceptable in ventilation plenum spaces, including plenum ceilings unless approved for this use.

Where weld fittings are used, use only long radius elbows having a centerline radius of 1.5 pipe diameters.

Where ASTM A53 type F pipe is specified, grade A Type E or S, or grade B Type E or S may be substituted at Contractor's option. Where the grade or type is not specified, Contractor may choose from those commercially available.

Where ASTM B88, type L H (drawn) temper copper tubing is specified, ASTM B88, type K H (drawn) temper copper tubing may be substituted at Contractor's option.

WELDER QUALIFICATIONS

Before any polyethylene fusion welding is performed, Contractor to submit certification that the welders to be used on this project have successfully demonstrated proper welding procedures in accordance with the Code of Federal Regulations, Title 49, Part 192, Section 192.285.

The Architect or Engineer reserves the right to test the work of any welder employed on the project, at the State's expense. If the work of the welder is found to be unsatisfactory, the welder shall be prevented from doing further welding on the project and all defective welds replaced.

P A R T 2 - P R O D U C T S

DOMESTIC WATER

ABOVE GROUND:

Type L copper water tube, H (drawn) temper, ASTM B88; wrought copper pressure fittings, ANSI B16.22; lead free (<.2%) solder, ASTM B32; flux, ASTM B813; copper phosphorous brazing alloy, AWS A5.8 BCuP. Copper mechanical grooved fittings and couplings on roll grooved pipe may be used in lieu of soldered fittings. Mechanically formed brazed tee connections may be used in lieu of specified tee fittings for branch takeoffs up to one-half (1/2) the diameter of the main.

Crosslinked Polyethylene (PEX-a Engel Method) plastic pipe and fittings, 1/2” to 2” sizes: ASTM F876, ASTM F877, AWWA C904, with ASTM F1960 cold expansion fittings, rated for a temperature of 180 degrees F at 100 psi, copper tube size (CTS). Transition fittings PEX-to-Metal, one-piece lead free, brass threaded or sweat adapter, with PEX-a reinforcing cold expansion ring. Fittings for PEXa to PEXa connection to be poly plastic. Multiport manifolds with valves shall be accessible. Multiport tees are not required to be accessible. Pipe and fittings by the same manufacturer, Uponor, Rehau, Sioux Chief or equal. Pipe system shall be installed and supported in accordance with the manufacturer’s instructions, and include full manufacturer warranty. Fixture connection stub-out piping shall transition to copper piping within wall, before entry into finished space, and include manufactured rigid support.
PEXa pipe 1” to 2” shall be provided in straight lengths, coil stock may be used for ½” and ¾” sizes. ½’ and ¾” pipe sizes shall be color coded blue for cold water, and red for hot and hot water return water.

DIELECTRIC UNIONS AND FLANGES

Watts Regulator Company, Lochinvar, Wilkins or EPCO Sales, Inc., dielectric unions 2" and smaller; dielectric flanges 2" and larger; with iron female pipe thread to copper solder joint or brass female pipe thread end connections, non-asbestos gaskets, having a pressure rating of not less than 175 psig at 180 degrees.

UNIONS AND FLANGES

Unions, flanges and gasket materials to have a pressure rating of not less than 150 psig at 180 degrees. Gasket material for flanges and flanged fittings shall be teflon type. Treated paper gaskets are not acceptable.

2" AND SMALLER STEEL:

ASTM A197/ANSI B16.3 malleable iron unions with brass seats. Use galvanized malleable iron on galvanized steel piping. Use stainless steel unions for stainless steel piping.

2" AND SMALLER COPPER:

ANSI B16.18 cast bronze union coupling or ANSI B15.24 Class 150 cast bronze flanges.

P A R T 3 - E X E C U T I O N

GENERAL

Install pipe and fittings in accordance with reference standards, manufacturers recommendations and recognized industry practices.

PREPARATION

Cut pipe ends square. Ream ends of piping to remove burrs. Clean scale and dirt from interior and exterior of each section of pipe and fitting prior to assembly.

ERECTION

Install all piping parallel to building walls and ceilings and at heights which do not obstruct any portion of a window, doorway, stairway, or passageway. Where interferences develop in the field, offset or reroute piping as required to clear such interferences. Coordinate locations of plumbing piping with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.

Where copper, steel, or plastic piping is embedded in masonry or concrete, provide protective sleeve covering of elastomeric pipe insulation.

Maintain piping in clean condition internally during construction.

Provide clearance for installation of insulation, access to valves and piping specialties.

Provide anchors, expansion joints, swing joints and/or expansion loops so that piping may expand and contract without damage to itself, equipment, or building.

Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment

PEXa pipe joint connections shall be installed per manufacturer's recommendations. Use manufacturer recommended cold-expansion tool for ASTM F 1960 connections.

Do not expose PEXa piping to direct sunlight. Provide cover to portions of piping exposed to direct sunlight.

Install all valves and piping specialties, including items furnished by others, as specified and/or detailed. Provide access to valves and specialties for maintenance. Make connections to all equipment, fixtures and systems installed by others where same requires the piping services indicated in this section.

COPPER PIPE JOINTS

Remove all slivers and burrs remaining from the cutting operation by reaming and filing both pipe surfaces. Clean fitting and tube with metal brush, emery cloth or sandpaper. Remove residue from the cleaning operation, apply flux and assemble joint to socket stop. Apply flame to fitting until solder melts when placed at joint. Remove flame and feed solder into joint until full penetration of cup and ring of solder appears. Wipe excess solder and flux from joint.

THREADED PIPE JOINTS

Use a thread lubricant or teflon tape when making joints; no hard setting pipe thread cement or caulking will be allowed.

DOMESTIC WATER

Maintain piping system in clean condition during installation. Remove dirt and debris from assembly of piping as work progresses. Cap open pipe ends where left unattended or subject to contamination.

Install interior water piping with drain valves where indicated and at low points of system to allow complete drainage. Install shutoff valves where indicated and at the base of risers to allow isolation of portions of system for repair. Do not install water piping within exterior walls.

Install drain valves to completely drain system during winterization of buildings.

FLUSHING AND DISINFECTION OF POTABLE WATER SYSTEMS

Prior to use, isolate and fill system with potable water. Allow to stand 24 hours. Flush each outlet proceeding from the service entrance to the furthest outlet for minimum of 1 minute and until water appears clear. Fill system with a solution of water and chlorine containing at least 10 parts per million of chlorine and allow to stand for 24 hours. Flush system with potable water until chlorine concentration is no higher than source water level.

Wait 24 hours after final flushing. Take samples of water for lab testing. The number and location of samples shall be representative of the system size and configuration and are subject to approval by Engineer. Test shall show the absence of coliform bacteria. If test fails, repeat disinfection and testing procedures until no coliform bacteria are detected. Submit test report indicating date and time of test along with test results.

Piping that is pressure tested shall be drained completely dry. The piping system is not to be left full of stagnant water. The piping system, water heaters and water softeners shall not be filled until within 10 days of occupancy to guard against microbial growth.

DIELECTRIC UNIONS AND FLANGES

Install dielectric unions or flanges at each point where a copper-to-steel pipe connection is required in domestic water systems.

UNIONS AND FLANGES

Install a union or flange at each connection to each piece of equipment and at other items which may require removal for maintenance, repair, or replacement. Where a valve is located at a piece of equipment, locate the flange or union connection on the equipment side of the valve. Concealed unions or flanges are not acceptable.

PIPING SYSTEM LEAK TESTS

Isolate or remove components from system which are not rated for test pressure. Test piping in sections or entire system as required by sequence of construction. Do not insulate or conceal pipe until it has been successfully tested.

If required for the additional pressure load under test, provide temporary restraints at fittings or expansion joints. Backfill underground water mains prior to testing with the exception of thrust restrained valves which may be exposed to isolate potential leaks.

For hydrostatic tests, use clean water and remove all air from the piping being tested by means of air vents or loosening of flanges/unions. Measure and record test pressure at the high point in the system.

Inspect system for leaks. Where leaks occur, repair the area with new materials and repeat the test; caulking will not be acceptable.

Entire test must be witnessed by the Division's representative. All pressure tests are to be documented on **Division of Facilities Development** forms to be provided to the contractor.

	Test	Initial Test		Final Test	
System	Medium	Pressure	Duration	Pressure	Duration
Above Ground Domestic Water	Water	N/A		100 psig	8 hr

CONSTRUCTION VERIFICATION ITEMS

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 22 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

END OF SECTION

PIPING SYSTEM TEST REPORT

State of Wisconsin
Department of Administration
Division of Facilities Development **Date Submitted:** _____

Project Name: _____

Location: _____ **DFD Project No:** _____

Contractor: _____

□ Plumbing □ Fire Sprinkler

Test Medium: □ Air □ Water □ Other _____

Test performed per specification section No. _____

Specified Test Duration _____ Hours Specified Test Pressure _____ PSIG

System Identification: _____

Describe Location: _____

_____

Test Date: _____

Start Test Time: _____ Initial Pressure: _____ PSIG

Stop Test Time: _____ Final Pressure: _____ PSIG

Tested By: _____ Witnessed By: _____

Title: _____ Title: _____

Signed: _____ Signed: _____

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SECTION 22 13 00
FACILITY SANITARY SEWERAGE
BASED ON DFD MASTER SPECIFICATION DATED 4/6/18

P A R T 1 - G E N E R A L

SCOPE

This section contains specifications for plumbing pipe and pipe fittings for this project. Included are the following topics:

PART 1 - GENERAL
- Scope
- Reference
- Reference Standards
- Shop Drawings
- Quality Assurance
- Delivery, Storage, and Handling
- Design Criteria

PART 2 - PRODUCTS
- Sanitary Waste and Vent

PART 3 - EXECUTION
- General
- Preparation
- Erection
- Copper Pipe Joints
- Threaded Pipe Joints
- Solvent Welded Pipe Joints
- Mechanical Hubless Pipe Connections
- Push-On Gasketed Pipe Connections
- Sanitary Waste and Vent
- Piping System Leak Tests
- Construction Verification Items

RELATED WORK

Section 01 91 01– Commissioning Process
Section 22 08 00 – Commissioning of Plumbing
22 05 29 - Hangers and Supports for Plumbing Piping and Equipment
22 05 14 - Plumbing Specialties

REFERENCE

Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

ANSI A21.4
ANSI A21.11
ANSI A21.51
ANSI B16.5 Pipe Flanges and Flanged Fittings
ANSI B16.22 Wrought Copper and Wrought Copper Alloy Solder Joint Pressure Fittings
ANSI B16.29 Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV
ASTM A53 Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless
ASTM A74 Cast Iron Soil Pipe and Fittings

ASTM A888	Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
ASTM B32	Solder Metal
ASTM B306	Copper Drainage Tube (DWV)
ASTM B813	Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube
ASTM D1785	Poly Vinyl Chloride (PVC) Plastic Pipe
ASTM D2241	Poly Vinyl Chloride (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2466	Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2564	Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Pipe and Fittings
ASTM D2665	Poly Vinyl Chloride (PVC) Plastic Drain, Waste and Vent Pipe and Fittings
ASTM D2729	Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings
ASTM D2855	Making Solvent Cemented Joints with Poly Vinyl Chloride (PVC) Pipe and Fittings
ASTM D3034	Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings
ASTM D3139	Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3212	Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3311	Drain, Waste and Vent (DWV) Plastic Fitting Patterns
ASTM F2618	CPVC Pipe and Fittings for Chemical Waste Drainage Systems
AWS A5.8	Brazing Filler Metal

SHOP DRAWINGS

Schedule from the contractor indicating the ASTM, or CISPI specification number of the pipe being proposed along with its type and grade if known at the time of submittal, and sufficient information to indicate the type and rating of fittings for each service.

Statement from manufacturer on his letterhead that pipe furnished meets the ASTM, or CISPI specification contained in this section.

QUALITY ASSURANCE

Substitution of Materials: Refer to Section GC – General Conditions of the Contract, Equals and Substitutions.

Order all copper, cast iron, steel, PVC and polyethylene pipe with each length marked with the name or trademark of the manufacturer and type of pipe; with each shipping unit marked with the purchase order number, metal or alloy designation, temper, size, and name of supplier.

Any installed material not meeting the specification requirements must be replaced with material that meets these specifications without additional cost to the State.

DELIVERY, STORAGE, AND HANDLING

Promptly inspect shipments to ensure that the material is undamaged and complies with specifications.

Cover pipe to prevent corrosion or deterioration while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade. Protect pipe, tube, and fitting ends so they are not damaged. Where end caps are provided or specified, take precautions so the caps remain in place. Protect fittings, flanges, and unions by storage inside or by durable, waterproof, above ground packaging.

Offsite storage agreements will not relieve the contractor from using proper storage techniques.

Storage and protection methods must allow inspection to verify products.

DESIGN CRITERIA

Use only new material, free of defects, rust and scale, and meeting the latest revision of ASTM, or CISPI specifications as listed in this specification.

Construct all piping for the highest pressures and temperatures in the respective system.

Piping that is not in accordance with ASTM E-84/UL723 for flame spread of <25 and smoke development of <50 shall not be utilized in ventilation plenum spaces, including plenum ceilings.

Where weld fittings or mechanical grooved fittings are used, use only long radius elbows having a centerline radius of 1.5 pipe diameters.

Where ASTM A53 type F pipe is specified, grade A type E or S, or grade B type E or S may be substituted at Contractor's option. Where the grade or type is not specified, Contractor may choose from those commercially available.

Where ASTM B88, type L H (drawn) temper copper tubing is specified, ASTM B88, type K H (drawn) temper copper tubing may be substituted at Contractor's option.

P A R T 2 - P R O D U C T S

SANITARY WASTE AND VENT

INTERIOR ABOVE GROUND:

Hubless cast iron soil pipe and fittings, ASTM A888; with no-hub couplings, CISPI 301, CISPI 310, ASTM A74. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Pipe Institute or receive prior approval of the Engineer. Cast iron piping and fittings shall be of A B & I Foundry, Charlotte Pipe and Foundry, or Tyler Pipe manufacturers.

Type M copper water tube, H (drawn) temper, ASTM B88; with cast copper drainage fittings (DWV), ANSI B16.23; wrought copper drainage fittings (DWV), ANSI B16.29; lead free (<.2%) solder, ASTM B32; flux, ASTM B813; copper phosphorous brazing alloy, AWS A5.8 BCuP.

PVC plastic pipe, Schedule 40, Class 12454 (PVC 1120), ASTM D1785; PVC plastic drain, waste and vent pipe and fittings, ASTM D2665; socket fitting patterns, ASTM D3311; primer, ASTM F656; solvent cement, ASTM D2564.

INTERIOR BELOW GROUND:

PVC plastic pipe, Schedule 40, Class 12454 (PVC 1120), ASTM D1785; PVC plastic drain, waste and vent pipe and fittings, ASTM D2665; socket fitting patterns, ASTM D3311; primer, ASTM F656; solvent cement, ASTM D2564.

P A R T 3 - E X E C U T I O N

GENERAL

Install pipe and fittings in accordance with reference standards, manufacturers recommendations and recognized industry practices.

PREPARATION

Cut pipe ends square. Ream ends of piping to remove burrs. Clean scale and dirt from interior and exterior of each section of pipe and fitting prior to assembly.

ERECTION

Install all piping parallel to building walls and ceilings and at heights which do not obstruct any portion of a window, doorway, stairway, or passageway. Where interferences develop in the field, offset or reroute piping as required to clear such interferences. Coordinate locations of plumbing piping with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.

Where copper or steel piping is embedded in masonry or concrete, provide protective sleeve covering of elastomeric pipe insulation.

Install underground warning tape 6"-12" below finished grade above all exterior below ground piping. Where existing underground warning tape is encountered, repair and replace.

Maintain piping in clean condition internally during construction.

Provide clearance for installation of insulation, access to valves and piping specialties.

Provide anchors, expansion joints, swing joints and/or expansion loops so that piping may expand and contract without damage to itself, equipment, or building.

Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment

Install all valves and piping specialties, including items furnished by others, as specified and/or detailed. Provide access to valves and specialties for maintenance. Make connections to all equipment, fixtures and systems installed by others where same requires the piping services indicated in this section.

COPPER PIPE JOINTS

Remove all slivers and burrs remaining from the cutting operation by reaming and filing both pipe surfaces. Clean fitting and tube with metal brush, emery cloth or sandpaper. Remove residue from the cleaning operation, apply flux and assemble joint to socket stop. Apply flame to fitting until solder melts when placed at joint. Remove flame and feed solder into joint until full penetration of cup and ring of solder appears. Wipe excess solder and flux from joint.

THREADED PIPE JOINTS

Use a thread lubricant or teflon tape when making joints; no hard setting pipe thread cement or caulking will be allowed.

SOLVENT WELDED PIPE JOINTS

Install in accordance with ASTM D2855 "Making Solvent Cemented Joints With PVC Pipe and Fittings". Saw cut piping square and smooth. Tube cutters may be used if they are fitted with wheels designed for use with PVC/CPVC pipe that do not leave a raised bead on pipe exterior. Support and restrain pipe during cutting to prevent nicks and scratches. Bevel ends 10-15 degrees and deburr interior. Remove dust, drips, moisture, grease and other superfluous materials from pipe interior and exterior. Check dry fit of pipe and fittings. Reject materials which are out of round or do not fit within close tolerance. Use heavy body solvent cement for large diameter fittings.

Maintain pipe, fittings, primer and cement between 40 and 100 degrees during application and curing. Apply primer and solvent using separate daubers (3" and smaller piping only) or clean natural bristle brushes about 1/2 the size of the pipe diameter. Apply primer to the fitting socket and pipe surface with a

scrubbing motion. Check for penetration and reapply as needed to dissolve surface to a depth of 4-5 thousandths. Apply solvent cement to the fitting socket and pipe in an amount greater than needed to fill any gap. While both surfaces are wet, insert pipe into socket fitting with a quarter turn to the bottom of the socket. Solvent cement application and insertion must be completed in less than 1 minute. Minimum of 2 installers is required on piping 4" and larger. Hold joint for 30 seconds or until set. Reference manufacturer recommendations for initial set time before handling and for full curing time before pressure testing. Cold weather solvent/cement may be utilized only under unusual circumstances and when specifically approved by the **DFD** Project Representative.

MECHANICAL HUBLESS PIPE CONNECTIONS

Place the gasket on the end of one pipe or fitting and the clamp assembly on the end of the other pipe or fitting. Firmly seat the pipe or fitting ends against the integrally molded shoulder inside the neoprene gasket. Slide the clamp assembly into position over the gasket. Tighten fasteners to manufacturers recommended torque.

PUSH-ON GASKETED PIPE CONNECTIONS

Clean pipe end, bell, gasket seat and gasket of dirt or debris. Coat end of pipe and gasket with gasket lubricant. Insure pipe is supported off the ground so lubricant does not pick up dirt. Push spigot end into gasket bell with levered pipe joining tool recommended by pipe manufacturer. Large diameter exterior mains may be joined by pushing end of pipe section with backhoe against wood blocking over pipe end. Insert to fully seated position or to reference mark on pipe.

SANITARY WASTE AND VENT

Verify invert elevations and building elevations prior to installation. Install exterior piping pitched to drain at indicated elevations and slope. Install interior piping pitched to drain at minimum slope of 1/4" per foot where possible and in no case less than 1/8" per foot for piping 3" and larger.

Install exterior piping below predicted frost level and not less than 5' bury depth to top of pipe wherever possible. Where piping is located above predicted frost level, provide frost protection in accordance with SPS 382.30(11)(c).

Flush piping inlets (floor drains, hub drains, mop basins, fixtures, etc.) with high flow of water at completion of project to demonstrate full flow capacity. Remove blockages and make necessary repairs where flow is found to be impeded.

PIPING SYSTEM LEAK TESTS

Isolate or remove components from system which are not rated for test pressure. Perform final testing for medical and lab gas with all system components in place. Test piping in sections or entire system as required by sequence of construction. Do not insulate or conceal pipe until it has been successfully tested.

If required for the additional pressure load under test, provide temporary restraints at fittings or expansion joints. Backfill underground water mains prior to testing with the exception of thrust restrained valves which may be exposed to isolate potential leaks.

For hydrostatic tests, use clean water and remove all air from the piping being tested by means of air vents or loosening of flanges/unions. Measure and record test pressure at the high point in the system.

For air or nitrogen tests, gradually increase the pressure to not more than one half of the test pressure; then increase the pressure in steps of approximately one-tenth of the test pressure until the required test pressure is reached. Examine all joints and connections with a soap bubble solution or equivalent method. System will not be approved until it can be demonstrated that there is no measurable loss of test pressure during the test period.

Inspect system for leaks. Where leaks occur, repair the area with new materials and repeat the test; caulking will not be acceptable.

Entire test must be witnessed by the Division's representative. All pressure tests are to be documented on ***Division of Facilities Development*** forms to be provided to the contractor.

	Test	Initial Test		Final Test	
System	Medium	Pressure	Duration	Pressure	Duration
Sanitary Waste and Vent	Water	N/A		10' water	2 hr

CONSTRUCTION VERIFICATION ITEMS

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 22 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

END OF SECTION

SECTION 22 30 00
PLUMBING EQUIPMENT
BASED ON DFD MASTER SPECIFICATION DATED 10/16/17

P A R T 1 - G E N E R A L

SCOPE

This section includes specifications for water heaters, water softeners, pumps and other equipment used for plumbing applications. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Documents
- Reference
- Quality Assurance
- Shop Drawings
- Operation and Maintenance Data

PART 2 - PRODUCTS
- Water Heaters
- Pumps
- Expansion Tanks

PART 3 - EXECUTION
- Installation
- Construction Verification Items
- Functional Performance Testing
- Agency Training

RELATED DOCUMENTS

Section 01 91 01– Commissioning Process
Section 22 08 00 – Commissioning of Plumbing
Section 22 05 23 - General-Duty Valves for Plumbing Piping
Section 22 05 15 - Piping Specialties
Section 22 05 13 - Common Motor Requirements for Plumbing Equipment.
Section 22 07 00 - Plumbing Insulation
Division 26 00 00 - Electrical

REFERENCE

Applicable provisions of Division 1 shall govern work under this section.

QUALITY ASSURANCE

Substitution of Materials: Refer to Section GC - General Conditions of the Contract, Article 7.

Plumbing products requiring approval by the State of Wisconsin Dept. of Safety and Professional Services must be approved or have pending approval at the time of shop drawing submission.

SHOP DRAWINGS

Include data concerning dimensions, capacities, materials of construction, ratings, certifications, weights, pump curves with net positive suction head requirements, manufacturer's installation requirements, manufacturer's performance limitations, and appropriate identification.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

P A R T 2 - P R O D U C T S

COMMERCIAL ATMOSPHERIC GAS FIRED WATER HEATER

Manufacturers: American, A.O. Smith, Bock, Bradford White, Lochinvar, Rheem, Ruud, State.

Type: Commercial natural gas fired atmospheric storage water heater. Design to be AGA certified for 180^{o} water with 3 year tank and parts warranty.

Efficiency:

>50 gallons or >75,000 Btu/h	Minimum Thermal Efficiency = 80% Maximum Standby Loss = (Q/800+110$\sqrt{V}$) Q=Input Btu/h, V=Volume Gallons

Tank: Steel glass lined tank rated for 150 psig complete with 2 removable magnesium anode rods or single impressed current anode rod, 4" tank access hand hole, foam or fiberglass insulation, painted steel jacket, vertical draft hood, drain valve and temperature and pressure relief valve.

Burner: Construct burner of cast iron, aluminized steel (natural gas only) or stainless steel.

Controls: 120 volt, 1 phase, 60 Hz controls consisting of junction box, 24 volt transformer, intermittent spark ignition, electric flue damper, operating thermostat with adjustable temperature control, energy cutoff with manual reset, gas valve and pressure regulator.

RESIDENTIAL ELECTRIC WATER HEATER

Manufacturers: A.O. Smith, American, Bradford White, Lochinvar, Rheem, Ruud, State.

Type: Electric storage domestic water heater. Design to be UL listed with 3 year commercial use tank warranty and 1 year parts warranty.

Efficiency:

$\leq$12 kW	Minimum Energy Factor = .97- (.00035 x Volume (gal))
>12 kW	Standby Loss (%/h) = .3+(27/measured tank volume)

Tank: Steel glass lined tank rated for 150 psig complete with removable magnesium anode rod, plastic diffuser type dip tube, inlet and outlet heat trap fittings, minimum R-20 polyurethane foam insulation, painted steel jacket, drain valve and temperature and pressure relief valve.

Elements: Dual 4500 watt heating elements to be replaceable threaded low watt density incoloy sheath with adjustable thermostat control, energy cutoff and wired for non-simultaneous operation.

IN-LINE SYSTEM LUBRICATED CENTRIFUGAL PUMPS

Manufacturer: Bell and Gossett, Grundfos, Taco.

Type: Horizontal single stage close coupled system lubricated in-line pumps, 125 psig maximum working pressure at operating temperature of 225^{o}F continuous. The manufacturer shall certify all pump ratings. All pumps to operate without excessive noise or vibration.

Casing: Bronze or stainless steel; flanged suction and discharge connection.

Impeller: Bronze, stainless steel or thermoplastic, keyed to the shaft, single suction enclosed type, hydraulically and dynamically balanced.

Bearings: System lubricated carbon sleeve bearings.

Shaft: Stainless steel or ceramic.

Seal: Stainless steel can isolating rotor and stator.

Motor: Provide pump with impedance protected motor sized for non-overloading over the entire pump curve. Furnish each pump and motor with a nameplate giving the manufacturer's name, serial number of pump, capacity in GPM and head in feet at design condition, horsepower, voltage, frequency, speed and full load current.

EXPANSION TANKS

Manufacturer: Amtrol, Bell and Gossett, Wessels.

Vertical steel precharged hydro-pneumatic expansion tank, 125 psi ASME labeled construction, complete with replaceable flexible butyl rubber bladder, system connection fitting, Schrader type air charge fitting, steel base ring stand, factory prime and enamel painted exterior finish, ASME relief valve. Materials exposed to water to be NSF or FDA approved for potable water service.

P A R T 3 - E X E C U T I O N

INSTALLATION

Install plumbing equipment where indicated in accordance with manufacturer's recommendations. Coordinate equipment location with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances. Locate equipment and arrange plumbing piping to provide access space for servicing all components.

Set commercial water heaters, commercial water softeners, storage tanks and booster pumps on concrete housekeeping pads. Adjust and level equipment.

Connect equipment to water and drain piping using unions or flanges and isolation valves.

Size temperature and relief valves per CSA ratings. Pipe temperature and pressure relief valves to floor drain or floor as indicated.

Startup and test equipment adjusting operating and safety controls for proper operation.

Lubricate pumps before startup. Adjust pumps for rated flow. Clean and blowdown strainers after 8 hours of operation.
Adjust compression tank precharge to scheduled minimum operating pressure prior to connecting to system.

CONSTRUCTION VERIFICATION ITEMS

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 22 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

FUNCTIONAL PERFORMANCE TESTING

Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 22 08 00 in accordance with the procedures defined for functional performance testing in Section 01 91 01.

AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01.

END OF SECTION

SECTION 22 42 00
COMMERCIAL PLUMBING FIXTURES
BASED ON DFD MASTER SPECIFICATION DATED 05/12/25

P A R T 1 - G E N E R A L

SCOPE

This section includes specifications for plumbing fixtures, faucets and trim.

RELATED WORK

Section 01 91 01– Commissioning Process
Section 22 05 00 – Common Work Results for Plumbing
Section 22 08 00 – Commissioning of Plumbing
Section 22 11 00 - Facility Water Distribution
Section 22 13 00 - Facility Sanitary Sewerage
Section 22 05 29 – Hangers and Supports for Plumbing Piping and Equipment
Section 22 05 14 - Plumbing Specialties

REFERENCE

Applicable provisions of Division 1 shall govern work under this section.

QUALITY ASSURANCE

Substitution of Materials: Refer to Section GC - General Conditions of the Contract, Equals and Substitutions.

Plumbing products requiring approval by the State of Wisconsin Dept. of Safety and Professional Services must be approved or have pending approval.

SUBMITTALS

Include data concerning sizes, utility sizes, rough in-dimensions, capacities, materials of construction, ratings, weights, trim, finishes, manufacturer's installation requirements, manufacturer's performance limitations, and appropriate identification.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

DESIGN CRITERIA

ANSI A112.6.1M-88 - Supports for Off-the Floor Plumbing Fixtures for Public Use.
ANSI A112.18.1-94 - Finished and Rough Brass Plumbing Fixture Fittings.

ANSI A112.19.1-90 - Enameled Cast Iron Plumbing Fixtures.
ANSI A112.19.2M-82 - Vitreous China Plumbing Fixtures.
ANSI A112.19.5-79(R1990) - Trim for Water Closet Bowls, Tanks and Urinals.
ASSE 1011-93 - Hose Connection Vacuum Breakers.
ASSE 1014-90 - Handheld Showers.
ASSE 1035-93 - Laboratory Faucet Backflow Preventers.

P A R T 2 - P R O D U C T S

PLUMBING FIXTURES

Manufacturers: Fixture descriptions establish fixture type, quality, materials, features and size. Products of the following manufacturers determined to be equal by the Architect/Engineer will be accepted.

- Water Closets - American Standard, Kohler, Toto, Zurn.
- Water Closet Seats - Bemis, Beneke, Centoco, Olsonite, Zurn.
- Urinals – American Standard, Kohler, Toto, Zurn.
- Lavatories – American Standard, Kohler, Toto, Zurn.
- Faucets - Chicago Faucet, Kohler, Sloan, Speakman, Symmons, Toto, Zurn.
- Drains - Chicago Faucet, Engineered Brass Co., Kohler, McGuire, Zurn.
- Stops and Supplies - Chicago Faucet Co., Kohler, McGuire, Zurn. (Heavy Duty Type Only)
- Flush Valves - Delany, Sloan, Toto, Zurn AV.
- Traps - Kohler, McGuire, Dearborn, Engineered Brass Co. (17 gauge Min.)
- Carriers and Supports - Josam, Smith, Wade, Watts Drainage, Zurn.
- Showers – Bradley, Chicago Faucet, Leonard, Powers, Sloan, Speakman, Symmons.

WATER CLOSETS

WC-1 - Floor mount bottom outlet white vitreous china siphon jet water closet with elongated bowl, antimicrobial finish, 1-1/2" top spud, 2-1/8" passageway, 15-1/4" rim height and 1.6 gallon flush. Flush valve handle 22" above rim.

- Fixture: Kohler Wellcomme K-96053-SS.
- Flush Valve: Sloan Royal 116-1.6
- Seat: Kohler Lustra K-4670-CA white solid plastic open front.

WC-2 - Floor mount bottom outlet white vitreous china siphon jet water closet with elongated bowl, antimicrobial finish, 1-1/2" top spud, 2-1/8" passageway, 16-7/8" rim height and 1.6 gallon flush. Flush valve handle located to the wide side of the stall and be ADA compliable for activation force.

- Fixture: Kohler Highcliff K-96057-SS.
- Flush Valve: Sloan Royal 111-1.6
- Seat: Kohler Lustra K-4670-CAwhite solid plastic open front.

URINALS

UR-1 - Floor mount white vitreous china washout urinal with 3/4" rear inlet spud, 2" outlet spud, removable stainless steel beehive strainer. Battery powered sensor operated flush valve 0.5 gallon per flush.

- Fixture: Kohler Branham K-25039-R-0.
- Flush Valve: Sloan Royal 995-0.5 concealed manual specialty urinal hydraulic flushometer.

LAVATORIES

L-1 - Wall mount white vitreous china lavatory drilled for concealed arm carrier with 4" on center faucet openings.

- Fixture: Kohler Kingston K-2007.
- Faucet: Chicago Faucet No.420-ABCP, 1.5 gpm, lever handle.
- Drain: McGuire 155A perforated strainer and 1-1/4" tailpiece.

- Trap: 1-1/4"x1-1/2" 17 ga. cast brass trap and tubular wall bend. With C.O. plug.
- Supplies & Stops: Chicago Faucet Co. No. STC-31-11-PR-AB w/ 3/8" risers and escutcheons.
- Carrier: Smith floor mounted concealed arm carrier adjusted for 31" height rim ht.

SHOWERS

SH-1 – On/off mixing valve, fixed shower head, metal construction, all chrome finish, 2.0 gpm flow rate, ADA compliant.

- Enclosure: Field built by others
- Valve: Symmons 3501-CYL-B-TRM
- Shower Head: Symmons 352SH

SH-2 – On/off mixing valve, diverter valve, fixed shower head, handheld shower head with 60" hose & in-line vacuum breaker wall connection, 30" slide bar with cradle from hand shower, metal construction, all chrome finish, 2.0 gpm flow rate, ADA compliant.

- Enclosure: Field built by others
- Valve: Symmons 3505-H321-V-CYL-B-X-2.0
- Shower Head: Symmons 352SH

PART 3 - EXECUTION

INSTALLATION

Install plumbing fixtures in accordance with manufacturers instructions. Set level and plumb. Secure in place to counters, floors and walls providing solid bearing, rigid and secure mounting. Bolt fixture carriers to floor and wall. Secure rough-in fixture piping to prevent movement of exposed piping.

Install each fixture with trap easily removable for servicing and cleaning. Install fixture stops in readily accessible location for servicing.

Install barrier free fixtures in compliance with IBC 1109, ICC A117.1 and Federal ADA Accessibility Guidelines. Install barrier free lavatory traps parallel and adjacent to wall and supplies and stops elevated to 27" above floor to avoid contact by wheelchair users. Wrap barrier free lavatory drains and traps with custom fitted resilient cushioned covering.

Each fixture shall have a stop valve installation to control the fixture. Stop valves shall be heavy duty type with brass stems and screwed or compression inlet connections.

Cover pipe penetrations with escutcheons. Exposed traps, stops, piping and escutcheons to be chrome plated brass, same items in concealed locations may be of rough brass finish.

Seal openings between walls, floors and fixtures with mildew-resistant silicone sealant same color as fixture.

Test fixtures to demonstrate proper operation. Replace malfunctioning units or components. Adjust valves for intended water flow rate to fixtures without splashing, noise or overflow. Adjust shower valve temperature limit stops to 110 degree maximum outlet temperature.

Protect fixtures during construction. At completion clean plumbing fixtures and trim using manufacturer's recommended cleaning methods and materials.

CONSTRUCTION VERIFICATION ITEMS

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 22 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

END OF SECTION

SECTION 23 05 00
COMMON WORK RESULTS FOR HVAC
BASED ON DFD MASTER SPECIFICATION DATED 3/28/2022

P A R T 1 - G E N E R A L

SCOPE

This section includes information common to two or more technical specification sections or items that are of a general nature, not conveniently fitting into other technical sections. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Quality Assurance
- Continuity of Existing Services
- Protection of Finished Surfaces
- Sleeves and Openings
- Sealing
- Submittals
- Off Site Storage
- Certificates and Inspections
- Operating and Maintenance Data
- Training of Owner Personnel
- Record Drawings

PART 2 - PRODUCTS
- Identification
- Sealing

PART 3 - EXECUTION
- Demolition
- Concrete Work
- Cutting and Patching
- Building Access
- Equipment Access
- Coordination
- Identification
- Lubrication
- Sleeves and Openings
- Sealing
- Agency Training

RELATED WORK

Section 01 91 01 – Commissioning Process
Section 23 05 13 - Common Motor Requirements for HVAC.
Section 23 33 00 - Air Duct Accessories.

REFERENCE

Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

Abbreviations of standards organizations referenced in other sections are as follows:

AABC	Associated Air Balance Council
ADC	Air Diffusion Council
AGA	American Gas Association
AMCA	Air Movement and Control Association
ANSI	American National Standards Institute
ARI	Air-Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials

EPA	Environmental Protection Agency
GAMA	Gas Appliance Manufacturers Association
IEEE	Institute of Electrical and Electronics Engineers
ISA	Instrument Society of America
MCA	Mechanical Contractors Association
MICA	Midwest Insulation Contractors Association
MSS	Manufacturer's Standardization Society of the Valve & Fitting Industry, Inc.
NBS	National Bureau of Standards
NEBB	National Environmental Balancing Bureau
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association. Inc.
UL	Underwriters Laboratories Inc.
ASTM E814	Standard Test Method for Fire Tests of Through-Penetration Fire Stops
ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials
UL1479	Fire Tests of Through-Penetration Firestops
UL723	Surface Burning Characteristics of Building Materials

QUALITY ASSURANCE
Refer to Division 1, General Conditions, Equals and Substitutions.

Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or engineering parameters from those indicated on the contract documents, the contractor is responsible for all costs involved in integrating the equipment or accessories into the system and for obtaining the performance from the system into which these items are placed. This may include changes found necessary during the testing, adjusting, and balancing phase of the project.

CONTINUITY OF EXISTING SERVICES
Do not interrupt or change existing services without prior written approval from the DFD Project Representative. When interruption is required, coordinate the down-time with the user agency to minimize disruption to their activities. Unless specifically stated, all work involved in interrupting or changing existing services is to be done during normal working hours.

PROTECTION OF FINISHED SURFACES
Refer to Division 1, General Requirements, Protection of Finished Surfaces.

Furnish one can of touch-up paint for each different color factory finish which is to be the final finished surface of the product. Deliver touch-up paint with other "loose and detachable parts" as covered in the General Requirements.

SLEEVES AND OPENINGS
Refer to Division 1, General Requirements, Sleeves and Openings.

SEALING
Sealing of sleeves/openings between ductwork, piping, etc. and the sleeve, structural or partition opening shall be the responsibility of the contractor whose work penetrates the opening.

SUBMITTALS
Refer to Division 1, General Conditions, Submittals.

Submit for all equipment and systems as indicated in the respective specification sections, marking each submittal with that specification section number. Mark general catalog sheets and drawings to indicate specific items being submitted and proper identification of equipment by name and/or number, as indicated in the contract documents.

Before submitting electrically powered equipment, verify that the electrical power and control requirements for the equipment are in agreement with the motor starter schedule on the electrical drawings. Include a statement on the shop drawing transmittal to the architect/engineer that the equipment submitted and the motor starter schedules are in agreement or indicate any discrepancies. See related comments in Section 23 05 13 in Part 1 under Electrical Coordination.

Include wiring diagrams of electrically powered equipment.

Submit sufficient quantities of shop drawings to allow the following distribution:

- Operating and Maintenance Manuals 2 copies
- Testing, Adjusting and Balancing Contractor 1 copy
- Division of Facilities Development 1 copy
- A/E 1 copy

OFF SITE STORAGE

Prior approval by DFD and the A/E will be needed. The contractor shall submit Storage Agreement Form AD-BDC-74 to DFD for consideration of off site materials storage.

Generally, ductwork, metal for making ductwork, duct lining, sleeves, pipe/pipe fittings and similar rough-in material will not be accepted for off site storage. For material that can be stored off site, no material will be accepted for off site storage unless shop drawings for that material have been approved.

CERTIFICATES AND INSPECTIONS

Refer also to Division 1, General Conditions, Permits, Regulations, Utilities and Taxes.

Obtain and pay for all required State installation inspections except those provided by the Architect/Engineer in accordance with code. Deliver originals of these certificates to the Division Project Representative. Include copies of the certificates in the Operating and Maintenance Instructions.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

1. Records of tests performed a to certify compliance with system requirements
2. Certificates of inspection by regulatory agencies
3. Valve schedules
4. Lubrication instructions, including list/frequency of lubrication
5. Copies of all approved shop drawings.
6. Manufacturer's wiring diagrams for electrically powered equipment
7. Temperature control record drawings and control sequences
8. Parts lists for manufactured equipment
9. Warranties
10. Additional information as indicated in the technical specification sections

TRAINING OF OWNER PERSONNEL

Instruct user agency personnel in the proper operation and maintenance of systems and equipment provided as part of this project; video tape all training sessions. Include not less than 4 hours of instruction, using the Operating and Maintenance manuals during this instruction. Demonstrate startup and shutdown procedures for all equipment. All training to be during normal working hours.

RECORD DRAWINGS

Refer to Division 1, General Requirements, Record Drawings.

In addition to the data indicated in the General Requirements, maintain temperature control record drawings on originals prepared by the installing contractor/subcontractor. Include copies of these record drawings with the Operating and Maintenance manuals.

P A R T 2 - P R O D U C T S

IDENTIFICATION

STENCILS:

Not less than 1 inch high letters/numbers for marking pipe and equipment.

SNAP-ON PIPE MARKERS:

Cylindrical self-coiling plastic sheet that snaps over piping insulation and is held tightly in place without the use of adhesive, tape or straps. Not less than 1 inch high letters/numbers and flow direction arrows for piping marking. W. H. Brady, Seton, Marking Services, or equal.

ENGRAVED NAME PLATES:
White letters on a black background, 1/16 inch thick plastic laminate, beveled edges, screw mounting, Setonply Style 2060 by Seton Name Plate Company or Emedolite- Style EIP by EMED Co., or equal by Marking Services, or W. H. Brady.

VALVE TAGS:
Round brass tags with 1/2 inch numbers, 1/4 inch system identification abbreviation, 1-1/4 inch minimum diameter, with brass jack chains or brass "S" hooks around the valve stem, available from EMED Co., Seton Name Plate Company, Marking Services, or W. H. Brady.

CEILING and ACCESS DOOR LABELS:
Clear polyester tape ¾" width with black printing W. H. Brady or equal.

SEALING
NON-RATED PENETRATIONS:
Pipe Penetrations:
At pipe penetrations of non-rated interior walls, floors and exterior walls above grade, use urethane caulk in annular space between pipe insulation and sleeve. For non-rated drywall, plaster or wood walls where sleeve is not required use urethane caulk in annular space between pipe insulation and wall material.

P A R T 3 - E X E C U T I O N

DEMOLITION
Perform all demolition as indicated on the drawings to accomplish new work. Where demolition work is to be performed adjacent to existing work that remains in an occupied area, construct temporary dust partition to minimize the amount of contamination of the occupied space. Where pipe or duct is removed and not reconnected with new work, cap ends of existing services as if they were new work. Coordinate work with the user agency to minimize disruption to the existing building occupants.

All pipe, wiring and associated conduit, insulation, ductwork, and similar items demolished, abandoned, or deactivated are to be removed from the site by the Contractor. All piping and ductwork specialties are to be removed from the site by the Contractor unless they are dismantled and removed or stored by the user agency. All designated equipment is to be turned over to the user agency for their use at a place and time so designated. Maintain the condition of material and/or equipment that is indicated to be reused equal to that existing before work began.

CONCRETE WORK
All cast-in-place concrete will be performed by the Division 3 Contractor unless otherwise noted. Provide all layout drawings, anchor bolts, metal shapes, and/or templates required to be cast into concrete or used to form concrete for support of mechanical equipment.

CUTTING AND PATCHING
Refer to Division 1, General Requirements, Cutting and Patching.

BUILDING ACCESS
Arrange for the necessary openings in the building to allow for admittance of all apparatus. When the building access was not previously arranged and must be provided by this contractor, restore any opening to its original condition after the apparatus has been brought into the building.

EQUIPMENT ACCESS
Install all piping, conduit, ductwork, and accessories to permit access to equipment for maintenance and service. Coordinate the exact location of wall and ceiling access panels and doors with the General Contractor, making sure that access is available for all equipment and specialties. Access doors in general construction are to be furnished by the Mechanical Contractor and installed by the General Contractor.

COORDINATION
Verify that all devices are compatible for the surfaces on which they will be used. This includes, but is not limited to, diffusers, register, grilles, and recessed or semi-recessed heating and/or cooling terminal units installed in/on architectural surfaces.

Coordinate all work with other contractors prior to installation. Any installed work that is not coordinated and that interferes with other contractor's work shall be removed or relocated at the installing contractor's expense.

Cooperate with the test and balance agency in ensuring Section 23 05 93 specification compliance. Verify system completion to the test and balance agency (flushing, pressure testing, chemical treatment, filling of liquid systems, proper pressurization and air venting of hydronic systems, clean filters, clean strainers, duct and pipe systems cleaned, controls adjusted and calibrated, controls cycled through their sequences, etc.), ready for testing, adjusting and balancing work. Install dampers, shutoff and balancing valves, flow measuring devices, gauges, temperature controls, etc., required for functional and balanced systems. Demonstrate the starting, interlocking and control features of each system so the test and balance agency can perform its work.

IDENTIFICATION

Identify equipment in mechanical equipment rooms by stenciling equipment number and service with one coat of black enamel against a light background or white enamel against a dark background. Use a primer where necessary for proper paint adhesion. Do not label equipment such as cabinet heaters and ceiling fans in occupied spaces.

Where stenciling is not appropriate for equipment identification, engraved name plates may be used.

Identify piping not less than once every 30 feet, not less than once in each room, adjacent to each access door or panel, and on both side of the partition where exposed piping passes through walls, floors or roofs. Place flow directional arrows at each pipe identification location. Use one coat of black enamel against a light background or white enamel against a dark background for stenciling, or provide snap-on pipe markers as specified in Part 2 – Products.

Identify valves with brass tags bearing a system identification and a valve sequence number. Valve tags are not required at a terminal device unless the valves are greater than ten feet from the device or located in another room not visible from the terminal unit. Provide a typewritten valve schedule indicating the valve number and the equipment or areas supplied by each valve; locate schedules in each mechanical room and in each Operating and Maintenance manual. Schedules in mechanical rooms to be framed under clear plastic.

Use engraved name plates to identify control equipment.

LUBRICATION

Lubricate all bearings with lubricant as recommended by the manufacturer before the equipment is operated for any reason. Once the equipment has been run, maintain lubrication in accordance with the manufacturer's instructions until the work is accepted by DFD. Maintain a log of all lubricants used and frequency of lubrication; include this information in the Operating and Maintenance Manuals at the completion of the project.

SLEEVES AND OPENINGS

Pipe penetrations in existing concrete floors: Core drill openings.

Pipe penetrations through existing floors located in food service areas that do not require a T rating: Core drill sleeve opening large enough to insert schedule 40 sleeve, extend sleeve 2 inches above the floor and grout area around sleeve with hydraulic setting, non-shrink grout. Size sleeve to allow insulated pipe to run through sleeve and paint the sleeve.

Where penetrating pipe or conduit weight is supported by floor, provide manufactured product or structural bearing collar designed to carry load.

DUCT SLEEVES:

Duct sleeves are not required in non-rated partitions or floors.

Provide sleeve required for fire dampers in fire-rated partitions and floors. Reference fire damper details on drawings.

SEALING

NON-RATED PENETRATIONS:

At all interior walls and exterior walls, pipe penetrations are required to be sealed. Apply sealant to both sides of the penetration in such a manner that the annular space between the pipe sleeve or cored opening and the pipe or insulation is completely blocked.

AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01.

END OF SECTION

SECTION 23 05 13
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
BASED ON DFD MASTER SPECIFICATION DATED 12/20/2023

P A R T 1 - G E N E R A L

SCOPE

This sections includes requirements for single and three phase motors that are used with equipment specified in other sections. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Quality Assurance
- Shop Drawings
- Operating and Maintenance Data
- Electrical Coordination
- Product Criteria

PART 2 - PRODUCTS
- Single Phase, Single Speed Motors

PART 3 - EXECUTION
- Installation

RELATED WORK

Section 01 91 01 – Commissioning Process
Section 23 09 14 - Pneumatic and Electric Instrumentation and Control Devices for HVAC
Division 26 00 00 - Electrical

REFERENCE

Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

ANSI/IEEE 112	Test Procedure for Polyphase Induction Motors and Generators
ANSI/NEMA MG-1	Motors and Generators
ANSI/NFPA 70	National Electrical Code

QUALITY ASSURANCE

Refer to division 1, General Conditions, Equals and Substitutions.

SHOP DRAWINGS

Refer to division 1, General Conditions, Submittals.

Include with the equipment which the motor drives the following motor information: motor manufacturer, horsepower, voltage, phase, hertz, rpm, full load efficiency. Include project wiring diagrams prepared by the contractor specifically for this work.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

1. Lubrication instructions, including list/frequency of lubrication
2. Table noting full load power factor, service factor, NEMA design designation, insulation class and frame type for each motor provided

ELECTRICAL COORDINATION

Electrical drawings and/or specifications show number, and horsepower rating of all motors furnished by this Contractor, together with their actuating devices if these devices are furnished by the Electrical Contractor. Should any discrepancy in size, horsepower rating, electrical characteristics or means of control be found for any motor or other electrical equipment after contracts are awarded, Contractor is to immediately notify the architect/engineer of such discrepancy. Costs involved in any changes required due to equipment

substitutions initiated by this contractor will be the responsibility of this contractor. See related comments in Section 23 05 00 - Common Work Results for HVAC, under Shop Drawings.

Electrical Contractor will provide all power wiring and control wiring, except temperature control wiring.

Furnish project specific wiring diagrams to Electrical Contractor for all equipment and devices furnished by this Contractor and indicated to be wired by the Electrical Contractor.

PRODUCT CRITERIA

Motors to conform to all applicable requirements of NEMA, IEEE, ANSI, and NEC standards and shall be listed by U.L. for the service specified.

Select motors for conditions in which they will be required to perform; i.e., general purpose, splashproof, explosion proof, standard duty, high torque or any other special type as required by the equipment or motor manufacturer's recommendations.

Furnish motors for starting in accordance with utility requirements and compatible with starters as specified.

P A R T 2 - P R O D U C T S

SINGLE PHASE, SINGLE SPEED MOTORS

Use NEMA rated 115 volt, single phase, 60 hertz motors for all motors 1/3 HP and smaller and as scheduled.

Use permanent split capacitor or capacitor start, induction run motors equipped with permanently lubricated and sealed ball or sleeve bearings and Class A insulation. Service factor to be not less than 1.35.

P A R T 3 - E X E C U T I O N

INSTALLATION

Mount motors on a rigid base designed to accept a motor, using shims if required under each mounting foot to get a secure installation.

When motor will be flexible coupled to the driven device, mount coupling to the shafts in accordance with the coupling manufacturer's recommendations. Using a dial indicator, check angular misalignment of the two shafts; adjust motor position as necessary so that the angular misalignment of the shafts does not exceed 0.002 inches per inch diameter of the coupling hub. Again using the dial indicator, check the shaft for run-out to assure concentricity of the shafts; adjust as necessary so that run-out does not exceed 0.002 inch.

When motor will be connected to the driven device by means of a belt drive, mount sheaves on the appropriate shafts in accordance with the manufacturer's instructions. Use a straight edge to check alignment of the sheaves; reposition sheaves as necessary so that the straight edge contacts both sheave faces squarely. After sheaves are aligned, loosen the adjustable motor base so that the belt(s) can be added and tighten the base so that the belt tension is in accordance with the drive manufacturer's recommendations. Frequently recheck belt tension and adjust if necessary during the first day of operation and again after 80 hours of operation.

Lubricate all motors requiring lubrication. Record lubrication material used and the frequency of use. Include this information in the maintenance manuals.

END OF SECTION

SECTION 23 05 23
GENERAL-DUTY VALVES FOR HVAC PIPING
BASED ON DFD MASTER SPECIFICATION DATED 11/19/24

P A R T 1 - G E N E R A L

SCOPE
This section includes valve specifications for all HVAC systems except where indicated under Related Work. Included are the following topics:

RELATED WORK
Section 01 91 01 – Commissioning Process
Section 23 09 14 - Pneumatic and Electric Instrumentation and Control Devices for HVAC

REFERENCE
Applicable provisions of Division 1 govern work under this section.

QUALITY ASSURANCE
Refer to division 1, General Conditions, Equals and Substitutions.

SUBMITTALS
Refer to division 1, General Conditions, Submittals.
Contractors shall submit a schedule of all valves indicating type of service, dimensions, materials of construction, and pressure/temperature ratings for all valves to be used on the project. Temperature ratings specified are for continuous operation.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

Delete the following if there are no additional requirements.
In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

DESIGN CRITERIA
Where valves are specified for individual mechanical services (i.e. hot water heating, steam, etc.) all valves shall be of the same manufacturer unless prior written approval is obtained from DFD.

P A R T 2 - P R O D U C T S

MANUFACTURERS
Anvil, Apollo, Armstrong, Bell & Gossett, Cash-Acme, Dresser Consolidated, Conval, Crane, Anderson Greenwood and Crosby, Danfoss-Flomatic, DeZurik, Durco, Fisher, Grinnell, Griswold, Hammond,

Hancock, Hoffman, Jamesbury, Keystone, Kunkle, Leslie, Lunkenheimer/Cincinnati, Metraflex, Milwaukee, Mueller, Newco, Nexus, Nibco, Powell, RP&C, Sarco, Spence, Stockham, Taco, Tasco, Thrush-Amtrol, Vogt, Watts, or approved equal.

NATURAL GAS SYSTEMS

SHUT OFF VALVES:
2" and smaller: Ball valve, bronze body, threaded ends, chrome-plated bronze or stainless steel ball, full or conventional port, teflon seat, blowout-proof stem, two-piece construction, suitable for 150 psig working pressure, U.L. listed for use as natural gas shut-off.

2-1/2" through 4": Cast iron body, flanged ends, bronze bearings, electroless nickel plated cast iron plug with Hycar resilient plug seal, Buna-N stem seal packing, lever actuator, 175 psi W.O.G., U.L. listed for use as natural gas shut-off.

5" and larger: Cast iron body, flanged ends, stainless steel bearings, resilient faced plugs, totally enclosed hand wheel actuators, 175 psi W.O.G., U.L. listed for use as natural gas shut-off.

DeZurik, Homestead, Rockwell, Walworth.

GAS PRESSURE REGULATORS:
2" and smaller: Cast iron body, aluminum spring and diaphragm, Nitrile diaphragm, threaded ends, 150 psi W.O.G., -20°F to 150°F.

P A R T 3 - E X E C U T I O N

GENERAL

Properly align piping before installation of valves in an upright position; operators installed below the valves will not be accepted.

Install valves in strict accordance with valve manufacturer's installation recommendations. Do not support weight of piping system on valve ends.

Install all valves with the stem in the upright position. Valves may be installed with the stem in the horizontal position only where space limitations do not allow installation in an upright position or where large valves are provided with chain wheel operators. Valves installed with the stems down, will not be accepted.

Install stem extensions when shipped loose from valve.

Prior to flushing of piping systems, place all valves in the full-open position.

SHUT-OFF VALVES:
Install shut-off valves at all equipment, at each branch take-off from mains, and at each automatic valve for isolation or repair.

GAS PRESSURE REGULATORS
When the gas pressure regulator is equipped with a vent connection, run a connection size vent to outside air in accordance with codes. Use a larger size vent when required by the manufacturer's installation instructions.

END OF SECTION

SECTION 23 05 29
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
BASED ON DFD MASTER SPECIFICATION DATED 03/08/2024

P A R T 1 - G E N E R A L

SCOPE
This section includes specifications for supports of all HVAC equipment and materials as well as piping system anchors. Included are the following topics:

RELATED WORK
Section 01 91 01 – Commissioning Process
Section 23 07 00 - HVAC Insulation

REFERENCE
Applicable provisions of Division 1 shall govern work under this section.

REFERENCE STANDARDS
MSS SP-58 Materials, Design, Manufacture, Selection, Application, and Installation

QUALITY ASSURANCE
Refer to Division 1, General Conditions, Equals and Substitutions.

DESCRIPTION
Provide all supporting devices as required for the installation of mechanical equipment and materials. All supports and installation procedures are to conform to the latest requirements of the ANSI Code for pressure piping.

Do not hang any mechanical item directly from a metal deck or run piping so it rests on the bottom chord of any truss or joist.

Support apparatus and material under all conditions of operation, variations in installed and operating weight of equipment and piping, to prevent excess stress, and allow for proper expansion and contraction.

Protect insulation at all hanger points; see Related Work above.

SUBMITTALS
Refer to division 1, General Conditions, Submittals and 01 33 00 Electronic Submittal Procedures.

Schedule of all hanger and support devices indicating shields, attachment methods, and type of device for each pipe size and type of service. Reference section 23 05 00.

All submittals are to comply with submission and content requirements specified in specification Section 01 91 01.

DESIGN CRITERIA
Materials and application of pipe hangers and supports shall be in accordance with MSS Standard Practice SP-58 unless noted otherwise.

Piping connected to base mounted pumps, compressors, or other rotating or reciprocating equipment is to have vibration isolation supports for a distance of one hundred pipe diameters or three supports away from the equipment, whichever is greater. Standard pipe hangers/supports as specified in this section are required beyond the 100 pipe diameter/3 support distance.

Piping flexible connections and vibration isolation supports are required for piping connected to coils that are in a fan assembly where the entire assembly is mounted on vibration supports; the vibration isolation supports are required for a distance of one hundred pipe diameters or three supports away from the equipment, whichever is greater. Piping flexible connection and vibration isolation supports are not required when the fan section is separately and independently isolated by means of vibration supports and duct flexible connections. Standard pipe hangers/supports as specified in this section are required when there are no vibration isolation devices in the piping and beyond the 100 pipe diameter/3 support distance.

Piping supported by laying on the bottom chord of joists or trusses will not be accepted.

Fasteners depending on soft lead for holding power or requiring powder actuation will not be accepted.

Allow sufficient space between adjacent pipes and ducts for insulation, valve operation, routine maintenance, etc.

P A R T 2 - P R O D U C T S

PIPE HANGER AND SUPPORT MANUFACTURERS
Anvil, B-Line, G-Strut, Fee and Mason, FNW, Kindorf, Michigan Hanger, Unistrut, or approved equal. Anvil figure numbers are listed below; equivalent material by other manufacturers is acceptable.

STRUCTURAL SUPPORTS
Provide all supporting steel required for the installation of mechanical equipment and materials, whether or not it is specifically indicated or sized, including angles, channels, beams, etc. to suspend or floor support tanks and equipment.

PIPE HANGERS AND SUPPORTS
HANGERS FOR STEEL PIPE SIZES 1/2" THROUGH 2":
Carbon steel, adjustable, clevis, black finish. Anvil figure 65 or 260.

HANGERS FOR STEEL PIPE SIZES 2-1/2" AND OVER:
Carbon steel, adjustable, clevis, black finish. Anvil figure 260.

Adjustable steel yoke, cast iron roll, double hanger. Anvil figure 181.

MULTIPLE OR TRAPEZE HANGERS:
Steel channels with welded spacers and hanger rods if calculations are submitted.

WALL SUPPORT:
Welded steel bracket with hanger. B-Line 3068 Series, Anvil 194 Series.

Perforated epoxy painted finish, 16-12 gauge min., steel channels securely anchored to wall structure with interlocking, split type, bolt secured, galvanized pipe/tubing clamps. B-Line type S channel with B-2000 series clamps, Anvil type AS200 H with AS 1200 clamps. When copper piping is being supported, provide flexible elastomeric/thermoplastic isolation cushion material to completely encircle the piping and avoid

contact with the channel or clamp, equal to B-Line B1999 Vibra Cushion or provide manufacturers clamp and cushion assemblies, B-Line BVT series, Anvil cushion clamp assembly.

VERTICAL RISER SUPPORT:
Carbon steel riser clamp, copper plated when used with copper pipe. Anvil figure 261 for steel pipe, figure CT121 for copper pipe.

FLOOR SUPPORT FOR PIPE SIZES THROUGH 4":
Cast iron adjustable pipe saddle, locknut nipple, floor flange, and concrete pier or steel support.

FLOOR SUPPORT FOR PIPE SIZES 5" AND OVER:
Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.

COPPER PIPE SUPPORT:
Carbon steel ring, adjustable, copper plated or polyvinylchloride coated.

INSULATION PROTECTION SHIELDS:
Galvanized carbon steel of not less than 18 gauge for use on insulated pipe 2-1/2 inch and larger. Minimum shield length is 12 inches. Equal to Anvil figure 167.

STEEL HANGER RODS:
Threaded both ends, threaded one end, or continuous threaded, black finish.

Size rods for individual hangers and trapeze support as indicated in the following schedule.

Total weight of equipment, including valves, fittings, pipe, pipe content, and insulation, are not to exceed the limits indicated.

Maximum Load (Lbs.) (650°F Maximum Temp.)	Rod Diameter (inches)
610	3/8
1130	1/2
1810	5/8
2710	3/4
3770	7/8
4960	1
8000	1-1/4

Provide rods complete with adjusting and lock nuts.

BEAM CLAMPS
MSS SP-58 Type 23 malleable black iron clamp for attachment to beam flange to 0.62 inches thick for single threaded rods of 3/8, 1/2, and 5/8 inch diameter, for use with pipe sizes 4 inch and less. Furnish with a hardened steel cup point set screw. Anvil figure 86.

MSS SP-58 Type 28 or Type 29 forged steel jaw type clamp with a tie rod to lock clamp in place, suitable for rod sizes to 1-1/2 inch diameter but limited in application to pipe sizes 8 inch and less without prior approval. Anvil figure 228.

CONCRETE INSERTS
Carbon steel expansion anchors, vibration resistant, with ASTM B633 zinc plating. Use drill bit of same manufacturer as anchor. Hilti, Rawl, Redhead.

ANCHORS
Use welding steel shapes, plates, and bars to secure piping to the structure.

EQUIPMENT CURBS
Prefabricated Metal Curb:

Constructed of not less than 18 gauge galvanized steel reinforced so it is structurally capable of supporting the intended load with no penetrations through the curb flashing, inside and outside corner sections that are mitered and continuously welded, filled with 3 pound density rigid fiberglass insulation, integral deck mounting flange, nominal two inch wood nailer, galvanized steel counter flashing. Do not use built-in metal

base flashings or cants. Use 18 inch high equipment curbs where the curb completely surrounds the perimeter of the equipment and there is no roof exposed to the weather.

Wood Build Sleeper Curb:

Constructed of wood blocking and anchored to the deck. The curb must be structurally capable of supporting the intended load with no penetrations through the curb flashing. Galvanized steel counter flashing. Do not use built-in metal base flashings or cants. Use 18 inch high equipment curbs where the curb completely surrounds the perimeter of the equipment and there is no roof exposed to the weather.

PIPE PENETRATIONS THROUGH ROOF

Multiple Pipe Penetrations:

Refer to acceptable Equipment Curb types listed above for curb specifications. An 8" high (minimum) curb height is required. The coping cap shall be constructed from laminated acrylic clad thermoplastic (ABS) with graduated step boots to accommodate various size pipes, stainless steel fastening screws for cover, stainless steel band clamps for securing boots around the pipe, and stainless steel band clamp or mechanical locking seal for securing boots around the ABS coping cap flanges.

Single Pipe Penetrations:

A stack flashing penetration may be utilized for single pipe penetrations through built up roofs and single ply membrane roofs. Utilize high temperature sealant for all high temperature applications. This includes but is not limited to steam condensate vent piping, steam safety relief piping, and flues.

A single pre-manufactured boot may be utilized for single pipe penetrations through single ply membrane roofs only.

P A R T 3 - E X E C U T I O N

INSTALLATION

Install supports to provide for free expansion of the piping and duct system. Support all piping from the structure using concrete inserts, beam clamps, ceiling plates, wall brackets, or floor stands. Fasten ceiling plates and wall brackets securely to the structure and test to demonstrate the adequacy of the fastening.

Piping shall be supported independently from ductwork and all other trades.

Where piping can be conveniently grouped to allow the use of trapeze type supports, use standard structural shapes for the supporting steel.

Trim steel hanger rods to within one inch of the final lock nut position. Hanger and support cutoff burrs shall be removed and sharp edges ground smooth.

Perform all welding in accordance with standards of the American Welding Society. Clean surfaces of loose scale, rust, paint or other foreign matter and properly align before welding. Use wire brush on welds after welding. Welds shall show uniform section, smoothness of weld metal and freedom from porosity and clinkers. Where necessary to achieve smooth connections, joints shall be dressed smooth.

HANGER AND SUPPORT SPACING

Place a hanger within 12 inches of each horizontal elbow, valve, strainer, or similar piping specialty item.

Where several pipes can be installed in parallel and at the same elevation, provide multiple or trapeze hangers.

Support riser piping independently of connected horizontal piping.

Adjust hangers to obtain the slope specified in the piping section of this specification.

Space hangers for pipe as follows:

Pipe Material	Pipe Size	Max. Spacing Horizontal	Max Spacing Vertical
Steel	1/2" through 1-1/4"	6'-6"	15'-0"
Steel	1-1/2" through 6"	10'-0"	15'-0"

PIPE SADDLES
Provide pipe saddles at each support location as detailed on plans.

VERTICAL RISER CLAMPS
Support vertical piping with clamps secured to the piping and resting on the building structure or secured to the building structure below at each floor at a minimum. Mid-story supports may be necessary to meet the requirements listed above.

EQUIPMENT CURBS
Secure bottom of support flat on roof deck. Secure equipment to curb in accordance with equipment manufacturer's instructions. Flashing and counter flashing by the Division 07 Contractor.

Fill the entire void space with compressible fiberglass insulation.

PIPE PENETRATION THROUGH ROOF
Install at points where pipes penetrate roof. Install as shown on the drawings, as detailed and according to the manufacturer's installation instructions. Flashing and counterflashing by the Division 07 Contractor.

CONSTRUCTION VERIFICATION
Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

END OF SECTION

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SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC
BASED ON DFD MASTER SPECIFICATION DATED 9/23/2024

P A R T 1 - G E N E R A L

SCOPE
This section includes air and water testing, adjusting and balancing for the entire project. Included are the following topics:

RELATED WORK
Section 01 91 01 – Commissioning Process
Section 23 05 00 Common Work Results for HVAC
Section 23 07 00 HVAC Insulation
Section 23 08 00 – Commissioning of HVAC
Section 23 09 14 Pneumatic and Electric Instrumentation and Control Devices for HVAC

REFERENCE
Applicable provisions of the General Conditions, Supplementary General Conditions and General Requirements in Division 1 govern work under this section.

REFERENCE STANDARDS
AABC	National Standards for Total System Balance, Sixth Edition, 2002.
ASHRAE	ASHRAE Handbook, 2007 HVAC Applications, Chapter 37, Testing Adjusting and Balancing.
NEBB	Procedural Standards for Testing Adjusting Balancing of Environmental Systems, Seventh Edition, 2005.
TABB	Tab Procedural Guide, First Edition, 2003.

DESCRIPTION
The Contractor will separately contract with an independent test and balance agency to perform all testing, adjusting, and balancing of air systems required for this project. Work related to the testing, adjusting, and balancing that must be performed by the installing mechanical contractor is specified in other section of these specifications.

Provide total mechanical systems testing, adjusting and balancing. Requirements include the balance of air distribution, adjustment of new and existing systems and equipment to provide design requirements indicated on the drawings, electrical measurement and verification of performance of all mechanical equipment, all in accordance with standards published by AABC, NEBB, or TABB.

Test, adjust and balance all air systems so that each room, piece of equipment or terminal device meets the design requirements indicated on the drawings and in the specifications.

Accomplish testing, adjusting and balancing work in a timely manner that allows partial occupancy of major buildings, occupancy of one building when the project involves many buildings, and completion of

the entire project in the time stated in the Instruction to Bidders and in accordance with the completion schedule established for this project.

Verify that provisions are being made to accomplish the specified testing, adjusting and balancing work. If problems are found, handle as specified in Part 3 under Deficiencies.

QUALITY ASSURANCE

Qualifications

An independent Firm specializing in the Testing and Balancing of HVAC systems for a minimum of 3 years. A Firm not engaged in the commerce of furnishing or providing equipment or material generally related to HVAC work other than that specifically related to installing Testing and Balancing components necessary for work in this section such as, but not limited to sheaves, pulleys, and balancing dampers.

A certified member of AABC or certified by NEBB or TABB in the specific area of work performed. Maintain certification for the entire duration of the project. If certification of firm or any staff performing work is terminated or expires during the duration of the project, contact DFD immediately.

Technicians on this project must have satisfactorily completed work on a minimum of (3) three projects of at least 50% in size, and of similar complexity. Size is defined as the quantity of each specific individual item requiring testing and balancing such as, but not limited to, equipment, devices, terminal devices, and grilles and diffusers.

Submit Qualifications of firm and project staff to DFD upon requested.

PRE-INSTALLATION MEETING AND SCHEDULING

The test and balance agency is required to attend a pre-installation meeting with all other project contractors before the construction process is started. The test and balance agency shall give the Mechanical Contractor a detailed schedule of testing and balancing tasks for incorporation into the project schedule.

PRE-BALANCE CONFERENCE

90 days prior to beginning testing, adjusting and balancing, schedule and conduct a conference with the Architect/Engineer, DFD's Project Representative and the mechanical system and temperature control system installing Contractors. Provide AE and Commissioning Provider (CxP) with a complete copy of the TAB plan for the project. The objective is final coordination and verification of system operation and readiness for testing, adjusting and balancing procedures and scheduling procedures with the above mentioned parties. Indicate work required to be completed prior to testing, adjusting, and balancing and identify the party responsible for completion of that work.

SUBMITTALS

Refer to division 1, General Conditions, Submittals. See also Related Work in this section.

Submit testing, adjusting and balancing reports bearing the seal and signature of the NEBB, AABC or TABB Certified Test and Balance Supervisor. The reports certify that the systems have been tested, adjusted and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed and are operating; and are an accurate record of all final quantities measured to establish normal operating values of the systems.

Submission:
Distribute electronic copies of the Report to the DFD Project Representative, the Agency Contact, the Prime A/E, the DFD Project Manager, John Chapman (John.Chapman@wisconsin.gov), and Mike Casper (Mike.Casper@wisconsin.gov).

Format: Cover page identifying project name, project number and descriptive title of contents. Divide the contents of the report into the below listed divisions:

- General Information
- Summary
- Air Systems

Contents: Provide the following minimum information, forms and data:

General Information: Inside cover sheet identifying Test and Balance Agency, Contractor, Architect, Engineer, Project Name and Project Number. Include addresses, contact names and telephone numbers. Also include a certification sheet containing the seal and signature of the Test and Balance Supervisor.

Summary: Provide summary sheet describing mechanical system deficiencies. Describe objectionable noise or drafts found during testing, adjusting and balancing. Provide recommendations for correcting unsatisfactory performances and indicate whether modifications required are within the scope of the contract, are design related or installation related. List instrumentation used during testing, adjusting and balancing procedures.

The remainder of the report to contain the appropriate standard NEBB, AABC, or TABB forms for each respective item and system. Fill out forms completely. Where information cannot be obtained or is not applicable indicate same.

P A R T 2 - P R O D U C T S

INSTRUMENTATION

Provide all required instrumentation to obtain proper measurements. Application of instruments and accuracy of instruments and measurements to be in accordance with the requirements of NEBB, AABC, or TABB Standards and instrument manufacturer's specifications.

All instruments used for measurements shall be accurate, and calibration histories for each instrument to be available for examination by DD upon request. Calibration and maintenance of all instruments to be in accordance with the requirements of NEBB, AABC, or TABB Standards

P A R T 3 - E X E C U T I O N

DAILY REPORTS

Submit to DFD's Project Representative daily work activity reports for each day on which testing and balancing work is performed. Reports shall include description of day's activities and description of any system deficiencies.

PRELIMINARY PROCEDURES

Review preconstruction meeting report, applicable construction bulletins, applicable change orders and approved shop drawings of equipment, outlets/inlets and temperature controls.

Check filters for cleanliness, dampers and valves for correct positioning, equipment for proper rotation and belt tension, temperature controls for completion of installation and hydronic systems for proper charge and purging of air.

Notify DFD's Project Representative on a daily basis during balancing. Identify deficiencies preventing completion of testing, adjusting and balancing procedures. Do not proceed until systems are fully operational with all components necessary for complete testing, adjusting and balancing. Installing Contractors are required to provide personnel to check and verify system completion, readiness for balancing and assist Balancing Agency in providing specified system performance.

PERFORMING TESTING, ADJUSTING AND BALANCING

Perform testing, adjusting and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards except as may be modified below.

Unless specifically instructed in writing, all work in this specification section is to be performed during the normal workday.

In areas containing ceilings, remove ceiling tile to accomplish balancing work; replace tile when work is complete and provide new tile for any tile that are damaged by this procedure. If the ceiling construction is such that access panels are required for the work of this section and the panels have not been provided, inform the owner's project representative.

Cut insulation, ductwork and piping for installation of test probes to the minimum extent necessary for adequate performance of procedures. Patch using materials identical to those removed, maintaining vapor barrier integrity and pressure rating of systems.

In air systems employing filters, blank off sufficient filter area to simulate a pressure drop that is midway between that of a clean filter and that of a dirty filter.

Measure and record system measurements at the fan to determine total flow. Adjust equipment as required to yield specified total flow at terminals. Proceed taking measurements in mains and branches as required for final terminal balancing. Perform terminal balancing to specified flows balancing branch dampers, deflectors, extractors and valves prior to adjustment of terminals.

Measure and record static air pressure conditions across fans, coils and filters. Indicate in report if cooling coil measurements were made on a wet or dry coil and if filter measurements were made on a clean or dirty filter. Spot check static air pressure conditions directly ahead of terminal units.

Adjust outside air, return air and relief air dampers for design conditions at both the minimum and maximum settings and record both sets of data. Balance modulating dampers at extreme conditions and record both sets of data. Balance variable air volume systems at maximum air flow rate, full cooling, and minimum flow rate, full heating; record all data.

Adjust register, grille and diffuser vanes and accessories to achieve proper air distribution patterns and uniform space temperatures free from objectionable noise and drafts within the capabilities of the installed system.

Provide fan and motor drive sheave adjustments necessary to obtain design performance. Provide drive changes specifically noted on drawings, if any. If work of this section indicates that any drive or motor is inadequate for the application, advise the owner's project representative by giving the representative properly sized motor/drive information (in accordance with manufacturers original service factor and installed motor horsepower requirements); Confirm any change will keep the duct system within its design limitations with respect to speed of the device and pressure classification of the distribution system. Required motor/drive changes not specifically noted on drawings or in specifications will be considered an extra cost and will require an itemized cost breakdown submitted to owner's project representative. Prior authorization is needed before this work is started.

Final air system measurements to be within the following range of specified cfm:

Fans	0% to +10%
Supply grilles, registers, diffusers	-5% to +5%
Return/exhaust grilles, registers	-5% to +5%

Contact the temperature control Contractor for assistance in operation and adjustment of controls during testing, adjusting and balancing procedures. Cycle controls and verify proper operation and setpoints. Include in report description of temperature control operation and any deficiencies found.

Permanently mark equipment settings, including damper and valve positions, control settings, and similar devices allowing settings to be restored. Set and lock memory stops.

Leave systems in proper working order, replacing belt guards, closing access doors and electrical boxes, and restoring temperature controls to normal operating settings.

Coordinate and assist CxP with all verification activities defined within section 01 91 01 including providing all required sampling date necessary for the commissioning process.

Coordinate air handling unit minimum outside air set points with the Temperature Control Contractor.

DEFICIENCIES

Division 23 00 00 contractor to correct any installation deficiencies found by the test and balance agency that were specified and/or shown on the Contract Documents to be performed as part of that division of work. Test and balance agency will notify the DFD's Project Representative of these items and instructions will be issued to the Division 23 00 00 contractor for correction of the deficient work. All corrective work to be done at no cost to the State of Wisconsin. Retest mechanical systems, equipment, and devices once corrective work is complete as specified.

FUNCTIONAL PERFORMANCE TESTING

Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 Commissioning of HVAC in accordance with the procedures defined for functional performance testing in Section 01 91 01. Notify the A/E and commissioning provider 5 business days prior to performing functional performance testing so that they may witness.

END OF SECTION

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SECTION 23 07 00
HVAC INSULATION
BASED ON DFD MASTER SPECIFICATION DATED 5/12/2025

P A R T 1 - G E N E R A L

SCOPE

This section includes insulation specifications for heating, ventilating and air conditioning piping, ductwork and equipment. Included are the following topics:

RELATED WORK

Section 01 91 01 – Commissioning Process
Section 23 05 00 - Common Work Results for HVAC
Section 23 08 00 - Commissioning of HVAC
Section 23 11 00 - Facility Fuel Piping
Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment
Section 23 31 00 - HVAC Ducts and Casings

REFERENCE

Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

ASTM C165	Test Method for Compressive Properties of Thermal Insulations
ASTM C177	Heat Flux and Thermal Transmission Properties
ASTM C195	Mineral Fiber Thermal Insulation Cement
ASTM C240	Cellular Glass Insulation Block
ASTM C302	Density of Preformed Pipe Insulation
ASTM C272	Water Absorption of Core Materials for Sandwich Constructions
ASTM C303	Density of Preformed Block Insulation
ASTM C355	Test Methods for Test for Water Vapor Transmission of Thick Materials
ASTM C449	Mineral Fiber Hydraulic Setting Thermal Insulation Cement
ASTM C518	Heat Flux and Thermal Transmission Properties
ASTM C534	Preformed Flexible Elastomeric Thermal Insulation
ASTM C547	Mineral Fiber Preformed Pipe Insulation

ASTM C552	Cellular Glass Block and Pipe Thermal Insulation
ASTM C553	Mineral Fiber Blanket and Felt Insulation
ASTM C612	Mineral Fiber Block and Board Thermal Insulation
ASTM C921	Properties of Jacketing Materials for Thermal Insulation
ASTM C1136	Flexible Low Permeance Vapor Retarders for Thermal Insulation
ASTM C1728	Standard for Aerogel Insulation
ASTM D412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension
ASTM D1621	Standard Test Method for Compressive Properties Of Rigid Cellular Plastics
ASTM D1622	Standard Test Method for Apparent Density of Rigid Cellular Plastics
ASTM D1940	Method of Test for Porosity of Rigid Cellular Plastics
ASTM D2126	Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging
ASTM D2240	Standard Test Method for Rubber Property—Durometer Hardness
ASTM D5590	Test Method for Determining the Resistance of Coatings to Fungal Defacement
ASTM E84	Surface Burning Characteristics of Building Materials
ASTM E814	Standard Test Method for Fire Tests of Penetration Firestop Systems
ASTM E2336	Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems
MICA	National Commercial & Industrial Insulation Standards
NFPA 225	Surface Burning Characteristics of Building Materials
UL 723	Surface Burning Characteristics of Building Materials

QUALITY ASSURANCE

Refer to division 1, General Conditions, Equals and Substitutions

Label all insulating products delivered to the construction site with the manufacturer's name and description of materials.

Insulation systems shall be applied by experienced contractors. Within the past five (5) years, the contractor shall be able to document the successful completion of a minimum of three (3) projects of at least 50% of the size and similar scope of the work specified in this section.

DESCRIPTION

Furnish and install all insulating materials and accessories as specified or as required for a complete installation. The following types of insulation are specified in this section:

- Pipe Insulation
- Duct Insulation

Install all insulation in accordance with the latest edition of MICA (Midwest Insulation Contractors Association) Standard and manufacturer's installation instructions. Exceptions to these standards will only be accepted where specifically modified in these specifications, or where prior written approval has been obtained from the DFD Project Representative.

DEFINITIONS

Concealed: shafts, furred spaces, space above finished ceilings, utility tunnels and crawl spaces. All other areas, including walk-through tunnels, shall be considered as exposed.

SHOP DRAWINGS

Refer to division 1, General Conditions, Submittals.

Submit a schedule of all insulating materials to be used on the project, including adhesives, fastening methods, fitting materials along with material safety data sheets and intended use of each material. Include manufacturer's technical data sheets indicating density, thermal characteristics, jacket type, and manufacturer's installation instructions. Include copies of the MICA plates that are applicable to this project.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

ENVIRONMENTAL REQUIREMENTS

Do not store insulation materials on grade or where they are at risk of becoming wet. Do not install insulation products that have been exposed to water.

Protect installed insulation work with plastic sheeting to prevent water damage.

P A R T 2 - P R O D U C T S

MATERIALS
Manufacturers: Armacell, CertainTeed, Manson, Childers, Dow, Extol, Fibrex, K-FLEX USA, Foster, Johns Manville, Knauf Insulation, Owens-Corning, VentureTape or approved equal.

Materials or accessories containing asbestos will not be accepted.

Use composite insulation systems (insulation, jackets, sealants, mastics, and adhesives) that have a flame spread rating of 25 or less and smoke developed rating of 50 or less, with the following exceptions:

Pipe insulation which is not located in an air plenum may have a flame spread rating not over 25 and a smoke developed rating no higher than 450 when tested in accordance with UL 723 and ASTM E84.

INSULATION TYPES
Insulating materials shall be fire retardant, moisture and mildew resistant, and vermin proof. Insulation shall be suitable to receive jackets, adhesives and coatings as indicated.

FLEXIBLE FIBERGLASS INSULATION:
Minimum nominal density of 1.0 lbs. per cu. ft., and thermal conductivity of not more than 0.30 at 75 degrees F mean temperature, rated for maximum service temperature of 250 degrees F.

RIGID FIBERGLASS INSULATION:
Minimum nominal density of 3 lbs. per cu. ft., and thermal conductivity of not more than 0.23 at 75 degrees F mean temperature, 0.25 at 125 degrees F, 0.27 at 150 degrees F, 0.29 at 200 degrees F, 0.32 at 250 degrees F, minimum compressive strength of 25 PSF at 10% deformation, rated for maximum service temperature of 450 degrees F.

ELASTOMERIC INSULATION:
Flexible closed cell, minimum nominal density of 5.5 lbs. per cu. ft., thermal conductivity of not more than 0.28 at 75 degrees F mean temperature, minimum compressive strength of 2 psi at 25% deformation, maximum water vapor permeability of 0.08 perm inch, maximum water absorption of 6% by weight, rated for service temperature range of -20 degrees F to 220 degrees F on piping and 180 degrees F where adhered to equipment.

ADHESIVES, MASTIC, SEALANTS, AND REINFORCING MATERIALS
Products shall be compatible with surfaces and materials on which they are applied and shall be suitable for use at operating temperatures of systems to which they are applied.

FIBERGLASS INSULATION ADHESIVE:
Must comply with ASTM C916, Type II: Foster 85-60, Childers CP-127, Duro Dyne SSG.

VAPOR RETARDING MASTIC:
For below ambient equipment/piping use a water-based mastic with a water vapor permeance of less than 0.04 perms at 40 mils dry film thickness per ASTM E 96: Childers CP-34, Foster 30-65 Vapor-Fas, , Knauf Insulation, KI-900 or KI-905, Vimasco 749.

Anti-fungal mastic to be used in the following locations;

- Exterior locations
- Parking ramps
- Chemical storage and hazardous waste storage rooms
- Locker/shower rooms

WEATHER BARRIER BREATHER MASTIC:
For above ambient equipment/piping use water based mastic with a permeance greater than 1.0 perms at 1/16" dry film thickness per ASTM E96. Foster 46-50 Weatherite, Childers Vi-Cryl CP-10/CP-11, Vimasco WC-5, Knauf Insulation KI-700 or KI-705.

LAGGING ADHESIVE / COATINGS:
For all indoors applications used in conjunction with canvas/glass cloth: Foster 30-36, Childers CP-50A MV1, Vimasco 713.

Anti-fungal adhesive/coating to be used in the following locations;

- Exterior locations
- Parking ramps
- Chemical storage and hazardous waste storage rooms
- Locker/shower rooms

REINFORCING MESH:
Use Foster 42-24 Mast A Fab, Childers Chil Glas #10 or Owens-Corning PC 79.

INSULATION JOINT SEALANT:
Joint sealants to be non-shrinking and permanently flexible.
Used on all below ambient piping to prevent moisture ingress.
For Elastomeric use Armaflex 520 or equal.

JACKETS
PVC FITTING COVERS AND JACKETS (PFJ):
White PVC film, gloss finish one side, semi-gloss other side, FS LP-535D, Composition A, Type II, Grade GU. Ultraviolet inhibited indoor/outdoor grade to be used where exposed to high humidity, ultraviolet radiation, in kitchens or food processing areas or installed outdoors. Jacket thickness to be minimum .02" indoors/.03"outdoors for piping 12" and smaller, .03" indoors/.04" outdoors for piping 15" and larger.

FOIL SCRIM KRAFT ALL SERVICE JACKETS (FSK):
Glass fiber reinforced foil kraft laminate, factory applied to insulation. Maximum permeance of .02 perms and minimum beach puncture resistance of 25 units.

PROTECTIVE METAL JACKETS (PMJ):
0.016 inch thick aluminum or 0.010 inch thick stainless steel with safety edge for indoor HVAC installations. 0.024 inch thick aluminum or 0.016 inch thick stainless steel with safety edge for Central Plant and Utility installations.

SELF-ADHERING JACKETS (SAJ):
5-ply, self-adhering multiple laminated waterproofing material with reflective aluminum foil, high density polymer films and cold weather acrylic adhesive providing zero (0.0) permeance. Minimum 6 mils material thickness, 25lb puncture resistance when tested in accordance with ASTM D1000 and flame spread/smoke developed rating of 10/20 when tested in accordance with UL 723.

Vapor retarding tape shall be specifically designed and manufactured for use with the self-adhering jacket specified above. Tape shall be provided by the same manufacturer that provides jacketing. Vapor retarding tapes used with self-adhering jackets shall have a maximum permeance of 0.0 perms.

FABRIC REINFORCED MASTIC JACKETS (FMJ):
Glass fiber reinforcing fabric imbedded in weather barrier mastic as per manufacturer's recommended procedure for 2 coat application.

INSULATION INSERTS AND PIPE SHIELDS
Manufacturers: B-Line, Pipe Shields, Value Engineered Products.

Construct inserts with calcium silicate or polyisocyanurate (service temperatures below 300 degrees F only), minimum 140 psi compressive strength. Piping 12" and larger, supplement with high density 600 psi structural calcium silicate insert. Provide galvanized steel shield. Insert and shield to be minimum 180 degree coverage on bottom supported piping and full 360 degree coverage on clamped piping. On roller mounted piping and piping designed to slide on support, provide additional load distribution steel plate.

Where contractor proposes shop/site fabricated inserts and shields, submit schedule of materials, thicknesses, gauges and lengths for each pipe size to demonstrate equivalency to pre-engineered/premanufactured product described above. On low temperature systems, high density rigid polyisocyanurate may be substituted for calcium silicate provided insert and shield length and shield gauge are increased to compensate for lower insulation compressive strength.

Precompressed 20# density molded fiberglass blocks, Hamfab or equal, of the same thickness as adjacent insulation may be substituted for calcium silicate inserts with one 1"x6" block for piping through 2-1/2" and three 1"x6" blocks for piping through 4". Submit shield schedule to demonstrate equivalency to pre-engineered/premanufactured product described above.

Wood blocks will not be accepted.

ACCESSORIES

All products shall be compatible with surfaces and materials on which they are applied and be suitable for use at operating temperatures of the systems to which they are applied.

Adhesives, sealants, and protective finishes shall be as recommended by insulation manufacturer for applications specified.

Insulation bands to be 3/4 inch wide, constructed of stainless steel. Minimum thickness to be 0.010 inch.

Tack fasteners to be stainless steel ring grooved shank tacks.

Staples to be clinch style.

Insulating cement to be ANSI/ASTM C195, hydraulic setting mineral wool.

Finishing cement to be ASTM C449.

Fibrous glass or canvas fabric reinforcing used with lagging adhesive shall have a minimum untreated weight of 6 oz./sq. yd.

Fungicidal water base duct liner coating (Foster 40-20 or equal) to be compatible with vapor retarding coating. This product must be EPA registered to be used inside HVAC ducts. Coating must comply with ASTM D 5590 with 0 growth rating.

P A R T 3 - E X E C U T I O N

EXAMINATION

Verify that all piping, equipment, and ductwork are tested and approved prior to installing insulation. Do not insulate systems until testing and inspection procedures are completed.

Verify that all surfaces are clean, dry and without foreign material before applying insulation materials.

INSTALLATION

All materials shall be installed by skilled labor regularly engaged in this type of work. All materials shall be installed in strict accordance with manufacturer's recommendations, building codes, and industry standards. Do not install products when the ambient temperature or conditions are not consistent with the manufacturer's recommendations. Surfaces to be insulated must be clean and dry.

Locate insulation and cover seams in the least visible location. All surface finishes shall be extended in such a manner as to protect all raw edges, ends and surfaces of insulation.

Install insulation with smooth and even surfaces. Poorly fitted joints or use of filler in voids will not be accepted. Provide neatly beveled and coated terminations at all nameplates, uninsulated fittings, or at other locations where insulation terminates.

Install fabric reinforcing without wrinkles. Overlap seams a minimum of 2 inches.

Use full length material (as delivered from manufacturer) wherever possible. Scrap piecing of insulation or pieces cut undersize and stretched to fit will not be accepted.

All pipe and duct insulation shall be continuous through walls, ceiling or floor openings and through sleeves except where firestop or firesafing materials are required. Vapor retarding jacket shall be maintained continuous through all penetrations.

Provide a continuous unbroken moisture vapor retarding jacket on insulation applied to systems noted below. Attachments to cold surfaces shall be insulated and vapor sealed to prevent condensation.

Provide a complete vapor retarding jacket for insulation on the following systems:

- Refrigerant
- Insulated Duct
- Equipment, ductwork or piping with a surface temperature below 65 degrees F

PROTECTIVE JACKET INSTALLATION

PVC FITTING COVERS AND JACKETS (PFJ):

Lap seams and joints a minimum of 2 inches and continuously seal PVC with welding solvent recommended by jacket manufacturer. Secure PVC fittings with welding solvent on seams and joints. Lap slip joint ends 4" without fasteners where required to absorb expansion and contraction. For sections where vapor retarding jacket is not required, and jacket requires routine removal, tack fasteners may be used. For systems requiring a vapor retarding jacket, apply a 1-1/2" band of mastic over ends, throat, seams and penetrations.

FOIL SCRIM KRAFT JACKETS (FSK):

Install according to manufacturer's recommendations using factory supplied lap seals and butt strip seals. In addition to factory adhesive, secure lap seals and tape with clinch type staples.

PROTECTIVE METAL JACKET (PMJ):

Lap seams a minimum of 2 inches. Secure with metal bands for end to end joints, and rivets or sheet metal screws for longitudinal joints. Rivets, screws, and bands to be constructed of the same material as the jacket. For piping with VRJ jacket provide metal bands at 12" centers, rivets and screws cannot be used. Locate longitudinal seams on the side (3:00 O'clock) for exterior applications. Seal laps with 1/8" bead of metal jacketing sealant to prevent water entry.

SELF-ADHERING JACKETS (SAJ):

Install according to manufacturer's recommendations. Cut allowing minimum 4" overlap on ends and 6" on longitudinal joints. Align parallel to surface. Remove release paper and press flat to surface to avoid wrinkles. Rub entire surface with plastic squeegee for full adhesion and sealing at joint overlaps. On exterior applications, provide a bead of compatible caulk along exposed edges.

Piping with self-adhering (SAJ) jackets shall have elbows, fittings, valves and butt joints wrapped with 2 layers of vapor retarding tape. Piping with a PVC jacket (PFJ) installed over the self-adhering (SAJ) jacket may be provided with a single, lapped layer of vapor retarding tape for elbows, fittings and valves under the PVC jacket. Vapor retarding tape shall be compatible with the jacket material used.

FABRIC REINFORCED MASTIC JACKETS (FMJ):

Glass fiber fabric shall be fitted without wrinkles. Glass fiber fabric shall be sized immediately upon application with lagging adhesive and shall be capable of drying within 6 hrs. Apply adhesive and coating in accordance with manufacturer's recommendations. All seams shall overlap not less than 2".

PIPING, VALVE, AND FITTING INSULATION

GENERAL:

Install insulation with butt joints and longitudinal seams closed tightly. Provide minimum 2" lap on jacket seams and 3" tape on butt joints, firmly cemented with lap adhesive unless otherwise noted. Additionally, secure with clinch style staples along seams and butt joints.

On systems requiring a vapor retarding jacket, seal off all raw ends of insulation and butt joints with vapor retarding mastic at intervals of not more than 20 feet on piping to create a vapor dam. Also provide a vapor dam on each side of valves, unions, and tees. Coat staples, longitudinal and transverse seams with vapor retarding mastic and on systems requiring vapor retarding jacket, coat insulated elbows, fittings, and valves with vapor retarding mastic.

Install insulation continuous through pipe hangers and supports with hangers and supports on the exterior of insulation. Where a vapor retarding jacket is not required or where roller hangers are not being used, hangers and supports may be attached directly to piping with insulation completely covering hanger or support and jacket sealed at support rod penetration. Where riser clamps are required to be attached directly to piping requiring vapor retarding jacket, extend insulation and vapor retarding jacketing/coating around riser clamp.

Where insulated piping is installed on hangers and supports, the insulation shall be installed continuous through the hangers and supports. High density inserts shall be provided as required to prevent the weight of the piping from crushing the insulation. Pipe shields are required at all support locations. The insulation shall not be notched or cut to accommodate the supporting channels.

INSULATION INSERTS AND PIPE SHIELDS:

Provide pipe shields at all hanger and support locations. Rigid insulation inserts shall be installed between the pipe and the insulation shields. Quantity and placement of inserts shall be according to the manufacturer's installation instructions; however, the inserts shall be no less than 12" in length. Inserts shall be of equal thickness to the adjacent insulation and shall be vapor sealed as required for system.

Provide insulation inserts and pipe shields at all hanger and support locations. Inserts may be omitted on 3/4" and smaller copper piping provided 12" long 22 gauge pipe shields are used.

FITTINGS AND VALVES:
Fittings, valves, unions, flanges, couplings and specialties may be insulated with factory molded or built up insulation of the same thickness as adjoining insulation. Where the ambient temperature exceeds 150 degrees F, cover insulation with fabric reinforcing and mastic. Where the ambient temperatures do not exceed 150 degrees, furnish and install PVC fitting covers.

ELASTOMERIC:
Where practical, slip insulation on piping during pipe installation when pipe ends are open. Miter cut fittings allowing sufficient length to prevent stretching. Completely seal seams and joints for vapor tight installation. For elastomeric insulation, apply full bed of adhesive to both surfaces. For polyolefin, seal factory preglued seams with roller and field seams and joints with full bed of hot melt polyolefin glue to both surfaces. Cover elastomeric insulation on systems operating below 40 degrees F with vapor retarding mastic.

PIPING PROTECTIVE JACKETS
In addition to the jackets specified in the pipe insulation schedule below the following protective jackets are required:

Provide a protective PVC jacket (PFJ) for the following insulated piping:
- Exterior refrigeration piping.

Provide a protective PVC (PFJ) or Fabric Reinforced Mastic (FMJ) jacket for the following insulated piping:
- All piping within mechanical rooms.

Provide a protective metal (PMJ) or self-adhering (SAJ) jacket for the following insulated piping:
- Exterior installed refrigeration piping.

PIPE INSULATION SCHEDULE:
Provide insulation on new and existing remodeled piping system as indicated in the following schedule:

SERVICE	INSULATION	JACKET	INSULATION THICKNESS BY PIPE SIZE				
			< 1"	1" to < 1-1/2"	1-1/2" to < 4"	4" to < 8"	8" and Larger
Refrigeration Suction							
> 40°F	Elastomeric	None	1.5"	1.5"	1.5"	1.5"	1.5"
40°F to 20°F	Elastomeric	None	1.5"	1.5"	1.5"	1.5"	1.5"

For systems with fluid temperatures 65° F or less, furnish and install removable elastomeric insulation covers, plugs or caps for all mechanical equipment and devices that require access by balancing contractors or service and maintenance personnel. Examples include but are not limited to: flow sensing devices, circuit setters, manual ball valve air vents, drain valves, blowdown valves, pressure/temperature test plugs, grease fittings, pump bearing caps, equipment labels, etc. Covers shall be tight fitting to ensure a complete vapor retarding barrier.

DUCT INSULATION
GENERAL:
Secure flexible blanket duct insulation on sides and bottom of ductwork over 24" wide with weld pins. Space fasteners 18" on center or less as required to prevent sagging. Compress insulation no more than 25%.

Secure rigid board insulation to ductwork with weld pins. Apply insulation with joints firmly butted together and placed as close as possible to the equipment surface. Pins shall be located a maximum of 3" from each edge and spaced no greater than 12" on center.

Install weld pins without damage to the interior galvanized surface of the duct. Clip pins back to washer and cover penetrations with tape of same material as jacket. Firmly butt seams and joints and cover with 4" tape

of same material as jacket. Seal tape with plastic applicator and secure with staples. All joints, seams, edges and penetrations to be fully vapor sealed with vapor retarding mastic.

Stop and point insulation around access doors and damper operators to allow operation without disturbing insulation or jacket material.

External supply duct insulation is not required where ductwork contains continuous 1" acoustical liner. Provide 4" overlap of external insulation over ends of acoustically lined sections.

Where insulated ductwork is supported by trapeze hangers, the insulation shall be installed continuous through the hangers. Drop the supporting channels required to facilitate the installation of the insulation. Where rigid board or flexible insulation is specified, install high density inserts to prevent the weight of the ductwork from crushing the insulation.

DUCTWORK PROTECTIVE COVERINGS:
In addition to the jackets specified in the duct insulation schedule below the following protective coverings are required:

Provide a protective covering of 2 coats of indoor/outdoor vapor retarding mastic with fibrous glass or canvas fabric covering (FMJ) or self-adhering jacket (SAJ) meeting 25/50 Flame Spread/Smoke Rating.for the following ductwork:

- Ductwork within 6' of floor, catwalks and mezzanines in mechanical rooms

DUCT INSULATION SCHEDULE:
Provide duct insulation on new and existing remodeled ductwork in the following schedule:

SERVICE	INSULATION TYPE	JACKET	THICKNESS
Outside air ducts	Rigid Fiberglass	FSK	2"
Mixed air ducts	Rigid Fiberglass	FSK	2"
Exposed supply ducts*	Rigid Fiberglass	FSK	2"
Concealed supply ducts	Flexible Fiberglass	FSK	2"
Exhaust and relief ducts downstream of motorized backdraft dampers	Rigid Fiberglass	FSK	2"
Combustion Air Ducts	Rigid Fiberglass	FSK	2"

* Exposed supply branch ducts located in the space they are serving do not require insulation. Exposed supply main ducts running through spaces they serve shall be insulated as exposed supply ducts scheduled above.

CONSTRUCTION VERIFICATION ITEMS
Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

END OF SECTION

SECTION 23 08 00
COMMISSIONING OF HVAC
BASED ON DFD MASTER SPECIFICATION DATED 01/17/17

P A R T 1 - G E N E R A L

SCOPE
This section includes commissioning forms for construction verification and functional performance testing. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Submittals

PART 2 - PRODUCTS
- (Not Used)

PART 3 – EXECUTION

Commissioning Forms

CV-23 07 00	HVAC Ductwork Insulation
CV-23 07 00	HVAC Piping Insulation
CV-23 09 14	Control Wiring and Devices
CV-23 11 00	Facilities Fuel Piping
CV-23 31 00	Ductwork and Casings
CV-23 33 00	Control Dampers
CV-23 33 00	Intake/Relief Hoods
CV-23 34 00	Ceiling Exhaust Fans
CV-23 34 00	Centrifugal Fans
CV-23 34 00	Destratification Fans
CV-23 34 00	Sidewall Propeller Fans
CV-23 51 00	Breechings, Chimneys and Stacks
CV-23 54 00	Gas Fired Furnaces
CV-23 55 00	Gas Fired Unit Heaters
CV-23 82 00	Electric Heaters

Functional Performance Test Forms

FPT-23 34 00	HVAC Fans
FPT-23 55 00	Gas Fired Furnaces
FPT-23 55 00	Gas Fired Unit Heaters
FPT-23 82 00	Electric Heaters

RELATED WORK
Section 01 91 01 – Commissioning Process

REFERENCE
Applicable provisions of Division 1 shall govern work under this section.

SUBMITTALS
Reference the General Conditions of the Contract for submittal requirements.

Reference Section 01 91 01 Commissioning Process for Construction Verification Checklist and Functional Performance Test submittal requirements.

P A R T 2 – P RO D U C T S

(Not Used)

P A R T 3 – E X E C U T I O N

COMMISSIONING FORMS
Commissioning forms are to be filled in as work progresses by the individuals responsible for installation and shall be completed for each installation phase.

Provide a description of the work completed since the last entry, the percentage of the total work completed for the system for that area and the step of installation or finalization.

Circle Yes or No for each commissioning form item. If the information requested for an item does not apply to the given stage of installation for the system, list it as "N/A". Explain all discrepancies, negative responses or N/A responses in the negative responses section.

Once the work is 100% complete and the responses to each item are complete and resolved for a given commissioning forms group, mark as complete, initial and date in the spaces provided.

Provide copies of the commissioning forms to the commissioning agent 2 days prior to construction progress meetings.

CV-23 07 00 – HVAC Ductwork Insulation

Equipment Identification/Tag: _____
Location:_____

A) DUCTWORK INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:				

Question Details

1) Ductwork clean, dry, pressure tested and approved prior to application of insulation.
2) Type and thickness of insulation complies with listed specification requirements for given system.
3) Insulation installed with smooth and even surfaces.
4) Insulation is secured per specification requirements for given insulation type and ductwork width.
5) Insulation seams and joints firmly butted together and covered with 4” tape of same material as jacket.
6) Insulation and vapor barrier continuous through non-rated sleeves.
7) Insulation is butted tightly against the fire stop with butt joints taped in rated construction.
8) Insulation stopped and pointed around access doors and damper operators to allow operation without disturbing insulation or jacket material.
9) Complete vapor barrier provided for all insulated ductwork.
10) Exposed fiberglass insulation covered and sealed at all permanent terminations and at end of work day.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

B) DEVICE & EQUIPMENT INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:		DATE:

Question Details

1) Insulated easily removable galvanized steel metal boxes or insulated easily removable elastomeric insulation sections provided for equipment, devices, labels and access panels.per specifications.
2) Air handling unit casings, chambers, or plenums (filters, mixing chambers, sound attenuators, etc.) insulated in accordance with requirements of adjacent duct insulation.
3) All control devices are mounted over ductwork insulation.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

CV-23 07 00 – HVAC Piping Insulation

Equipment Identification/Tag: _____
Location:_____

A) PIPING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ **CHECKLIST GROUP COMPLETE**				**INITIALS:**					**DATE:**				

Question Details

1) Piping clean, dry, pressure tested and approved prior to application of insulation.
2) Type and thickness of insulation complies with listed specification requirements for given system and pipe size.
3) Insulation installed with smooth and even surfaces, without the use of filler in voids.
4) Butt joints and longitudinal seams closed tightly with a minimum of 2” lap on jacket seams and 2” tape on butt joints.
5) All longitudinal seams stapled as specified.
6) All seams and staples sealed with vapor barrier mastic on systems that require a vapor barrier.
7) Full-length material installed, with no piecing of scraps or stretching of material.
8) Insulation continuous through sleeves and openings with vapor barriers continuous through all penetrations.
9) Complete vapor barrier and vapor dams provided for all piping systems operating below 65ºF including at high density inserts at hanger locations.
10) Exposed fiberglass insulation covered and sealed at all permanent terminations and at end of work day.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

B) VALVE, FITTING & EQUIPMENT INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)								
				1)	2)	3)	4)	5)	6)	7)	8)	9)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:			

Question Details

1) Fittings, valves, unions, flanges, couplings and specialties insulated with factory molded or built up insulation of the same thickness as adjoining insulation.
2) Where temperatures exceed 150°F fittings, valves, unions, flanges, couplings and specialties are covered with fabric reinforcing and mastic. PVC fitting covers may be used where temperatures do not exceed 150° F.
3) PVC fitting covers secured with tack fasteners and 1-1/2" band of mastic over ends, throat, seams or penetrations or for systems requiring vapor barrier, vapor barrier mastic.
4) Equipment access manholes, fittings, nameplates or ASME stamps left un-insulated with insulation beveled and sealed at these locations.
5) Equipment insulation installed with smooth and even surfaces per specifications requirements.
6) No insulation provided at hot water piping inside radiation, convector, or cabinet heater enclosures, steam traps and piping unions for systems not requiring a vapor barrier.
7) Reheat coil piping, fittings and valves (with the exception of unions) up to coil connection are insulated.
8) For systems with fluid temperatures 65° F or less, removable elastomeric insulation covers, plugs or caps with complete vapor barrier provided for all equipment, devices, labels and valves.
9) Vapor dams have been provided per specification for piping systems requiring a vapor barrier.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

CV-23 09 14 – Control Wiring and Devices

Equipment Identification/Tag: _____
Location:_____

A) WIRING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)								
				1)	2)	3)	4)	5)	6)	7)	8)	9)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:			

Question Details

1) All cabling identified at both ends according to Section 23 09 14.
2) A minimum of 5’ of cable provided in DDC panel for all electronic input/output devices, sensors, relays and interlocking wiring to allow for termination by the DDC Contractor.
3) All high voltage and low voltage wiring (includes low voltage cable) installed in metal conduit, Electrical Non-metallic Tubing (ENT), or Electrical Metallic Tubing (EMT), as scheduled per specifications.
4) All conduit installed and supported in accordance with electrical sections (Division 26) of this specification and the National Electrical Code.
5) Bushings installed at all conduit terminations.
6) Conduit is a minimum of 1/2 " for low voltage control wiring and pipe fill does not exceed 40%.
7) Control panels serving equipment fed by emergency power also served by emergency power.
8) "Hand/off/auto" selector switches installed on systems where automatic interlock controls are specified and "hand/off/auto" selector switches are not supplied with the equipment controlled.
9) All equipment requiring maintenance is accessible (valves, junction boxes, etc.).

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

B) CONTROL DEVICES INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:			DATE:							

Question Details

1) Thermometers installed at each point of temperature transmission (sensors) and control, except reheat coils, unless the drawings indicate a thermometer is to be installed.
2) Room thermostats and sensors installed at the location and height indicated on the drawings and aligned with light switches and humidistats.
3) Any room thermostats or sensors mounted on an exterior wall mounted on a thermally insulated sub-base.
4) Where thermostats or sensors are mounted on exterior walls or in any location where air transfer will affect the measured temperature or humidity the conduit and any other opening that will effect the measurement are sealed.
5) Guards provided on thermostats in entrance hallways, other public areas, or in locations where thermostat is subject to physical damage.
6) For horizontal steam or hot water coils, low limit thermostat elements distributed (serpentine) horizontally across the coil to cover every square foot of coil.
7) For integral face and bypass coils the low limit thermostat elements are installed on the leaving face of the heating coil inside the damper enclosure.
8) Straightening vanes installed upstream of air flow measuring stations where required per manufacturers recommendations.
9) Where flow meters are located more than five feet above the floor or where they cannot be read due to equipment location, provide remote mounting of the flow meter display and programming controls four to five feet above finished floor.
10) For VFD installations, a separate current switch provided in parallel with the VFD motor status relay when a bypass starter is provided on the VFD to prove motor status in the bypass mode.
11) All control devices and boxes mounted on insulated ductwork are mounted over the insulation.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

C) FINALIZATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)	6)	7)	8)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:		

Question Details

1) All penetrations through fire rated wall assemblies have been sealed per specification requirements.
2) All penetrations through non-rated wall assemblies have been sealed per specification requirements for given space type.
3) All wiring is properly labeled with control ID number of circuit within ½" of device and terminal connection.
4) All control devices with the exception of dampers, valves, and terminal unit devices labeled with permanent printed labels that correspond to control drawings.
5) Temperature control wiring and tubing junction and pullboxes identified utilizing spray painted green covers.
6) Pressure and/or differential set points of pressure sensors re-adjusted after final balancing is completed.
7) Threshold settings for current switch adjusted to indicate belt or coupling loss after final balancing.
8) As-built control drawings of all systems served by each local panel provided in a location adjacent to or inside of panel cover. Provide a protective cover or envelope for drawings.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

CV-23 11 00 – Facilities Fuel Piping

Equipment Identification/Tag: _____
Location:_____

A) PRE-INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)				
				1)	2)	3)	4)	5)
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:			DATE:	

Question Details

1) All piping, valves, etc. are clean and free of damage prior to installation.
2) Temporary protective coating is provided on cast iron and steel valves during storage.
3) Temporary end caps are provided on piping and fittings until installation.
4) Contractors installing fuel oil piping in the City of Madison are approved installers by the Madison Fire Department and plans have been submitted and approved by the Madison Fire Department.
5) Welder procedure qualification records (PQR) and welding procedure specifications (WPS) submitted to A/E and DFD.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

B) GENERAL PIPING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)					
				1)	2)	3)	4)	5)	6)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:				DATE:	

Question Details

1) Piping is free to expand and contract without noise or damage to hangers, joints, or the building.
2) Changes in pipe sizes are made with the proper size reducing fittings, reducing elbow or reducing tees, and no bushings are utilized.
3) Pipe hanger spacing complies with specification requirements.
4) All equipment requiring maintenance is accessible (valves, etc.).
5) Piping allows access to equipment that is part of this system or another system.
6) Piping is not run through any plenums rated for ventilation.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

C) FUEL OIL PIPING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)					
				1)	2)	3)	4)	5)	6)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:				DATE:	

Question Details

1) Double or triple swing joints provided in the pipe lines connected to underground fuel oil tanks, except straight fill lines and test wells, to permit the tanks to settle without impairing the tightness of the pipe connections.
2) Tank fill piping terminated at least two feet from any building wall.
3) Vent pipe pitched to drain toward tank without sags or traps in which liquid may collect.
4) Where two or more tanks are indicated to be vented through a common line, the point of connection between the individual vent lines is not be lower than the top of any fill pipe opening.
5) All vent pipes terminated outside of the building, not less than two feet measured vertically or horizontally from any building opening, not less than twenty five feet from any outside air intake louver, and with a weatherproof and flameproof vent cap or hood.
6) Flexible piping connections installed in supply and return lines at each engine.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

D) NATURAL GAS PIPING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)				
				1)	2)	3)	4)	5)
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:			DATE:	

Question Details

1) Horizontal piping pitched down 1" in 60 feet in the direction of flow.
2) 4" minimum depth dirt leg installed at the bottom of each vertical run and at each appliance.
3) All branch connections to the main branched from the top or side of the main.
4) If an above ground vent terminates in an area subject to snow accumulation, line terminated at least five feet above grade.
5) Each gas pressure reducing valve vent and relief valve vent run separately to a point outside of the building, terminated with a screened vent cap, and located according to gas utility regulations.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

E) VALVE & FITTING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:			DATE:	

Question Details

1) All welded piping cleaned before all regulators and control valves by placing target cloth over piping and blowing compressed air through line until cloth is clean and free of debris.
2) All valves are in an upright vertical position with handles in a horizontal position and fully operated without removal or alteration of handle.
3) Isolation valves provided at all equipment connections, main branches and sub-branches.
4) Horizontal fuel oil supply, return, gauge and vent pipes are at least 18" below grade at its highest point and slopes 1/4" per foot upwards from the tank or special monitoring.
5) Fuel oil return line from each engine to the main oil tank or the day tank contains no manual or automatic valves to restrict the flow.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

F) TESTING CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:		DATE:	

Question Details

1) Piping tested utilizing air at specified pressure and duration as per specification for given fuel type.
2) For natural gas piping, testing completed with air at specified pressure and duration as per specification with no measurable loss of pressure during test period.
3) All leaks identified during testing have been repaired and test re-done until satisfactory conditions are accomplished.
4) Test conducted with all piping of tested system or section visible during testing.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

G) FINALIZATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:		DATE:	

Question Details

1) All exposed piping which passes through a wall, ceiling or floor is provided with escutcheon plates.
2) Piping labels and direction of flow is provided per specification requirements.
3) All penetrations through fire rated wall assemblies have been sealed per specification requirements.
4) All penetrations through non-rated wall assemblies have been sealed per specification requirements for given space type.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

CV-23 31 00 – Ductwork and Casings

Equipment Identification/Tag: _____
Location:_____

A) GENERAL DUCTWORK INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:				

Question Details

1) Ductwork is clean and free of damage prior to installation.
2) Ductwork is installed in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, 2nd Edition, 1995.
3) Where two different metal ducts meet, the joint is installed in such a manner that metal ducts do not contact each other by using proper seal or compound.
4) No reductions to duct to less than six inches in any dimension and/or aspect ratio greater than 8:1 are present.
5) Duct is pitched toward outside air intakes and drain to outside of building. Solder or seal seams to form watertight joints.
6) All equipment and systems requiring maintenance are accessible (valves, junction boxes, etc.).
7) All seams, joins and penetrations sealed in accordance with SMACNA seal class "A" standards, except transfer ductwork with pressure classification below 2".
8) All duct openings sealed to maintain duct system cleanliness.
9) Ductwork supported in accordance with SMACNA HVAC Duct Construction Standards, except secure wire method is not utilized.
10) Sheet metal thickness complies with the requirements of Section 23 21 00.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

B) SUPPLY DUCTWORK INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:		DATE:

Question Details

1) Duct is pitched toward outside air intakes and drain to outside of building. Solder or seal seams to form watertight joints.
2) All seams, joins and penetrations sealed in accordance with SMACNA seal class "A", except transfer ductwork with pressure classification below 2".
3) Manual balancing damper installed in each branch duct and for each diffuser or grille.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

C) KITCHEN, DUST COLLECTION & GENERAL EXHAUST DUCTWORK INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)						
				1)	2)	3)	4)	5)	6)	7)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:	

Question Details

1) Bracing and reinforcement provided to the outside of the kitchen ductwork to prevent breathing, rattling, vibration or sagging of duct.
2) Ductwork supports provided at intervals no greater than 5’ for kitchen ductwork, and no fasteners or hangers penetrate duct.
3) Horizontal kitchen ductwork is pitched back to hood at 1 inch per foot.
4) Grease tight access doors of the same material and thickness as the duct and as large as possible, up to 24 inches in any dimension provided on duct sides of all kitchen ductwork at each change in direction, not less than every 10 lineal feet of duct, including risers, and not less than 1-1/2 inches from the bottom of the duct.
5) Exhaust ductwork is pitched to drain back to equipment or exhaust grille.
6) Water tight drain pan provided at all low points or at locations where moisture may collect, with drain pan piped to nearest floor drain.
7) Access doors and clean out doors provided on duct sides of dust collection exhaust ductwork at each change in direction, at junctions with vertical ducts, at devices requiring periodic inspection and maintenance, and not less than every 10 lineal feet of duct, including risers.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

D) FUME & PERCHLORIC ACID EXHAUST DUCTWORK INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)								
				1)	2)	3)	4)	5)	6)	7)	8)	9)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:			

Question Details

1) For all rectangular duct and round duct 36 inch diameter and larger, PCD sealant provided at the corrosive side of the gasket.
2) For round duct less than 36-inch diameter, slip coupling connection sealed with PCD sealant provided.
3) Duct sealer applied on male end connectors before and after insertion to cover the entire joint.
4) 316 stainless steel fasteners provided at all couplings, with maximum screw spacing of 12 inches o. c. and a minimum of 3 equally spaced screws per joint.
5) Fasteners not located at bottom of duct.
6) Any damage to the PVC coating repaired with a PVC aerosol spray or similar PVC product as soon as installation of the piece with a damaged coating is completed.
7) Interior and exterior joints and seams ground and polished smooth for perchloric duct.
8) Duct pitched to drain back to hood or other drain point detailed on the drawings.
9) Perchloric acid exhaust ducts labeled with 4 inch high red stenciled "Perchloric Acid Exhaust" legend every ten feet.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

E) DUCT ACCESSORIES INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:				

Question Details

1) Turning vanes installed in all rectangular, mitered elbows in accordance with SMACNA standards and/or manufacturer's recommendations.
2) Fire dampers installed in sleeves with retaining angles on both sides of rated partition, with ductwork connections meeting manufacturer requirements.
3) Where it is necessary to set dampers out from the rated wall, install a sleeve extension encased in two hour rated fire proofing insulation. Install an access door at each fire damper, located to permit resetting the damper or replacing the fusible link.
4) Access doors provided in size, location and quantity specified under contract documents, including before and after all duct mounted coils.
5) Pressure relief doors provided on VAV systems to protect ductwork damage in the case of equipment or controls malfunction.
6) Flexible duct connections provided for all connections to rotating or vibrating equipment, including air handling units (unless unit is internally isolated), fans, or other motorized equipment.
7) Flexible duct connections in corrosive environments or fume exhaust systems, provided with a double layer of the Teflon coated fabric.
8) Manual volume dampers are constructed with continuous shafts according to SMACNA Duct Construction Standards Fig. 2-12 and Fig. 2-13.
9) Manual volume damper blades are two gauges thicker than the surrounding duct according to SMACNA Duct Construction Standards Fig. 2-12 and Fig. 2-13.
10) Manual volume damper handles are extended beyond the surface of external duct insulation according to Section 23 33 00.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

F) FLEXIBLE DUCTWORK INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)						
				1)	2)	3)	4)	5)	6)	7)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:	

Question Details

1) Flexible ductwork is clean and free from damage prior to installation.
2) Flexible duct used for final connections of air inlets and outlets at diffuser, register, and grille locations only.
3) Where flexible duct is used, it is installed with the minimum length required to make the final connections, but no greater than 5 feet in length, and no more than one (1) 90° bend.
4) Inner jacket of flexible duct secured in place with stainless steel metal band clamp.
5) Insulation vapor barrier jacket secured in place with steel or nylon draw band.
6) Flexible ductwork does not penetrate walls.
7) Individual sections of flexible ductwork are of one piece construction.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

G) FINALIZATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:				

Question Details

1) All penetrations through fire rated wall assemblies have been sealed per specification requirements.
2) All penetrations through non-rated wall assemblies have been sealed per specification requirements for given space type.
3) Each fire damper manually tested for proper operation and any defective dampers repaired or replaced. Access doors labeled “FIRE DAMPER” according to IMC requirements.
4) Fire/smoke damper linkages coordinated with operators so dampers are closed when the air system is not operating.
5) All dirt and foreign matter removed from the entire duct system and diffusers, registers, grilles and the inside of air-handling units cleaned before operating fans.
6) Duct systems with cleaned with high power vacuum machines where systems have been used for temporary heat, air-conditioning, or ventilation purposes during construction.
7) All ductwork leakage tested in accordance with test methods described in Section 5 of SMACNA HVAC Air Duct Leakage Test Manual, with test pressure equal to the duct pressure class.
8) Leakage rate does not exceed more than 5% of the system air quantity for low pressure ductwork, determined in accordance with Appendix C of the SMACNA HVAC Air Duct Leakage Test Manual.
9) Leakage rate does not exceed more that 1% of the system air quantity for high pressure ductwork, determined in accordance with Appendix C of the SMACNA HVAC Air Duct Leakage Test Manual.
10) Ductwork randomly tested for structural integrity and deflection limits do not exceed those listed in accordance with Chapter 7 of SMACNA HVAC Duct Construction Standards, 3.0 Performance Requirements.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

CV-23 33 00 – Control Dampers

Equipment Identification/Tag: _____
Location:_____

Group/Item	Group/Task Description			Submitted	Delivered
A	*MODEL VERIFICATION*				
1	Manufacturer				
2	Model				
3	Serial Number				
4	Height / Width (in / in)			/	/
5	Capacity (fpm / in W.C.)			/	/
6	Actuator Manufacturer				
7	Actuator Model				
8	Control Air Pressure (psig) (if applicable)				
9	Voltage (V) (if applicable)				
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	

Group/Item	Group/Task Description			Response	
B	*PHYSICAL CHECKS*				
1	Unit is free from physical damage.			YES	NO
2	All components/accessories present.			YES	NO
3	Unit tags affixed.			YES	NO
4	Installation and startup manual provided.			YES	NO
5	Manufacturer's ratings readable/accurate.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	
C	*HANGING*				
1	Unit secured as required by manufacturer and specifications.			YES	NO
2	Unit is level.			YES	NO
3	Adequate clearance around unit for service.			YES	NO
4	All components accessible for maintenance.			YES	NO
5	Unit labeled and is easy to see.			YES	NO
6	Access door provided at unit for inspection of linkages and actuator.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	
D	*CONTROLS INSTALLATION*				
1	Damper actuator installed and wiring/tubing terminated properly.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	
E	*STARTUP*				
1	Damper open/close sequence verified and acceptable.			YES	NO
2	Operation of end switch verified and acceptable (if applicable).			YES	NO
3	Damper opens and closes smoothly.			YES	NO
4	Control wiring labeled per specification requirements.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-23 33 00 – Intake/Relief Hoods

Equipment Identification/Tag: _____
Location:_____

Group/Item	Group/Task Description			Submitted	Delivered
A	*MODEL VERIFICATION*				
1	Manufacturer				
2	Model				
3	Serial Number				
4	Height / Width (in / in)			/	/
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	

Group/Item	Group/Task Description			Response	
B	*PHYSICAL CHECKS*				
1	Unit is free from physical damage.			YES	NO
2	All components/accessories present.			YES	NO
3	Dampers operate freely and smoothly.			YES	NO
4	Unit tags affixed.			YES	NO
5	Installation manual provided.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	
C	*INSTALLATION*				
1	Unit secured as required by manufacturer and specifications.			YES	NO
2	Adequate clearance around unit for service.			YES	NO
3	All components accessible for maintenance.			YES	NO
4	Dampers are free of debris and have full range of motion.			YES	NO
5	Openings sealed for duration of construction.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-23 34 00 – Ceiling Exhaust Fans

Equipment Identification/Tag: _____
Location:_____

Group/Item	Group/Task Description			Submitted	Delivered
A	*MODEL VERIFICATION*				
1	Manufacturer				
2	Model				
3	Serial Number				
4	Capacity / Static Pressure (cfm / in. w.g.)			/	/
5	Motor Power / Speed (hp / rpm)			/	/
6	Voltage / Phase / Frequency (V / - / Hz)			/ /	/ /
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
B	*PHYSICAL CHECKS*				
1	Unit is free from physical damage.			YES	NO
2	Openings are sealed with plastic.			YES	NO
3	All components present.			YES	NO
4	Installation and startup manual provided.			YES	NO
5	Unit tags affixed.			YES	NO
6	Manufacturer's ratings readable/accurate			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
C	*INSTALLATION*				
1	Unit secured as required by manufacturer and specifications.			YES	NO
2	Unit is supported independently of ceiling framework (recessed lay-in units only).			YES	NO
3	Equipment location coordinated with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances.			YES	NO
5	Adequate clearance around unit for service.			YES	NO
6	All components accessible for maintenance.			YES	NO
7	Unit is flush to finished ceiling (recessed or lay-in units ONLY).			YES	NO
8	Unit labeled and is easy to see.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
D	*DUCTWORK*				
1	Adequate locations available for testing and balancing unit.			YES	NO
2	All dampers and sensors are accessible (access panels).			YES	NO
3	Flexible duct connections of proper material installed.			YES	NO
4	All dampers close tightly and stroke fully and easily.			YES	NO
5	Ductwork is clean and free of debris.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
E	*ELECTRICAL*				
1	Local disconnect installed in accessible and visible location.			YES	NO
2	Each motor terminal box is connected with a minimum 12", maximum 36" piece of flexible conduit to a fixed junction box.			YES	NO
3	Motor rotation is in correct direction.			YES	NO
4	All electrical connections are tight.			YES	NO
5	All electrical components are grounded.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
F	*CONTROLS INSTALLATION (if applicable)*				
1	Thermostat wiring installed and communication verified.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
G	*MECHANICAL STARTUP*				
1	Unit is clean.			YES	NO
2	Unit grille attached and is clean.			YES	NO
3	Light of proper wattage and type installed (if applicable).			YES	NO
4	System starts and runs without any unusual noise or vibration.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
H	*CONTROLS STARTUP (if applicable)*				
1	Temperature control sequence verified and acceptable.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-23 34 00 – Centrifugal Fans

Equipment Identification/Tag: _____
Location:_____

Group/Item	Group/Task Description		Submitted	Delivered
A	*MODEL VERIFICATION*			
1	Manufacturer			
2	Model			
3	Serial Number			
4	Fan Type			
5	Capacity / Static Pressure (cfm / in. w.g.)		/	/
6	Motor Power / Speed (hp / rpm)		/	/
7	NEMA Nominal Efficiency			
8	Voltage / Phase / Frequency (V / - / Hz)		/ /	/ /
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description		Response	
B	*PHYSICAL CHECKS*			
1	Unit is free from physical damage.		YES	NO
2	Openings are sealed with plastic.		YES	NO
3	All components present.		YES	NO
4	Installation and startup manual provided.		YES	NO
5	Unit tags affixed.		YES	NO
6	Manufacturer's ratings readable/accurate		YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description		Response	
C	*INSTALLATION*			
1	Unit secured as required by manufacturer and specifications.		YES	NO
2	Equipment location coordinated with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances.		YES	NO
3	Unit is totally isolated (without rigid contact) from structure, ductwork or other stationary equipment or devices.		YES	NO
4	Shipping bolts have been removed (if applicable).		YES	NO
5	Adequate clearance around unit for service.		YES	NO
6	All components accessible for maintenance.		YES	NO
7	Drain pipe extended to collection pan (grease laden roof exhaust fans ONLY).		YES	NO
8	Drain connection reduced down to ½" fitting and left open (non-grease laden roof exhaust fans ONLY).		YES	NO
9	Unit labeled and is easy to see.		YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description		Response	
D	*DUCTWORK*			
1	Adequate locations available for testing and balancing of unit.		YES	NO
2	Inlet and outlet ductwork are free of transitions and/or obstructions for ductwork length or distance specified by manufacturer.		YES	NO
3	All dampers and sensors are accessible (access panels).		YES	NO
4	Flexible duct connections of proper material installed.		YES	NO
5	All dampers close tightly and stroke fully and easily.		YES	NO
6	Ductwork is clean and free of debris.		YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
E	*ELECTRICAL*				
1	Local disconnect installed in accessible and visible location.			YES	NO
2	Each motor terminal box is connected with a minimum 12", maximum 36" piece of flexible conduit to a fixed junction box.			YES	NO
3	Motor NEMA Nominal Efficiency complies with Section 23 05 13.			YES	NO
4	Motor rotation is in correct direction.			YES	NO
5	All electrical connections are tight.			YES	NO
6	All electrical components are grounded.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
F	*CONTROLS INSTALLATION (if applicable)*				
1	Remote start and stop wiring installed and communication verified.			YES	NO
2	Remote status wiring installed and communication verified.			YES	NO
3	Remote alarm wiring installed and communication verified.			YES	NO
4	Thermostat wiring installed and communication verified.			YES	NO
5	Damper actuators installed and calibration verified.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
G	*MECHANICAL STARTUP*				
1	Unit is clean.			YES	NO
2	Fan and motor lubricated and aligned.			YES	NO
3	Belt sheaves have been properly aligned per the specifications (if applicable).			YES	NO
4	Fan belts have proper tension and are in good condition (if applicable).			YES	NO
5	Protective shrouds for fan and belts in place and secure.			YES	NO
6	System starts and runs without any unusual noise or vibration.			YES	NO
7	Manufacturer's startup checklist completed and attached.			YES	NO
8	All damage to unit finish is repaired.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
H	*CONTROLS STARTUP (if applicable)*				
1	Remote start/stop from BAS verified and acceptable.			YES	NO
2	Interlock with associated unit/system verified and acceptable.			YES	NO
3	Temperature control sequence verified and acceptable.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-23 34 00 – Destratification Fans

Equipment Identification/Tag: _____
Location:_____

Group/Item	Group/Task Description			Submitted	Delivered
A	*MODEL VERIFICATION*				
1	Manufacturer				
2	Model				
3	Serial Number				
4	Voltage / Phase / Frequency (V / - / Hz)			/ /	/ /
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
B	*PHYSICAL CHECKS*				
1	Unit is free from physical damage.			YES	NO
2	All components present.			YES	NO
3	Installation manual provided.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
C	*INSTALLATION*				
1	Unit secured as required by manufacturer and specifications.			YES	NO
2	Adequate clearance around unit for service.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
D	*ELECTRICAL*				
1	Local disconnect installed in accessible and visible location.			YES	NO
2	Speed control module installed and operation verified.			YES	NO
3	All electrical connections are tight.			YES	NO
4	All electrical components are grounded.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
E	*MECHANICAL STARTUP*				
1	Unit is clean.			YES	NO
2	System starts and runs without any unusual noise or vibration.			YES	NO
3	Blades adjusted and balanced for stable operation.			YES	NO
4	All damage to unit finish is repaired.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-23 34 00 – Side Wall Propeller Fans

Equipment Identification/Tag: _____
Location:_____

Group/Item	Group/Task Description		Submitted	Delivered
A	*MODEL VERIFICATION*			
1	Manufacturer			
2	Model			
3	Serial Number			
4	Capacity / Static Pressure (cfm / in. w.g.)		/	/
5	Motor Power / Speed (hp / rpm)		/	/
6	NEMA Nominal Efficiency			
7	Voltage / Phase / Frequency (V / - / Hz)		/ /	/ /
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description		Response	
B	*PHYSICAL CHECKS*			
1	Unit is free from physical damage.		YES	NO
2	Openings are sealed with plastic.		YES	NO
3	All components present.		YES	NO
4	Installation and startup manual provided.		YES	NO
5	Unit tags affixed.		YES	NO
6	Manufacturer's ratings readable/accurate		YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description		Response	
C	*INSTALLATION*			
1	Unit secured as required by manufacturer and specifications.		YES	NO
2	Equipment location coordinated with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances.		YES	NO
3	Backdraft damper is installed at distance from fan as specified by manufacturer.		YES	NO
4	Shipping bolts have been removed (if applicable).		YES	NO
5	Adequate clearance around unit for service.		YES	NO
6	All components accessible for maintenance.		YES	NO
7	Unit labeled and is easy to see.		YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description		Response	
D	*ELECTRICAL*			
1	Local disconnect installed in accessible and visible location.		YES	NO
2	Each motor terminal box is connected with a minimum 12", maximum 36" piece of flexible conduit to a fixed junction box.		YES	NO
3	Motor NEMA Nominal Efficiency complies with Section 23 05 13.		YES	NO
4	Motor rotation is in correct direction.		YES	NO
5	All electrical connections are tight.		YES	NO
6	All electrical components are grounded.		YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description		Response	
E	*CONTROLS INSTALLATION (if applicable)*			
1	Thermostat wiring installed and communication verified.		YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
G	*MECHANICAL STARTUP*				
1	Unit is clean.			YES	NO
2	Fan and motor lubricated and aligned.			YES	NO
4	Belt sheaves have been properly aligned per the specifications (if applicable).			YES	NO
5	Fan belts have proper tension and are in good condition (if applicable).			YES	NO
6	Protective shrouds for fan and belts in place and secure.			YES	NO
7	System starts and runs without any unusual noise or vibration.			YES	NO
8	Manufacturer's startup checklist completed and attached.			YES	NO
9	All damage to unit finish is repaired.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
H	*CONTROLS STARTUP (if applicable)*				
1	Temperature control sequence verified and acceptable.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-23 51 00 – Breechings, Chimneys and Stacks

Equipment Identification/Tag: _____
Location:_____

A) CONDENSING APPLIANCE VENTS INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)				
				1)	2)	3)	4)	5)
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:			DATE:	

Question Details

1) All vents pitched up from equipment to point of termination outside of facility.
2) Hanger spacing complies with specification requirements.
3) Termination of vent is above and/or at least 10’ from any outside air intake, operable window, door, or equipment intake.
4) Vents are leak tight.
5) Drain connection provided at base of exhaust vent and piped to nearest drain.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

B) DOUBLE WALL METAL STACKS & BREECHINGS INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)								
				1)	2)	3)	4)	5)	6)	7)	8)	9)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:			

Question Details

1) Stack, breeching and accessories installed in accordance with minimum clearances for combustibles as specified in UL listing.
2) All breechings pitched up from equipment to chimney or stack.
3) Minimum number of joints utilized in breechings and all connections aligned and smooth internally.
4) Hanger and support spacing complies with specification requirements.
5) Vent dampers provided at draft hood outlet for all natural draft applications.
6) All joints sealed with manufacturer recommended sealants for positive pressure stacks and breechings.
7) Slip joints provided at equipment connections to allow removal of equipment without removal or dismantling of breechings, chimneys, or stacks.
8) Open breeching and chimney ends capped at completion of work day.
9) Breechings, chimneys and stacks cleaned internally and externally at conclusion of installation.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

C) REFRACTORY LINED STACKS & BREECHINGS INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)							
				1)	2)	3)	4)	5)	6)	7)	8)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:		

Question Details

1) Stack, breeching and accessories installed in accordance with minimum clearances for combustibles as specified in UL listing.
2) All breechings pitched up from equipment to chimney or stack.
3) Minimum number of joints utilized in breechings as possible and all connections aligned and smooth internally.
4) Hanger and support spacing complies with specification requirements.
5) Condensate drain provided at base of stack with piping to nearest drain.
6) Slip joints provided at equipment connections to allow removal of equipment without removal or dismantling of breechings, chimneys, or stacks.
7) Open breeching and chimney ends capped at completion of work day.
8) Breechings, chimneys and stacks cleaned internally and externally at conclusion of installation.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

CV-23 54 00 – Gas Fired Furnaces

Equipment Identification/Tag: _____
Location:_____

Group/Item	Group/Task Description	Submitted	Delivered
A	*MODEL VERIFICATION*		
1	Manufacturer		
2	Model		
3	Serial Number		
4	Supply Air Flow / External Static Pressure (cfm / in W.C.)	/	/
5	Outside Air Flow (cfm)		
6	Cooling Capacity (MBH) (if applicable)		
7	Refrigerant Type (if applicable)		
8	Heating Input / Output (MBH / MBH)	/	/
9	Fuel Type		
10	Gas Inlet Pressure (psig)		
11	Motor Speed / Power (rpm / hp)	/	/
12	Voltage / Phase / Frequency (V / - / Hz)	/ /	/ /
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____

Group/Item	Group/Task Description	Response	
B	*PHYSICAL CHECKS*		
1	Unit is free from physical damage.	YES	NO
2	All openings are sealed with plastic plugs or sheeting.	YES	NO
3	All components present.	YES	NO
4	Installation and startup manual provided.	YES	NO
5	Unit tags affixed.	YES	NO
6	Manufacturer's ratings readable/accurate	YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____

Group/Item	Group/Task Description	Response	
C	*INSTALLATION*		
1	Unit secured and supported as required by manufacturer and specifications.	YES	NO
2	Unit is set on concrete housekeeping pad and is level.	YES	NO
3	Equipment location coordinated with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances.	YES	NO
4	Adequate clearance around unit for service.	YES	NO
5	All components accessible for maintenance.	YES	NO
6	Shipping bolts have been removed.	YES	NO
7	Unit labeled and is easy to see.	YES	NO
8	Construction filters provided in unit per specification requirements.	YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____

Group/Item	Group/Task Description	Response	
D	*REFRIGERANT PIPING (if applicable)*		
1	All piping components have been installed (in the correct order) as required by contract document or manufacturer.	YES	NO
2	Piping arranged for ease of unit removal.	YES	NO
3	Piping supported as required by specifications.	YES	NO
4	Piping is clean.	YES	NO
5	Piping and valves properly checked and free of leaks.	YES	NO
6	Piping insulation is complete and installed as per specifications.	YES	NO
7	All valves and test ports are easily accessible.	YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
E	*REFRIGERANT PIPING (if applicable)*				
1	All piping components have been installed (in the correct order) as required by contract document or manufacturer.			YES	NO
2	Piping arranged for ease of unit removal.			YES	NO
3	Piping supported as required by specifications.			YES	NO
4	Piping is clean.			YES	NO
5	Piping and valves properly checked and free of leaks.			YES	NO
6	Piping insulation is complete and installed as per specifications.			YES	NO
7	All valves and test ports are easily accessible.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
F	*GAS PIPING*				
1	Gas supply is the same type as listed on the unit data plate.			YES	NO
2	Pressure reducing valves provide correct pressure to unit.			YES	NO
3	Gas cock / valve and union provided on gas supply.			YES	NO
4	Drip / dirt leg and cap provided on gas supply.			YES	NO
5	Pressure relief valves are piped to outdoors.			YES	NO
6	Piping and valves properly checked and free of leaks.			YES	NO
7	Gas utility company inspected installation (if required).			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
G	*DUCTWORK*				
1	Adequate locations available for testing and balancing of unit.			YES	NO
2	Outdoor and return air arrangement complies with manufacturer instructions.			YES	NO
3	Flexible duct connections of proper material installed.			YES	NO
4	Ductwork is clean and free of debris.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
H	*ELECTRICAL*				
1	Local disconnect installed in accessible and visible location.			YES	NO
2	Each motor terminal box is connected with a minimum 12", maximum 36" piece of flexible conduit to a fixed junction box.			YES	NO
3	Motor rotation is in correct direction.			YES	NO
4	All electrical connections are tight.			YES	NO
5	All electrical components are grounded.			YES	NO
6	Element inspected for damage prior to applying power (if applicable).			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
I	*CONTROLS INSTALLATION*				
1	Exterior condensing unit wiring installed and communication verified (if applicable).			YES	NO
2	Thermostat wiring installed and communication verified.			YES	NO
3	Vent pressure switch wiring installed and communication verified.			YES	NO
4	Safety items installed and verified (blower access, etc.)			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
J	*MECHANICAL STARTUP*				
1	Unit is clean.			YES	NO
2	Fan and motor lubricated and aligned.			YES	NO
3	Belt sheaves have been properly aligned per the specifications (if applicable).			YES	NO
4	Fan belts have proper tension and are in good condition (if applicable).			YES	NO
5	All bent or crushed fins have been combed out.			YES	NO
6	System starts and runs without any unusual noise or vibration.			YES	NO
7	Manufacturer's startup checklist completed and attached.			YES	NO
8	Final filters installed.			YES	NO
9	All damage to unit finish is repaired.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
K	*CONTROLS STARTUP*				
1	Occupancy schedule programmed and verified.			YES	NO
2	Cooling sequence of control verified and acceptable (if applicable).			YES	NO
3	Heating sequence of control verified and acceptable.			YES	NO
4	Unoccupied sequence of control verified and acceptable (if applicable).			YES	NO
5	Blower de-energizes when blower access door is opened.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-23 55 00 – Gas Fired Unit Heaters

Equipment Identification/Tag: _____
Location:_____

Group/Item	Group/Task Description			Submitted	Delivered
A	*MODEL VERIFICATION*				
1	Manufacturer				
2	Model				
3	Serial Number				
4	Capacity (cfm)				
5	Heating Input / Output (MBH / MBH)			/	/
6	Motor Speed / Power (rpm / hp)			/	/
7	Voltage / Phase / Frequency (V / - / Hz)			/ /	/ /
8	Fuel Type				
9	Gas Inlet Pressure (psig)				
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
B	*PHYSICAL CHECKS*				
1	Unit is free from physical damage.			YES	NO
2	The water and gas openings are sealed with plastic plugs.			YES	NO
3	All components present.			YES	NO
4	Installation and startup manual provided.			YES	NO
5	Unit tags affixed.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
C	*INSTALLATION*				
1	Unit suspended at height specified in contract documents as required by manufacturer and specifications.			YES	NO
2	Equipment location coordinated with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances.			YES	NO
3	Adequate clearance around unit for service.			YES	NO
4	All components accessible for maintenance.			YES	NO
5	Unit labeled and is easy to see.			YES	NO
6	Protective covering applied.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
D	*VENTILATION AND COMBUSTION AIR SUPPLY*				
1	Sufficient fresh air supply for proper unit operation.			YES	NO
2	Overall ductwork length and restrictions comply with manufacturer requirements.			YES	NO
3	Ductwork is the same cross-sectional area as openings.			YES	NO
4	All ductwork is properly sealed and sloped per manufacturer specifications.			YES	NO
5	Vertical gas vents terminate with a listed cap or other roof assembly and are installed according to their manufacturer's instructions.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description	Response	
E	*VENT PIPE SYSTEM*		
1	Draft hood for atmospheric burners properly installed.	YES	NO
2	Vent connectors securely fastened with screws and supported properly to maintain 6-inch clearance.	YES	NO
3	Vent connector made of approved material and sloped correctly.	YES	NO
4	Vent pipe system in accordance with "National Fuel Gas Code", NFPA 54, ANSI Z223.1-Latest Edition or prevailing provisions of local codes.	YES	NO
5	Combustion air and venting is extended to outside of building as indicated on the drawings and terminated according to the manufacturer's instructions.	YES	NO
6	Overall ductwork length and restrictions comply with manufacturer requirements.	YES	NO
7	Flue baffle engaged in slots provided in the flue tube.	YES	NO
8	Flue way, draft hood or vent pipe system not obstructed in any way.	YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____

Group/Item	Group/Task Description	Response	
F	*GAS PIPING*		
1	Gas supply is the same type as listed on the unit data plate.	YES	NO
2	Pressure regulators are provide correct pressure to unit.	YES	NO
3	Gas cock / valve and union provided on gas supply.	YES	NO
4	Drip / dirt leg and cap provided on gas supply.	YES	NO
5	Pressure regulator vent is piped to the exterior of the building and is terminated at least 10-feet from fresh air intakes, operable windows and doors..	YES	NO
6	Piping and valves properly checked and free of leaks.	YES	NO
7	Gas utility company inspected installation (if required).	YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____

Group/Item	Group/Task Description	Response	
G	*ELECTRICAL*		
1	Local disconnect installed in an accessible location	YES	NO
2	Motor rotation in the proper direction	YES	NO
3	All electrical connections are tight	YES	NO
4	All electrical components are grounded	YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____

Group/Item	Group/Task Description	Response	
H	*CONTROLS INSTALLATION*		
1	Thermostat wiring installed and communication verified.	YES	NO
2	Combustion and vent pressure switches installed and communication verified.	YES	NO
3	Safety items installed and verified (pump failure, high temperature, etc.)	YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____

Group/Item	Group/Task Description	Response	
I	*MECHANICAL STARTUP*		
1	Protective coverings removed.	YES	NO
2	Unit is clean.	YES	NO
3	Fan and motor lubricated and aligned.	YES	NO
4	System starts and runs without any unusual noise or vibration.	YES	NO
5	Manufacturer's startup checklist completed and attached.	YES	NO
6	All damage to unit finish is repaired.	YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
J	*CONTROLS STARTUP*				
1	Temperature control sequence verified and acceptable.			YES	NO
2	All safeties and alarms verified and acceptable.			YES	NO
3	Control wiring labeled per specification requirements.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-23 82 00 – Electric Heaters

Equipment Identification/Tag: _____
Location:_____

Group/Item	Group/Task Description			Submitted	Delivered
A	*MODEL VERIFICATION*				
1	Manufacturer				
2	Model				
3	Serial Number				
4	Capacity (cfm)				
5	Total Heating Capacity (kW) (if applicable)				
6	Total Heating Capacity (MBH / gpm) (if applicable)			/	/
7	Total Heating Capacity (MBH / lb/hr) (if applicable)			/	/
8	Motor Speed / Power (rpm / hp)			/	/
9	Voltage / Phase / Frequency (V / - / Hz)			/ /	/ /
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
B	*PHYSICAL CHECKS*				
1	Unit is free from physical damage.			YES	NO
2	Water openings are sealed with plastic plugs (if applicable).			YES	NO
3	All components present.			YES	NO
4	Installation and startup manual provided.			YES	NO
5	Unit tags affixed.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
C	*INSTALLATION*				
1	Unit secured as required by manufacturer and specifications.			YES	NO
2	Equipment location coordinated with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances.			YES	NO
3	Unit installed a minimum of 6" above finished floor level for toilet and shower spaces (if applicable).			YES	NO
4	Adequate clearance around unit for service.			YES	NO
5	All components accessible for maintenance.			YES	NO
6	Unit labeled and is easy to see.			YES	NO
7	Construction filters installed.			YES	NO
8	Protective covering applied.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
D	*ELECTRICAL*				
1	Local disconnect installed in an accessible location			YES	NO
2	Motor rotation in the proper direction			YES	NO
3	All electrical connections are tight			YES	NO
4	All electrical components are grounded			YES	NO
5	Element inspected for damage prior to applying power (if applicable).			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
E	*CONTROLS INSTALLATION (if applicable)*				
1	Thermostat wiring installed and communication verified.			YES	NO
2	Strap on aquastat installed and communication verified.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description	Response
H	*MECHANICAL STARTUP*	

Construction Verification Checklist
23 82 00 – Electric Heaters

Group/Item	Group/Task Description			Response	
1	Protective coverings removed.			YES	NO
2	Unit is clean.			YES	NO
3	Fan and motor lubricated and aligned.			YES	NO
4	System starts and runs without any unusual noise or vibration.			YES	NO
5	Manufacturer's startup checklist completed and attached.			YES	NO
6	Temperature setpoint for unit mounted thermostat set per contract documents (if applicable).			YES	NO
7	Unit access doors and cover can be opened and closed without damage to unit or wall/ceiling finish.			YES	NO
8	All damage to unit finish is repaired.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

FUNCTIONAL PERFORMANCE TEST FORMS

FPT-23 34 00 - HVAC Fans

Equipment Identification/Tag: _____
Location: _____

Test Duration
Date: _____ Start Time: _____ End Time _____

Estimated Duration: _____
Cx Provider(s): _____
_____
_____
_____
Applicable Equipment: _____
_____

Objectives
This test is performed to investigate the functionality of HVAC fan with associated system.

Instrumentation

Instrument	Accuracy	Measurement
N/A	N/A	N/A

Stated Sequence
Refer to Section 23 09 93 for sequence of operation.

Sampling Set
All units and all sequences, except fans controlled exclusively by interlock and/or switch which are to be verified under construction verification.

Procedure
1. Remote Start/Stop
    a. Verify fan is in occupied mode. If not override system into occupied mode.
    b. Override "on" command to "off".
    c. Verify unit de-energizes.
    d. Return "on" command to normal operation.
    e. Verify unit is energized.
    f. Return system to normal operation.
2. Thermostatically Controlled (Exhaust Applications)
    a. Record temperature setpoint of system/zone.
    b. Record current temperature of system/zone.
    c. If fan is on, adjust temperature setpoint to be 10º above current system/zone temperature.
    d. Verify fan is de-energized and allow to stabilize for 10 minutes.
    e. Return system to normal operation.
    f. If fan is off, adjust temperature setpoint to be 10º below current system/zone temperature.
    g. Verify fan is de-energized and allow to stabilize for 10 minutes.
    h. Return system to normal operation.
3. Thermostatically Controlled (Supply Applications)
    a. Record temperature setpoint of system/zone.
    b. Record current temperature of system/zone.
    c. If fan is on, adjust temperature setpoint to be 10º below current system/zone temperature.
    d. Verify fan is de-energized and allow to stabilize for 10 minutes.
    e. Return system to normal operation.
    f. If fan is off, adjust temperature setpoint to be 10º above current system/zone temperature.
    g. Verify fan is de-energized and allow to stabilize for 10 minutes.
    h. Return system to normal operation.
4. Blade Pitch (Vaneaxial Fans ONLY)
    a. Verify fan is in occupied mode. If not override system into occupied mode.
    b. Record static pressure setpoint of system.
    c. Record current static pressure of system.

d. Adjust static pressure setpoint to be 1 in. W.C. below current system pressure.
e. Visually verify fan blades uniformly and smoothly close down and allow to stabilize for 10 minutes.
f. Return system to normal operation.
g. Visually verify fan blades uniformly and smoothly open.

Results
Remote Start/Stop:
Unit is energized and de-energized when commanded by building automation system? YES NO

Thermostatically Controlled (Exhaust Applications):
Initial Temperature Setpoint: _____
System/Zone Temperature: _____
Adjusted Temperature Setpoint: _____

Fan is energized or de-energized in response to increases and decreases of temperature setpoint? YES NO

Thermostatically Controlled (Supply Applications):
Initial Temperature Setpoint: _____
System/Zone Temperature: _____
Adjusted Temperature Setpoint: _____

Fan is energized or de-energized in response to increases and decreases of temperature setpoint? YES NO

Blade Pitch (Vaneaxial Fans ONLY):
Initial Static Pressure Setpoint: _____
System Static Pressure: _____
Adjusted Static Pressure Setpoint: _____

Blades pitch closed in responses to a decreased static pressure setpoint in a uniform and smooth motion? YES NO
Blades pitch open in responses to an increased static pressure setpoint in a uniform and smooth motion? YES NO

Conclusion
Acceptable Criteria: Unit is energized when called upon by BAS. Unit is energized and de-energized in response to fluctuations in system or zone temperatures. Unit blades pitch closed and open uniformly and smoothly in response to fluctuations in system static pressure (vaneaxial fans ONLY).

Comments:

Observations:

Final Status: ❑ Accepted ❑ Not Accepted

Relevant Trend Data
Fan run status, system/zone temperature, system static pressure, blade pitch

Witnesses

Name	**Signature**

FPT-23 54 00 - Gas Fired Furnaces

Equipment Identification/Tag: _____
Location: _____

Test Duration
Date: _____ Start Time: _____ End Time _____

Estimated Duration: _____
Cx Provider(s): _____
_____
_____
_____
Applicable Equipment: _____
_____

Objectives
This test is performed to investigate the ability of the gas fried furnace to maintain space temperatures.

Instrumentation

Instrument	Accuracy	Measurement
N/A	N/A	N/A

Stated Sequence
Refer to Section 23 09 93 for sequence of operation.

Sampling Set
All units and all sequences.

Procedure
1. Cooling / Heating
    a. Verify unit is in occupied mode. If not override system into occupied mode.
    b. Verify space temperature setpoint for cooling is [XX°F].
    c. Verify space temperature setpoint for heating is [XX°F].
    d. Record space temperature.
    e. Override space temperature setpoint to be 5° above current space temperature.
    f. Verify burner fires to maintain space temperature.
    g. Allow unit to stabilize at new setpoint for 10 minutes.
    h. Return space temperature setpoint to normal operation.
    i. Verify refrigerant coil and remote condensing unit energize to maintain space temperature.
    j. Allow unit to stabilize at setpoint for 10 minutes.
    k. Return system to normal operation.
2. Unoccupied Mode
    a. Verify unit is in unoccupied mode. If not override system into unoccupied mode.
    b. Verify that the unoccupied space temperature setpoint is 60°F for heating and 84°F for cooling.
    c. Override unoccupied heating space temperature setpoint to be 10° above current space temperature (ensure cooling setpoint is at least 10° above override value).
    d. Verify unit energizes and burner fires to maintain space temperature.
    e. Return unoccupied heating space temperature setpoint to normal operation.
    f. Override unoccupied cooling space temperature setpoint to be 10° below current space space (ensure heating setpoint is at least 10° below override value).
    g. Verify unit energizes refrigerant coil and remote condensing unit energize to maintain space temperature.
    h. Return system to normal operation.
3. Alarms and Safeties:
    a. Verify unit is in occupied mode. If not override system into occupied mode.
    b. Disconnect power to vent exhauster or vent pressure switch to simulate a blocked vent.
    c. Override space temperature setpoint to be 5° above current space temperature.
    d. Verify burner does not fire.
    e. Return system to normal operation.

Results

Cooling / Heating:

Space temperature setpoint for cooling is [XX°F]?	Y / N
Space temperature setpoint for heating is [XX°F]?	Y / N
Space Temperature:	
Burner fires to maintain space temperature (±1°F) on call for heating?	Y / N
Refrigerant coil and remote condensing unit energize to maintain space temperature (±1°F) on call for cooling?	Y / N

Unoccupied Mode:

Unoccupied space temperature setpoint is 60°F for heating and 84°F for cooling?	Y / N
Space Temperature:	
Unit energizes and burner fires to maintain space temperature under call for heating?	Y / N
Unit energizes and refrigerant coil and remote condensing unit energize to maintain space temperature under call for cooling?	Y / N

Alarms and Safeties:

Burner does not fire on call for heating when vent pressure switch fails? YES NO

Conclusion

Acceptable Criteria: All setpoints comply with contract documents. Unit complies with all stated sequences in full.

Comments:

Observations:

Final Status: ❑ Accepted ❑ Not Accepted

Relevant Trend Data

Unit status, space temperature, space temperature setpoint

Witnesses

Name	**Signature**

FPT-23 55 00 - Gas Fired Unit Heaters

Equipment Identification/Tag: _____
Location: _____

Test Duration
Date: _____ Start Time: _____ End Time _____

Estimated Duration: _____
Cx Provider(s): _____
_____
_____
_____
Applicable Equipment: _____
_____

Objectives
This test is performed to investigate the ability of the unit heater to maintain the setpoint temperature for the space.

Instrumentation

Instrument	Accuracy	Measurement
N/A	N/A	N/A

Stated Sequence
Refer to Section 23 09 93 for sequence of operation.

Sampling Set
All sequences for a minimum of 20% of total units present.

Procedure
1. Heating Unoccupied
    a. Verify unit is in unoccupied mode. If not override system into unoccupied mode.
    b. Verify that the unoccupied space temperature setpoint is [XX°F].
    c. Record current space temperature.
    d. Adjust the unoccupied space temperature setpoint to be 10°F above the current temperature.
    e. Verify the unit energizes after delay of [X] minutes.
    f. Return system to normal operation
    g. Verify unit remains energized for [X] minute(s) prior to de-energizing.
2. Heating Occupied
    a. Verify unit is in occupied mode. If not override system into occupied mode.
    b. Verify that the occupied space temperature setpoint is [XX°F].
    c. Record current space temperature.
    d. Adjust the occupied space temperature setpoint to be 10°F above the current temperature.
    e. Verify the unit energizes after delay of [X] minutes.
    f. Return system to normal operation.
3. Alarms and Safeties
    a. Verify unit is in occupied mode. If not override system into occupied mode.
    b. Adjust the occupied space temperature setpoint to be 10°F above the current temperature.
    c. Disconnect lead to combustion air pressure switch.
    d. Verify alarm is generated at BAS head end and unit de-energizes.
    e. Return combustion air pressure switch to normal operation.
    f. Disconnect lead to vent pressure switch.
    g. Verify alarm is generated at BAS head end and unit de-energizes.
    h. Return vent pressure switch to normal operation.
    i. Record high temperature limit setpoint.
    j. Adjust the high temperature limit setpoint to be 5° lower than the current discharge air temperature of the unit.
    k. Verify alarm is generated at BAS head end and unit de-energizes.
    l. Return system to normal operation.

Results

Heating Unoccupied (if applicable):

Unoccupied Space Temperature Setpoint:	
Unoccupied space temperature setpoint complies with contract documents?	Y / N
Space Temperature:	
Adjusted Temperature Setpoint:	
Unit is energized in response to increases of temperature setpoint?	Y / N
Energization Time Delay:	
De-Energization Time Delay:	

Heating Occupied:

Occupied Space Temperature Setpoint:	
Occupied space temperature setpoint complies with contract documents?	Y / N
Space Temperature:	
Adjusted Temperature Setpoint:	
Unit is energized in response to increases of temperature setpoint?	Y / N
Energization Time Delay:	
De-Energization Time Delay:	

Alarms and Safeties:

	SETPOINT	*APPROVED*
Combustion air pressure	N/A	Y / N
Vent pressure	N/A	Y / N
High temperature limit	[XXXºF]	Y / N

Conclusion

Acceptable Criteria: All setpoints comply with contract documents. Unit energizes and de-energizes per stated heating sequence. All alarm and safeties operate per specified sequence and initiate appropriate alarm conditions at BAS head end.

Comments:

Observations:

Final Status: ❑ Accepted ❑ Not Accepted

Relevant Trend Data

Unit run status, space temperature

Witnesses

Name	**Signature**

FPT-23 82 00 - Electric Heaters

Equipment Identification/Tag: _____
Location: _____

Test Duration
Date: _____ Start Time: _____ End Time _____

Estimated Duration: _____
Cx Provider(s): _____
_____
_____
_____
Applicable Equipment: _____
_____

Objectives
This test is performed to investigate the ability of the electric heater to provide specified heat to the space.

Instrumentation

Instrument	Accuracy	Measurement
N/A	N/A	N/A

Stated Sequence
Refer to Section 23 09 93 for sequence of operation.

Sampling Set
All sequences for a minimum of 20% of total units present.

Procedure
1. Heating – Local Thermostat
    a. Verify that the space temperature setpoint is set.
    b. Record current space temperature.
    c. Adjust the space temperature setpoint to be 10°F above the current temperature.
    d. Verify the unit energizes.
    e. Return system to normal operation.

Results
Heating – Local Thermostat:

Space Temperature Setpoint:	_____
Space temperature setpoint complies with contract documents?	Y / N
Space Temperature:	_____
Adjusted Temperature Setpoint:	_____

Unit is energized in response to increases of temperature setpoint and control valve is visually found to open? YES NO

Conclusion
Acceptable Criteria: Unit energizes and de-energizes per stated heating sequence.

Comments:

Observations:

Final Status: ❑ Accepted ❑ Not Accepted

Witnesses

Name	**Signature**

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SECTION 23 09 14
PNEUMATIC AND ELECTRIC INSTRUMENTATION AND CONTROL DEVICES FOR HVAC
BASED ON DFD MASTER SPECIFICATION DATED 10/15/2024

P A R T 1 - G E N E R A L

SCOPE
This section includes control system specifications for all HVAC work as well as related control for systems found in other specification sections. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Quality Assurance
- Reference Standards
- System Description
- Submittals
- Demolition
- Design Criteria
- Operation and Maintenance Data
- Material Delivery and Storage

PART 2 - PRODUCTS
- Control Dampers
- Electric/Electronic Thermostats
- Time Clocks
- Gas Detection Systems
- Power Supplies

PART 3 - EXECUTION
- Installation
- Wire and Air Piping Conduit and Tubing Installation Schedule
- Control Dampers
- Preconstruction Review Meeting
- Construction Verification
- Functional Performance Testing
- Agency Training

RELATED WORK
Section 01 91 01– Commissioning Process
Section 23 08 00 – Commissioning of HVAC
Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC - Coordination
Section 23 09 93 - Sequence of Operation
Section 23 33 00 - Ductwork Accessories - for control damper installation

Division 23 - HVAC - Equipment provided to be controlled or monitored
Division 26 - Electrical - Installation requirements & Equipment provided to be controlled or monitored
Division 28 - Electronic Safety and Security

REFERENCE
Applicable provisions of Division 1 govern work under this section.

QUALITY ASSURANCE
Installing contractor must be a manufacturer's branch office or an authorized representative of a Direct Digital Control (DDC) equipment manufacturer that provides engineering and commissioning of the DDC equipment. Submit written confirmation of such authorization from the manufacturer. Indicate in letter of authorization that installing contractor has successfully completed all necessary training required for engineering, installation, and commissioning of equipment and systems and that such authorization has been in effect for a period of not less than three years. DDC equipment may or may not be required to be installed by this contractor as part of the project, but the intent of this quality assurance specification is to ensure that the installing contractor has the capabilities to engineer, install, and commission the field devices supplied under this section for temperature control.

REFERENCE STANDARDS

ANSI B16.22	Wrought Copper and Wrought Copper Alloy Solder Joint Pressure Fittings
ANSI/ASTM B32	Specification for Solder Metal
ASTM B75	Seamless Copper Tube
ASTM D1693	Environmental Stress-Cracking of Ethylene Plastics
ASTM D 635	Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
AMCA 500-D	Laboratory Method of Testing Dampers for Rating

SYSTEM DESCRIPTION

System is to be stand alone electric/electronic.

All electrical wiring is to be permanently tagged or labeled (within one inch of terminal strip) with a numbering system to correspond with the "Record Drawings". Tags or labels shall be printed not hand written.

SUBMITTALS

Include the following information:

Manufacturer's data sheets indicating model number, pressure/temperature ratings, capacity, methods and materials of construction, installation instructions, and recommended maintenance. General catalog sheets showing a series of the same device is not acceptable unless the specific model is clearly marked.

Schematic flow diagrams of systems showing fans, pumps, coils, dampers, valves, and other control devices. Each control device provided under this Section shall be uniquely labeled. Duplicate labeling may be used within similar mechanical systems. Label each device with setting or adjustable range of control. Indicate all wiring, clearly, differentiating between factory and field installed wiring. Wiring should be shown in schematics that detail contact states, relay references, etc. Diagrammatic representations of devices alone are not acceptable.

Details of construction, layout, and location of each temperature control panel within the building, including instruments location in panel and labeling. Also include on drawings location of mechanical equipment controlled (room number), horsepower and flow of motorized equipment (when this data is available on plans), locations of all remote sensors and control devices (either by room number or column lines).

Schedule of control dampers indicating size, leakage rating, arrangement, pressure drop at design airflow, and number and size of operators required.

Provide a complete description of each control sequence for equipment.

Prior to request for final payment, submit record documents which accurately record actual location of control components including panels, thermostats, wiring, and sensors. Incorporate changes required during installation and start-up.

The user agency may choose to review the submittals and record control drawings to ensure they are in compliance with the contract documents.

All submittals are to comply with submission and content requirements specified in specification Section 01 91 01.

DEMOLITION

Where existing control devices, piping, or wiring are discontinued from use, remove, and turn over to owner. If owner does not want them remove from premises. Remove any previously abandoned control devices in a similar manner.

DESIGN CRITERIA

Size all control apparatus to properly supply and/or operate and control the apparatus served.

Provide control devices subject to corrosive environments with corrosion protection or construct them so they are suitable for use in such an environment.

Provide devices exposed to outside ambient conditions with weather protection or construct them so they are suitable for outdoor installation.

Use only UL labeled products that comply with NEMA Standards. Electrical components and installation to meet all requirements of the electrical sections (Division 26) of project specifications.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

1. Lubrication instructions, including list/frequency of lubrication
2. List indicating types and grades of oil and/or grease, packing materials, normal and abnormal tolerances for devices, and method of equipment adjustment.
3. Table noting full load power factor, service factor, NEMA design designation, insulation class and frame type for each motor provided
4. A complete set of record control drawings.

MATERIAL DELIVERY AND STORAGE

Provide factory shipping cartons for each piece of equipment and control device. This contractor is responsible for storage of equipment and materials inside and protected from the weather.

P A R T 2 - P R O D U C T S

CONTROL DAMPERS

Provide control dampers shown on the plans and as required to perform the specified functions. Dampers shall be rated for velocities that will be encountered at maximum system design and rated for pressure equal or greater than the ductwork pressure class as specified in Section 23 31 00 of the ductwork where the damper is installed.

Use only factory fabricated dampers with mechanically captured replaceable resilient blade seals, stainless steel jamb seals and with entire assembly suitable for the maximum temperature and air velocities encountered in the system.

All dampers in stainless steel, PCD coated steel, PVC, PTFE, or fiberglass ductwork shall be constructed of stainless steel.

All dampers in aluminum ductwork shall be constructed of stainless steel or aluminum.

Dampers in galvanized ductwork shall be constructed of galvanized steel and/or aluminum.

All dampers, unless otherwise specified, to be rated at a minimum of 180º F working temperature. Leakage testing shall be certified to be based on latest edition of AMCA Standard 500-D and all dampers, unless otherwise specified, shall have leakage ratings as follows:

Damper Class	Differential Pressure	Leakage
Class IA	1” w.g.	$\leq$3 CFM/ft^2
Class I	4” w.g.	$\leq$8 CFM/ft^2
Class I	8” w.g.	$\leq$11 CFM/ft^2
Class I	12” w.g.	$\leq$14 CFM/ft^2

Leakage rate dampers for differential pressures that they will encounter at maximum system design pressures.

Steel framed dampers: Nailor models 2010 & 2020; Greenheck models VCD-33 & VCD-42; Johnson Controls model VD-1630; Ruskin Models CD60 & CD40; other approved equal.

Aluminum frame and blade dampers: Nailor models 2010EAF & 202EAF; Greenheck model VCD-43; Ruskin model CD50; Arrow model AFD-20; other approved equal.

Dampers used for directed mixing of airstreams, i.e., outside air and return air, to be parallel blade type and sized for an air velocity of 1800 to 2000 fpm with the damper blades shall be arranged so that the air streams are directed at one another to facilitate mixing. Dampers used for throttling or modulating

applications other than air stream mixing to be opposed blade type. Two position dampers may be parallel or opposed blade type.

Dampers used for isolation on the discharge of centrifugal fans shall have damper blades perpendicular to the fan shaft to minimize system effect. Dampers mounted with blades vertically shall be designed for vertical blade orientation.

Dampers for applications other than fume exhaust to have frames of not less than 16 gauge galvanized steel or 12 gauge extruded aluminum. Blades to be two-ply steel airfoil of not less than 2 x 20 gauge galvanized steel (14 gauge equivalent) or extruded aluminum airfoil, with stainless steel, acetal, Celcon, bronze, or nylon bearings. Maximum allowable blade width is 8 inches. Use plated steel linkage hardware.

Maximum damper width is 48 inches; where required width exceeds 48 inches, use multiple damper sections. Inside frame free area shall be a minimum of 90% of total inside duct area.

Multiple width damper sections shall utilize jack shaft linkages unless noted below. Sections over 144 inches wide shall be actuated from two locations on the jack shaft. Double width damper sections for two-position operation may be actuated without jack shafts if each damper section is actuated separately. Dampers that have multiple width and multiple vertical sections shall have a jackshaft for each vertically stacked set of dampers and be provided with crossover linkages between jack shafts to transfer uneven loading.

Jack shafts shall be extended outside of the ductwork for external actuator mounting. Provide bearings on the point of exit for support of damper shafts to prevent wear on the shaft and the ductwork. If locating actuators out of the air stream is impossible, obtain mounting location approval from the designer unless the contract documents indicate in air stream mounting is acceptable. In no cases shall damper actuators for fume exhaust systems be located in the air stream or require entering the air stream to service an actuator.

Provide weatherproof NEMA 4 enclosures (Belimo N4 option or equal, Belimo ZS-100 or ZS-150 are not acceptable) that have removable covers that have clasps or machine screws (no sheet metal screws) and that do not require removing fasteners from the ductwork to prevent actuator failure or freeze-up when mounting in locations exposed to harsh environments or outdoor locations.

Size operators for smooth and positive operation of devices served, and with sufficient torque capacity to provide tight shutoff against system temperatures and pressure encountered. For electric modulating actuation, use fully proportional actuators with zero and span adjustments. For two-position electric actuation use 24 VAC for DDC controlled actuators, 120 VAC actuators may be used for hardwire interlocking. See 23 09 15 for specific type of input signal required. Actuator stroke times shall match the requirements of the DDC controllers provided under 23 09 23 or 23 09 24, and/or the specific system requirements for proper operation. All electric actuators will be provided with overload protection to prevent motor from damage when stall condition is encountered. Equip operators with spring return for applications involving fire, freeze protection, moisture protection or specified normally open/closed operation. If spring return actuators are not available for applications because of torque requirements or other application requirements, stored energy fail safe may be used if approved by the AE. Face and bypass dampers for heating applications shall fail to the face position. For all two position isolation dampers that are controlled by the DDC system, provide actuators that are powered open and closed and do not utilize the actuator fail position spring for DDC commanded operation unless specified. This is to prevent fast closure by the spring return. Dampers wired to fan power can utilize the actuator fail position spring to actuate the damper.

Where control sequences require damper position indication or interlock, provide damper end switches integral to the damper actuators with form “C” contacts. Damper end switches shall have adjustable positions that can be set for proving the damper open, closed, or both depending on the specified application. End switch contact ratings shall be suitable for application. Where multiple banks of dampers are provided and not physically interlocked, end switches shall be provided for each bank of dampers and wired together to prove all dampers are in the position to be indicated. End switches shall not contain mercury.

All power required for electric actuation shall be provided by this contractor if it is not able to be directly provided from the DDC controller.

Provide operators with linkages and brackets for mounting on device served.

ELECTRIC/ELECTRONIC THERMOSTATS

ELECTRIC THERMOSTATS:

For single setpoint applications, provide line or low voltage electric type suitable for heating or heating and cooling as required. Provide the required number of heating and/or cooling stages required for the application. For line voltage ventilation applications utilizing fans and where specified in the sequence of operations, provide an integral manual On/Off/Auto selector switch. Minimum contact rating shall be equal or greater to electrical load of device being controlled. For all thermostats not located in mechanical rooms, provide concealed adjustment. For thermostats located in mechanical rooms, provide exposed adjustment.

LOW VOLTAGE ELECTRONIC THERMOSTATS:

Manufacturers: Honeywell, Johnson Controls, Viconics, or equal.

Where unoccupied setpoints are specified, provide electronic programmable type with seven day setup/setback scheduling with a minimum of two occupied and unoccupied schedules per day through keypad entry on front of unit. For heating and cooling applications, provide automatic heating/cooling switchover. For applications that control fans, provide fan override switch. For ventilation or packaged economizer applications provide a dry contact for ventilation damper or economizer initiation. For thermostat control of economizer, provide a 0-10VDC modulated output for economizer damper control.

For applications that require integration to the building automation system, provide a BACnet communication interface. If a communication interface is specified, occupancy scheduling in the thermostat is not required.

TIME CLOCKS

UL listed, digital, 7-day, minimum of 10 on/off programs per day, holiday programming, automatic daylight savings switchover, and minimum of seven-day battery back-up.

GAS DETECTION SYSTEMS

Manufacturers: ACI, Toxalert, Dräeger, Enmet, Honeywell Analytical, MSA or approved alternate

Each detector shall be complete package with remote or local space sensors, detection instruments, local indication of current measured value for each sensor and status indicator lights for power and status of each sensor. Devices not requiring remote mounting shall be housed in metal control panel. Status indicators shall be mounted on panel faceplate. Units shall have adjustable setpoints and self-test diagnostics.

Gas to be Detected:CO, and NO2

Alarm Setpoint:
CO: low level control signal alarms 15 PPM, 25 PPM, 35 PPM and high alarm 100 PPM
NO2: low alarm 1 PPM, high alarm 3 PPM

Range:
CO: 0-2 times Alarm Setpoint
NO2: 0-10 ppm NO2

Provide remote sensor required for gases to be detected.
Signal: 4-20 mA; Below 4 mA indicates sensor failure.

Housing: NEMA 4X
Temperature:
CO: -4°F to 122°F
NO: -4°F to 122°F

POWER SUPPLIES

Provide all required power supplies for transducers, sensors, transmitters, and relays. All low voltage transformers shall have a resettable secondary circuit breaker and be listed as class 2 power supplies. All transformer assemblies in enclosures shall have isolated high and low voltage compartments with separate removeable covers for connections.

P A R T 3 - E X E C U T I O N

INSTALLATION

Install system with trained mechanics and electricians employed by the control equipment manufacturer or an authorized representative of the manufacturer. Where installing contractor is an authorized

representative of the control manufacturer, such authorization shall have been in effect for a period of no less than three years.

Install all control equipment, accessories, wiring, and piping in a neat and workmanlike manner. All control devices must be installed in accessible locations. This contractor shall verify that all control devices furnished under this Section are functional and operating the mechanical equipment as specified in Section 23 09 93.

Label all control devices except for terminal unit devices with permanent printed labels that correspond to control drawings. Labeling for each device shall be unique within each mechanical system. Temperature control junction and pull boxes shall be identified utilizing spray painted green covers. Other electrical system identification shall follow the 26 05 53 specification. For control devices mounted above accessible ceilings, label the ceiling tile grid at the ceiling tile that is to be removed for access to the control device. The label shall be pre-printed using clear polyester tape with black bold 28 size font for ceilings under 12 feet. For ceilings over 12 feet high, use bold 40 size font. For accessible ceilings, use an arrow to point at ceiling tile to be removed for access.

All control devices and electrical boxes mounted on insulated ductwork shall be mounted over the insulation. Provide mounting stand-offs where necessary for adequate support. Cutting and removal of insulation to mount devices directly on ductwork is not acceptable. This contractor shall coordinate with the insulation contractor to provide for continuous insulation of ductwork.

Mounting of electrical or electronic devices shall be protected from weather if the building is not completely enclosed. This Contractor shall be solely responsible for replacing any equipment that is damaged by water that infiltrates the building if equipment is installed prior to the building being enclosed.

Provide all electrical relays and wiring, line, and low voltage, for control systems, devices, and components. Install all high voltage and low voltage wiring (includes low voltage cable) in metal conduit, Electrical Non-metallic Tubing (ENT), or Electrical Metallic Tubing (EMT), as scheduled below and hereafter referred to generically as conduit except above accessible ceilings as noted below. See Wire and Air Piping Conduit Installation Schedule below for specific conduit or tubing to be used. All raceways, enclosures, fittings, and associated supports shall be provided and installed according to the requirements set forth in Division 26, NFPA 70 (NEC) and Chapter SPS 316 of the Wisconsin Administrative Code. All conduits shall be routed parallel and/or perpendicular to walls and adjacent piping. Raceways shall be located to maintain headroom and working clearance around equipment and devices that require inspection and service.

In general, support all raceways from the building structure. No component of a raceway system shall be secured to corrugated metal roof deck. Do not impose on the installations of other trades. Securing conduit, rods, straps, hangers, etc. to suspended ceiling components, electrical raceways, plumbing piping, fire protection sprinkler piping, HVAC piping or ductwork, or their associated support systems, will not be accepted.

Conduit shall be a minimum of 1/2 " for low voltage control provided the pipe fill does not exceed 40%.

Minimum low voltage wiring gauge to be 18 AWG for outputs and 20 AWG for inputs. All low voltage wiring to be stranded.

Low voltage wiring can be run without conduit above accessible lay-in tile ceilings. All wiring in mechanical rooms, above inaccessible hard ceilings, exterior locations, and in any exposed areas, and in all other locations shall be installed in conduit. Wire for wall sensors shall be installed in conduit concealed in the wall. Wiring for radiation valves shall be installed in conduit concealed in the wall. For retrofit installations, all wiring for sensors and valves shall be installed in conduit concealed in new walls. Sensor wiring for existing walls shall be installed without conduit and concealed in the wall (fished) where possible. If running wire concealed in the existing wall is not possible, install in surface raceway as specified or if not specified, consult with the AE for raceway type and color to be provided.

Where low voltage wiring is installed free-air, installation shall comply with the following:

- Wiring shall utilize the cable tray wherever possible.

- Wiring shall run at right angles and be kept clear of other trades work.

- Wiring shall be supported utilizing "J" or "Bridal-type" steel mounting rings anchored to ceiling concrete, piping supports, walls above ceiling or structural steel beams. Mounting rings shall be of open design (not a closed loop) to allow additional wire to be strung without being threaded through the ring. For mounting rings that do not completely surround the wire, attach the wire to the mounting ring with a strap.

- Supports shall be spaced at a maximum 4-foot interval unless limited by building construction. If wiring "sag" at mid-span exceeds 6-inches; another support shall be used.

- Wall penetrations shall be sleeved, and fire stopped as specified.

- Wiring shall not be supported from existing cabling, existing tubing, plumbing or steam piping, ductwork, any component of a suspended ceiling, or electrical or communications conduit.

Start/stop and safety relays for motor loads shall be mounted remotely at the VFD or starter being controlled. Label these relays per above tagging requirements and locate in position on the VFD or starter where the label and power indication light for the relay is visible.

All pneumatic tubing, cabling and electrical wiring terminated at controllers, devices and terminal strips are to be permanently tagged or labeled with permanent adhesive labels within one inch of terminal strip with a numbering system to correspond exactly with the "Record Drawings". Jumpers where both ends of the wire are visible and terminations are within 6” of each other do not need to be labeled. Spare wires are to be labeled as “Spare” with unique number designations.

After completion of installation, test and adjust control equipment. Submit data showing set points and final adjustments of controls.

WIRE AND AIR PIPING CONDUIT AND TUBING INSTALLATION SCHEDULE

The following conduit schedule shall apply to both polyethylene tubing and wire in conduit where conduit is specified for air tubing or wiring. Conduit and tubing referenced below shall meet specifications in Section 26 05 33 and as defined below.

Air piping shall be run in independent conduit without wiring. In no cases shall wiring and air piping share a conduit, raceway, or cable tray.

Where air piping and wiring share a trough or wire management system above a control panel, code required separation shall be provided.

Conduit other than that specified below for specific applications shall not be used.

Exposed Outdoor Locations: Rigid steel conduit.

Concealed in Concrete and Block Walls: Rigid steel conduit. Schedule 40 PVC conduit. Electrical Nonmetallic Tubing (ENT).

Concealed Dry Interior Locations: Rigid steel conduit. Intermediate metal conduit. Electrical Metallic Tubing (EMT).

Exposed Dry Interior Locations: Rigid steel conduit. Intermediate metal conduit. Electrical metallic tubing.

Exposed Dry Interior Locations for Control Devices with Conduit Connections: EMT or Flexible Metal Conduit (FMC). Minimum length shall be one foot (300 mm); maximum length shall be three feet (900 mm). Minimum size FMC of 3/8”.

Exposed Dry Interior Locations for Control Devices without Conduit Connections: Where HVAC equipment control panels or devices do not provide for the direct connection of conduits, exposed wiring may be extended to complete the final connections in dry locations, providing it does not exceed 18 inches in length.

CONTROL DAMPERS

All control dampers furnished by the control manufacturer are to be installed by the Mechanical Contractor under the coordinating control and supervision of the Control Contractor in locations shown on plans or where required to provide specified sequence of control.

Damper end switches, where required, shall be integral to the actuator that is mounted to the damper drive shaft or auxiliary shaft attached to a damper drive blade. End switches shall be adjusted to prove the damper the position opposite the fail position of the damper actuator unless the control sequence requires a different position to be proven to accomplish the specified control sequence.

Coordinate installation with the sheetmetal installer to obtain smooth duct transitions where damper size is different than duct size. Blank off plates will not be accepted.

Each operator shall serve a maximum damper area of 36 square feet. Where larger dampers are used, provide multiple operators.

ROOM THERMOSTATS AND TEMPERATURE SENSORS

Check and verify location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Locate room thermostats and sensors 48 inches above floor. Align with light switches and humidistats. For drywall installations, thermostat mounting shall use a back-box attached to a wall stud, drywall anchors are not acceptable.

Any room thermostats or sensors mounted on an exterior wall shall be mounted on a thermally insulated sub-base. Subbase to provide a minimum of one half inch of insulation.

For thermostats or sensors seal the conduit and any other opening to prevent air movement that could affect the measurement.

PRECONSTRUCTION REVIEW MEETING

This contractor shall attend a meeting or meetings as required prior to construction to review the control system on the project. The meeting attendees shall consist of the AE of Record, DFD, CxP, User Agency, Section 23 09 14 Contractor, Section 23 09 23 or 23 09 24 Contractor, and the Division 23 Contractor. All sequences covered within specification section 23 09 93 and related system configurations and devices shall be reviewed in detail and any corrections to the sequences and mechanical systems shall be made through the DFD construction change process.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

FUNCTIONAL PERFORMANCE TESTING

For commissioning of control systems, the following items shall be complete by the contractor prior to functional performance testing:

- Completed functional performance tests written by the commissioning agent shall have been reviewed at the controls Preconstruction Review Meeting.
- All point to point checkout for each input/output shall be complete and documented.
- All changes to the design need to be incorporated prior to testing.

AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01.

Contractor to provide factory authorized representative and/or field personnel knowledgeable with the operations, maintenance and troubleshooting of the system and/or components defined within this section for a minimum period of 4 hours.

END OF SECTION

SECTION 23 09 93
SEQUENCE OF OPERATION FOR HVAC CONTROLS
BASED ON DFD MASTER SPECIFICATION DATED 3/28/2022

P A R T 1 - G E N E R A L

SCOPE
This section includes control sequences for HVAC equipment as well as equipment furnished by others that may need monitoring or control. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Description of Work
- Submittals
- Operation and Maintenance Data
- Design Criteria

PART 2 - PRODUCTS
- Not Applicable

PART 3 - EXECUTION
- General Control
- Terminal Unit Control – Electric
- Exhaust Fan Control
- Outside Air Intake
- Destratification Fan Control
- Functional Performance Testing

RELATED WORK
Applicable provisions of Division 1 govern work under this Section.

Section 01 91 01 – Commissioning Process
Section 23 08 00 – Commissioning of HVAC
Section 23 09 14 - Pneumatic and Electric Controls
Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC – Coordination
Section 23 54 00 – Stand Alone Control Sequence for Furnaces
Section 23 55 00 – Stand Alone Control Sequence for Gas Fired Heaters

Division 23 - HVAC - Equipment provided to be controlled or monitored.
Division 26 - Electrical - Equipment provided to be controlled or monitored.
Division 28 - Electronic Safety and Security

REFERENCE
Section 23 09 14 work includes furnishing and installing all field devices, including electronic sensors for the DDC of this section, equipment, and all related field wiring, interlocking control wiring between equipment, pneumatic tubing, sensor mounting, etc., that is covered in that section.

Motorized control dampers and actuators, thermowells (temperature sensing wells), automatic control valves and their actuators are also covered in Section 23 09 14.

DESCRIPTION OF WORK
Control sequences are hereby defined as the manner and method by which automatic controls function. Requirements for each type of operation are specified in this section.

Operation equipment, devices and system components required for automatic control systems are specified in other Division 23 control sections of these specifications.

All temperature, humidity, and pressure sensing, and all other control signal transportation for the control sequences shall be furnished under Section 23 09 14. All pneumatic, electronic, and electric input/output signals shall be extended under Section 23 09 14.

Sequences for equipment controlled by electric self-contained controls are accomplished by hardware provided under Section 23 09 14.

SUBMITTALS
Refer to Division 1, General Conditions, Submittals, Section 23 05 00 and 23 09 14 for descriptions of what should be included in the submittals.

Shop drawings shall be provided by the contractor providing equipment under Section 23 09 14. The contractor providing the 23 09 14 equipment shall provide a complete narrative of the sequence of operation for equipment that is controlled directly from that equipment. The narrative of the sequence of operation shall not be a verbatim copy of the sequences contained herein but shall reflect the actual operation as applied by the contractor.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

DESIGN CRITERIA
Reference Section 23 09 14.

P A R T 2 - P R O D U C T S

Not applicable to this Section – reference Section 23 09 14 for product descriptions.

P A R T 3 - E X E C U T I O N

GENERAL:

SETPOINTS:
All setpoints indicated in the control specification are to be adjustable. The setpoints indicated herein are only specified as a calculated starting point (or initial system operation). It is expected that setpoint adjustments and control loop tuning shall be required to provide optimum system operation based on requirements of the building. The control contractor shall work with the balancing contractor and the user Agency to provide the final system setpoint adjustments and control loop tuning after the system is in operation and building is in use. Document all final setpoints on the as-built control drawings. Any questions regarding the intended operation of the HVAC equipment and control systems shall be referred to the HVAC design engineer through the appropriate construction communication process. The following setpoints should be used as initial setpoints unless otherwise specified in the individual control sequences or instructed by the user Agency. If the contractor fails to check with the user Agency for final setpoints, they shall adjust setpoints at no additional cost.

Occupied Space Terminal Unit Heating: 68º F
Occupied Space Terminal Unit Cooling: 76º F
Unoccupied Space Terminal Unit Heating: 62º F
Unoccupied Space Terminal Unit Cooling: 82º F
Entry Way Heating: 60° F
Mechanical or Unoccupied Space Ventilation: 82º F
Mechanical or Unoccupied Space Heating: 60º F

ANTI-CYCLING:
When HVAC equipment or a sequence is specified to be started and stopped by a temperature, humidity, pressure setpoint or any other controlled variable, there shall be an adjustable differential setpoint that shall be set to prevent short cycling of the systems and equipment due to minor changes in the controlled variable. Temperature differential setpoints shall be set at 2º F and non-temperature setpoints shall be set at 10% of the controlled range unless otherwise specified. Setpoints shall indicate at when the process should be turned on. Heating and cooling differentials shall be set for above setpoint and shall be used to turn the process off. For example, an economizer sequence called to switch at 68º F, would turn on at 68º F and off at 70º F since it is a cooling function. A heating lockout setpoint of 50º F would turn on heating control at 50º F and off at 52º F Non-temperature differentials shall be set above setpoint if the setpoint is indicating a minimum value or below setpoint if the setpoint is indicating a maximum value. Provide minimum runtime timers for loads that are cycled to prevent over-cycling. Timers shall be set as specified or as needed to prevent damage or excessive wear to the equipment. Unless otherwise specified in the individual control sequences, fans and pumps shall have a minimum runtime on timers of 15 minutes (adj.) and off timers of 5 minutes (adj.) and

staged condensing units shall have on timers of 10 minutes (adj.) and off timers of 5 minutes (adj.) or the recommended timers by the manufacturer. Safeties shall override runtime timers.

DEADBANDS:
Provide deadbands for all DDC control loops to prevent constant hunting of output signals to controlled devices. Deadbands shall be set to provide adequate control around setpoint as follows unless otherwise specified in the individual control sequences:

Temperature Control: ±0.5º F
Humidity Control: ±1% RH
Airflow Control: ±2% of total flow
AHU Static Pressure Control: ±0.01 in. w.c.

DAMPER INTERLOCKS FOR FANS WITH STARTERS:
For fan systems with magnetic starters and shutoff dampers specified with end switches, the damper interlock shall be hardwired in such a way that the damper shall open if the fan starter hand / off / auto switch is in the hand or in the auto position and being called to start. After the damper end switch has proven the damper open, a hardwire interlock from the end switch to the starter holding coil for the fan shall cause the fan to start. For fan systems that are ducted in parallel, see specific sequence for fan system on interlock requirements.

FAN SYSTEM ISOLATION DAMPER CONTROL
For fans that have isolation dampers that are controlled by the DDC system, the dampers shall be powered open and closed and not utilize the actuator fail position spring (if specified) to operate. Dampers that are wired to fan power shall use the fail position spring in the actuator to actuate the damper.

FAN INTERLOCKING:
Provide interlocks between supply and return or exhaust fan systems as scheduled on the plans or called out in individual control sequences. If DDC controlled, interlocks shall be done through DDC start/stop points unless otherwise specified in individual control sequences. If not DDC controlled, interlocks shall be accomplished via hardwire interlocks between fan starters or VFD's.

THERMOSTATS AND SENSORS:
All devices and equipment including terminal units, specified to be controlled in a control sequence by a thermostat or sensor, shall be provided with a thermostat or sensor, whether or not the device is indicated on the plans. Consult the HVAC design engineer for the thermostat or sensor location.

TERMINAL UNIT CONTROL – DDC and ELECTRIC:
ELECTRIC UNIT HEATER CONTROL:
Provide an integral electric thermostat to maintain space temperature.

EXHAUST FAN CONTROL:
MLSP HEAD QUARTERS CEILING EXHAUST FAN CONTROL (CEF-1, CEF-2):
Interlock exhaust fan operation with occupancy sensor. Exhaust fan damper shall remain open whenever fan is operating.

MLSP SHOP INTERMITTENT EXHAUST FAN CONTROL (EF-1, EF-2):
Standalone controls shall operate exhaust fans, outside air dampers, exhaust dampers, space sensors, and time clock as follows.

Upon a signal from any space sensor that CO level is above 35 ppm (adjustable) or NO2 level is above 1 ppm (adjustable) the associated motorized dampers shall open and the associated exhaust fan shall operate.

Upon a drop of CO level and NO2 level below thresholds above for 20 minutes, the associated exhaust fan shall stop and the associated motorized dampers shall close.

Additionally, the system shall run a minimum of 5 hours per day. Count the runtime of the last 24 hours. If runtime is less than 5 hours, operate the system for 15 minutes each hour until the 24 counter reaches 5 hours.

RASP SHOP WALL MOUNTED PROPELLER FAN (EF-1)
Provide a switch to operate the fan and the motor operated damper.

OUTSIDE AIR INTAKE CONTROL:

Motorized backdraft damper associated with roof mounted intake hood shall be open when MLSP Shop furnace F-1 is operating.

DESTRATIFICATION FAN CONTROL:

Provide a wall switch for fan operation and a dial for speed control.

FUNCTIONAL PERFORMANCE TESTING

Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 in accordance with the procedures defined for functional performance testing in Section 01 91 01.

END OF SECTION

SECTION 23 11 00
FACILITY FUEL PIPING
BASED ON DFD MASTER SPECIFICATION DATED 10/25/2016

P A R T 1 - G E N E R A L

SCOPE
This section contains specifications for fuel pipe and fuel pipe fittings for this project. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Shop Drawings
- Quality Assurance
- Delivery, Storage, and Handling
- Design Criteria
- Welder Qualifications

PART 2 - PRODUCTS
- Natural Gas
- Propane
- Vents and Relief Valves
- Unions and Flanges

PART 3 - EXECUTION
- Preparation
- Erection
- Welded Pipe Joints
- Threaded Pipe Joints
- Natural Gas and Propane
- Vents and Relief Valves
- Unions and Flanges
- Gaskets
- Piping System Leak Tests
- Construction Verification Items
- Piping System Leakage Test Report

RELATED WORK
Section 01 91 01– Commissioning Process
Section 23 05 23 - General-Duty Valves for HVAC Piping
Section 23 08 00 – Commissioning of HVAC

REFERENCE
Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS
ANSI B16.3	Malleable Iron Threaded Fittings
ASTM A53	Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless
ASTM A234	Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures

SHOP DRAWINGS
Refer to division 1, General Conditions, Submittals.

Contractor shall submit schedule indicating the ASTM specification number of the pipe being proposed along with its type and grade and sufficient information to indicate the type and rating of fittings for each

service.

TYPE E OR S STEEL PIPE:
Mill certification papers, also known as material test reports, for the pipe furnished for this project, in English. Heat numbers on these papers to match the heat numbers stenciled on the pipe. Chemical analysis indicated on the mill certification papers to meet or exceed the requirements of the referenced ASTM specification.

QUALITY ASSURANCE
Order all Type E and Type S steel pipe with heat numbers rolled, stamped, or stenciled to each length or each bundle, depending on the size of the pipe, and in accordance with the appropriate ASTM specification.

Any installed material not meeting the specification requirements must be replaced with material that meets these specifications without additional cost to the Owner.

DELIVERY, STORAGE, AND HANDLING
Promptly inspect shipments to insure that the material is undamaged and complies with specifications.

Cover pipe to eliminate rust and corrosion while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade. Protect pipe, tube, and fitting ends so they are not damaged. Where end caps are provided or specified, take precautions so the caps remain in place.

Offsite storage agreements will not relieve the contractor from using proper storage techniques.

Storage and protection methods must allow inspection to verify products.

DESIGN CRITERIA
Use only new material, free of defects, rust and scale, and meeting the latest revision of ASTM specifications as listed in this specification.

Construct all piping for the highest pressures and temperatures in the respective system in accordance with ANSI B31, but not less than 125 psig unless specifically indicated otherwise.

Non-metallic piping will be acceptable only for the services indicated. It will not be acceptable in occupied spaces and ventilation plenum spaces, including plenum ceilings.

Where weld fittings or mechanical grooved fittings are used, use only long radius elbows having a centerline radius of 1.5 pipe diameters.

Where ASTM A53 grade A pipe is specified, ASTM A53 grade B pipe may be substituted at Contractor's option. Where the grade or type is not specified, Contractor may choose from those commercially available.

WELDER QUALIFICATIONS

Before any metallic welding is performed, Contractor to submit his Standard Welding Procedure Specification together with the Procedure Qualification Record as required by Section IX of the ASME Boiler and Pressure Vessel Code and/or the National Certified Pipe Welding Bureau.

Before any polyethylene fusion welding is performed, Contractor to submit certification that the welders to be used on this project have successfully demonstrated proper welding procedures in accordance with the Code of Federal Regulations, Title 49, Part 192, Section 192.285.

The A/E or DFD reserves the right to test the work of any welder employed on the project, at the Contractor's expense. If the work of the welder is found to be unsatisfactory, the welder shall be prevented from doing further welding on the project.

PART 2 - PRODUCTS

NATURAL GAS

2" and Smaller: ASTM A53, type E or S, standard weight (schedule 40) black steel pipe with ASTM A197/ANSI B16.3 class 150 black malleable iron threaded fittings or ASTM A234 grade WPB/ANSI B16.9 standard weight, seamless, carbon steel weld fittings.

2-1/2" and Larger: ASTM A53, type E or S, standard weight black steel pipe with ASTM A234 grade WPB/ANSI B16.9 standard weight, seamless, carbon steel weld fittings.

PROPANE

2" and Smaller: ASTM A53, type E or S, standard weight (schedule 40) black steel pipe with ASTM A197/ANSI B16.3 class 150 black malleable iron threaded fittings or ASTM A234 grade WPB/ANSI B16.9 standard weight, seamless, carbon steel weld fittings.

2-1/2" and Larger: ASTM A53, type E or S, standard weight black steel pipe with ASTM A234 grade WPB/ANSI B16.9 standard weight, seamless, carbon steel weld fittings.

VENTS AND RELIEF VALVES

Use pipe and pipe fittings as specified for the system to which the relief valve or vent is connected.

UNIONS AND FLANGES

2" and Smaller: ASTM A197/ANSI B16.3 malleable iron unions with brass seats. Use black malleable iron on black steel piping and galvanized malleable iron on galvanized steel piping. Use unions of a pressure class equal to or higher than that specified for the fittings of the respective piping service but not less than 250 psi.

2-1/2" and Larger: ASTM A181 or A105, grade 1 hot forged steel flanges of threaded, welding and of a pressure class compatible with that specified for valves, piping specialties and fittings of the respective piping service. Flanges smaller than 2-1/2" may be used as needed for connecting to equipment and piping specialties. Use raised face flanges ANSI B16.5 for mating with other raised face flanges on equipment with flat ring or full face gaskets. Use ANSI B16.1 flat face flanges with full face gaskets for mating with other flat face flanges on equipment.

Provide ASTM A 193 B7 grade bolts and A 194 2H grade nuts & hardened washers for connections (Star washers for grounding.)

GASKETS

Fuel Oil and Natural Gas Systems: Branded, compressed, non-asbestos sheet gaskets. Klingersil C4401, Garlock 3000, JM Clipper 978-C or approved equal.

PART 3 - EXECUTION

PREPARATION

Remove all foreign material from interior and exterior of pipe and fittings.

ERECTION

Install all piping parallel to building walls and ceilings and at heights which do not obstruct any portion of a window, doorway, stairway, or passageway. Where interferences develop in the field, offset or reroute piping as required to clear such interferences. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.

Provide anchors, expansion joints, swing joints and/or expansion loops so that piping may expand and contract without damage to itself, equipment, or building.

Mitered ells, notched tees, and orange peel reducers are not acceptable. On threaded piping, bushings are not acceptable.

"Weldolets" and "Threadolets" may be used for branch takeoffs up to one-half (1/2) the diameter of the main.

Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment.

Install all valves, and piping specialties, including items furnished by others, as specified and/or detailed. Make connections to all equipment installed by others where that equipment requires the piping services indicated in this section.

WELDED PIPE JOINTS

Make all welded joints by fusion welding in accordance with ASME Codes, ANSI B31, and State Codes where applicable.

All pipe welding shall be completed by Qualified Welders in accordance with the Contractor's Procedure Specifications.

Contractor will ensure that these steps are followed where pipe sections will be joined by welding:

1. Cleaning – Welding surfaces will be clean and free of defects.
2. Alignment – Inside diameter of piping components will be aligned as accurately as possible. Internal misalignment shall not exceed 1/16".
3. Spacing – Pipe sections will be spaced to allow deposition of weld filler material through the entire weld joint thickness.
4. Girth Butt Welds:
    a. Girth butt welds shall be complete penetration welds.
    b. Concavity will not exceed 1/32"
    c. Under cuts will not exceed 1/32"
    d. As welded surfaces are permitted however surfaces will be free from coarse ripples, grooves, abrupt ridges and valleys.

Electrodes shall be Lincoln, or approved equal, with coating and diameter as recommended by the manufacturer for the type and thickness of work being done.

THREADED PIPE JOINTS

Use a Teflon based thread lubricant or Teflon tape when making joints; no hard setting pipe thread cement or caulking will be allowed.

NATURAL GAS AND PROPANE

Pitch horizontal piping down 1" in 60 feet in the direction of flow. Install a 4" minimum depth dirt leg at the bottom of each vertical run and at each appliance. When installing mains and branches, cap gas tight each tee or pipe end which will not be immediately extended. All branch connections to the main shall be from the top or side of the main.

Do not install gas pipe in a ventilation air plenum.

If an above ground vent terminates in an area subject to snow accumulation, terminate the line at least five feet above grade.

Install a shut off valve at each appliance. Provide a valved connection at the main for equipment and appliances furnished by others.

Piping through a roof shall be run through an approved roof penetration with flashing and counter flashing.

Each gas pressure reducing valve vent and relief valve vent shall be run separately to a point outside of the building, terminated with a screened vent cap, and located according to gas utility regulations.

Clean all welded piping before all regulators and control valves. Test by placing target cloth over piping and blow with compressed air. Clean piping until target cloth is clean and free of debris.

VENTS AND RELIEF VALVES

Install vent and relief valve discharge lines as indicated on the drawings, as detailed, and as specified for each specific valve or piping specialty item. In no event is a termination to occur less than six feet above a roof line.

UNIONS AND FLANGES

Install a union or flange, as required, at each automatic control valve and at each piping specialty or piece of equipment which may require removal for maintenance, repair, or replacement. Where a valve is located at a piece of equipment, locate the flange or union connection on the equipment side of the valve. Concealed unions or flanges are not acceptable.

GASKETS

Store horizontally in cool, dry location and protect from sunlight, water and chemicals. Inspect flange surfaces for warping, radial scoring or heavy tool marks. Inspect fasteners, nuts and washers for burrs or cracks. Replace defective materials.

Align flanges parallel and perpendicular with bolt holes centered without using excessive force. Center gasket in opening. Lubricate fastener threads, nuts and washers with lubricant formulated for application.

Draw flanges together evenly to avoid pinching gasket. Tighten fasteners in cross pattern sequence (12 – 6 o'clock, 3 – 9 o'clock, etc.), one pass by hand and four passes by torque wrench at 30% full torque, 60% full torque and two passes at full torque per ASME B16.5.

PIPING SYSTEM LEAK TESTS

Verify that the piping system being tested is fully connected to all components and that all equipment is properly installed, wired, and ready for operation. If required for the additional pressure load under test, provide temporary restraints at expansion joints or isolate them during the test. Verify that hangers can withstand any additional weight load that may be imposed by the test.

Provide all piping, fittings, blind flanges, and equipment to perform the testing.

Conduct pressure test with test medium of air or water unless specifically indicated. Minimum test time is indicated in the table below; additional time may be necessary to conduct an examination for leakage. Each test must be witnessed by the Division's representative. If leaks are found, repair the area with new materials and repeat the test; caulking will not be acceptable.

For hydrostatic tests, use clean water and remove all air from the piping being tested by means of air vents or loosening of flanges/unions. Measure and record test pressure at the high point in the system.

For air tests, gradually increase the pressure to not more than one half of the test pressure; then increase the pressure in steps of approximately one-tenth of the test pressure until the required test pressure is reached. Examine all joints and connections with a soap bubble solution or equivalent method. The piping system exclusive of possible localized instances at pump or valve packing shall show no evidence of leaking. After testing is complete, slowly release the pressure in a safe manner.

Measure natural gas system test pressure with a water manometer or an equivalent device calibrated in increments not greater than 0.1 inch water column. System will not be approved until it can be demonstrated that there is no measurable loss of test pressure during the test period.

Conduct fuel oil system test so as not to impose a pressure of more than 10 psig on the tank. Instead of a pressure test, suction lines may be tested under a vacuum of not less than 20 inches of mercury maintained for at least one hour.

System	Pressure	Medium	Duration
Natural gas	100 psig	Air	24 hr
Propane	100 psig	Air	24 hr

All pressure tests are to be documented on a Division of Facilities Development form included in this specification.

On piping that cannot be tested because of connection to an active line, provide temporary blind flanges and hydrostatically test new section of piping. After completion of test, remove temporary flanges and make final connections to piping. Die penetrate test pass weld or x-ray the piping that was not hydrostatically tested up to the active system.

CONSTRUCTION VERIFICATION ITEMS

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

END OF SECTION

PIPING SYSTEM LEAKAGE TEST REPORT

State of Wisconsin
Department of Administration
Division of Facilities Development

Date Submitted: _____

Project Name: _____

Location: _____ **DFD Project No:** _____

Contractor: _____

☐ **HVAC** ☐ **Refrigeration** ☐ **Controls**

☐ **Power Plant** ☐ **Plumbing** ☐ **Sprinkler**

Test Medium: ☐ **Air** ☐ **Water** ☐ **Other** _____

Test performed per specification section No. _____

Specified Test Duration _____ **Hours** **Specified Test Pressure** _____ **PSIG**

System Identification: _____

Describe Location: _____

_____

Test Date: _____

Start Test Time: _____ **Initial Pressure:** _____ **PSIG**

Stop Test Time: _____ **Final Pressure:** _____ **PSIG**

Tested By: _____ **Witnessed By:** _____

Title: _____ **Title:** _____

Signed: _____ **Signed:** _____

Date: _____ **Date:** _____

Comments: _____

_____

_____

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SECTION 23 31 00
HVAC DUCTS and CASINGS
BASED ON DFD MASTER SPECIFICATION DATED 09/13/2024

P A R T 1 - G E N E R A L

SCOPE

This section includes specifications for all duct systems used on this project. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Quality Assurance
- Shop Drawings
- Design Criteria
- Delivery, Storage And Handling

PART 2 - PRODUCTS
- General
- Ductwork Pressure Class
- Materials
- Low Pressure Ductwork (Maximum 2 inch pressure class)
- Duct Sealant
- Gaskets

PART 3 - EXECUTION
- Installation
- Ductwork Support
- Low Pressure Duct (Maximum 2 inch pressure class)
- Cleaning
- Leakage Test
- Structural Test
- Construction Verification

RELATED WORK

Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC
Section 23 08 00 – Commissioning of HVAC
Section 23 33 00 – Air Duct Accessories

REFERENCE

Applicable provisions of Division 1 govern work under this Section.

REFERENCE STANDARDS

ASTM A90	Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
ASTM A623	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
ASTM A527	Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality
ASTM 924	Standard Specification for General Requirements for Sheet Steel, Metallic-coated by the Hot-dip Method
ASTM E 84	Test Method for Surface Burning Characteristics of Building Materials
ASTM C 1338	Test Method for Determining Fungal Resistance of Insulation Materials and Facings
ASTM C 916	Standard Specification for Adhesives for Duct Thermal Insulation
NFPA 90A	Standard for the Installation of Air Conditioning and Ventilating Systems
UL 181	Standard for Safety for Factory Made Air Ducts and Air Connectors.

QUALITY ASSURANCE
Refer to division 1, General Conditions, Equals and Substitutions.

SHOP DRAWINGS
Refer to division 1, General Conditions, Submittals.

Include manufacturer's data and/or Contractor data for the following:

- Fabrication and installation drawings.
- Schedule of duct systems including material of construction, gauge, pressure class, system class, method of reinforcement, joint construction, fitting construction, and support methods, all with details as appropriate.
- Duct sealant and gasket material.

DESIGN CRITERIA
Construct all ductwork to be free from vibration, chatter, objectionable pulsations and leakage under specified operating conditions.

Use material, weight, thickness, gauge, construction and installation methods as outlined in the following SMACNA publications, unless noted otherwise:

- HVAC Duct Construction Standards, Metal and Flexible, 4th Edition, 2020
- HVAC Air Duct Leakage Test Manual, 2nd Edition, 2012
- HVAC Systems - Duct Design, 4th Edition, 2006
- Rectangular Industrial Duct Construction Standard, 2nd Edition, 2004
- Round Industrial Duct Construction Standards, 2nd Edition, 1999
- Thermoplastic Duct (PVC) Construction Manual, 2nd Edition, 1995

Use products which conform to NFPA 90A, possessing a flame spread rating of not over 25 and a smoke developed rating no higher than 50.

DELIVERY, STORAGE AND HANDLING
Promptly inspect shipments to ensure that Ductwork is undamaged and complies with the specification.

Protect Ductwork against damage.

Protect Ductwork by storing inside or by durable, waterproof, above ground packaging. Do not store material on grade. Protect Ductwork from dirt, dust, construction debris and foreign material. Where end caps/packaging are provided, take precautions so caps/packaging remain in place and free from damage.

Offsite storage agreements do not relieve the contractor from using proper storage techniques.

Storage and protection methods must allow inspection to verify products.

P A R T 2 - P R O D U C T S

GENERAL
All sheet metal used for construction of duct shall be 24 gauge or heavier except for round and spiral ductwork and spiral duct take-offs 12” and below may be 26 gauge where allowed in SMACNA HVAC Duct Construction Standards, Metal and Flexible, 4th Edition, 2020.

Duct sizes indicated on plans are net inside dimensions; where duct liner is specified, dimensions are net, inside of liner.

DUCTWORK PRESSURE CLASS
Minimum acceptable duct pressure class, for all ductwork except transfer ductwork, is 2 inch W.G. positive or negative, depending on the application. Transfer ductwork minimum acceptable duct pressure class is 1

inch W.G. positive or negative, depending on the application. Duct system pressure classes not indicated on the drawings to be as follows:

	Calc. S.P. in	Pressure Class in
Supply duct	1	2
Exhaust air ducts	0.5	2
Return air ducts	1	2
Outside air ducts	1	2

MATERIALS

Galvanized Steel Sheet:

Use ASTM A 653 galvanized steel sheet of lock forming quality. Galvanized coating to be 1.25 ounces per square foot, both sides of sheet, G90 in accordance with ASTM A90. Provide "Paint Grip" finish or galvanneal sheet metal for ductwork that will be painted.

LOW PRESSURE DUCTWORK (Maximum 2 inch pressure class)

Fabricate and install ductwork in sizes indicated on the drawings and in accordance with SMACNA recommendations, except as modified below.

Construct so that all interior surfaces are smooth. Use slip and drive or flanged and bolted construction when fabricating rectangular ductwork. Use spiral lock seam construction when fabricating round spiral ductwork. Sheet metal screws may be used on duct hangers, transverse joints and other SMACNA approved locations if the screw does not extend more than 1/2 inch into the duct.

Use elbows and tees with a center line radius to width or diameter ratio of 1.5 wherever space permits. When a shorter radius must be used due to limited space, install single wall sheet metal splitter vanes in accordance with SMACNA publications, Type RE 3. Where space will not allow and the C value of the radius elbow, as given in SMACNA publications, exceeds 0.31, use rectangular elbows with turning vanes as specified in Section 23 33 00. Square throat-radius heel elbows will not be acceptable. Straight taps or bullhead tees are not acceptable.

Where rectangular elbows are used, provide turning vanes in accordance with Section 23 33 00.

Provide expanded take-offs or 45 degree entry fittings for branch duct connections with branch ductwork airflow velocities greater than 700 fpm. Square edge 90-degree take-off fittings or straight taps will not be accepted.

Button punch snaplock construction will not be accepted on aluminum ductwork.

Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream of equipment shall not exceed 30 degrees; convergence downstream shall not exceed 45 degrees.

DUCT SEALANT

Manufacturer: 3M 800, 3M 900, H.B. Fuller/Foster, Hardcast, Hardcast Peal & Seal, Lockformer cold sealant, Mon-Eco Industries, United Sheet Metal, or approved equal. Silicone sealants are not allowed in any type of ductwork installation.

Install sealants in strict accordance with manufacturer's recommendations, paying special attention to temperature limitations. Allow sealant to fully cure before pressure testing of ductwork, or before startup of air handling systems.

GASKETS

2 Inch Pressure Class And Lower:

Soft neoprene or butyl gaskets in combination with duct sealant for flanged joints.

3 Inch Pressure Class And Higher:

Butyl gaskets.

PART 3 - EXECUTION

INSTALLATION

Verify dimensions at the site, making field measurements and drawings necessary for fabrication and erection. Check plans showing work of other trades and consult with Architect in the event of any interference.

Make allowances for beams, pipes or other obstructions in building construction and for work of other contractors. Transform, divide or offset ducts as required, in accordance with SMACNA HVAC Duct Construction Standards, Figure 4-7, except do not reduce duct to less than six inches in any dimension and do not exceed an 8:1 aspect ratio. Where it is necessary to take pipes or similar obstructions through ducts, construct easement as indicated in SMACNA HVAC Duct Construction Standards, Figure 4-8, Fig. E. In all cases, seal to prevent air leakage. Pipes or similar obstructions may not pass through high pressure or fume exhaust ductwork.

Test openings for test and balance work will be provided under Section 23 05 93.

Provide frames constructed of angles or channels for coils, filters, dampers or other devices installed in duct systems, and make all connections to such equipment including equipment furnished by others. Secure frames with gaskets and screws or nut, bolts and washers.

Install duct to pitch toward outside air intakes and drain to outside of building. Solder or seal seams to form watertight joints.

Where two different metal ducts meet, the joint shall be installed in such a manner that metal ducts do not contact each other by using proper seal or compound.

Install all motor operated dampers and connect to or install all equipment furnished by others. Blank off all unused portions of louvers, as indicated on the drawings, with 1-1/2 inch board insulation with galvanized sheet metal backing on both sides.

Do not install ductwork through dedicated electrical rooms or spaces unless the ductwork is serving this room or space.

Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

Provide adequate access to ductwork for cleaning purposes.

Provide temporary capping of ductwork openings to prevent entry of dirt, dust and foreign material.

Protect diffusers, registers and grilles with plastic wrap or some other approved form of protection to maintain dirt and dust free and to prevent entry of dirt, dust and foreign material into the Ductwork.

During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

DUCTWORK SUPPORT

Support ductwork in accordance with SMACNA HVAC Duct Construction Standards, Figure 5-5, except supporting ductwork with secure wire method is not allowed.

Stainless steel air-craft cable hanging systems are allowed on round ductwork under 12 inches diameter if installed utilizing two fasteners with two cable loops. Support with 3/32 inch, 7 x 7, stainless steel air-craft cable, with matching serrated spring loaded wedge mechanism fasteners rated for actual load. Comply with the manufacturer’s installation instructions.

LOW PRESSURE DUCT (Maximum 2 inch pressure class)

Seal all ducts, except for transfer ducts, in accordance with SMACNA seal class "A"; all seams, joints, and penetrations shall be sealed.

Install a manual balancing damper in each branch duct and for each diffuser or grille. The use of splitter dampers, extractors, or grille face dampers will not be accepted for balancing dampers.

Hangers must be wrapped around bottom edge of duct and securely fastened to duct with sheet metal screws or pop rivets. Trapeze hangers may be used at contractor's option.

CLEANING

Remove all dirt and foreign matter from the entire duct system and clean diffusers, registers, grilles and the inside of air-handling units before operating fans.

Clean duct systems with high power vacuum machines where systems have been used for temporary heat, air-conditioning, or ventilation purposes during construction. Protect equipment that may be harmed by excessive dirt with filters, or bypass during cleaning.

LEAKAGE TEST

Test all ductwork in accordance with test methods described in Section 4 of SMACNA HVAC Air Duct Leakage Test Manual. Do not insulate ductwork until it has been successfully tested. Test pressure shall be equal to the duct pressure class.

If excessive air leakage is found locate leaks, repair the duct in the area of the leak, seal the duct, and retest.

Leakage rate shall not exceed more than 5% of the system air quantity for low pressure ductwork, determined in accordance with Appendix C of the SMACNA HVAC Air Duct Leakage Test Manual.

Leakage rate shall not exceed more that 1% of the system air quantity for high pressure ductwork, determined in accordance with Appendix C of the SMACNA HVAC Air Duct Leakage Test Manual.

Leakage test for ductwork downstream of air terminal devices may be omitted but will not relieve the contractor from duct sealing requirements.

Submit a signed report to the Division's Construction Representative, indicating test apparatus used, results of the leakage test, and any remedial work required to bring duct systems into compliance with specified leakage rates.

STRUCTURAL TEST

Random test all ductwork per DFD direction. Do not insulate ductwork until it has been successfully tested. Test pressure shall be equal to the duct pressure class.

Deflection limits shall not exceed those listed in accordance with Chapter 11 of SMACNA HVAC Duct Construction Standards, 3.0 Performance Requirements.

Submit a signed report to the Division's Construction Representative, indicating test apparatus used, results of the structural test, and any remedial work required.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

APPENDIX

DUCT LEAKAGE TEST REPORT

State of Wisconsin Department of Administration	**DFD Project Number:_____**
Division of Facilities Development	**Date Submitted:_____**

Project	**Name:**_____		
	Location:_____		
	Contractor:_____		
System	**Fan No:**_____	**Leakage Class (C_L):**_____	
Data	**Fan Design CFM:**_____	**Duct Pressure Class (P_C):**_____	
		Test Pressure (P_T):_____	
Test			
Equipment	**Manufacturer:**_____	**Model No:**_____	**Serial No:**_____

For large systems, use the reverse side for a simple sketch of the entire duct system. Then use letter designations to indicate the various duct sections being tested at one time. Also use the reverse side for test comments.

Note that due to normal construction sequencing it is usually necessary to test risers separately prior to enclosing chases.

Design Data					**Field Test Data**							
			Allowable Leakage		**Diameter**		**Pressure (in. wc.)**					
Duct Section	**Duct Shape**	**Duct Surface (Ft^2)**	**Leakage Factor ($P^{.65}C_L$)**	**CFM for Section**	**Tube (D_1)**	**Orifice (D_2)**	**In Duct (P)**	**Across Orifice (P_{drop})**	**Date**	**Performed By**	**Observed By**	**Actual CFM**
TOTAL												

DUCT STRUCTURAL TEST REPORT

State of Wisconsin **DFD Project Number:_____**
Department of Administration
Division of Facilities Development **Date Submitted:_____**

Project **Name:_____**
Location:_____
Contractor:_____

System Data **Fan No:_____**
Description of Test Method:_____
_____
_____

Test Equipment **Manufacturer:_____** **Model No:_____** **Serial No:_____**

Indicate the various duct sections being tested at one time. Also use the reverse side for test comments.

Design Data								Field Test Data						
Duct Test Location	Ductwork Shape		Duct Pressure Class	Allowable Ductwork Wall Deflection		Allowable Joint/ Reinforcement Deflection		Pressure (in. wc.) In Duct	Measured Ductwork Wall Deflection		Measured Joint/ Reinforcement Deflection		Per-formed By/ Date	Wit-nessed By/ Date
	H	W		H	W	H	W		H	W	H	W		

END OF SECTION

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SECTION 23 33 00
AIR DUCT ACCESSORIES
BASED ON DFD MASTER SPECIFICATION DATED 09/13/2024

P A R T 1 - G E N E R A L

SCOPE
This section includes accessories used in the installation of duct systems. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Quality Assurance
- Shop Drawings
- Operation and Maintenance Data

PART 2 - PRODUCTS
- Manual Volume Dampers
- Turning Vanes
- Control Dampers
- Access Doors
- Flashings
- Duct Flexible Connections
- Hoods for Intake and Exhaust
- Louvers

PART 3 - EXECUTION
- Manual Volume Dampers
- Turning Vanes
- Control Dampers
- Access Doors
- Flashings
- Duct Flexible Connections
- Hoods for Intake and Exhaust
- Louvers
- Construction Verification

RELATED WORK
Section 23 05 29 – Hanger and Supports for HVAC Piping and Equipment
Section 23 08 00 – Commissioning of HVAC
Section 23 31 00 – HVAC Ducts and Casings

REFERENCE
Applicable provisions of Division 1 govern work under this Section.

REFERENCE STANDARDS

NFPA 90A	Standard for Installation of Air Conditioning and Ventilating Systems
SMACNA	HVAC Duct Construction Standards - Metal and Flexible, 4th Edition, 2020
UL 214	
UL 555 (6th edition)	Standard for Fire Dampers and Ceiling Dampers
UL 555S (4th edition)	Leakage Rated Dampers for Use in Smoke Control Systems

QUALITY ASSURANCE
Refer to division 1, General Conditions, Equals and Substitutions

SHOP DRAWINGS
Refer to division 1, General Conditions, Submittals.

Submit for all accessories and include dimensions, capacities, ratings, installation instructions, and appropriate identification.

Include certified test data on dynamic insertion loss, self-noise power levels, and aerodynamic performance of sound attenuators.

Submit manufacturer's color charts where finish color is specified to be selected by the Architect/Engineer.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

P A R T 2 - P R O D U C T S

MANUAL VOLUME DAMPERS
Manufacturers: Ruskin, Vent Products, Air Balance, or approved equal.

Dampers must be constructed in accordance with SMACNA Fig. 7-4, Fig. 7-5, and notes relating to these figures, except as modified below.

Reinforce all blades to prevent vibration, flutter, or other noise. Construct dampers in multiple sections with mullions where width is over 48 inches. Use rivets or tack welds to secure individual components; sheet metal screws will not be accepted. Provide operators with locking devices and damper position indicators for each damper; use an elevated platform on insulated ducts. Provide end bearings or bushings for all volume damper rods penetrating ductwork constructed to a 3" w.c. pressure class or above.

TURNING VANES
Manufacturers: Aero Dyne, Anemostat, Barber-Colman, Hart & Cooley, or approved equal.

Construct turning vanes and runners for square elbows in accordance with SMACNA Fig. 4-3 and Fig. 4-4 except use only airfoil type vanes. Construct turning vanes for short radius elbows and elbows where one dimension changes in the turn in accordance with SMACNA Chart 4-1 and Fig. 4-10.

CONTROL DAMPERS
Control dampers are specified in section 23 09 14.

ACCESS DOORS
General:
Access doors to be designed and constructed for the pressure class of the duct in which the door is to be installed. Doors in exposed areas shall be hinged type with cam sash lock. Hinges shall be aluminum or steel full length continuous piano type. Doors in concealed spaces shall be secured in place with cam sash latches. For both hinged and non-hinged doors provide sufficient number of camp sash latches to provide air tight seal when door is closed. Do not use hinged doors in concealed spaces if this will restrict access. Use minimum 1” deep 24 gauge galvanized steel double wall access doors with minimum 24 gauge galvanized steel frames. For non-galvanized ductwork, use minimum 1” deep double wall access door with frame that shall use materials of construction identical to adjacent ductwork. Provide double neoprene gasket that shall provide seals from the frame to the door and frame to the duct. When access doors are installed in insulated ductwork or equipment provide insulated doors with insulation equivalent to what is provided for adjacent ductwork or equipment. Access doors constructed with sheet metal screw fasteners will not be accepted.

FLASHINGS
Provide flashing to completely weatherproof connection of ductwork to louvers. Flashing to be constructed of material similar to louver material.

Flashing and counterflashing for roof curbs will be provided by others.

Flashing and curbs for duct and pipe penetrations of roof assemblies to be in accordance with details.

DUCT FLEXIBLE CONNECTIONS
Material to be fire retardant, be UL 214 listed, and meet the requirements of NFPA 90A.

Connections to be a minimum of 3 inches wide, crimped into metal edging strip, and air tight. Connections to have adequate flexibility and width to allow for thermal expansion/contraction, vibration of connected equipment, and other movement.

General Applications:
Use coated glass fiber fabric for all applications. Material for inside applications other than corrosive environments, fume exhaust, or kitchen exhaust to be double coated with neoprene, air and water tight, suitable for temperatures between -10°F and 200°F, and have a nominal weight of 30 ounces per square yard.

HOODS FOR INTAKE AND EXHAUST
Manufacturers: Acme, Ammerman, Carnes, Cook, Greenheck, Louvers and Dampers, Penn, or approved equal.

Use low silhouette type hoods.

Construct hoods of aluminum.

Provide bird screen and motor operated damper for each hood.

LOUVERS
Louver Provided by Division 23 Contractor:
Manufacturers: Airolite K6776, Industrial Louvers 658, American Warming and Ventilating LE-31, Construction Specialties 6177, Ruskin ELF6375DX or approved equal.

Similar to Airolite Type K6776, extruded aluminum alloy not less than 12 gauge (.081" thick), 6063 series frame and blades, all-welded assembly, 35 degree or 45 degree blades with water baffle, 6 inches thick. Provide with bird screen of ½" x ½" mesh aluminum in 12 gauge aluminum frame and an aluminum sill. Locate the bird screen inside of the louver unless noted otherwise.

Louver to bear the AMCA certified ratings seal for both air performance and water penetration, having a free area not less than 50% based on a 48" x 48" section, a water penetration less than 0.1 oz/square foot under AMCA test at 1000 feet per minute, and an intake pressure drop less than 0.20 inches of water at 1000 feet per minute.

Finish to be anodized or Kynar 500 in a custom color to be selected by the Architect. Furnish sufficient paint in the same color as the louver to paint the outer surface of panels over unused portions of louvers and to paint the interior portion of ductwork visible through the louvers.

P A R T 3 - E X E C U T I O N

MANUAL VOLUME DAMPERS
Install manual volume dampers in each branch duct and for each grille, register, or diffuser as far away from the outlet as possible while still maintaining accessibility to the damper. Install so there is no flutter or vibration of the damper blade(s).

TURNING VANES
Install turning vanes in all rectangular, mitered elbows in accordance with SMACNA standards and/or manufacturer's recommendations.

Install double wall, airfoil, 2 inch radius vanes in ducts with vane runner length 18" or greater and air velocity less than 2000 fpm. Install double wall, airfoil, 4-1/2 inch radius vanes in ducts with vane runner length 18" or greater and air velocity 2000 fpm or greater.

If duct size changes in a mitered elbow, use single wall type vanes with a trailing edge extension. If duct size changes in a radius elbow or if short radius elbows must be used, install sheetmetal turning vanes in accordance with SMACNA Chart 4-1 and Figure 4-10.

CONTROL DAMPERS
Install dampers in locations indicated on the drawings, as detailed, and according to the manufacturer's instructions. Provide adequate operating clearance and access to the operator. Install an access door adjacent to each control damper for inspection and maintenance.

ACCESS DOORS
Install access doors where specified, indicated on the drawings, and in locations where maintenance, service, cleaning or inspection is required. Examples include, but are not limited to motorized dampers, fire and

smoke dampers, smoke detectors, fan bearings, heating and cooling coils, filters, valves, and control devices needing periodic maintenance.

Size and numbers of duct access doors to be sufficient to perform the intended service. Minimum access door size shall be 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder access, or other size as indicated. Install access doors on both inlet and outlet sides of reheat coils as well as other duct mounted coils.

FLASHINGS
Flashing for roof curbs, equipment supports or rails located on roof, will be installed by others.

DUCT FLEXIBLE CONNECTIONS
Install at all duct connections to rotating or vibrating equipment, including air handling units (unless unit is internally isolated), fans, or other motorized equipment in accordance with SMACNA Figure 7-8. Install thrust restraints to prevent excess strain on duct flexible connections at fan inlets and outlets; see Related Work.

For applications in corrosive environments or fume exhaust systems, use a double layer of the Teflon¿ coated fabric when making the connector.

HOODS FOR INTAKE AND EXHAUST
Install in locations indicated on the drawings, coordinating the roof opening location with the General Prime Contractor. Curbs are covered in Section 23 05 29.

LOUVERS
Furnish louvers to the General Prime Contractor for mounting in exterior walls. Connect outside air intake duct to the louver, sealing all connections air and water tight.

Provide bird screen on inside of active louver area where none is provided with louvers. Where louvers are equipped with inside birdscreen, remove screen at all locations where duct connections are not made.

Install insulated metal panel on unused portion of louver. Panels must be sealed weathertight to louver assembly with flashing as required for proper drainage to outside of building. Paint outside surface of panel to match louver prior to installation. Where ductwork is visible through louver when viewed from outside the building, paint inside of duct to match louver color.

CONSTRUCTION VERIFICATION
Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

END OF SECTION

SECTION 23 34 00
HVAC FANS
BASED ON DFD MASTER SPECIFICATION DATED 04/05/2017

P A R T 1 - G E N E R A L

SCOPE
This section includes specifications for fans that are not an integral part of a manufactured device. Included are the following topics:

RELATED WORK
Section 01 91 01 – Commissioning Process
Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment
Section 23 05 13 - Common Motor Requirements for HVAC Equipment
Section 23 08 00 – Commissioning of HVAC

REFERENCE
Applicable provisions of Division 1 govern work under this Section.

REFERENCE STANDARDS

AMCA 203	AMCA Fan Application Manual - Troubleshooting
AMCA 210	Laboratory Method of Testing Fans for Rating
AMCA 300	Reverberant Room Method for Sound Testing of Fans
NFPA 90A	Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 96	Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
UL 762	Power Roof Ventilators For Restaurant Exhaust Appliances

QUALITY ASSURANCE
Refer to division 1, General Conditions, Equals and Substitutions.

SHOP DRAWINGS
Refer to division 1, General Conditions, Submittals.

Include dimensions, capacities, fan curves, materials of construction, ratings, weights, motors and drives, sound power levels, appropriate identification and vibration isolation for all equipment. Sound power levels to be based on tests performed in accordance with AMCA Standard 300.

Submit color selection charts for equipment where applicable.

Fan curves shall indicate the relationship of CFM to static or total pressure for various fan speeds. Brake horsepower, recommended selection range, and limits of operation are to also be indicated on the curves. Indicate operating point on the fan curves at design air quantity and indicate the manufacturer's recommended drive loss factor for the specific application. Tabular fan performance data is not acceptable.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

DESIGN CRITERIA
Tested and certify all fans in accordance with the applicable AMCA test code.

Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at scheduled static pressure. The motor furnished with the fan shall not operate into the motor service factor when operating under these conditions.

Consider drive efficiency in motor selection according to manufacturer's published recommendation or according to AMCA Publication 203, Appendix L.

Where inlet and outlet ductwork at any fan is changed from that shown on the drawings, provide any motor, drive and/or wiring changes required due to increased static pressure or baffling necessary to prevent uneven airflow or improve mixing.

All internal insulation and other components exposed to the airstream are to meet the flame spread and smoke ratings contained in NFPA 90A.

All roof mounted equipment to be provided with curbs or equipment stands in accordance with specification in Section 23 05 29.

P A R T 2 - P R O D U C T S

GENERAL
Use fan size, class, type, arrangement, and capacity as scheduled.

Furnish complete with motors, wheels, drive assemblies, bearings, vibration isolation devices, and accessories required for specified performance and proper operation. All single phase motors to have inherent thermal overload protection.

Provide variable pitch sheaves for drives 3 hp and smaller, fixed pitch sheaves for drives 5 hp and larger. Design all drives for 150% of motor rating.

Use OSHA approved belt guards that totally enclose the entire drive. Construct guards of expanded metal to allow for ventilation; provide tachometer openings at shaft locations.

Statically and dynamically balance all fans so they operate without objectionable noise or vibration.

IN-LINE CENTRIFUGAL FANS
Manufacturers: Acme, PennBarry, Cook, Greenheck, New York Blower, Peerless, Penn, S&P, Twin City, or approved equal.

Construct housing of welded steel with reinforcing to prevent distortion. Furnish with streamlined inlet cones and multiple straightening vanes following the fan wheel to minimize noise and reduce turbulence. Provide each housing with a bolted and gasketed access door for inspection of drive and fan wheel. Use non-overloading airfoil blade fans welded to the wheel cones. Isolate belt drives from airstream with a belt tube. Externally mount motors on an adjustable base. Bearings to be grease lubricated, self-aligning ball bearing type with grease seal and external grease fitting. Unless a special coating is scheduled, paint fans with a prime coat after metal cleaning and surface preparation. Apply a second coat of paint to all exterior surfaces.

Design all vertically mounted fans to withstand the vertical thrust loads.

SIDEWALL PROPELLER FANS
Manufacturers: Greenheck, Penn, ACME, Cook, S&P or approved equal.

Constructed of steel with angle iron reinforcing and motor support frame, die formed propeller blades with a welded reinforcing gusset on the backside for added rigidity, direct drive as scheduled, 24 volt electrically operated control damper with blade edge and jamb seals, damper operator, birdscreen, and screened

inlet/fan guard. Unless a special coating is scheduled, paint fans with a prime coat after metal cleaning and surface preparation; apply a second coat of paint to all exterior surfaces.

Provide factory fabricated wall sleeves.

CEILING EXHAUST FANS
Carnes, Greenheck, Penn, Jenn-Air, Cook, ACME, S&P or approved equal.

Centrifugal blower wheel, steel housing with acoustical lining, integral exhaust grille, adjustable mounting brackets to allow for any ceiling thickness, permanently lubricated motor, integral junction box with permanently lubricated and thermally protected motor factory wired, 24 volt electrically operated control damper with blade edge and jamb seals, and damper operator.

Provide wall, eave, or roof discharge assembly, as indicated on the drawings.

DIRECTIONAL DESTRATIFICATION FANS
Airius, Zoo Fans, Greenheck, or approved equal.

U.L. listed, all metal construction, baked enamel finish with factory standard color selected by Architect or as scheduled. Motors to be totally enclosed, impedance protected, single speed, of split capacitor design with permanently lubricated ball bearings.

Provide solid state variable speed controls as scheduled.

P A R T 3 - E X E C U T I O N

INSTALLATION
Install as shown on the drawings, as detailed, and according to manufacturer's installation instructions. On units provided with a drain connection, reduce drain connection down to ½" fitting and leave open.

Install thrust restraints in accordance with the requirements of Section 23 05 48.

Contractor shall balance blade assembly of destratification fans after installation to assure stable operation.

CONSTRUCTION VERIFICATION ITEMS
Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 01 91 01 in accordance with the procedures defined for construction verification checklists.

FUNCTIONAL PERFORMANCE TESTING
Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 in accordance with the procedures defined for functional performance testing in Section 01 91 01.

END OF SECTION

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SECTION 23 51 00
BREECHINGS, CHIMNEYS, AND STACKS
BASED ON DFD MASTER SPECIFICATION DATED 5/1/17

P A R T 1 - G E N E R A L

SCOPE

This section includes specifications for all breechings, chimneys, stacks, emergency generator exhaust pipe, and automatic vent dampers. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Quality Assurance
- Shop Drawings
- Design Criteria
- Welder Qualifications

PART 2 - PRODUCTS
- Double Wall Positive Pressure Vents and Breeching

PART 3 - EXECUTION
- Installation
- Cleaning and Protection
- Construction Verification Items

RELATED WORK

Section 01 91 01 – Commissioning Process
Section 23 07 00 - HVAC Insulation
Section 23 08 00 – Commissioning of HVAC

REFERENCE

Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

UL 959
ANSI/ASTM C64
ANSI/ASTM C105

ANSI/ASTM A525	Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dipped Process
ASTM A527	Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dipped Process, Lock-Forming Quality
ASTM A53	Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A234	Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures

QUALITY ASSURANCE

Refer to division 1, General Conditions, Equals and Substitutions

SHOP DRAWINGS

Refer to division 1, General Conditions, Submittals.

Include materials of construction, dimensions, weight, support and layout of breechings. Where factory built units are used, submit layout drawings indicating plan view and elevations. Identify all methods of support and building structural members utilized for such support.

Submit manufacturer's installation instructions including required clearance to combustible materials.

DESIGN CRITERIA

Follow the requirements of NFPA 211 and State codes.

Factory built vents and chimneys used for venting natural draft appliances shall comply with NFPA 211 and be UL listed and labelled.

WELDER QUALIFICATIONS

Before any metallic welding is performed, the Contractor shall submit his Standard Welding Procedure Specifications, Procedure Qualification Records and Qualification Test Records for each Welder along with associated continuity records to demonstrate compliance with ASME Section IX, paragraph QW-322.

The Contractor shall maintain a complete set of welder qualification documents at the jobsite, including Test Records and Continuity Records for each welder.

The A/E or DFD reserves the right to test the work of any welder employed on the project, at the Contractor's expense. Testing will include a visual examination of the pipe and weld and may include radiography of any suspect welds. If the work of the welder is found to be unsatisfactory, the welder shall be prevented from doing further welding on the project. Any welds deemed unacceptable will be repaired at the contractor's expense.

P A R T 2 - P R O D U C T S

DOUBLE WALL POSITIVE PRESSURE VENTS AND BREECHING

Manufacturers: Selkirk Metalbestos, Metal-Fab, Van Packer, Stacks Inc., General Products Co., or approved equal.

Stack, breeching, and accessory fittings to be double wall type with minimum 1" air space between walls, and U.L. listed for continuous operation at 1400°F under positive pressure.

Inner pipe to be type 304 stainless steel of 0.035" minimum thickness for sizes through 36" ID and minimum thickness of 0.048" for sizes over 36" ID.

Construct outer jacket of aluminized steel where located inside building, and Type 304 stainless steel where located outside building. Minimum thickness of outer jacket to be 24 gage for sizes 10 inches to 24 inches and 20 gage for sizes 28 inches to 48 inches.

Join sections with high temperature acid-resistance joint cement and steel drawbands. Stacks to be self supporting and mounted on a concrete foundation. Allow for expansion of stacks from -20°F. to 1100°F.

Provide all necessary accessories including flashing, counter-flashing, cable guys where required, cleanout, drain, exit cone, roof thimble and necessary supports. Coat all external welded joints and seams with galvanized paint. Provide expansion guides for stacks over 40 feet in height.

P A R T 3 - E X E C U T I O N

INSTALLATION

DOUBLE WALL POSITIVE PRESSURE VENT

Install stack, breeching, and accessories in accordance with the manufacturer's recommendations, maintaining minimum clearances from combustibles specified in UL listing.

Support breechings from building structure with suitable ties, braces, hangers and anchors to hold shape and prevent buckling. Minimum support for vertical sections shall be at all floor penetrations. Support from floor structure, roof structure, or adjacent structural surfaces. Verify load bearing capacity of support points with Architect/Engineer.

Install breechings with a minimum of joints. Align connections accurately and maintain smooth internal surfaces.

Install concrete inserts for support of breechings, chimneys, and stacks in coordination with formwork.

Maintain UL listed minimum clearances from combustibles.

Install stacks plumb. Pitch breeching upward from fuel-fired equipment to chimney or stack.

Provide drain points as shown and per the manufactures recommendation to allow proper draining of condensate. Provide Flue Gas Condensate pH Neutralization at each drain piping termination point.

Clean breechings, chimneys, and stacks during installation, removing dust and debris.

At appliances, provide slip joints to allow removal of appliances without removal or dismantling of breechings, chimneys, or stacks.

Seal all joints of positive pressure stacks and breeching in accordance with manufacturer's recommendations, using only sealants recommended by stack manufacturer.

CLEANING AND PROTECTION

Clean breeching internally during installation to remove dust and debris. Clean external surfaces to remove welding slag and mill film.

At ends of breeching and chimneys which are not completed or connected to equipment, provide temporary closure which will prevent entrance of dust and debris until final connections are made.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

END OF SECTION

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SECTION 23 54 00
GAS FIRED FURNACES
BASED ON DFD MASTER SPECIFICATION DATED 10/1/2012

PART 1 - GENERAL

SCOPE
This section includes specifications for gas fired furnaces. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Quality Assurance
- Energy Efficiency
- Submittals
- Operation and Maintenance Data
- Warranty

PART 2 - PRODUCTS
- Furnaces

PART 3 - EXECUTION
- Installation
- Furnaces
- Construction Verification Items
- Functional Performance Testing
- Agency Training

RELATED WORK
Section 01 91 01 – Commissioning Process
Section 23 08 00 – Commissioning of HVAC
Section 23 11 00 - Facility Fuel Piping
Section 23 05 23 - General-Duty Valves for HVAC Piping
Section 23 05 13 - Common Motor Requirements for HVAC Equipment
Section 23 51 00 - Breechings, Chimneys, and Stacks

REFERENCE
Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

AGA	American Gas Association
ANSI Z21.64	Direct Vent Central Furnaces
GAMA	Gas Appliance Manufacturers Association
NEC	National Electrical Code

QUALITY ASSURANCE
Refer to division 1, General Conditions, Equals and Substitutions.

ENERGY EFFICIENCY
Provide gas furnaces that bear the ENERGY STAR label and meet the ENERGY STAR specifications for energy efficiency.

SUBMITTALS
Refer to division 1, General Conditions, Submittals.

Include specific manufacturer and model numbers, equipment identification corresponding to project drawings and schedules, dimensions, capacities, materials of construction, ratings, weights, power requirements and wiring diagrams, filter information and information for all accessories.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

WARRANTY
Furnace primary and secondary heat exchangers warranted for 20 years under normal use and maintenance. Remainder of furnace components warranted for 1 year from date of start up.

PART 2 - PRODUCTS

FURNACES
Manufacturers: Bryant, Carrier, Lennox, Trane or York.

Direct vent, sealed combustion, condensing type AGA certified for use with natural gas or propane as scheduled on the drawings. Minimum annual fuel utilization efficiency (A.F.U.E.) of 91. All ratings are to be certified by GAMA. All wiring shall comply with the National Electrical Code.

22 gauge steel casing with baked enamel finish or prepainted galvanized steel. Insulate casing back and side panels with foil faced fiberglass insulation.

Construct primary heat exchanger of aluminized steel. Construct secondary heat exchanger of stainless steel with aluminum fins or of polypropylene laminated steel. Aluminized steel multi-port in-shot burner with hot surface or electronic spark ignition, approved for vertical or sidewall venting.

AGA listed gas controls including manual main shut-off valve, double automatic gas valves for redundancy and gas pressure regulator.

Centrifugal type blower fan statically and dynamically balanced with multiple speed, direct drive or belt drive fan motor. Provide low energy induced draft blower for heat exchanger prepurge and combustion gas venting.

Provide unit with 2” thick 30% efficient disposable type panel air filter and filter holding rack with a maximum filter face velocity of 250 fpm.

Provide solid state integral control unit with all necessary controls and relays including but not limited to:
-Pressure switch for airflow of flue products through furnace and out vent system
-Rollout switch with manual reset to prevent overtemperature in burner area
-Electronic flame sensor
-Blower access safety interlock
-Timed blower start after main burners ignite
-Factory installed 24 v transformer for controls and thermostat
-LED’s to indicate status and to aid in troubleshooting

For units scheduled with cooling, provide unit with matching cased "A" configuration cooling coil for upflow units, "V" configuration cooling coil for downflow units, and vertical flat face configuration cooling coil for horizontal units.

Minimum 1/2" OD seamless copper tubing mechanically bonded to heavy ripple edged aluminum fins with thermal expansion valve, holding charge and copper tube stubs for field piping.

Non-corrosive stainless steel or polymer drain pan with 3/4" NPT drain connection.

20 gauge steel Coil casing with baked enamel finish and fiberglass insulation.

This Contractor shall provide all temperature control and interlocking necessary to perform the specified control sequence. All wiring is to be in conduit in accordance with Division 26 00 00 - Electrical. All relays, transformers and controls are to be in enclosures.

Provide a 7 day programmable thermostat with 2 occupied periods per day, automatic changeover, separate heating and cooling set points for both occupied and unoccupied modes. Provide auxiliary controls on sub-base to open minimum outside air damper during occupied mode. Equal to Honeywell model T7300 with Q7300 sub-base.

During occupied mode run the supply fan continuously, open the outside air damper and cycle the cooling or heating as required to maintain occupied space temperature cooling or heating set point. During unoccupied mode close the outside air damper and cycle the supply fan and cooling or heating as required to maintain unoccupied cooling or heating space temperature set point.

PART 3 - EXECUTION

INSTALLATION

Install units as shown on plans, as detailed and according to the manufacturer's installation instructions.

Pipe vents from gas regulator to outside (where regulators are provided).

Install remote panels and thermostats where indicated on the drawings. Provide all wiring between remote panels/thermostats and the gas fired item.

FURNACES

Install on concrete housekeeping pad, steel stand or suspend unit from structure as indicated on the drawings. Pipe condensate to floor drain.

Provide schedule 40 PVC, ASTM D1785 combustion air and vent piping and fittings with solvent welded joints as indicated on the drawings. Terminate as recommended by the furnace manufacturer.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

FUNCTIONAL PERFORMANCE TESTING

Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 in accordance with the procedures defined for functional performance testing in Section 01 91 01.

AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01.

Contractor to provide factory authorized representative and/or field personnel knowledgeable with the operations, maintenance and troubleshooting of the system and/or components defined within this section for a minimum period of 4 hours.

END OF SECTION

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SECTION 23 55 00
FUEL-FIRED HEATERS
BASED ON DFD MASTER SPECIFICATION DATED 10/1/2012

PART 1 - GENERAL

SCOPE

This section includes specifications for fuel-fired heaters. Included are the following topics:

RELATED WORK

Section 01 91 01– Commissioning Process
Section 23 08 00 – Commissioning of HVAC
Section 23 11 00 - Facility Fuel Piping
Section 23 05 23 - General-Duty Valves for HVAC Piping
Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment
Section 23 05 13 - Common Motor Requirements for HVAC Equipment
Section 23 51 00 - Breechings, Chimneys, and Stacks.

REFERENCE

Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

AGA	American Gas Association
ANSI Z83.4	Direct Gas Fired Makeup Air Heaters
ANSI Z83.6	Gas Fired Infrared Heaters
GAMA	Gas Appliance Manufacturers Association
NEC	National Electrical Code

QUALITY ASSURANCE

Refer to division 1, General Conditions, Equals and Substitutions.

SUBMITTALS

Refer to division 1, General Conditions, Submittals.

Include specific manufacturer and model numbers, equipment identification corresponding to project drawings and schedules, dimensions, capacities, materials of construction, ratings, weights, power requirements and wiring diagrams, filter information and information for all accessories.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

WARRANTY

Gas fired unit heaters heat exchangers warranted for five years. Remainder of unit heater components warrated for 1 year from startup.

PART 2 - PRODUCTS

GAS FIRED UNIT HEATERS
Manufacturers: Modine, Reznor, Sterling or Trane

Horizontal discharge, direct vent sealed combustion type. AGA certified for use with propane gas. Minimum combustion efficiency (Ec) of 80%. All wiring shall comply with the National Electrical Code.

Construct casing of cold rolled steel with baked enamel finish. Direct drive propeller type fan statically and dynamically balanced and including fan safety guard and adjustable vertical and horizontal louvers for control of air diffusion on discharge of unit. Aluminized steel burners, electronic spark ignition with electronic flame supervision and timed lockout control. Heavy gauge aluminized steel heat exchanger and factory installed induced draft blower for heat exchanger prepurge and combustion gas venting. Provide a hinged access panel on the bottom of the unit to access the burner or provide side access (pull out drawer) to burner assembly. Single point power connection. Unit must be approved for vertical or side wall venting

Provide spark ignited intermittent pilot system with electronic flame supervision

AGA gas controls, including manual main shut-off valve, 24 volt redundant combination gas control valve with 100 percent safety shut-off valve and main gas pressure regulator.

Provide fan controls and limit safety controls including but not limited to:
-Pressure switch to verify combustion/exhaust gas airflow
-high limit controls
-Fan time delay to delay the fan start until the heat exchanger reaches a predetermined temperature and to allow the fan to operate, after burner shut down, to remove heat exchanger residual heat.

This Contractor shall provide all temperature control and interlocking necessary to perform the specified control sequence. All relays, transformers and controls are to be in enclosures. Provide factory installed 24 volt control transformer along with 24 v wall mounted thermostat. All wiring shall be in conduit in accordance with Division 26 00 00 - Electrical and comply with the NEC.

Provide an electric space thermostat to maintain space temperature.

The thermostat calls for heat. The power exhauster relay is energized, starting the power exhauster motor. Once the motor has reached full speed, the differential pressure switch closes. The pilot valve opens and the ignitor sparks for 70 seconds in an attempt to light the pilot. Once the pilot is lit, the flame sensor proves the pilot and stops the ignitor from sparking. On single stage units, the main gas valve is opened and the main burner is lit to 100% full fire. On two stage units, the gas valve may open at either 50% or 100%, depending on what the two stage thermostat is calling for. The air mover starts after 30 to 90 seconds to allow the heat exchanger to warm up. The unit continues to operate until the thermostat is satisfied, at which time both the main and pilot valves close 100%. The air mover stops after 30 to 90 seconds to remove residual heat from the heat exchanger.

Provide an air inlet/vent termination assembly and threaded hanger connections.

PART 3 - EXECUTION

INSTALLATION

Install units as shown on plans, as detailed and according to the manufacturer's installation instructions.

Pipe vents from gas regulator to outside (where regulators are provided).

Install remote panels and thermostats where indicated on the drawings. Provide all wiring between remote panels/thermostats and the gas fired item.

GAS FIRED UNIT HEATERS
Install units and connect gas, combustion air and vent piping as instructed by the manufacture and in compliance with applicable code requirements. Suspend from building structure to maintain headroom

beneath units as indicated in section 23 05 29. Connect combustion air and venting to outside of building as indicated on the drawings and terminate per the manufacturer's instructions.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

FUNCTIONAL PERFORMANCE TESTING

Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 in accordance with the procedures defined for functional performance testing in Section 01 91 01.

AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01.

Contractor to provide factory authorized representative and/or field personnel knowledgeable with the operations, maintenance and troubleshooting of the system and/or components defined within this section for a minimum period of 2 hours.

END OF SECTION

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SECTION 23 62 13
PACKAGED AIR-COOLED REFRIGERANT COMPRESSOR AND CONDENSING UNITS
BASED ON DFD MASTER SPECIFICATION DATED 10/1/2012

P A R T 1 - G E N E R A L

SCOPE

This section includes specifications for air cooled condensing units for use with split system type air conditioning. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Quality Assurance
- Submittals
- Operation and Maintenance Data
- Delivery, Storage and Handling
- Warranty

PART 2 – PRODUCTS
- Units up to 5 Tons
- Refrigerant Piping Specialties

PART 3 - EXECUTION
- Installation
- Startup
- Construction Verification Items
- Functional Performance Testing
- Agency Training

RELATED WORK

Section 01 91 01 – Commissioning Process
Section 23 05 00 - Common Work Results for HVAC
Section 23 08 00 – Commissioning of HVAC

REFERENCE

Applicable provisions of Division 1 shall govern work under this section.

REFERENCE STANDARDS

ARI 210/240	Unitary Air Conditioning and Heat Pump Equipment
ARI 365	Commercial and Industrial Unitary Air Conditioning Condensing Units
ASHRAE 15	Safety Standard for Refrigeration Systems
ASHRAE 90.1	(2004 edition)Energy Standard for Buildings Except Low Rise Residential Buildings
NEC	National Electrical Code
ASTM B117	Standard Practice for Operating Salt Spray (fog) Apparatus
UL	Underwriters Laboratory

QUALITY ASSURANCE

Refer to division 1, General Conditions, Equals and Substitutions.

Unit Energy Efficiency Ratio (EER), Coefficient of Performance (COP) and Integrated Part Load Value (IPLV) shall meet the minimum applicable requirements of ASHRAE 90.1(2004 edition). Units that are labeled ENERGY STAR® will be acceptable.

Rate unit performance in accordance with the latest edition of ARI Standard 365 or ARI Standard 210/240, whichever is applicable for the equipment.

Construct units in accordance with ASHRAE 15, UL standards and the NEC. Units shall carry the UL label.

Factory run test units to see that each control device operates properly. Pressure test, evacuate, charge with holding charge of refrigerant and full oil charge prior to shipping from the factory.

SUBMITTALS
Refer to division 1, General Conditions, Submittals

Submit air cooled condensing unit shop drawings including the following information: specific manufacturer and model numbers, dimensional and weight data, required clearances, materials of construction, capacities and ratings, stages of unloading capacity achievable without hot gas bypass (and with hot gas bypass if applicable), refrigerant type and charge, component information, size and location of piping connections, electrical connections, wiring diagrams and information for all specialties and accessories.

Submit manufacturer's installation and start-up instructions, maintenance data, troubleshooting guide, parts lists, controls and accessories.

At substantial completion, submit warranty certificate and copy of start-up report.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

DELIVERY, STORAGE AND HANDLING
Comply with manufacturer's instructions for storing, rigging, unloading, and transporting units. Protect units from physical damage. Leave factory-shipping covers in place until installation.

Ship units to jobsite fully assembled

WARRANTY
Provide a one year parts and labor warranty on the entire unit beginning upon substantial completion of project.

Provide a five year parts warranty on the compressor(s) beginning upon substantial completion of project.

PART 2 – PRODUCTS

UNITS UP TO 5 TONS
Manufacturers: Carrier, Trane, York, McQuay or approved equal.

Provide factory assembled, outdoor mounted, air-cooled condensing unit suitable for on grade or rooftop installation. Include compressor, air cooled condenser, refrigerant, lubrication system, interconnecting wiring, safety and operating controls, motor starting components and additional features as specified herein or required for safe, automatic operation. Capacity and steps of unloading as indicated in the equipment schedule. Refrigerant is to be R-454B.

CABINET
Construct cabinet of heavy gauge, galvanized steel coated with weather resistant paint. Provide removable access panels to facilitate full access to the compressor, fan and control components.

COMPRESSOR
Provide hermetic reciprocating or scroll type compressor with built in motor winding temperature and current protection, liquid and suction service valves, gage ports, sight glass and liquid line filter dryer. Provide crankcase heater with reciprocating type compressors. Mount compressors on vibration isolators.

CONDENSER
Provide condenser coils with aluminum alloy plate fins mechanically fastened to seamless copper tubing with integral subcooler. Construct coils with design working pressure suitable for the refrigerant.

Provide direct-drive statically and dynamically balanced propeller type fans with vertical or horizontal discharge as indicated on the drawings and guards constructed of heavy gage PVC coated wire or galvanized steel.

POWER WIRING
Provide factory installed 24-volt control circuit with fusing; control power transformer and all associated internal wiring. Provide a single point power connection to the unit(s). Provide factory installed magnetic contactors for compressor and condenser motors.
Electrical characteristics shall be as indicated in the equipment schedule.

CONTROLS
Provide high/low refrigerant pressure cutouts with manual reset and anti-short cycle compressor timer.

Unit must be capable of operating down to ambient temperature of 40 deg F. Provide low ambient lockout to prevent compressor from operating below 40 degrees.

REFRIGERANT PIPING SIZING
The unit manufacturer shall verify the *final refrigeration pipe sizing* process to insure conformance to specific unit requirements such as max lengths, refrigerant velocities, unloading considerations and proper oil return. This contractor shall provide refrigeration piping drawings from the field which details the way the piping will actually be installed.

REFRIGERANT PIPING ACCESSORIES
Provide all refrigerant piping specialties with a maximum working pressure of full vacuum to 450 psig and a maximum working temperature of 225 deg F.

Flexible pipe connectors: Double braided bronze hose flexible pipe connectors with solder end connections.

Filter Dryers: For circuits 15 tons and over provide angle pattern filter dryers with replaceable core. For circuits below 15 tons provide straight pattern filter dryers without replaceable core.

Sight glasses: Two piece brass construction with solder end connections. Include color indicator for sensing moisture.

Solenoid Valves: Two way normally closed with two piece brass body, full port, stainless steel plug, stainless steel spring, teflon diaphragm and solder end connections. Provide replaceable coil assembly.

Hot Gas Bypass Valves: Provide with integral solenoid valve, external equalizer connection and adjustable pilot assembly.

Thermostatic Expansion Valves: Brass body, bronze disc, neoprene seat, bronze bonnet, stainless steel spring and solder end connections.

Charging Valves: Provide ¼" SAE brass male flare access ports with finger tight, quick seal caps. Provide 2-inch long copper extension sections.

Check valves: Spring loaded type with bronze body, bronze disc, neoprene seat, bronze bonnet, stainless steel spring and solder end connections.

PART 3 - EXECUTION

INSTALLATION

Install units, piping and accessories in accordance with the manufacturer's written instructions and recommendations. Mount unit(s) on a precast concrete pad on grade.

Maintain adequate service access and airflow clearances for all components as recommended by the manufacturer and as indicated on the drawings.

Charge unit(s) with full oil charge and refrigerant charge based on the entire refrigeration system pipe size and length.

Provide all control wiring in conduit in compliance with Section 23 0914 OR Section 23 09 15 and Division 26 00 00 - Electrical.

Coordinate power wiring requirements with the electrical trade.

STARTUP

Adjust units for maximum operating efficiency, adjust all controls to required final settings and demonstrate that all components are functioning properly. Submit four copies of a written startup report following the initial start up. Include in the report: work done to the system, all readings taken, a statement certifying that the refrigeration system(s) are leak free and a statement certifying that the unit(s) have been placed in proper running condition as recommended by the manufacturer and as intended in the drawings and specifications.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

FUNCTIONAL PERFORMANCE TESTING

Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 in accordance with the procedures defined for functional performance testing in Section 01 91 01.

AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01.

Contractor to provide factory authorized representative and/or field personnel knowledgeable with the operations, maintenance and troubleshooting of the system and/or components defined within this section for a minimum period of 2 hours.

END OF SECTION

SECTION 23 82 00
HEATING AND COOLING TERMINAL UNITS
BASED ON DFD MASTER SPECIFICATION DATED 12/11/23

P A R T 1 - G E N E R A L

SCOPE

This section includes specification for heating and cooling terminal equipment using water and/or steam as the source. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Quality Assurance
- Shop Drawings
- Operation and Maintenance Data
- Design Criteria

PART 2 - PRODUCTS
- Electric Heaters

PART 3 - EXECUTION
- Installation
- Electric Heaters
- Construction Verification Items
- Functional Performance Testing
- Agency Training

RELATED WORK

Section 01 91 01 – Commissioning Process
Section 23 08 00 – Commissioning of HVAC
Section 23 05 23 - General-Duty Valves for HVAC Piping
Section 23 05 13 - Common Motor Requirements for HVAC Equipment
Section 23 36 00 - Air Duct Accessories

REFERENCE

Applicable provisions of Division 1 govern work under this Section.

REFERENCE STANDARDS

ARI 210 Standard for Unitary Air-Conditioning Equipment
ARI 410 Standard for Forced-Circulation Air-Cooling and Air-Heating Coils
CS 140

QUALITY ASSURANCE

Refer to division 1, General Conditions, Equals and Substitutions

SHOP DRAWINGS

Refer to division 1, General Conditions, Submittals.

Include dimensions, capacities, materials of construction, ratings, weights, wiring diagrams, and appropriate identification for all equipment in this section. Include color selection chart where applicable.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

DESIGN CRITERIA

Forced Circulation Coils: Ratings certified in accordance with ARI 410.

Electrical Equipment and heaters shall be UL listed for the service specified.

Electrical components and work must be in accordances with National Electrical Code.

PART 2 - PRODUCTS

ELECTRIC HEATERS
Manufacturers: Berko, Chromalox, Markel, Trane, or approved equal.

Use corrosion resistant heating elements, designed and spaced for even distribution of air across the heating element, and installed to prevent noise of expansion and contraction.

Provide units with necessary overheat protection, reset devices, air flow interlock switch, contactors, transformers, local non-fused disconnect switch that is prewired, and other controls as may be required by codes.

Fan powered units must be provided with thermostat and controls to maintain fan operation until residual heat in the heating elements has been dissipated. The fans and motors shall be balanced and mounted for vibration free operation.

Construct cabinets of 20 gauge steel, furnished exposed cabinets with a baked enamel finish in one of the manufacturer's standard colors, selected by Architect.

PART 3 - EXECUTION

INSTALLATION

Install units in accordance with manufacturer's installation instructions.

Install branch water or steam/condensate piping to each unit with a minimum of three elbows to allow for expansion and contraction of the piping system.

Coordinate location of units with other trades to assure correct recess size for recessed units.

After installation, provide protective covers to prevent accumulation of dirt on units during balance of construction.

ELECTRIC HEATERS
Install units where indicated on the drawings and details.

Electric heaters located in toilet and shower rooms must be installed at least 6” above the finished floor.

Units will be wired by the Electrical Contractor.

CONSTRUCTION VERIFICATION
Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

FUNCTIONAL PERFORMANCE TESTING
Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 in accordance with the procedures defined for functional performance testing in Section 01 91 01.

AGENCY TRAINING
All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01.

END OF SECTION

SECTION 26 05 00
COMMON WORK RESULTS FOR ELECTRICAL
BASED ON DFD MASTER ELECTRICAL SPEC DATED 12/26/23

PART 1 - GENERAL

The electrical work included in all other divisions is the responsibility of the contractor performing the division 26 work unless noted otherwise.

PROJECT OVERVIEW
This project consists of the renovation of multiple DNR buildings, approximately as follows;

This project consists of the renovation of (2) new toilet and shower buildings at Devils Lake State Park in Baraboo, Wisconsin. The primary electrical work associated with the project is the reinstallation of a new electrical service & panel to the new buildings, and the lighting/power throughout the buildings. The existing site underground feeds will be removed/modified accordingly.

This project consists of modifications in concessions building at Devils Lake State Park in Baraboo, Wisconsin. The primary electrical work with the project is providing power for new condensing unit, electric heaters, and replacing existing electrical panel.

This project consists of modifications in shop building at Mirror Lake State Park in Baraboo, Wisconsin. The primary electrical work with the project is upgrading lighting, removing and replacing ceiling fans, and misc. electrical receptacle updates.

This project consists of modifications in residence & garage at Mirror Lake State Park in Baraboo, Wisconsin. The primary electrical work with the project is removing existing lights and receptacles and adding new lights and receptacles to renovated patio area.

This project consists of modifications in park headquarters building at Mirror Lake State Park in Baraboo, Wisconsin. The primary electrical work with the project is replacing fluorescent lights with LED lights, replace lighting in entryway and multiple bathrooms, replace exhaust fans, replace electric heat, and add new ceiling fan.

This project consists of modifications in shop building at Rocky Arbor State Park in Wisconsin Dells, Wisconsin. The primary electrical work with the project is adding a 50A receptacle and 50A breaker in existing panel for welder, remove and replace interior lights, new receptacle to exterior of building, and new site lighting pole and fixture.

SCOPE
The work under this section includes basic electrical requirements, which are applicable to all Division 26 sections. This section includes information common to two or more technical specification sections or items that are of a general nature, not conveniently fitting into other technical sections. Included are the following topics:

PART 1 - GENERAL
- Project Overview
- Scope
- Related Work
- Reference Standards
- Regulatory Requirements
- Quality Assurance
- Continuity of Existing Services and Systems
- Protection of Finished Surfaces
- Approved Electrical Testing Laboratories
- Sleeves and Openings
- Sealing
- Work by State and/or User Agency
- Intent
- Omissions
- Submittals
- Project/Site Conditions

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

Section 01 91 01 or 01 91 02 – Commissioning Process

REFERENCE STANDARDS

Abbreviations of standards organizations referenced in this and other sections are as follows:

ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
EPA	Environmental Protection Agency
ETL	Electrical Testing Laboratories, Inc.
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society
ISA	Instrument Society of America
NBS	National Bureau of Standards
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
NRTL	Nationally Recognized Testing Laboratory
UL	Underwriters Laboratories Inc.
DSPS	Wisconsin Department of Safety and Professional Services

REGULATORY REQUIREMENTS

All work and materials are to conform in every detail to applicable rules and requirements of the Wisconsin State Electrical Code (SPS 316), the National Electrical Code (NFPA 70), other applicable National Fire Protection Association codes, the National Electrical Safety Code, and present manufacturing standards (including NEMA).

All Division 26 work shall be done under the direction of a currently licensed State of Wisconsin Master Electrician.

All Division 26 work shall comply with SPS 101.862 and SPS 305.40 for electrical wiring integral with pre-manufactured structures.

QUALITY ASSURANCE

Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or engineering parameters from those indicated on the contract documents, the contractor is responsible for all costs involved in integrating the equipment or accessories into the system and the assigned space, and for obtaining the performance from the system into which these items are placed.

Manufacturer references used herein are intended to establish a level of quality and performance requirements unless more explicit restrictions are stated to apply.

All materials, shall be listed by and shall bear the label of an approved Nationally Recognized Testing Laboratory (NRTL) as identified by the United States Occupational Safety and Health Administration (OSHA), per the OSHA Nationally Recognized Testing Laboratory Program. If none of the approved electrical testing laboratories has published standards for a particular item, then other national independent testing standards, if available, applicable, and approved by DFD, shall apply and such items shall bear those labels. Where one of the approved electrical testing laboratories has an applicable system listing and label, the entire system, shall be so labeled.

CONTINUITY OF EXISTING SERVICES AND SYSTEMS

No outages shall be permitted on existing systems except at the time and during the interval specified by the user agency and by the DFD Project Representative. The institution may require written approval. Any outage must be scheduled when the interruption causes the least interference with normal institutional schedules and business routines. No extra costs will be paid to the Contractor for such outages which must occur outside of regular weekly working hours.

This Contractor shall restore any circuit interrupted as a result of this work to proper operation as soon as possible. Note that institutional operations are on a seven-day week schedule.

PROTECTION OF FINISHED SURFACES

Furnish one can of touch-up paint for each different color factory finish furnished by the Contractor. Deliver touch-up paint with other "loose and detachable parts" as covered in the General Requirements.

APPROVED ELECTRICAL TESTING LABORATORIES

The following laboratories are approved for providing electrical product safety testing, listing and labeling services as required in these specifications:

A Nationally Recognized Testing Laboratory (NRTL) as identified by the United States Occupational Safety and Health Administration (OSHA), per the OSHA Nationally Recognized Testing Laboratory Program.

SLEEVES AND OPENINGS

Refer to Division 1, General Requirements, Sleeves and Openings.

SEALING

Sealing of sleeves/openings between conduits, cable trays, wireways, troughs, cablebus, busduct, etc. and the sleeve, structural or partition opening shall be the responsibility of the contractor whose work penetrates the opening.

WORK BY STATE AND/OR USER AGENCY

PCB equipment (other than light fixture ballasts) removal and disposal, if required, will be by the DFD under separate contract.

Electrical testing not described in these contract documents will be by the DFD under separate contract.

INTENT

The Contractor shall furnish and install all the necessary materials, apparatus, and devices to complete the electrical equipment and systems installation herein specified, except such parts as are specifically exempted herein.

If an item is either called for in the specifications or shown on the plans, it shall be considered sufficient for the inclusion of said item in this contract. If a conflict exists within the Specifications or exists within the Drawings, the Contractor shall furnish the item, system, or workmanship, which is the highest quality, largest, or most closely fits the DFD's intent (as determined by the DFD Project Manager). Refer to the General Conditions of the Contract for further clarification.

It must be understood that the details and drawings are diagrammatic. The Contractor shall verify all dimensions at the site and be responsible for their accuracy.

All sizes as given are minimum except as noted.

Materials and labor shall be new (unless noted or stated otherwise), first class, and workmanlike, and shall be subject at all times to the DFD's and/or A/E's inspections, tests and approval from the commencement until the acceptance of the completed work.

Whenever a particular manufacturer's product is named, it is intended to establish a level of quality and performance requirements unless more explicit restrictions are stated to apply.

OMISSIONS

No later than ten (10) days before bid opening, the Contractor shall call the attention of the DFD to any materials or apparatus the Contractor believes to be inadequate and to any necessary items of work omitted.

SUBMITTALS

Submit for all equipment and systems as indicated in the respective specification sections, marking each submittal with that specification section number. Mark general catalog sheets and drawings to indicate specific items being submitted and proper identification of equipment by name and/or number, as indicated in the contract documents. Failure to do this may result in the submittal(s) being returned to the Contractor for correction and resubmission. Failing to follow these instructions does not relieve the Contractor from the requirement of meeting the project schedule.

On request from the DFD, the successful bidder shall furnish additional drawings, illustrations, catalog data, performance characteristics, etc.

Submittals shall be grouped to include complete submittals of related systems, products, and accessories in a single submittal. Mark dimensions and values in units to match those specified. Include wiring diagrams of electrically powered equipment.

The submittals must be approved before fabrication is authorized.

Submit sufficient quantities of submittals to allow the following distribution:

Operating and Maintenance Manuals	2 copies
User agency	1 copy
A/E	1 copy
DFD Field Office	1 copy

PROJECT/SITE CONDITIONS

Install Work in locations shown on drawings, unless prevented by project conditions.

Prepare drawings showing proposed rearrangement of work to meet project conditions, including changes to work specified in other sections. Obtain permission of DFD before proceeding.

Tools, materials and equipment shall be confined to areas designated by the DFD and user agency.

WORK SEQUENCE AND SCHEDULING

Install work in phases to accommodate user agency's occupancy requirements. During the construction period coordinate electrical schedule and operations with DFD's Construction Representative.

WORK BY OTHER TRADES

Every attempt has been made to indicate in this trade's specifications and drawings all work required of this Contractor. However, there may be additional specific paragraphs in other trade specifications and addenda, and additional notes on drawings for other trades which pertain to this trade's work, and thus those additional requirements are hereby made a part of these specifications and drawings.

Electrical details on drawings for equipment to be provided by others are based on preliminary design data only. This Contractor shall lay out the electrical work and shall be responsible for its correctness to match equipment actually provided by others.

OFFSITE STORAGE

Prior approval by DFD and the A/E will be needed. The contractor shall submit Storage Agreement Form DOA-4528 to DFD for consideration of off-site materials storage. In general, building wire, conduit, fittings and similar rough-in material will not be accepted for off-site storage. No material will be accepted for off-site storage unless shop drawings for the material have been approved.

SALVAGE MATERIALS
No materials removed from this project shall be reused unless specifically noted otherwise. All materials removed shall become the property of and shall be disposed of by the Contractor.

CERTIFICATES AND INSPECTIONS
Obtain and pay for all required installation inspections, except those provided by the DFD, in accordance with the Wisconsin Administrative Code. Deliver originals of these certificates to the DFD's Project Representative.

The Electrical Contractor is responsible for coordination of DFD electrical inspections. Prior to the start of significant on-site electrical work, the contractor shall schedule a pre-installation meeting with the DFD Electrical Inspector to discuss the inspection requirements and review the contract requirements (also see Article 15 of the General Conditions). The Electrical Contractor shall be present when the DFD Electrical Inspector conducts the electrical inspections.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

1. Manufacturer’s wiring diagrams for electrically powered equipment.
2. All required passwords required to gain local access to equipment and controllers.

RECORD DRAWINGS
The Contractor shall maintain at least one copy each of the specifications and drawings on the job site at all times.

The DFD will provide the Contractor with a suitable set of contract drawings on which daily records of changes and deviations from contract shall be recorded. Dimensions and elevations on the record drawings shall locate all buried or concealed piping, conduit, or similar items.

The daily record of changes shall be the responsibility of Contractor's field superintendent. No arbitrary mark-ups will be permitted.

At completion of the project, the Contractor shall submit the marked-up record drawings to the Architect/Engineer prior to final payment.

PART 2 - PRODUCTS

ACCESS PANELS AND DOORS
Lay-in Ceilings:
Removable lay-in ceiling tiles in 2 x 2 foot or 2 x 4 foot configuration provided under other divisions are sufficient; no additional access provisions are required unless specifically indicated.

Metal Pan Ceilings:
Removable sections of ceiling tile held in position by pressure fit will be provided under other divisions.

Plaster Walls and Ceilings, Concealed Cavities:
16 gauge frame with not less than a 20 gauge hinged door panel, prime coated steel for general applications, stainless steel for use in toilets, showers and similar wet areas, concealed hinges, screwdriver operated cam latch for general application, key lock for use in public areas, UL listed for use in fire rated partitions if required by the application. Use the largest size access opening possible, consistent with the space and the equipment needing service; minimum size 20” x 30”.

IDENTIFICATION
See Electrical section 26 05 53 – Identification for Electrical Systems.

PART 3 - EXECUTION

EXCAVATION AND BACKFILL
Perform all excavation and backfill work to accomplish indicated electrical systems installation unless noted otherwise.

CONCRETE WORK
The Division 3 Contractor will perform all cast-in-place concrete unless noted otherwise elsewhere. Provide all layout drawings, anchor bolts, metal shapes, and/or templates required to be cast into concrete or used to form concrete for the support of electrical equipment.

CUTTING AND PATCHING
Refer to Division 1, General Requirements, Cutting and Patching.

BUILDING ACCESS
Arrange for the necessary openings in the building to allow for admittance of all apparatus. When the building access was not previously arranged and must be provided by this contractor, restore any opening to its original condition after the apparatus has been brought into the building.

EQUIPMENT ACCESS
Install all piping, conduit, ductwork, and accessories to permit access to equipment for maintenance. Coordinate the exact location of wall and ceiling access panels and doors with the General Contractor, making sure that access is available for all equipment and specialties. Where access is required in plaster or drywall walls or ceilings, furnish the access doors to the General Contractor and reimburse the General Contractor for installation of those access doors.

COORDINATION
The Contractor shall cooperate with other trades and DFD in locating work in a proper manner. Should it be necessary to raise or lower or move longitudinally any part of the electrical work to better fit the general installation, such work shall be done at no extra cost to the DFD, provided such decision is reached prior to actual installation. The Contractor shall check location of electrical outlets with respect to other installations before installing.

The Contractor shall verify that all devices are compatible for the surfaces on which they will be used. This includes, but is not limited to light fixtures, panelboards, devices, etc. and recessed or semi-recessed heating units installed in/on architectural surfaces.

Coordinate all work with other contractors prior to installation. Any installed work that is not coordinated and that interferes with other contractor's work shall be removed or relocated at the installing contractor's expense.

Coordinate all equipment requirements with the various contractors and the Owner. Review the complete set of drawings and specifications to determine the extent of wiring, starters, devices, etc., required. Coordinate the available fault current- equipment including control panels and internal components shall be rated to interrupt the available fault current.

SLEEVES AND OPENINGS
Conduit penetrations in new poured concrete horizontal construction requiring F and T rating: Form opening using hole form or core drill opening. Alternatively provide cast in place fire stopping devices/sleeves.

Conduit penetrations in new poured concrete horizontal construction requiring F rating but no T rating: Same as conduit penetrations in new poured concrete construction requiring F and T ratings except that schedule 40 steel pipe sleeves may also be used.

Conduit penetrations in new poured concrete horizontal construction that do not require F or T ratings: Provide schedule 40 steel pipe sleeve, form opening using hole form or core drill opening.

Where penetrating conduit weight is supported by floor, provide manufactured product or structural bearing collar designed to carry load.

HOUSEKEEPING AND CLEAN UP
The Contractor shall clean up and remove from the premises, on a daily basis, all debris and rubbish resulting from its work and shall repair all damage to new and existing equipment resulting from its work. When job is complete, this Contractor shall remove all tools, excess material and equipment, etc., from the site.

AGENCY TRAINING
All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01 or 01 91 02.

Contractor to provide factory authorized representative and/or field personnel knowledgeable with the operations, maintenance and troubleshooting of the system and/or components defined within this section for a minimum period of 4 hours.

END OF SECTION

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SECTION 26 05 02
ELECTRICAL DEMOLITION FOR REMODELING
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/21

PART 1 - GENERAL

SCOPE

This project consists of the demolition associated with multiple DNR building projects as follows;

This project consists of the construction of (2) new toilet and shower buildings at Devils Lake State Park in Baraboo, Wisconsin. The primary electrical work associated with the project is the reinstallation of a new electrical service & panel to the new buildings, and the lighting/power throughout the buildings. The existing site underground feeds will be removed/modified accordingly.

This project consists of the modifications in concessions building at Devils Lake State Park in Baraboo, Wisconsin. The primary electrical work with the project is providing power for new condensing unit, electric heaters, and replacing existing electrical panel.

This project consists of modifications in shop building at Mirror Lake State Park in Baraboo, Wisconsin. The primary electrical work with the project is upgrading lighting, removing and replacing ceiling fans, and misc. electrical receptacle updates.

This project consists of modifications in residence & garage at Mirror Lake State Park in Baraboo, Wisconsin. The primary electrical work with the project is removing existing lights and receptacles and adding new lights and receptacles to renovated patio area.

This project consists of modifications in park headquarters building at Mirror Lake State Park in Baraboo, Wisconsin. The primary electrical work with the project is replacing fluorescent lights with LED lights, replace lighting in entryway and multiple bathrooms, replace exhaust fans, replace electric heat, and add new ceiling fan.

This project consists of modifications in shop building at Rocky Arbor State Park in Wisconsin Dells, Wisconsin. The primary electrical work with the project is adding a 50A receptacle and 50A breaker in existing panel for welder, remove and replace interior lights, new receptacle to exterior of building, and new site lighting pole and fixture.

Included are the following topics:

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

PART 2 - PRODUCTS

MATERIALS AND EQUIPMENT

Materials and equipment for patching and extending work as specified in the individual Sections.

PART 3 - EXECUTION

EXAMINATION

Verify field measurements and circuiting arrangements as shown on Drawings.

Verify that abandoned wiring and equipment serve only abandoned facilities.

Verify whether or not PCB ballasts exist in light fixtures which will be disposed of. If PCB light fixture ballasts exist, then follow requirements in **PCB BALLAST HANDLING** and **LAMP AND PCB BALLAST DISPOSAL** below.

Demolition Drawings are based on casual field observation and/or existing record documents. Report discrepancies to the User Agency, Architect/Engineer and DFD Field Representative before disturbing existing installation.

Beginning of demolition means installer accepts existing conditions.

PREPARATION

Disconnect electrical systems in walls, floors, and ceilings scheduled for removal.

Coordinate utility service outages with the User Agency, DFD Field Representative, and Architect/Engineer. Also, if applicable, coordinate utility service outages with the local Utility Company.

Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations and follow the safe working practice requirements of NFPA 70E.

Existing Electrical Service: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Obtain permission from the User Agency and DFD Field Representative at least 48hours before partially or completely disabling system. Minimize outage duration. If required, make temporary connections to maintain service in areas adjacent to work area.

DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

Remove, relocate, and extend existing installations as necessary, to accommodate new construction and to meet all requirements of these specifications. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.

Remove abandoned wiring to source of supply.

Remove exposed abandoned conduit and abandoned conduit above accessible ceiling finishes, unless noted otherwise on drawings. Cut conduit flush with walls and floors, and patch surfaces. If certain conduits and boxes are abandoned but not scheduled for removal, they shall be shown on the "As Built Drawings".

Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit and wiring servicing them is abandoned and removed. Provide blank cover for abandoned outlets which are not removed.

Disconnect and remove abandoned panelboards and distribution equipment.

Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.

Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.

Provide revised typed circuit directory in panelboards that have circuits removed.

Repair adjacent construction and finishes damaged during demolition and extension work.

Maintain access to existing electrical installations which remain active. Modify installation or provide access panel as appropriate.

Provide supplemental support for conduits that are routed through demolition area, and are to remain. Supplemental support shall be added so that the conduit meets the support requirements of electrical specification section 26 05 33.

PCB BALLAST HANDLING

Generally, all high power factor fluorescent light ballasts manufactured before 1978 and some HID ballasts contain polychlorinated biphenyl (PCB) compounds in their capacitors. The Contractor shall inspect all ballasts in all light fixtures and take the actions described below.

The disposal of all ballasts labeled as "NON-PCBs" or "NO PCBs" shall become the responsibility of the Contractor. If the PCB content is not stated on the ballast label, the ballast shall be handled as a PCB ballast.

All PCB ballasts shall be removed from the light fixtures and shall have the wires clipped off. However, before removal, all PCB ballasts shall be carefully inspected for leaks. If a ballast appears to be leaking (evidenced by potting compound leaking out or by an oily film on the ballast surface) the ballast must be handled per EPA and DNR PCB regulations. Basically, this means the ballast is to be carefully removed from the fixture and placed in an approved drum. See paragraph below for the drum specifications. The person removing the ballast from the fixture shall wear protective gloves, eye protection, and protective clothing as necessary.

If the fixture has also been contaminated, it must be cleaned to less than 10 micrograms/100 square centimeters contamination before disposal. This cleaning must be done by an approved PCB contractor and is not considered a part of this contract. Contact DFD for contractor approval before commencing with the cleanup.

The PCB ballasts shall then be placed in US DOT approved drums (barrels). The contractor may furnish their own drums or obtain them from **Veolia ES Technical Solutions (800-255-5092 or 262 255-6655**). The quantity and size of the drums will be determined by the contractor at the time of construction, 30 and 55 gallon drums are typically available.

These PCB drums shall be placed in storage with the cover that came with the barrels, in a location within a building, as designated by the Building Manager or DFD Field Representative. The drums are not to be placed outside where they are exposed to weather.

THESE PCB BALLASTS ARE NOT TO BE REMOVED FROM THE WORK SITE BY THE CONTRACTOR. To do so would be a violation of DNR and DOT hazardous waste regulations and may result in a fine to the Contractor.

The Contractor shall label and mark the PCB storage drums with EPA approved PCB labels and the storage area with signs, marks and lines to meet the regulations of Wisconsin Code NR 157 – Management of PCBs and Products Containing PCBs.

The Contractor shall also provide approved PCB absorbent materials to be stored immediately adjacent to the drum storage area. Do not place loose absorbent material in the drums.

The Contractor shall provide to the DFD Field Representative, in written form, a total count of these ballasts (or their total weight by drum) and where they are stored.

See Lamp and PCB Ballast Disposal instructions below.

LAMP AND PCB BALLAST DISPOSAL

All lamps (fluorescent, incandescent, and HID) contain mercury and/or lead (in the base) as well as other heavy metals and compounds which are regulated by the EPA and DNR during the disposal process. As a result, regulations have been issued covering the handling and disposal of all lamps. Lamps which have been removed from service for disposal shall be handled as follows by the Contractor:

The Contractor shall very carefully remove all lamps (fluorescent, incandescent, and HID) from light fixtures before removal of the fixture from its mounted position. This is to reduce the likelihood that the lamp(s) will be broken. The Contractor will be charged the cost difference between disposal of broken and unbroken lamps, for all lamps broken in excess of 1% of the total lamps removed in the project.

The contractor shall contact **Veolia ES Technical Solutions (800-255-5092 or 262-255-6655)** to coordinate the storage and pickup of disposed lamps and PCB ballasts. The contractor may furnish their own containers or obtain them from **Veolia ES Technical Solutions**. Removed lamps and PCB ballasts shall be placed in containers by the contractor, marked with the number and type of lamp and PCB ballast, and placed in storage at a location on the user agency's property. The

contractor shall label the area as “Hazardous Material Storage”. The contractor shall make arrangements for pickup of the lamps and PCB ballasts with **Veolia ES Technical Solutions**, shall provide a count of all stored lamps and PCB ballasts, and shall fill out any required forms.

When making disposal arrangements with **Veolia ES Technical Solutions**, the contractor shall make sure to notify them of the DFD project number, DFD project name and DFD Project Manager, for invoicing purposes. Invoicing from **Veolia ES Technical Solutions**, shall be sent to the DFD Project Manager for direct charge payment from the project (lamp and PCB ballast disposal costs to be paid by DFD), and shall indicate the proper DFD project number, name, and PM.

The contractor shall coordinate the lamp and PCB ballast disposal with the DFD Field Representative.

END OF SECTION

SECTION 26 05 04
CLEANING, INSPECTION, AND TESTING OF ELECTRICAL EQUIPMENT
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23

PART 1 - GENERAL

SCOPE

The work under this section includes the required cleaning, inspection, adjustment, maintenance and testing of electrical equipment, as specified herein. This applies only to new electrical and existing electrical equipment being furnished, modified, worked on or serviced by this contractor for this project. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work

PART 2 - PRODUCTS
- Not Used

PART 3 - EXECUTION
- General Inspection and Cleaning of All Electrical Equipment
- Grounding Systems
- Ground Fault Systems
- Panelboards
- Cables
- Light Fixtures
- Occupancy Sensors

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

Section 01 91 01 or 01 91 02 – Commissioning Process

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

GENERAL INSPECTION AND CLEANING OF ALL ELECTRICAL EQUIPMENT

Inspect for physical damage and abnormal mechanical and electrical conditions.

Any item found to be out of tolerance, or in any other way defective as a result of the required inspection or testing, shall be reported to the DFD. Procedure for repair and/or replacement will be outlined. After appropriate corrective action is completed the item shall be re-tested.

Compare equipment nameplate information with the latest single line diagram and report any discrepancies.

Verify proper auxiliary device operation and indicators.

Check tightness of accessible bolted electrical joints. Use torque wrench/ screw driver method.

Make a close examination of equipment and remove any shipping brackets, insulation, packing, etc. that may not have been removed during original installation.

Make a close examination of equipment and remove any dirt or other forms of debris that may have collected in existing equipment or in new equipment during installation.

Clean All Equipment:
- Vacuum inside of panelboards, switchboards, switchgear, transformer core and coils, bus ducts, MCC's, and the exterior of all Communications and Electronic Safety and Security hardware and equipment.
- Loosen attached particles and vacuum them away.
- Wipe all insulators with a clean, dry, lint free rag.
- Clean insulator grooves.

Re-vacuum inside surfaces as directed by the DFD Construction Representative or Inspector

Inspect equipment anchorage.

Inspect equipment and bus alignment.

Check all heater elements for operation and control.

Lubricate nonelectrical equipment per manufacturer's recommendations.

GROUNDING SYSTEMS
Inspect the ground system for adequate termination at all devices.

GROUND FAULT SYSTEMS
Inspect for physical damage.

Inspect the neutral main bonding connection to assure:
- Zero sequence system is grounded upstream of sensor.
- Ground strap systems are grounded downstream from the sensing device.
- Ground connection is made ahead of the neutral disconnect link.

PANELBOARDS
Torque all the connections per the manufacturers spec. Verify phase wires, color coding, separate neutral and mechanical bonding. Verify circuit breaker operation. Verify the directory.

Vacuum clean the panelboard enclosure.

CABLES
600 Volt cable:
- Visually inspect cables, lugs, connectors and all other components for physical damage and proper connections.
- Check all cable connectors for tightness (with a torque wrench) and clearances. Torque test conductor terminations to manufacturer's recommendations.

LIGHT FIXTURES
Check the bonding and proper lamping. Verify that recessed fixtures are installed with hold down clips. Confirm operation of the fixture with the proper switch or sensor.

OCCUPANCY SENSORS
Confirm operation of the sensor per the manufacturer’s specification.

END OF SECTION

SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
BASED ON DFD MASTER ELECTRICAL SPEC DATED 12/22/21

PART 1 - GENERAL

SCOPE
The work under this section includes furnishing and installing required wiring and cabling systems including pulling, terminating and splicing. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- References
- Submittals
- Project Conditions

PART 2 - PRODUCTS
- General
- Building Wire
- Aboveground Wire for Exterior Work
- Underground Wire for Exterior Work
- Wiring Connectors

PART 3 - EXECUTION
- General Wiring Methods
- Wiring Installation in Raceways
- Wiring Connections and Terminations
- Field Quality Control
- Wire Color
- Branch Circuits
- Construction Verification Items

RELATED WORK
Applicable provisions of Division 1 govern work under this Section.

Section 26 05 33 – Raceway and Boxes for Electrical Systems.
Section 26 05 53 – Identification for Electrical Systems.
Section 26 08 00 - Commissioning of Electrical.
Section 01 91 01 or 01 91 02 – Commissioning Process

REFERENCES
SPS 316- Electrical

SUBMITTALS
Submit product data: Provide for each cable assembly type.

Submit factory test reports: Indicate procedures and values obtained.

Submit shop drawings for modular wiring system including layout of distribution devices, branch circuit conduit and cables, circuiting arrangement, and outlet devices.

Submit manufacturer's installation instructions. Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements.

PROJECT CONDITIONS
Verify that field measurements are as shown on Drawings.

Conductor sizes are based on copper.

Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as required for project conditions.

Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.

PART 2 - PRODUCTS

GENERAL
All wire shall be new, delivered to the site in unbroken cartons and shall be less than one year old out of manufacturer's stock.

All conductors shall be copper. All ground conductors shall be copper.

Insulation shall have a 600 volt rating.

All conductors shall be stranded.

> Stranded conductors may only be terminated with UL OR ETL Listed type terminations or methods: e.g. stranded conductors may not be wrapped around a terminal screw but must be terminated with a crimp type device or must be terminated in an approved back wired method.

BUILDING WIRE
Description: Single conductor insulated wire 90 degree C.

Insulation: Type THHN/THWN-2, XHHW-2 insulation.

ABOVEGROUND WIRE FOR EXTERIOR WORK
Description: Single conductor insulated wire, 90 degree C.

Insulation: Type XHHW-2 insulation.

UNDERGROUND WIRE FOR EXTERIOR WORK
Description: Stranded single or multiple conductor insulated wire, 90 degree C.

Insulation: Type USE-2, XHHW-2, RHW-2 insulation.

This wiring shall be used in all underground feeder and branch circuit applications, except THHN/THWN-2 is permitted when run in a concrete-encased ductbank.

WIRING CONNECTORS
Split Bolt Connectors: Not acceptable.

Solderless Pressure Connectors: High copper alloy terminal. May be used only for cable termination to equipment terminals. Not approved for splicing.

Twist Type Wire Connectors: Solderless twist type spring connector (wire-nut) with insulating cover for copper wire splices and taps. Use for conductor sizes 10 AWG and smaller. The manufacturer’s wire fill capacity must be followed. Use Silicone filled twist type spring connectors in all wet location areas.

Mechanical Spring Actuation Connectors: Toolless type spring actuation connector (push-in) with spacers for copper wire splices and taps. Use for conductor sizes 12 AWG and smaller. The manufacturer’s wire fill capacity must be followed. Use in interior, dry locations only.

All wire connectors used in underground or exterior pull boxes or hand holes shall be gel filled twist connectors or a connector designed for damp and wet locations. Gel filled twist type connectors can be used for copper conductor sizes 6 AWG and smaller for site lighting applications. The manufacturer’s wire fill capacity must be followed.

Mechanical Connectors: Bolted type tin-plated; high conductivity copper alloy; spacer between conductors; beveled cable entrances.

Compression (crimp) Connectors: Long barrel; seamless, tin-plated electrolytic copper tubing; internally beveled barrel ends. Connector shall be clearly marked with the wire size and type and proper number and location of crimps. Connector must be installed with a crimper tool listed for use with the manufacturer and type of compression connector.

Insulation Piercing Connectors: Molded insulated body, copper teeth, wrench tightened, UL 486B Listed. May be used only for connection of a tap conductor in run and tap type applications when main conductor is 8 AWG and larger.

PART 3 - EXECUTION

GENERAL WIRING METHODS

All wire and cable shall be installed in conduit.

Do not use wire smaller than 12 AWG for power and lighting circuits.

All phase, neutral and ground conductors shall be sized to prevent excessive voltage drop at rated circuit ampacity. As a minimum use 10 AWG conductors for 20 ampere, 120 volt branch circuit home runs longer than 100 feet (30 m), and for 20 ampere, 277 volt branch circuit home runs longer than 200 feet (61 m).

Ground conductor size shall be increased per NEC 250.122(B) when phase and phase/neutral conductors are increased in size.

Make conductor lengths for parallel conductors equal.

Splice only in junction or outlet boxes.

No conductor less than 10 AWG shall be installed in exterior underground conduit.

Identify ALL low voltage wire, 600V and lower, per section 26 05 53.

Neatly train and lace wiring inside boxes, equipment, and panelboards.

WIRING INSTALLATION IN RACEWAYS

Pull all conductors into a raceway at the same time. Use Listed water or silicone based wire pulling lubricant for pulling 4 AWG and larger wires and for other conditions when necessary. Wax based lubricants are not allowed. Pulling lubricant is not required for low friction type products where the cable manufacturer recommends that cables be pulled without lube.

Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed.

Completely and thoroughly swab raceway system before installing conductors.

Place all conductors of a given circuit (this includes phase wires, neutral (if any), and ground conductor) in the same raceway. If parallel phase and/or neutral wires are used, then place an equal number of phase and neutral conductors in same raceway or cable.

Manufacturers maximum pulling tensions shall be not be exceeded and individual pulls shall not exceed 270 degrees.

In high ambient spaces, mechanical rooms, utility rooms and exterior exposed conduit, 90 degree C, XHHW-2 conductors shall be utilized.

WIRING CONNECTIONS AND TERMINATIONS

Splice only in accessible junction boxes.

Wire splices and taps shall be made firm, and adequate to carry the full current rating of the respective wire without soldering and without perceptible temperature rise.

All splices shall be so made that they have an electrical resistance not in excess of two feet (600 mm) of the conductor.

Use solderless twist type spring connectors (wire nuts) with insulating covers for copper wire splices and taps, 10 AWG and smaller or toolless type actuation connectors (push-in) with spacers for copper wire splices and taps, 12 AWG and smaller. Use mechanical or compression connectors for wire splices and taps, 8 AWG and larger. Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of the wiring.

Thoroughly clean wires before installing lugs and connectors.

At all splices and terminations, leave tails long enough to cut splice out and completely re-splice.

FIELD QUALITY CONTROL

Field inspection and testing will be performed under provisions of Section 26 05 04.

WIRE COLOR

General:

Solid colored insulation is required for all THHN/THWN-2 wire. For other wire types use colored wire or identify wire with colored tape at all terminals, splices and boxes. Wire shall be colored as indicated below.

In existing facilities, use existing color scheme.

Traveler conductors run between 3 and 4 way switches shall be colored pink or purple.

Neutral Conductors: White for 120/208V systems. Where there are two or more neutrals in one conduit, each shall be individually identified with a different stripe.

Branch Circuit Conductors: Three or four wire home runs shall have each phase uniquely color coded.

Feeder Circuit Conductors: Each phase shall be uniquely color coded.

Ground Conductors: Green colored insulation for THHN/THWN-2 wire. For other wire types use green colored wire or identify wire with green tape at both ends and at all access points, such as panelboards, motor starters, disconnects and junction boxes. When isolated grounds are required, contractor shall provide green with yellow tracer.

BRANCH CIRCUITS

The use of single-phase, multi-wire branch circuits with a common neutral is not permitted. All single-phase branch circuits shall be furnished and installed with an individual accompanying neutral, sized the same as the phase conductors.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01 or 01 91 02.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23

PART 1 - GENERAL

SCOPE

The work under this section includes grounding electrodes and conductors, equipment grounding conductors, and bonding for Electrical systems. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- References
- Submittals
- Regulatory Requirements

PART 2 - PRODUCTS
- Mechanical Connectors
- Compression Connectors
- Conductors

PART 3 - EXECUTION
- Examination
- General
- Less Than 600 Volt System Grounding
- Field Quality Control
- Identification and Labeling
- Construction Verification Items
- Warranty

All hardware, cables and related termination and support hardware shall be furnished, installed, wired, tested, labeled, and documented by the Contractor, as detailed in this and related sections.

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

Section 26 08 00 - Commissioning of Electrical.
Section 01 91 01 or 01 91 02 – Commissioning Process

REFERENCES

ANSI/IEEE 81 (Latest edition) - Guide to Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Grounding System
ANSI/IEEE 142 (Latest edition) - Recommended Practice for Grounding of Industrial and Commercial Power Systems
UL 467 Electrical Grounding and Bonding Equipment
IEEE 837 - IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding
TIA-607-C - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

SUBMITTALS

Product Data: Provide data for grounding electrodes and connections.

Provide samples of ground labels.

Test Reports: Indicate overall resistance to ground and resistance of each electrode.

Manufacturer's Instructions: Include instructions for preparation, installation and examination of exothermic connectors.

REGULATORY REQUIREMENTS

Conform to requirements of NFPA 70.

Furnish products listed and classified by Underwriters Laboratories, Inc. or testing firm acceptable to authority having jurisdiction as suitable for purpose specified and shown.

PART 2 - PRODUCTS

CONCRETE-ENCASED GROUNDING ELECTRODE FOR POLE BASES
Fabricate per NFPA 70, Article 250.52 (A)(3)(2) using 20 feet (6m) of bare copper wire not smaller than bare seven-strand #4 AWG. If concrete foundation is less than 20 feet (6m) long, coil excess conductor within the base of the foundation. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts.

MECHANICAL CONNECTORS
The mechanical connector bodies shall be manufactured from high strength, high conductivity cast copper alloy material. Bolts, nuts, washers and lock washers shall be made of Silicon Bronze and supplied as a part of the connector body and shall be two hole, two bolt type.

Split bolt connector types are NOT allowed. Exception: the use of split bolts is acceptable for grounding of wire-basket type cable tray, and for cable shields/straps of medium voltage cable.

The connectors shall meet or exceed UL 467 and be clearly marked with the catalog number, conductor size and manufacturer.

COMPRESSION CONNECTORS
The compression connectors shall be manufactured from pure wrought copper. The conductivity of this material shall be no less than 99% by IACS standards.

Each connector shall be factory filled with an oxide-inhibiting compound.

The connectors shall meet or exceed the performance requirements of IEEE 837, latest revision.

The connectors shall be clearly marked with the manufacturer, catalog number, conductor size and the required compression tool settings.

The installation of the connectors shall be made with a compression tool and die system, as recommended by the manufacturer of the connectors, and shall be irreversible.

Pre-crimping of the ground rod is required for all irreversible compression connections to a ground rod.

Terminal lug for communication system grounding shall be compression type and conform to the following:
- Material: Tin Plated Copper (aluminum not permitted).
- Wire Size: to match conductor
- Number of Stud Holes: 2
- Stud Hole Size: 3/8”
- Bolt Hole Spacing: per TIA-607-C
- Tongue Angle: Straight

CONDUCTORS
Material: Stranded copper (aluminum not permitted).

Grounding Electrode Conductor: Bare seven-strand conductors. Size as shown on drawings, specifications or as required by NFPA 70, whichever is larger.

Feeder and Branch Circuit Equipment Ground: Size as shown on drawings, specifications or as required by NFPA 70, whichever is larger. Differentiate between the normal ground and the isolated ground when both are used at the same facility.

Branch Circuit Equipment Ground shall be proportionately increased in size when routed with phase conductors increased in size.

BUS/BUSBAR
Material: Copper (aluminum not permitted).

Size:
- All Power systems: 1/4" X 2", length as needed (24” minimum).

Busbars:

Be pre-drilled to accommodate two-hole lugs.
3/8” stud hole size; hole spacing per TIA-607-C.
Incorporate insulators and stand-off brackets that electrically isolate busbar from mounting surface.

Provide main ground busbar located adjacent to main electrical service equipment to terminate all ground conductors.

PART 3 - EXECUTION

EXAMINATION
Verify that final backfill and compaction has been completed before driving rod electrodes.

GENERAL
Install Products in accordance with manufacturer's instructions.

Mechanical connections shall be accessible for inspection and checking. No insulation shall be installed over mechanical ground connections.

Ground connection surfaces shall be cleaned and all connections shall be made so that it is impossible to move them. Attach grounds permanently before permanent building service is energized.

All grounding conductor connections to Busbars shall be via two hole lugs.

Terminate each grounding conductor on its own terminal lug. Sharing a single lug by multiple conductors is not allowed.

All grounding electrode conductors and individual grounding conductors shall be installed in SCH 80 PVC conduit, in exposed locations.

Each grounding electrode conductor shall be labeled at each terminated end as to system served and location of second termination.

LESS THAN 600 VOLT ELECTRICAL SYSTEM GROUNDING
Supplementary Grounding Electrode: Use driven ground rod on exterior of building

Provide code sized copper grounding electrode conductor from electrical room ground bus to secondary switchboard ground bus, each separately derived system neutral, secondary service system neutral to street side of water meter, building steel, ground rod, and any concrete encased electrodes. Provide bonding jumper around water meter. Provide physical protection as required.

Equipment Grounding Conductor: Provide separate, insulated equipment grounding conductor within each raceway. Terminate each end on suitable lug, bus, enclosure or bushing. Provide a ground wire from each device to the respective enclosure.

Bond together system neutrals, service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, receptacle ground connectors, and plumbing systems.

Bond together each metallic raceway, pipe, duct and other metal object entering space under access floors. Bond to under floor ground grid. Use #4 AWG bare copper conductor.

FIELD QUALITY CONTROL
Inspect grounding and bonding system conductors and connections for tightness and proper installation.

Testing of grounding system resistance is to be witnessed by the DFD Electrical Inspector or Construction Representative. Provide test report of grounding system resistance in final O&M manuals and noted on record drawings.

Provide resistance test at each electrical and telecommunications Busbar to ground.

IDENTIFICATION AND LABELING
Label Grounds at point of termination.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01 or 01 91 02.

Record locations of all electrical and telecommunications grounding electrodes, busbars and grounding conductors as installed including recorded ground resistance test results.

WARRANTY

See Division 1, General Conditions, and General Requirements.

END OF SECTION

SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23

PART 1 - GENERAL

SCOPE
The work under this section includes conduit and equipment supports, straps, clamps, steel channel, etc., and fastening hardware for supporting electrical work. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Submittals
- Quality Assurance

PART 2 - PRODUCTS
- Support Channel
- Conduit Supports
- Threaded Rod
- Hardware

PART 3 - EXECUTION
- Installation

RELATED WORK
Applicable provisions of Division 1 govern work under this Section.

Section 01 91 01 or 01 91 02 – Commissioning Process
Section 26 05 53 – Identification for Electrical Systems

SUBMITTALS
Product Data: Provide data for support channel.

QUALITY ASSURANCE
Support systems shall be adequate for weight of equipment and conduit, including wiring, which they carry.

PART 2 - PRODUCTS

SUPPORT CHANNEL
Epoxy Painted
Strut shall be made from steel meeting the minimum mechanical properties of ASTM A1011 SS Grade 33, then painted with water born epoxy applied by a cathodic electro-deposition process.

All fittings and hardware shall be zinc plated in accordance with ASTM B633 (SC3 for fittings, SC1 for threaded hardware).

Hot-dip Galvanized Steel
Strut shall be made from steel meeting the minimum mechanical properties of ASTM A1011 SS, Grade 33 and shall be hot-dip galvanized after fabrication in accordance with ASTM A123.

Fittings shall be manufactured from steel meeting the minimum requirements of ASTM A907 SS, Grade 33, and hot-dip galvanized after fabrication in accordance with ASTM A123.

All hardware shall be stainless steel Type 304 or chromium zinc ASTM F1136 Gr. 3.

All hot-dip galvanized after fabrication products must be returned to point of manufacture after coating for inspection and removal of all sharp burrs.

Stainless Steel
All strut, fittings and hardware shall be made of AISI Type 304 or Type 316 stainless steel as indicated.

CONDUIT SUPPORTS
Conduit clamps, straps, supports, etc., shall be steel or malleable iron.

One-hole straps shall be heavy duty type. All straps shall have steel or malleable backing plates when rigid steel conduit is installed on the interior or exterior surface of any exterior building wall.

Bar joist conduit/box hangers: Spring Steel Clips with Snap-Close Clamps (Conduit Supports): Conduit clamps shall pivot a full 360 degrees and shall snap close around the conduit. Push-in type conduit clamps are not allowed. Spring clips shall require a hammer to install onto supporting surface.

Stud wall applications: Spring Steel Clips with Push-in or Snap-Close Conduit Clamps (Conduit Supports): Conduit clamps shall pivot a full 360 degrees. Spring clips shall require a fastener to install onto stud.

Box/conduit hanger with rod/wire clip (a.k.a. antlers): One assembly provides support for electrical box and conduit from drop wire or rod. Conduit clamps shall snap close around the conduit.

Spring Steel Clip products shall be provided with corrosion resistance and be warranted against failure from corrosion for a period of ten (10) years from date of manufacture.

THREADED ROD
Minimum sized threaded rod for supports shall be 3/8" for trapezes and single conduits 1-1/4" and larger, and ¼" for single conduits 1" and smaller.

HARDWARE
Corrosion resistant, or as noted for each product above.

PART 3 - EXECUTION

INSTALLATION
Fasten hanger rods, conduit clamps, and outlet-, junction-, and pull-boxes to building structure using pre-cast insert system, preset inserts, beam clamps, or expansion anchors.

Use toggle bolts or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls; expansion anchors or preset inserts in solid masonry walls; self-drilling anchors or expansion anchors on concrete surfaces; sheet metal screws in sheet metal studs and wood screws in wood construction. If nail-in anchors are used, they must be removable type anchors.

Powder-actuated fasteners are not permitted.

Do not fasten supports to piping, ductwork, mechanical equipment, cable tray or conduit.

Do not fasten to suspended ceiling systems.

Do not drill structural steel members unless approved by DFD.

In wet locations, mechanical rooms, and electrical rooms, install free-standing electrical equipment on 3.5-inch (89 mm) concrete pads.

Install surface-mounted cabinets and panelboards with a minimum of four anchors. At all cabinet and panelboard locations on concrete or concrete block walls, and at ALL locations below grade, provide steel channel supports to stand cabinet one inch (25 mm) off wall (7/8" Uni-strut or 3/4" painted fire-retardant plywood is acceptable). In above-grade equipment rooms that have drywall walls, the cabinets and panelboards may be mounted to the drywall if backing is provided in the stud walls behind the equipment.

Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud walls.

Furnish and install all supports as required to fasten all electrical components required for the project, including free standing supports required for those items remotely mounted from the building structure, catwalks, walkways etc.

Fabricate supports from galvanized structural steel or steel channel, rigidly welded or bolted to present a neat appearance. Use hexagon head bolts with spring lock washers under all nuts.

Support Channel
Use one of the following types of support channel as appropriate for the installed environment:

- Indoor: Epoxy Painted Steel, Hot-dipped Galvanized Steel, or as noted on the drawings.

- Exterior and wet locations: Hot-dipped Galvanized Steel or Stainless Steel, as appropriate for the environment or as noted on the drawings. Type 316 stainless steel shall be used for Food Service type environments. Epoxy painted support channel shall not be used for exterior installations.

- Manholes, steam pits, steam tunnels, or corrosive environments: Stainless Steel Type 316.

- Field cuts: File and de-bur cut ends of support channel and paint to prevent rusting. For epoxy-painted support channel, paint cut ends to match the original color. For hot-dipped galvanized support channel, spray cut ends with cold galvanized paint.

Support Wires

Support wires that are installed in addition to the ceiling grid support wires to provide secure support for raceways, cables assemblies, boxes, cabinets, and fittings shall be secured at both ends (e.g., the ceiling structure at the top and the ceiling grid at the bottom) per NEC 300.11(A).

Compressed-air power-actuated fasteners may ONLY be used for the installation of separate ceiling wires required for support of conduits and aircraft cable hung light fixtures.

Support wires shall be identified per specification section 26 05 53.

Spring Steel Clip Conduit Supports for 30 amp or less branch circuits

Spring steel clips with snap-close clamps may be used to support conduit/ box from bar joist (steel truss) systems.

Stud wall applications: Spring steel clips with push-in or snap-close conduit clamps may be used to support conduit in interior metal stud wall applications. Use screw fasteners to install conduit clamp onto stud.

Conduit/box hanger with rod/wire clip (a.k.a. antlers) and multi conduit/box support systems: Above suspended ceiling only.

END OF SECTION

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SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23

PART 1 - GENERAL

SCOPE

This section describes the products and execution requirements relating to furnishing and installing raceways and boxes and related systems as part of a raceway system for electrical, and other low-voltage systems for the project. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- References
- Submittals

PART 2 - PRODUCTS
- General
- Rigid Metal Conduit (RMC) and Fittings
- Intermediate Metal Conduit (IMC) and Fittings
- Electrical Metallic Tubing (EMT) and Fittings
- Liquidtight Flexible Metal Conduit (LFMC) and Fittings
- Rigid Polyvinyl Chloride Conduit (PVC) and Fittings
- Conduit Supports
- Conduit Water Sealant
- Pull and Junction Boxes
- Outlet Boxes

PART 3 - EXECUTION
- Conduit Sizing, Arrangement, and Support
- Conduit Installation
- Conduit Installation Schedule
- Coordination of Box Locations
- Pull and Junction Box Installation
- Outlet Box Installation
- Construction Verification Items

RELATED WORK

Applicable provisions of Division 1 govern work under this section.

Section 01 91 01 or 01 91 02 – Commissioning Process
Section 26 08 00 - Commissioning of Electrical.
Section 26 05 26 – Grounding and Bonding for Electrical Systems
Section 26 05 29 – Hangers and Supports for Electrical Systems.
Section 26 27 02 – Equipment Wiring Systems.
Section 26 27 26 – Wiring Devices.

REFERENCES

Wisconsin Administrative Code SPS 316 - Electrical
ANSI/SCTE 77-2017 – Specifications for Underground Enclosure Integrity

SUBMITTALS

Boxes - provide product data showing configurations, finishes, dimensions, and manufacturer's instructions.

Conduits in Concrete Slabs Above Grade - provide proposed conduit routing and sizing to Structural Engineer prior to approval of installation to verify structural integrity and fire rating of concrete slab.

PART 2 - PRODUCTS

GENERAL

All steel fittings and conduit bodies shall be galvanized.

All conduit transitional fittings shall be listed for installed application.

Condulet fittings shall be threaded rigid entering condulets.

No cast metal or split-gland type fittings permitted.

All condulet covers must be fastened to the condulet body with screws and be of the same manufacture.

Mogul-type condulets 2 inch (50 mm) and larger, shall be permitted.

C-condulets shall not be used in lieu of pull boxes.

All boxes shall be of sufficient size to provide free space for all conductors enclosed in the box and shall comply with NEC requirements.

RIGID METAL CONDUIT (RMC) AND FITTINGS
Conduit: Heavy wall threaded, galvanized steel.

Fittings and Conduit Bodies: Use all steel threaded fittings and conduit bodies.

Expansion Fittings/Expansion Joints: Expansion Fittings shall be Internal Grounding type and shall not rely on external bonding jumpers to maintain grounding continuity between raceway components.

INTERMEDIATE METAL CONDUIT (IMC) AND FITTINGS
Conduit: Galvanized Steel, threaded.

Fittings and Conduit Bodies: Use all Steel threaded fittings and conduit bodies.

Expansion Fittings/Expansion Joints: Expansion Fittings shall be Internal Grounding type and shall not rely on external bonding jumpers to maintain grounding continuity between raceway components.

ELECTRICAL METALLIC TUBING (EMT) AND FITTINGS
Conduit: Steel, Unthreaded thin wall galvanized tubing.

Fittings: All steel, compression or set screw type. No push-on or indenter types permitted.

Transitional fitting: ½-1": All steel and malleable iron; 1 ¼" and above: All steel, Malleable iron and Die cast where not subjected to physical damage and with project specific DFDM electrical inspector approval.

Conduit Bodies: All steel conduit bodies.

LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC) AND FITTINGS
Conduit: flexible, steel, galvanized, spiral strip with an outer Liquidtight, nonmetallic, sunlight-resistant jacket.

Fittings and Conduit Bodies: ANSI/NEMA FB 1, compression type. There shall be a metallic cover/insert on the end of the conduit inside the connector housing to seal the cut conduit end.

RIGID POLYVINYL CHLORIDE CONDUIT (PVC) AND FITTINGS
Conduit: Rigid non-metallic conduit, Schedule 40 PVC minimum, Listed, sunlight resistant, rated for 90^0 C conductors. Schedule 80 for locations exposed to physical damage or as required.

Fittings and Conduit Bodies: NEMA TC 2, Listed.

CONDUIT SUPPORTS
See specification Section 26 05 29.

CONDUIT WATER SEALANT
Description: Conduit sealant used to prevent water from entering buildings via conduits.

Sealant shall seal conduits against water and gas intrusion, such as Polywater® FST™-250 Foam Duct Sealant, Raychem RDSS Rayflate Duct Sealing System, or approved alternate. Sealant shall be re-enterable, shall be compatible with the conduit and conductor types being used, and shall comply with NEC 225.27, 230.8, and 300.5(G).

Manufacturer names and catalog numbers are used to develop quality and performance requirements only. Products manufactured by others may be acceptable provided they meet or exceed the specifications.

PULL AND JUNCTION BOXES

Interior Sheet Metal Boxes: code gauge galvanized steel, screw covers, flanged and spot-welded joints and corners.

Interior Sheet Metal Boxes larger than 12 inches (300 mm) in any dimension shall have a hinged cover or a chain installed between box and cover. Boxes 9 square-feet or larger shall have hinged covers and a single cover shall not exceed 10 square-feet.

Interior Sheet Metal Boxes connected to an exterior underground raceway, shall have a drain fitting located in the bottom.

Exterior Boxes and Wet Location Installations: Type 4 and Type 6, flat-flanged, surface-mounted junction box, UL listed as rain-tight. Galvanized cast ironbox and cover with ground flange, neoprene gasket, and stainless steel cover screws.

Box extensions and adjacent boxes within 48 inches of each other are not allowed for the purpose of creating more wire capacity.

Junction boxes 6 inch-by-6 inch or larger size shall be without stamped knock-outs.

Wireways shall not be used in lieu of junction boxes.

Handhole and Box Covers: Polymer- Concrete.

Handhole and box bottoms: Open.

Handholes and boxes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.

Handhole and cover Assembly Load Rating: ANSI/SCTE Tier8or better.

Covers: Weatherproof, secured by tamper-resistant locking devices with non-skid finish.

Cover Label: ELECTRIC

Units shall be designed – typically with a flared wall and footed base – to prevent frost heaving.

OUTLET BOXES

Sheet Metal Outlet Boxes: galvanized steel, with stamped knockouts.

Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; include 3/8 inch male fixture studs where required.

Concrete Ceiling Boxes: Concrete type.

Cast Boxes: Cast ferroalloy or aluminum, deep type, gasketed cover, threaded hubs.

PART 3 - EXECUTION

CONDUIT SIZING, ARRANGEMENT, AND SUPPORT

EMT is permitted to be used in sizes 4 inch (100 mm) and smaller for power and low-voltage systems. See CONDUIT INSTALLATION SCHEDULE below for other limitations for EMT and other types of conduit.

Size power conductor raceways for conductor type installed. Conduit size shall be 1/2 inch (16 mm) minimum except **all homerun conduits shall be 3/4 inch (21 mm),** or as specified elsewhere. **Caution: Per the NEC, the allowable conductor ampacity is reduced when more than three current-carrying conductors are installed in a raceway. Contractor must take the NEC ampacity adjustment factors into account when sizing the raceway and wiring system.**

Size communications and other low-voltage systems raceways as follows:

Control, security, signal, and other low-voltage applications (not including AV): 1/2 inch minimum.

Arrange conduit to maintain 6'-8" clear headroom and present a neat appearance.

Route exposed conduit and conduit above accessible ceilings parallel and perpendicular to walls and adjacent piping.

Maintain minimum 6 inch (150 mm) clearance between conduit and piping. Maintain 12 inch (300 mm) clearance between conduit and heat sources such as flues, steam pipes, and heating appliances.

Arrange conduit supports to prevent distortion of alignment by wire pulling operations. Fasten conduit using galvanized pipe straps, conduit racks (lay-in adjustable hangers), clevis hangers, or bolted split stamped galvanized hangers.

Group conduit in parallel runs where practical and use conduit rack (lay-in adjustable hangers) constructed of steel channel with conduit straps or clamps. Provide space for 25 percent additional conduit.

Do not fasten conduit with wire or perforated pipe straps. Before conductors are pulled, remove all wire used for temporary conduit support during construction.

Support and fasten metal conduit at a maximum of 8 feet (2.4 m) on center.

Supports shall be independent of the installations of other trades, e.g. ceiling support wires, HVAC pipes, other conduits, etc., unless so approved or detailed.

Conceal all conduits except where noted on the drawings or approved by the Architect/Engineer. Contractor shall verify with Architect/Engineer all surface conduit installations except in mechanical rooms.

Changes in direction shall be made with symmetrical bends, cast steel boxes, stamped metal boxes or cast steel conduit bodies.

For indoor and exposed exterior conduits, no continuous conduit run shall exceed 100 feet (30 meters) without a junction box.

For exterior below grade conduits, no continuous conduit run shall exceed 250 feet (75 meters) without hand hole, manhole or pull box without project specific DFDM electrical inspector approval.

All conduits installed in exposed areas shall be installed with a box offset before entering box.

CONDUIT INSTALLATION

Cut conduit square; de-burr cut ends.

Conduit shall not be fastened to the corrugated metal roof deck nor drywall or suspended ceiling grids. Bring conduit to the shoulder of fittings and couplings and fasten securely.

Use conduit hubs for fastening conduit to cast boxes. Use sealing locknuts or conduit hubs for fastening conduit to sheet metal boxes in damp or wet locations.

Threads cut in the field, and factory threads of conduit and nipples not coated with corrosion protection, shall be coated with an approved electrically conductive compound per NEC 300.6.

Corrosion inhibitor, when used in the food service environment, shall be approved for Food Service locations.

Terminate all conduit (except for terminations into conduit bodies) using conduit hubs, or connectors with one locknut, or utilize double locknuts (one each side of box wall).

Provide bushings for the ends of all conduit not terminated in box walls. Refer to Section 26 05 26 – Grounding and Bonding for Electrical Systems for grounding bushing requirements.

Provide insulated bushings where raceways contain 4 AWG or larger conductors.

Communication and Low Voltage systems conduits shall terminate in horizontal plane.

Use pendants supported from swivel hangers in exposed ceiling/ structure locations where necessary to mount boxes supporting luminaires and wiring devices. Installation method shall comply with NEC 314.23 (H).

Install no more than the equivalent of the following for building:

Three 90 degree bends between boxes for electrical systems.

Two 90 degree bends between boxes for communications and other low voltage systems. Note: Offsets shall be considered 90 degrees.

No single bend may exceed 90 degrees.

Use hydraulic one-shot conduit bender or factory elbows for bends in conduit larger than 2 inch (50 mm) size unless sweep elbows are required.

Bend conduit according to manufacturer's recommendations. Torches or open flame shall not be used to aid in bending of PVC conduit.

Use suitable conduit caps or other approved seals to protect installed conduit against entrance of dirt and moisture.

Provide 1/8 inch (3 mm) nylon pull string in empty conduit, except sleeves and nipples.

Install listed expansion-deflection fitting or other approved means shall be used where a raceway crosses a structural joint for expansion, contraction or deflection, used in buildings, bridges, parking garages or other structurers.

Install expansion joints where direct-buried conduit is subject to Earth Movement by settlement or frost per NEC 300.5(J), especially where conduit exits the ground exposed and enters a box, cabinet, or enclosure attached to a building or structure.

Install expansion fitting in exterior PVC conduit runs per NEC table 352.44 utilizing a minimum temperature change of 120 degree F.

Avoid moisture traps where possible. Where moisture traps are unavoidable, provide junction boxes with drain fittings at conduit low points.

Where conduit passes between areas of differing temperatures such as into or out of cool rooms, freezers, unheated and heated spaces, buildings, etc., provide condulet or box with duct seal or other means to prevent the passage of moisture and water vapor through the conduit.

Route conduit through roof openings for piping and ductwork where possible.

Use NRTL listed metallic grounding clamps when terminating conduit to cable tray.

Ground and bond conduit under provisions of Section 26 05 26.

Conduit is not permitted in any slab topping of two inches (50 mm) or less.

Conduits in Concrete Slab Above Grade: Provide proposed conduit routing and sizing to Structural Engineer for approval prior to installation to verify structural integrity and fire rating of concrete slab.

Maximum Size Conduit in Concrete Slabs Above Grade: 1 inch (25 mm). Do not route conduits to cross each other in slabs above grade. Minimum conduit spacing shall be 6 inches on center.

PVC conduit in concrete pole bases shall transition to galvanized rigid metal conduit 12 inches before it enters a concrete pole base. Inside the pole base, the elbow shall be galvanized rigid metal conduit. From the elbow, the conduit shall transition back to PVC as it continues up and out the top of the concrete pole base.

PVC conduit shall transition to galvanized rigid metal conduit before it enters a foundation wall or up through a concrete floor.

PVC conduit shall be allowed without need of transition to galvanized rigid metal conduit up through concrete floor and concrete equipment pads for pad mounted transformers and switchgear. Provide a PVC

connector and bushing, or bell-ends, on each conduit entry. Coordinate conduit installation with submittals and shop drawings for transformers and switchgear.

Identify conduit under provisions of Section 26 05 53.

All Aluminum conduits shall not be in direct contact with concrete.

All conduit installed underground (exterior to building) shall be buried a minimum of 24 inches below finished grade, whether or not the conduit is concrete encased. Install warning tape 12" below finish grade over all buried conduits. Underground warning tape shall be detectable, 2" wide minimum, 5 mil thickness, containing a foil core. Tape color shall be red and labeled with the words "CAUTION-BURIED ELECTRIC LINE BELOW" as manufactured by Presco or similar.

Conduits penetrating underground foundation walls: Individual conduits or each conduit as part of a ductbank penetrating underground foundation walls (excluding manholes) shall be sealed against water intrusion into the building.

Clean PVC conduit with solvent, and dry before application of glue. The temperature rating of glue/cement shall match weather conditions. Apply full even coat of cement/glue to entire area that will be inserted into fitting. The entire installation shall meet manufacturer's recommendations.

CONDUIT INSTALLATION SCHEDULE

Conduit other than that specified below for specific applications shall not be used.

- Underground Installations That Penetrate Foundation Walls: Rigid metal conduit within five feet (1.5 m) of the foundation wall. Conduit may transition to Fiberglass Resin Conduit (BG) or PVC conduit five feet (1.5 m) from the foundation walls.

- Underground Installations That Do Not Penetrate Foundation Walls: Rigid metal conduit, or PVC conduit.

- Underground Installations Emerging from Grade: Buried conduit emerging from grade shall be Rigid metal conduit extending from the minimum cover distance of 24 inches below grade to the conduit termination point above grade. Refer to DFD detail.

- Underground Installations Under Concrete Slab: Rigid metal conduit or Schedule 40 PVC conduit.

- Underground Installations Emerging through Concrete Slab: Rigid metal conduit.

- Concealed in Poured Concrete Walls: Rigid Metal Conduit, PVC conduit.

- Concealed in Concrete Block Walls: Electrical metallic tubing, PVC conduit.

- Within Concrete Slab: Rigid Metal conduit or PVC conduit.

- Emerging from Within Concrete Slab: Rigid Metal conduit.

- Exposed Outdoor Locations: Rigid Metal conduit, Intermediate Metal conduit.

- Wet Interior Locations: Exposed: Rigid metal conduit.

- Concealed Dry Interior Locations: Rigid metal conduit, Intermediate metal conduit, Electrical metallic tubing, PVC conduit (Ground conductor).

- Interior Building Grounding Electrode Conductor: Schedule 80 PVC.

- Exposed Dry Interior Locations: Rigid metal conduit, Intermediate metal conduit, Electrical metallic tubing.

- Motor and equipment connections: Liquidtight flexible metal conduit (LFMC) in all locations except in Mechanical equipment plenum spaces where Flexible Metal Conduit (FMC) shall be utilized. Minimum length shall be one foot (300 mm); maximum length shall be three feet (900

mm). Conduit must be installed perpendicular to direction of equipment vibration to allow conduit to freely flex.

- Exposed Dry Interior Locations for HVAC control devices with Conduit Connections: Electrical metallic tubing.

- Exposed Dry Interior Locations for HVAC control devices without Conduit Connections: Where HVAC equipment control panels or devices do not provide for the direct connection of conduits, exposed Class 2 wiring may be extended to complete the final connections in dry locations, provided it does not exceed 18 inches in length.

- Light fixtures: Refer to specification section 26 51 13.

COORDINATION OF BOX LOCATIONS

Provide electrical boxes as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections, and code compliance.

Electrical box locations shown on Contract Drawings are approximate unless dimensioned. Verify location of floor boxes and outlets in offices and work areas prior to rough-in.

No outlet, junction, or pull boxes shall be located where it will be obstructed by other equipment, piping, lockers, benches, counters, etc.

Conduit and boxes shall not be fastened to the metal roof deck. If conduit and boxes are required to be located and installed on roof decks, the conduit and boxes are required to be spaced minimum 1-5/8 inch off the lowest part of the metal roof decking material, per NEC 300.4 (E).

It shall be the Contractor's responsibility to study drawings pertaining to other trades, to discuss location of outlets with workmen installing other piping and equipment and to fit all electrical outlets to job conditions.

In case of any question or argument over the location of an outlet, the Contractor shall refer the matter to the Architect/Engineer and install outlet as instructed by the Architect/Engineer.

The proper location of each outlet is considered a part of this contract and no additional compensation will be paid to the Contractor for moving outlets which were improperly located.

Locate and install boxes to allow access to them. Where installation is inaccessible, coordinate locations and provide 18 inch (450 mm) by 24 inch (600 mm) access doors. Boxes must be installed within 12” from edge of the access door.

Locate and install to maintain headroom and to present a neat appearance.

Install boxes to preserve fire resistance rating of partitions and other elements, using approved materials and methods.

Boxes installed in the building envelop shall be sealed with caulking materials or closed with gasketing systems compatible with the construction materials and locations per IEC 502.4.3.

PULL AND JUNCTION BOX INSTALLATION

Pull boxes and junction boxes shall be minimum 4 inches square (100 mm) by 2 1/8 inches (54 mm) deep for use with 1 inch (25 mm) conduit and smaller. On conduit systems using 1 1/4 inch (31.75 mm) conduit, minimum junction box size shall be 4 11/16 inches square by 2 1/8 inches deep.

Where used with raceway(s) containing conductors of 4 AWG or larger, pull box shall be sized as required unless otherwise noted on the drawings.

Where used with raceway(s) containing conductors on systems over 600V, size pull box per NEC 314 Part IV unless otherwise noted as larger on the drawings.

Locate pull boxes and junction boxes above accessible ceilings, in unfinished areas or furnish and install DFD approved access panels in non-accessible ceilings where boxes are installed. All boxes are to be readily-accessible.

Provide Pull and Junction boxes for communications and other low voltage applications (a) in any section of conduit longer than 100 feet, (b) where there are bends totaling more than 180 degrees between pull points or pull boxes and (c) wherever there is a reverse bend in run. Locate boxes on straight section of raceway (e.g. do not use boxes in place of raceway bends).

Support pull and junction boxes independent of conduit.

IN GRADE HANDHOLES AND BOXES

Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

Unless otherwise indicated and detailed, support units on a level bed of crushed stone or gravel, graded from 1/2 inch (12.5 mm) sieve to No. 4 (4.25 mm) sieve and compacted to same density as adjacent undisturbed earth.

Elevation: In finished areas, set so cover surface will be flush with finished grade.

Unless approved by DFD review staff, handholes and boxes shall **NOT** be installed in paved or concrete drives or walks.

Units shall be selected with depth sufficient to allow for conductor bending/ wire management and allow sufficient conduit elevation above compacted bed to prevent water infiltration in conduit.

Provide four (4) sets of the tool(s) required to access tamper resistant locking covers. In addition, provide the tool(s) model number to allow for ordering of additional sets. Tools and bits, shall be turned over to owners representative, prior to project closeout.

Provide conduit sealant to seal conduits against water and gas intrusion, such as Polywater® FST™-250 Foam Duct Sealant, Raychem RDSS Rayflate Duct Sealing System, or approved alternate. Sealant shall be re-enterable, shall be compatible with the conduit and conductor types being used, and shall comply with NEC 225.27, 230.8, and 300.5(G).

OUTLET BOX INSTALLATION

Do not install boxes back-to-back in walls. Provide minimum 6 inch (150 mm) separation, except provide minimum 24 inch (600 mm) separation in acoustic-rated walls.

Power:

Recessed (1/4 inch maximum) outlet boxes in masonry, concrete, tile construction, or drywall shall be minimum 4 inch square, with device rings. Device covers shall be square-cut except rounded corner plaster rings are allowed in drywall applications. Angle cut plaster rings are not permitted. Coordinate masonry cutting to achieve neat openings for boxes. A single gang box can be used in drywall and masonry, for a single device location, when a single conduit enters box.

Shallow 4 inch square by 1 1/2 inch deep boxes can be used as device boxes for power provided the box and plaster ring is sized for installed device and conductors.

Low Voltage:

Recessed (1/4 inch maximum) outlet boxes in masonry, concrete, tile construction or drywall shall be minimum 4 11/16 inch square by 2 1/8 inch deep with single gang device ring (unless noted otherwise on drawings or in companion specifications). Device covers shall be square-cut except rounded corner plaster rings are allowed in drywall applications. Angle cut plaster rings are not permitted. Coordinate masonry cutting to achieve neat openings for boxes.

Provide knockout closures for unused openings.

Support boxes independently of conduit except for cast boxes that are connected to two rigid metal conduits, both supported within 12 inches (300 mm) of box.

Use multiple-gang boxes where more than one device are mounted together; do not use sectional boxes. Sectional boxes may only be used with the pre-approval of the State of Wisconsin DFD Electrical Inspector

for remodeling applications where it is impractical to install multi-gang boxes. Provide non-metallic barriers to separate wiring of different voltage systems.

Install boxes in walls without damaging wall insulation.

Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.

Ceiling outlets shall be 4 inch square, minimum 2 1/8 inch (54 mm) deep except that concrete boxes and plates will be approved where applicable. Position outlets to locate luminaires as shown on reflected ceiling plans.

In inaccessible ceiling areas, position outlets and junction boxes within 6 inches (150 mm) of recessed luminaire, to be accessible through luminaire ceiling opening.

Provide recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs, accurately positioning to allow for surface finish thickness. Use stamped steel stud bridges for flush outlets in hollow stud wall, and adjustable steel channel fasteners for flush ceiling outlet boxes.

Align wall-mounted outlet boxes for switches, thermostats, and similar devices.

Provide cast ferroalloy or aluminum outlet boxes in exterior and wet locations.

Surface wall outlets shall be 4 inch (100 mm) square with raised covers for one and two gang requirements. For three gang or larger requirements, use gang boxes with non-overlapping covers.

Outlet Box adjustable ring and depth device applications:

Provide box extenders for boxes that are set too far back in the wall due to un-anticipated wall finishes. Place the box extender over the existing box face to make the box face flush with the wall finish.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01 or 01 91 02.

END OF SECTION

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SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23

PART 1 - GENERAL

SCOPE
The work under this section includes the requirements relating to the furnishing and installation of Identification for Electrical Systems. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Submittals

PART 2 - PRODUCTS
- Materials

PART 3 - EXECUTION
- General
- Box Identification
- Power, Control and Signal Wire Identification
- Wiring Device Identification
- Support Wire Identification
- Nameplate Engraving for Electrical Equipment
- Panelboard Directories

RELATED WORK
Applicable provisions of Division 1 shall govern work under this section.

Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
Section 26 05 23 – Control-Voltage Electrical Power Cables
Section 01 91 01 or 01 91 02 – Commissioning Process

SUBMITTALS
Include schedule for nameplates.

Prior to installation, the contractor shall provide samples of all label types planned for the project. These samples shall include examples of the lettering to be used. Samples shall be mounted on 8 1/2" x 11" sheets, explaining their purposed use.

PART 2 - PRODUCTS

MATERIALS
Labels: All labels shall be permanent, and machine generated. NO HANDWRITTEN OR NON-PERMANENT LABELS ARE ALLOWED.

Wire Labels: All wiring labels shall be white/transparent nylon or vinyl, self-laminating, wraparound type. Flag type labels are not allowed. The labels shall be of adequate size to accommodate the circumference of the cable being labeled and properly self-laminate over the full extent of the printed area of the label.

Tape (wiring phase identification only): Scotch #35 tape in appropriate colors for system voltage and phase. Embossed tape shall not be permitted for any application.

Nameplates: Engraved multi-layer laminated plastic. See Electrical Equipment Identification in the Execution section for nameplate color and size requirements.

See Box Identification and Wiring Device Identification sections for allowed usage of permanent marker.

PART 3 - EXECUTION

GENERAL
Clean all surfaces before attaching labels with the label manufacturer's recommended cleaning agent. Install all labels firmly as recommended by the label manufacturer. Labels shall be installed plumb and neatly on all equipment.

Install nameplates parallel to equipment lines. Secure nameplates to equipment fronts using screws, rivets or manufacturer approved adhesive or cement.

Provide all warning labels to electrical equipment as required per NEC 110.16 and 110.21. Provide available fault current labeling to service equipment as required per NEC 110.24.

BOX IDENTIFICATION

All junction and pull boxes shall be identified by color, based on the following color scheme:

Power Systems	**Color(s)**
Secondary Power – 208Y/120V, 240/120V	White

Other Systems	**Color(s)**
Temperature Control	Green
Lighting Control 0-10VDC	Purple

Other Systems not identified above, boxes shall be left in natural finish and be further identified as shown on drawings or approved shop drawings.

The means of junction and pull box identification shall be as follows:

1. Boxes 8" Square or Smaller – Concealed (Above Accessible Ceilings).
    - Color identified utilizing fully painted covers. If box contains power wiring, the box shall be further identified with circuit numbers and source panel designation, using machine-generated adhesive label or neatly hand-written permanent marker.
2. Boxes 8" Square or Smaller – Exposed.
    - Color identified utilizing fully painted covers. If box contains power wiring, the box shall be further identified with circuit numbers and source panel designation, using machine-generated adhesive label or engraved nameplate.
3. Boxes Larger than 8" Square – Concealed (Above Accessible Ceilings).
    - Color identified utilizing 4" x 4" minimum-sized painted patch, or color-correct machine-generated adhesive label. If box contains power wiring, the box shall be further identified with circuit numbers and source panel designation using machine-generated adhesive label or neatly hand-written permanent marker. Letter height shall be ½" minimum.
4. Boxes Larger than 8" Square – Exposed.
    - Color identified utilizing 4" x 4" minimum-sized painted patch, or color-correct engraved nameplate. If box contains power wiring, the box shall be further identified with circuit numbers and source panel designation using engraved nameplate. Letter height shall be ½" minimum.

POWER, CONTROL AND SIGNALING WIRE IDENTIFICATION

Provide wire labels on each conductor in panelboard gutters, all boxes, and at load connection. Identify with branch circuit or feeder number for power and lighting circuits, and with wire number as indicated on schematic and interconnection diagrams or equipment manufacturer's shop drawings for control and signaling wires.

All wiring shall be labeled within 2 to 4 inches of terminations. Each end of a wire or cable shall be labeled as soon as it is terminated, including wiring used for temporary purposes.

WIRING DEVICE IDENTIFICATION

Wall switches, receptacles, occupancy sensors, photocells, poke-through fittings, access floor boxes, and time clocks shall be identified with circuit numbers and panelboard source (ex. Panel ABC-3). In exposed areas, identifications should be made inside of device covers, unless directed otherwise. Use machine-generated adhesive labels, or neatly hand-written permanent marker.

SUPPORT WIRE IDENTIFICATION

Support wires that are installed in addition to the ceiling grid support wires to provide secure support for raceways, cables assemblies, boxes, cabinets, and fittings shall be distinguishable from the ceiling grid support wires per NEC 300.11(A). This identification shall be either approximately 6 inches of fluorescent orange paint, or orange tape flags 3/4 inches high-by-2 inches wide (minimum) within 12 inches of the bottom of the support wires.

ELECTRICAL EQUIPMENT IDENTIFICATION

Nameplates for all panelboards, circuit breakers, disconnect switches, and transformers shall be based on the following color scheme:

Power Systems	Color(s)
Secondary Power – 208Y/120V, 240/120V	Black letters on White background

Provide nameplates of minimum letter height as scheduled below:
All Panelboards (Distribution, Branch, Sub-feed, and Feed-Through), Switchboards and Motor Control Centers: 1 inch (25 mm); identify equipment designation (same designation used by the main distribution center). 1/2 inch (13 mm); identify voltage rating, source and room location of the source.

Panelboards serving NEC 700, 701 or 702 loads shall identify which branch they serve.

Both panels in a double tub application shall be labeled.

Circuit Breakers, Switches, and Motor Starters in Distribution Panelboards, Switchboards and Motor Control Centers: 1/2 inch (13 mm); identify circuit number and load served, including location.

Individual Disconnect Switches, Enclosed Circuit Breakers, and Motor Starters: ½ inch (13 mm); identify voltage, source and load served.

PANELBOARD DIRECTORIES

Typed directories for panelboards shall be covered with clear plastic and shall have a metal frame. Room number on directories shall be Owner's numbers, not Plan numbers unless Owner so specifies.

END OF SECTION

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SECTION 26 05 73
SHORT CIRCUIT/COORDINATION STUDY
AND
ARC FLASH RISK ASSESSMENT
BASED ON DFD MASTER SPECIFICATION DATED 09/03/24

PART 1 - GENERAL

SCOPE
The electrical contractor shall retain the services of an independent third party firm, or the equipment manufacturer's technical services group, to perform a short circuit/coordination study and arc flash risk assessment as described herein.

Preliminary studies shall be submitted to the A/E prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment for manufacture to ensure the characteristics and ratings of the proposed overcurrent devices will be satisfactory. The final submittal shall capture any changes in circuit lengths, wire sizes, additional loads, etc. that may occur during the construction project.

The studies shall include all portions of the electrical distribution system from the normal power source or sources, and emergency/standby sources, down to and including the smallest OCPD in the distribution system (for short circuit calculations). Normal system connections and those which result in maximum fault conditions shall be adequately covered in the study.

The firm should be currently involved in medium- and low-voltage power system evaluation. The study shall be performed, stamped and signed by a registered professional engineer in the State of Wisconsin. Credentials of the individual(s) performing the study and background of the firm shall be submitted to the A/E for approval prior to start of the work. A minimum of five (5) years experience in power system analysis is required for the individual in charge of the project.

The firm performing the study should demonstrate capability and experience to provide assistance during start up as required.

The study and assessment shall be performed on SKM Dapper, Captor and PowerTool software or EasyPower product suite software.

Included are the following topics:

RELATED WORK
Applicable provisions of Division 1 govern work under this section.

Section 26 24 16 – Panelboards
Section 01 91 01 or 01 91 02 – Commissioning Process

REFERENCE STANDARDS

Standards listed in the IEEE "Buff Book", latest edition
National Fire Protection Association (NFPA) 70E, latest addition
IEEE 1584 – Guide for Performing Arc Flash Calculations

DATA COLLECTION FOR THE STUDY

The contractor shall provide the required data for preparation of the studies. The engineer performing the system studies shall furnish the contractor with a listing of the required data immediately after award of the contract.

The contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to release of the equipment for manufacture.

SUBMITTALS

THIRD PARTY QUALIFICATIONS

Submit qualifications of individual(s) who will perform the work to the A/E for approval prior to commencement of the studies.

PRELIMINARY REPORT

Submit a draft of the studies to the A/E for review prior to delivery of the final study to the Owner. Make all additions or changes as required by the reviewer.

For building construction projects, submit a draft of the studies to the A/E for review prior to A/E approval of project electrical switchgear, panelboard and generator shop drawings.

FINAL STUDY REPORT

Provide studies in conjunction with equipment submittals to verify equipment ratings required.

The results of the power system studies shall be summarized in a final report and provided in the following formats. Provide (2) bound hard copies of the final report. Provide (2) electronic copies (on CD) of the final report and one-line diagrams in PDF format. Provide (2) electronic copies (on CD) of the final report in MS Word format and the one-line diagrams in CAD format.

Also provide (2) electronic copies (on CD) of all files generated by the SKM or EasyPower software for all scenarios evaluated in the studies. The files shall permit the studies to be opened, reviewed or updated by any user of the analysis software used for the studies.

The report shall typically include the following sections:

I. Overview
II. Short Circuit Study
    - SC-1 Purpose
    - SC-2 Explanation of Data
    - SC-3 Assumptions
    - SC-4 Analysis of Results
    - SC-5 Recommendations
    - SC-6 Fault Analysis Input Report from Software Program
    - SC-7 Fault Contribution Report
III. Protective Device Coordination Study
    - PDC-1 Purpose
    - PDC-2 Explanation of Data
    - PDC-3 Assumptions
    - PDC-4 Analysis of Results
    - PDC-5 Recommendations (Including NEC 700-32 Requirement)
    - PDC-6 Results from Software Program

PDC-7 Example Drawings

IV. Arc Flash Study

ARC-1 Purpose
ARC-2 Explanation of Data
ARC-3 Assumptions
ARC-4 Analysis of Results
ARC-5 Recommendations
ARC-6 Arc Flash Evaluation Report from Software Program

V. Prioritized Recommendations and Conclusions

VI. Appendices

APP-1 One-line Diagrams from Software Program
APP-2 AutoCAD One-line Diagrams
APP-3 Protective Device Summaries from Software Program
APP-4 Reference Data
APP-5 Sample Work Permit Form
APP-6 Copy of Warning Labels, including study date

The above sections shall include the following items in detail:

- Obtain available fault current from the local utility company.

- Short circuit studies shall evaluate the available fault current at each bus (each change of impedance), including all three-phase motors.

- Coordination study recommendations for relay settings, breaker settings, and motor protection settings.

- Recommendations for improving the coordination and/or load distribution, as well as ground fault requirements.

- Worst case Arc Flash values (highest incident energy) for project specific scenarios (low short circuit and high short circuit for each possible power supply source).

- Arc flash values for two maintenance cases, which define the arc flash values available at the equipment that would be available if the instantaneous trip of the upstream circuit breaker is set at a minimum value. This is recommended if someone has to work on live equipment.

- IEEE standard one-line diagram with equipment evaluation and circuit breaker settings that clearly define the system data and are easy to interpret. The diagrams should include the bus names and references used in the studies.

- Recommendations to reduce the arc flash incident energy in all areas that are subject to 8 calories per square centimeter or greater of available incident energy.

- Condition of Maintenance information for any existing equipment included in the study.

- Prioritized report summarizing all recommendations from this study. This shall include observed NEC code violations and their corrective action.

- The contractor shall provide a one-line diagram that meets IEEE/ANSI standard 141, mounted on 24” x 36” (minimum) Styrofoam backboard. This one-line diagram shall be mounted in each electrical room.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

SHORT CIRCUIT AND COORDINATION STUDY

The short circuit, coordination, and arc flash hazard studies shall be performed using SKM Dapper, Captor and PowerTool for Windows software or EasyPower product suite Windows based software packages. In the short circuit study, provide calculation methods and assumptions, the base per unit quantities selected, one-line diagrams, source impedance data including power company system characteristics, typical calculations, and recommendations. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed 3-phase bolted fault at each supply switchgear lineup, unit substation primary and secondary terminals, low voltage switchgear lineup, switchboard, motor control center, distribution panelboard, pertinent branch circuit panelboard, and other significant locations throughout the system. Provide a ground fault current study for the same system areas, including the associated zero sequence impedance data. Include in tabulations fault impedance, X to R ratios, asymmetry factors, motor contribution, short circuit KVA, and symmetrical and asymmetrical fault currents.

In the protective device coordination study, provide time-current curves graphically indicating the coordination proposed for the system, centered on conventional, full-size, log-log forms. Include with each curve sheet a complete title and one-line diagram with legend identifying the specific portion of the system covered by that particular curve sheet. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics. Tabulate recommended device tap, time dial, pickup, instantaneous, and time delay settings.

Include on the curve sheets power company relay and fuse characteristics, system medium-voltage equipment relay and fuse characteristics, low-voltage fuse characteristics, circuit breaker trip device characteristics, pertinent transformer characteristics, pertinent transformer characteristics, pertinent motor and generator characteristics, and characteristics of other system load protective devices. Include at least all devices down to largest branch circuit and largest feeder circuit breaker in each motor control center, and main breaker in branch panelboards.

Include all adjustable settings for ground fault protective devices. Include manufacturing tolerance and damage bands in plotted fuse characteristics. Show transformer full load and 150, 400, or 600 percent currents, transformer magnetizing inrush, ANSI transformer withstand parameters, and significant symmetrical and asymmetrical fault currents. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed.

Select each primary protective device required for a delta-wye connected transformer so that its characteristic or operating band is within the transformer characteristics, including a point equal to 58 percent of the ANSI withstand point to provide secondary line-to-ground fault protection. Where the primary device characteristic is not within the transformer characteristics, show a transformer damage curve. Separate transformer primary protective device characteristic curves from associated secondary device characteristics by a 16 percent current margin to provide proper coordination and protection in the event of secondary line-to-line faults. Separate medium-voltage relay characteristic curves from curves for other devices by at least a 0.4-second time margin.

Include complete fault calculations as specified herein for each proposed and ultimate source combination. Note that source combinations may include present and future supply circuits, large motors, or generators as noted on drawing one-lines.

When Current Limiting fuses are utilized as part of the distribution system, the current limiting characteristics shall be accounted for when doing calculations downstream. Manufacturer’s data utilizing maximum fault current- Apparent RMS Symmetrical Current that the fuse will let through during fault conditions shall be used. If modeling software does not take this into account, values shall be manually entered prior to doing calculations.

Utilize equipment load data for the study obtained by the Contractor from contract documents, including contract addendums issued prior to bid openings.

Include fault contribution of all motors in the study. Notify the Engineer in writing of circuit protective devices not property rated for fault conditions.

Provide settings for the chiller motor starters or obtain from the mechanical contractor, include in the study package, and comment.

When an emergency generator is provided, include phase and ground coordination of the generator protective devices, to meet NEC 700.32 requirements. Show the generator decrement curve and damage curve along with the operating characteristic of the protective devices. Obtain the information from the generator manufacturer and include the generator actual impedance value, time constants and current boost data in the study. Do not use typical values for the generator.

Evaluate proper operation of the ground relays in 4-wire distributions with more than one main service circuit breaker, or when generators are provided, and discuss the neutral grounds and ground fault current flows during a neutral to ground fault.

For motor control circuits, show the MCC full-load current plus symmetrical and asymmetrical of the largest motor starting current to ensure protective devices will not trip major or group operation.

FIELD SETTINGS

The Contractor shall perform field adjustments of the protective devices as required to place the equipment in final operating condition. The settings shall be in accordance with the approved short circuit study, protective device coordination study and arc flash risk assessment.

Necessary field settings and adjustments of devices and minor modifications to equipment to accomplish conformance with the approved short circuit and protective device coordination study shall be carried out by the Contractor at no additional cost to the owner.

ARC FLASH RISK ASSESSMENT

As part of the short circuit and coordination study, arc flash risk assessment shall be included. The study shall include the following:

1. Determine and document all possible utility and generator/emergency sources that are capable of being connected to each piece of electrical gear. Calculations shall be based on highest possible source connection.

2. Calculations to conform to National Fire Protection Association (NFPA) 70E recognized means of calculation standards. All incident energy units shall be calculated in calories per square centimeter.

3. Provide recommended boundary zones and personal protective equipment (PPE) based on the calculated incident energy and requirements of NFPA 70E for each piece of electrical gear.

Electrical Contractor shall provide warning labels as required by OSHA based upon the results of the arc flash risk assessment. At a minimum, the labeling shall contain the following information: nominal system voltage, arc flash boundary, limited approach boundary, restricted approach boundary, available incident energy and the corresponding working distance or the arc flash PPE category, minimum arc rating of clothing, and study date. Label shall also include the name or logo and the phone number of the company performing the study.

Arc flash warning labels shall be affixed to all electrical equipment that is likely to require examination, adjustment, servicing or maintenance while energized. This includes, but is not limited to, medium-voltage switchgear, transformers, switchboards, panel boards, three-phase disconnect switches, transfer switches, motor control centers, motor controllers, and three-phase motor disconnect switches.

END OF SECTION

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SECTION 26 08 00
COMMISSIONING OF ELECTRICAL
BASED ON DFD MASTER SPECIFICATION DATED 03/01/21

PART 1 - GENERAL

SCOPE
This section includes commissioning forms for construction verification and functional performance testing. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Submittals

PART 2 - PRODUCTS
- (Not Used)

PART 3 – EXECUTION
- Commissioning Forms
  - CV-26 05 19 Low-Voltage Electrical Power Conductors and Cables
  - CV-26 05 26 Grounding and Bonding for Electrical Systems
  - CV-26 05 33 Raceways and Boxes for Electrical Systems
  - CV-26 24 16 Panelboards
  - CV-26 27 28 Disconnect Switches
  - CV-26 51 13 Interior Lighting Fixtures, Lamps and Ballasts
  - CV-26 56 29 Site Lighting

RELATED WORK
Section 01 91 01 or 01 91 02 – Commissioning Process

REFERENCE
Applicable provisions of Division 1 shall govern work under this section.

SUBMITTALS
Reference the General Conditions of the Contract for submittal requirements.

Reference Section 01 91 01 or 01 91 02 Commissioning Process for Construction Verification Checklist and Functional Performance Test submittal requirements.

PART 2 – PRODUCTS

(Not Used)

PART 3 – EXECUTION

COMMISSIONING FORMS
Commissioning forms are to be filled in as work progresses by the individuals responsible for installation and shall be completed for each installation phase.

Provide a description of the work completed since the last entry, the percentage of the total work completed for the system for that area and the step of installation or finalization.

Circle Yes or No for each commissioning form item. If the information requested for an item does not apply to the given stage of installation for the system, list it as “N/A”. Explain all discrepancies, negative responses or N/A responses in the negative responses section.

Once the work is 100% complete and the responses to each item are complete and resolved for a given commissioning forms group, mark as complete, initial and date in the spaces provided.

Provide copies of the commissioning forms to the commissioning agent 2 days prior to construction progress meetings.

CV-26 05 19 – Low-Voltage Electrical Power Conductor and Cables

Equipment Identification/Tag: _____
Location: _____

A) CONDUCTOR AND CABLING PULLING CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)						
				1)	2)	3)	4)	5)	6)	7)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS: _____					DATE: _____	

Question Details

1) Conductor and cabling sized to maintain less than a 3% voltage drop for rated length and ampacity of circuit.
2) Conductors and cabling coloring match specification requirements for given voltage, wire gauge, and leg of circuit.
3) Conduits swabbed to remove foreign material prior to pulling cables.
4) All cables pulled though conduit at the same time, with pulling lubricant used to ease pulling tensions.
5) Excess cable provided at each termination and splice point for purpose of multiple terminations or splices to be performed.
6) Emergency power conductors and cabling pulled in separate conduits from normal power systems.
7) Outdoor cables not to be terminated within 8 hours to be properly sealed and protected from moisture intrusion until termination.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

B) CONDUCTOR AND CABLE TERMINATIONS & SPLICES CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)							
				1)	2)	3)	4)	5)	6)	7)	8)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:		_____			DATE:		_____

Question Details

1) Installed lugs match the pads on the equipment to which the cable will be mounted.
2) All lug terminations are connected per connection torque valve as recommended by the manufacturer.
3) Splices made only in accessible junction boxes.
4) All conductors and cables cleaned prior to termination.
5) All splices made so that the electrical resistance of the splice does not exceed the equivalent resistance of 2’ of conductor.
6) Solderless spring type pressure connectors with insulating covers used for all wires splices and taps of conductors and cabling 10AWG and smaller.
7) Mechanical or compression connectors used for all wire splices and taps of conductors and cabling 8 AWG and larger.
8) Uninsulated conductors and connectors taped with electrical tape equivalent to 150% of the insulation value of the conductor.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

C) TESTING & FINALIZATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)				
				1)	2)	3)	4)	5)
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:		_____		DATE: _____

Question Details

1) All exposed conductors and cabling has been visually inspected for physical damage and any damaged conductors and cabling has been replaced.
2) Conductors and cabling jacket and insulation are in good condition.
3) All cable terminations have been checked for proper tightness and clearances per specification and manufacturer recommendations and any adjustments necessary have been made.
4) For aluminum conductors and cabling all specified acceptance tests have been performed on all cables, terminations, and splices and are approved prior to energizing.
5) All splices and terminations are to be tagged within 2” to 4” of splice or termination and in accordance with specification requirements.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

CV-26 05 26 – Grounding and Bonding for Electrical Systems

Equipment Identification/Tag: _____
Location: _____

A) GENERAL GROUNDING AND BONDING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)									
				1)	2)	3)	4)	5)	6)	7)	8)	9)	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
❑ CHECKLIST GROUP COMPLETE				INITIALS: _____					DATE: _____				

Question Details

1) Mechanical connections accessible for inspection and checking, with no insulation of connections.
2) Ground connection surfaces cleaned and all connections made permanent.
3) Grounds attached permanently before permanent building service is energized.
4) Grounding electrode conductors installed in PVC conduit or rigid galvanized steel conduit and bonded at both ends to the grounding electrode conductor with an approved grounding fitting.
5) Grounding electrode is correct size and length.
6) Grounded conductor run to each service disconnecting means and its enclosure.
7) Separate insulated equipment grounding conductor installed with phase conductors within each raceway.
8) All metallic systems (water, gas, sprinkler, etc.) and lightning protection system bonded to ground system.
9) System bonded within 5’ from point of entry into building to at least two of the following: metal underground water pipe, metal frame of building, concrete encased

electrodes, ground ring, (underground local systems such as storage tanks, conduit, or piping), ground rod installed 8’ deep or at 45-degree angle and distanced a minimum of 6’ apart., ground plate buried 2-1/2’ deep.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

B) MEDIUM VOLTAGE GROUNDING AND BONDING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)								
				1)	2)	3)	4)	5)	6)	7)	8)	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
❑ CHECKLIST GROUP COMPLETE				INITIALS:		_____			DATE:		_____	

Question Details

1) Ground bus installed 18" above finished floor with insulated standoffs 36” on center, completely around the perimeter of the room (vault) containing the high voltage switchgear and unit substation.
2) Six ground rods provided equally spaced around high voltage switchgear room and connected to ground bus with 4/0 copper.
3) Separate 4/0 copper conductors provided from ground bus to, XO terminal of each transformer, each high voltage switch ground bus, and secondary service equipment ground bus.
4) Full size 600V copper THHN/THWN or XHHW-2 grounding conductor provided in each conduit, raceway or enclosure which contains high voltage conductors, and terminated at ground bus of equipment containing high voltage terminations.
5) Each enclosure containing high voltage parts (switches, fuses, transformers, pull boxes, etc.) bonded to room ground bus with 4/0 copper conductor.
6) All conduits containing high voltage conductors or secondary service conductors bonded to penetrated enclosures using grounding bushing and #4 copper conductor.
7) #10 stranded wire provided from each termination shield drain wire to ground bus within enclosure.
8) Ground rod provided in each section of each secondary switchboard with 4/0 copper wire connection to ground rod and to switchgear ground bus.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

C) LOW VOLTAGE (<600V) GROUNDING AND BONDING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)									
				1)	2)	3)	4)	5)	6)	7)			
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO			
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO			
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO			
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO			
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO			
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO			
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO			
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO			
❑ CHECKLIST GROUP COMPLETE				INITIALS:		_____			DATE:	_____			

Question Details

1) Code sized copper grounding electrode conductor provided from secondary switchboard ground bus, each separately derived system neutral, secondary service system neutral to street side of water meter, building steel, ground rod, and any concrete encased electrodes.
2) Bonding jumper provided around water meter.
3) Bond together system neutrals, service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, grounding conductor bonded in raceways and cables, receptacle ground connectors, and plumbing systems.
4) Separate insulated equipment grounding conductor provided within each raceway.
5) Ground wire provided from each device to the respective enclosure.
6) Communications system grounding conductor provided at point of service entrance and connected to building common grounding electrode system.
7) Telecommunications and audio visual systems installed with an isolated grounding system with only one ground point at the electrical service entrance for the building per specification requirements.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

CV-26 05 33 – Raceway and Boxes for Electrical Systems

Equipment Identification/Tag: _____
Location: _____

A) CONDUIT & FITTINGS PRE-INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)
				YES NO	YES NO
				YES NO	YES NO
				YES NO	YES NO
				YES NO	YES NO
				YES NO	YES NO
				YES NO	YES NO
				YES NO	YES NO
				YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS: _____	DATE: _____

Question Details

1) Conduit type and material in accordance with specification requirements for given application and location.
2) Conduit sufficiently sized to accommodate cabling and fill requirements of contract document.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

B) CONDUIT & FITTINGS INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)									
				1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS: _____					DATE: _____				

Question Details

1) Conduit support spacing complies with specification requirements.
2) All conduit supported independently of piping, ductwork, equipment, cable tray or other conduit.
3) Bends in conduit minimized with required bends conforming to specification requirements and no more than an equivalent of three 90 degree bends between boxes.
4) Moisture traps are avoided as much as possible. When unavoidable, a junction box is provided with drain fitting at conduit low point.
5) All equipment requiring maintenance is accessible.
6) Minimum 6” clearance between conduit and piping, and 12” clearance between conduit and heat sources such as flues, steam pipes, and heating appliances is provided.
7) No continuous conduit run exceeds 100’ without a junction box.
8) Expansion-deflection joints installed where conduit crosses building expansion joints.
9) Where conduit passes between areas of differing temperatures, listed conduit seals are provided.
10) At end of work day suitable conduit caps or other approved seals provided for incomplete work to protect installed conduit against entrance of dirt and moisture.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

C) RACEWAY & GUTTER INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)							
				1)	2)	3)	4)	5)	6)	7)	8)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:		

Question Details

1) Raceway and gutter support spacing and methods comply with specification requirements.
2) All raceways supported independently of piping, ductwork, equipment, cable tray or other conduit.
3) Suitable insulating bushings and inserts provided at connections to outlets and corner fittings.
4) All equipment requiring maintenance is accessible.
5) Expansion-deflection joints installed where conduit crosses building expansion joints.
6) Oil tight gutters included gaskets at each joint.
7) Rain-tight gutters are installed in horizontal position only.
8) At end of work day suitable caps or other approved seals provided for incomplete work to protect installed raceways and gutters against entrance of dirt and moisture.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

D) JUNCTION, PULL AND OUTLET BOXES INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)								
				1)	2)	3)	4)	5)	6)	7)	8)	9)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:		_____			DATE:		_____	

Question Details

1) Boxes provided in locations as per contract documents, Engineer's direction or as necessary for splicing and terminations.
2) Box type and material in accordance with specification requirements for given application and location.
3) No outlet box located where it will be obstructed by other equipment, piping, lockers, benches, counters, etc.
4) All boxes supported independently of conduit, piping, ductwork, equipment, or cable tray.
5) No outlet boxes installed back-to-back in walls, and minimum 6" separation between all boxes, except for installations in acoustic walls where a minimum 24" separation between boxes is provided.
6) All boxes are accessible, and where installation is inaccessible, 18" by 24" access door has been provided.
7) Mounting heights for outlet boxes corresponds with contract document requirements.
8) All recessed outlet boxes in finished areas are mounted to the correct depth to accommodate and be flush to final surface finish.
9) Knockout closures provided for unused openings.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

E) FINALIZATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)									
				1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS: _____					DATE: _____				

Question Details

1) All penetrations through fire rated wall assemblies have been sealed per specification requirements.
2) All penetrations through non-rated wall assemblies have been sealed per specification requirements for given space type.
3) Conduits that penetrate the building envelope are sealed to prevent intrusion of air and moisture and are accessible.
4) All conduit junction boxes are painted and tagged in accordance with specification requirements.
5) All splices and terminations are to be tagged within 2” to 4” of splice or termination and in accordance with specification requirements.
6) 1/8” nylon pull string provided in all empty conduits, except sleeves and nipples.
7) Grounding and bonding of conduits and raceways conform to specification requirements.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

CV-26 24 16 – Panelboards

Equipment Identification/Tag: _____
Location: _____

Group/Item	Group/Task Description	Submitted	Delivered
A	*MODEL VERIFICATION*		
1	Manufacturer		
2	Model		
3	Catalog Number		
4	Voltage / Phase / Frequency (V / - /Hz)	/ /	/ /
5	Main Amps (A)		
6	Circuit Count		
7	kAIC rating (kA)		
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____

Group/Item	Group/Task Description	Response	
B	*PHYSICAL CHECKS*		
1	Unit is free from physical damage.	YES	NO
2	All components/accessories present.	YES	NO
3	Circuit breaker capacities documented.	YES	NO
4	Unit tags affixed.	YES	NO
5	Manufacturer's ratings readable/accurate.	YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____
C	*INSTALLATION*		
1	Unit secured as required by manufacture, specifications, and seismic zone requirements.	YES	NO
2	Adequate clearance around unit for service per table NEC-110.26.	YES	NO
3	Top of tub set at 6' from finished floor unless specified otherwise in contract documents.	YES	NO
4	Conduit feeds are aligned with openings and accommodate seismic motion.	YES	NO
5	Unit is level, plumb, and square.	YES	NO
6	Unit labeled and is easy to see.	YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____
D	*WIRING*		
1	Three spare ¾" empty conduits provided (recessed units ONLY).	YES	NO
2	Unit is adequately grounded to grounding lug for intended use.	YES	NO
3	Proper phasing has occurred in relationship to phase conductors.	YES	NO
4	All connections are terminated properly.	YES	NO
5	All electrical connections are tight.	YES	NO
6	All cables are permanently labeled relative to use.	YES	NO
❑ **CHECKLIST GROUP COMPLETE**	**INITIALS:** _____	**DATE:**	_____
E	*STARTUP*		
1	All protective coverings have been removed.	YES	NO
2	Unit has been cleaned of all debris and dirt on interior of unit.	YES	NO
3	Insulators and supports show no signs of damage or cracks.	YES	NO

Group/Item	Group/Task Description			Response	
4	Current transformers secured and wired per manufacturer instructions (metering applications ONLY).			YES	NO
5	All electronic circuit breaker settings have been adjusted to desired setting (if applicable).			YES	NO
6	Ground-fault-protection (GFP) trip and time delays have been adjusted to desired setting (if applicable).			YES	NO
7	All wiring connections verified for proper torques values and are acceptable.			YES	NO
8	Phase-to-phase, phase-to-ground, and neutral-to-ground, and dielectric tests have been accomplished and results are acceptable.			YES	NO
9	No hazards or adverse circumstances exist per continuity and high potential tests.			YES	NO
10	Insulation megger test accomplished and results acceptable.			YES	NO
11	Unit energized by authorized personnel.			YES	NO
12	All damage to unit finish is repaired.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
F	*TESTING & FINALIZATION*				
1	Overcurrent protective devices have been manually exercised.			YES	NO
2	Solid state circuit breaker self-diagnostics completed.			YES	NO
3	Electronic circuit breaker trip unit tests completed.			YES	NO
4	Ground-fault-protection (GFP) system tested and certified.			YES	NO
5	Filler plates provided for all unused spaces.			YES	NO
6	As-built circuit index provided and attached to interior of unit door.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-26 27 28 – Disconnect Switches

Equipment Identification/Tag: _____
Location: _____

Group/Item	Group/Task Description			Submitted	Delivered
A	*MODEL VERIFICATION*				
1	Manufacturer				
2	Model				
3	Serial Number				
4	Voltage (V)				
5	Ampere Rating (A)				
6	kAIC Rating (kA)				
7	Horsepower Rating (HP)				
8	Enclosure Type				
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
B	*PHYSICAL CHECKS*				
1	Unit is free from physical damage.			YES	NO
2	All components/accessories present.			YES	NO
3	Unit tags affixed.			YES	NO
4	Manufacturer's ratings readable/accurate.			YES	NO
5	Unit is rated "Heavy Duty".			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
C	*INSTALLATION*				
1	Unit secured as required by manufacturer and specification requirements.			YES	NO
2	Adequate clearance around unit for service.			YES	NO
3	Conduit feeds are aligned with openings and accommodate seismic motion.			YES	NO
4	Unit is level, plumb, and square.			YES	NO
5	Unit labeled and is easy to see.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
D	*WIRING*				
1	Unit is adequately grounded for intended use.			YES	NO
2	All connections are terminated properly.			YES	NO
3	All electrical connections are tight.			YES	NO
4	All cables are permanently labeled relative to use.			YES	NO
5	Fuses have been installed in all switches.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-26 51 13 – Interior Light Fixtures, Lamps and Ballasts

Equipment Identification/Tag: _____
Location: _____

A) INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)									
				1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS: _____					DATE: _____				

Question Details

1) Fixtures, ballasts, and lamps are free from damage.
2) Identical ballasts provided for each fixture type.
3) All fixtures and exit signs installed in locations specified in contract documents.
4) Fixtures do not impede access to other systems or equipment for maintenance.
5) Suspended fixtures and exit signs are hung independent of any other fixture, system, or equipment, are level, and are suspended with appropriate materials and methods defined within the contract documents.
6) Fixtures larger than 2'x4' or greater than 50 lbs. are supported independently from ceiling framing.
7) All recessed fixtures are installed flush to ceiling or wall finish.
8) All recessed fixtures are installed to permit removal and access to lamps from below.
9) All wall mounted fixtures and exit signs are mounted at heights specified in contract documents.

10) All fixtures are supported and installed in accordance with manufacturer and specification requirements.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

B) WIRING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)				
				1)	2)	3)	4)	5)
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:			DATE:	

Question Details

1) Fixture and accessories grounded and bonded to branch circuit grounding conductor.
2) Maximum of 6’ of flexible conduit provided for lay-in, recessed fixtures.
3) All electrical connections are tight.
4) All conductors are labeled per specification requirements.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

C) STARTUP & TESTING CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS: _____		DATE: _____	

Question Details

1) Emergency indicating button/lamp visible and verified to be operational (if applicable).
2) Associated emergency ballast tested and operation verified (if applicable).
3) Occupancy sensor and associated fixture(s) tested and operation verified (if applicable).
4) Lighting control schedules programmed and operation verified for all associated fixtures (if applicable).

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

D) FINALIZATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)									
				1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:		_____			DATE:		_____		

Question Details

1) Protective covering removed.
2) Lens, trim ring and other architectural accessories installed.
3) Recessed fixtures are flush to finished surface with no visible gaps.
4) Code-required hardware is installed to secure recessed grid-supported fixtures in place.
5) Recessed fixtures in fire rated assemblies have been sealed per manufacturer and specification requirements to maintain assembly rating.
6) Number and type of lamps specified for each fixture installed and operational.
7) Fluorescent lamps installed in fixtures with dimming ballasts have been burned in at 100% rated output for a minimum of 100 hours.
8) Fixture adjusted and aimed for specific task or effect per contract documents and/or Architect's directions.
9) All damages to fixture finish repaired.
10) Fixtures and lens are clean.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

CV-26 56 29 – Site Lighting

Equipment Identification/Tag: _____
Location: _____

A) INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)								
				1)	2)	3)	4)	5)	6)	7)	8)	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:			

Question Details

1) Fixtures, ballasts, and lamps are free from damage.
2) Identical ballasts provided for each fixture type.
3) Base with conduit stubs provided in location and per contract documents for all pole mounted fixtures.
4) Pole anchors extend a minimum of 2” above base.
5) All fixtures installed in locations specified in contract documents.
6) All wall mounted fixtures are mounted at heights specified in contract documents.
7) Fixture poles are plumb.
8) All penetrations of facility envelope have been filled and sealed per specification requirements.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

B) WIRING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)				
				1)	2)	3)	4)	5)
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:				DATE:

Question Details

1) Fixture, accessories, pole, and pole base grounding are bonded to branch circuit grounding conductor.
2) All electrical connections are tight.
3) All conductors are labeled per specification requirements.
4) Ensure all ungrounded conductors for individual poles are protected with in-line fuses.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

C) TESTING & FINALIZATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)							
				1)	2)	3)	4)	5)	6)	7)	8)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:		_____			DATE:		_____

Question Details

1) Emergency lighting operation verified (if applicable).
2) Lighting control schedules programmed and operation verified for all associated fixtures (if applicable).
3) Protective covering removed.
4) Lens and other accessories installed.
5) Number and type of lamps specified for each fixture installed and operational.
6) Fixture adjusted and aimed for specific task or effect per contract documents and/or Architect's directions.
7) All damages to fixture finish repaired.
8) Fixtures, lenses, and photometric surfaces are clean.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

SECTION 26 24 16
PANELBOARDS
BASED ON DFD MASTER ELECTRICAL SPEC DATED 09/03/24

PART 1 - GENERAL

SCOPE
The work under this section includes main, distribution and branch circuit panelboards. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- References
- Submittals
- Operation and Maintenance Data
- Spare Parts

PART 2 - PRODUCTS
- Branch Circuit Panelboards
- Coordination of Overcurrent Protective Devices

PART 3 - EXECUTION
- Installation
- Field Quality Control
- Construction Verification Items
- Agency Training

RELATED WORK
Applicable provisions of Division 1 govern work under this Section.

Section 26 05 73 - Short Circuit/Coordination Study and Arc Flash Risk Assessment
Section 26 08 00 - Commissioning of Electrical
Section 01 91 01 or 01 91 02 – Commissioning Process

REFERENCES
ANSI C57.13 – Instrument Transformers
NEMA AB 1 - Molded Case Circuit Breakers
NEMA KS 1 - Enclosed Switches
UL-891 - Dead Front Switchboards

SUBMITTALS
Include outline and support point dimensions, voltage, main bus ampacity, circuit breaker arrangement and sizes, and interrupting ratings confirming a fully-rated system for all equipment and components.

Submit required short circuit coordination study per specification section 26 05 73 to the consulting engineer for review and approval. Submittal shall be on or before date of panelboard equipment submittal.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

SPARE PARTS
Keys: Furnish 2 keys for each panelboard to Owner.

Handle lock-off: Furnish (2) 20/1P circuit breaker handle lock-off devices for each panelboard to Owner.

One set of three spare fuses of each size and type utilized.

PART 2 - PRODUCTS

BRANCH CIRCUIT PANELBOARDS
Lighting and Appliance Branch Circuit Panelboards: Circuit breaker type.

The panelboard and overcurrent devices contained within shall be **fully-rated.**

Enclosure: Type 4X; Minimum cabinet size: 5-3/4 inches (144 mm) deep; 20 inches (508 mm) wide with 5" minimum gutter space top and bottom. Constructed of galvanized code gauge steel. Panel enclosure (back box) shall be of non-stamped type (without KO's) to avoid concentric break out problem.

Cabinet front cover and cabinet shall be Type 4X, 304 stainless steel in wet and damp locations including kitchen, food service and therapeutic/pool applications.

Provide surface cabinet front with concealed trim clamps, concealed hinge and flush cylinder lock all keyed alike. Front cover shall be hinged to allow access to wiring gutters without removal of panel trim. Hinged trim shall be held in place with screw fasteners. Finish in manufacturer's standard gray enamel.

Provide metal directory holders with clear plastic covers. Holder to be factory mounted.

Provide panelboards with copper bus (phase buses, bus fingers, etc.), ratings as scheduled on Drawings. Provide ground bars in all panelboards. Phase, neutral and ground bar terminations can be dual rated ALCU9. All spaces shall have bus fully extended and drilled for the future installation of breakers.

Incoming conductors shall terminate at lug landing pads rated for the panelboard.

Provide compression type lugs to accommodate the conductor shown on drawings.

Minimum System (i.e. individual component) Short Circuit Rating: As shown on the Drawings and as required by short circuit/ coordination study.

Molded Case Circuit Breakers: Bolt-on type thermal magnetic trip circuit breakers. Provide UL Class A ground fault interrupter circuit breakers as shown on Drawings. Provide circuit breakers UL listed as Type HACR for air conditioning equipment branch circuits.

Do not use tandem circuit breakers.

Circuit breakers shall be bolt-on type with common trip handle for all poles. No handle ties of any sort will be approved.

Provide a minimum of 10% spare circuit breakers in branch panelboards.

All of the panelboards provided under this section shall be by the same manufacturer.

All panelboards installed side by side (double tub) shall utilize same enclosure height.

Double tub panelboard installations shall identify type of feed to adjacent panelboard- sub-feed or feed-thru. Identification shall be integral with panel label.

Provide service entrance rated panelboards where required.

COORDINATION OF OVERCURRENT PROTECTIVE DEVICES

Provide a coordination study of the electrical system and recommend set points for all of the overcurrent and ground fault trip adjustments on the equipment provided. The coordination study and set point recommendations shall be submitted to the consulting engineer for approval. Submittal shall be on or before date of switchboard and panelboard equipment submittal. The study shall meet the requirements of specification section 26 05 73.

PART 3 - EXECUTION

INSTALLATION

See section 26 05 29 for support requirements.

Install panelboards plumb with wall finishes.

Height:

Branch panelboards: 6’-0” to top of panelboard.

Install a crimp type stud termination to stranded conductor when terminating on circuit breakers without a captive assembly rated for terminating stranded conductors.

Provide filler plates for unused spaces in panelboards.

See section 26 05 53 for identification requirements. Provide typed circuit directory for each panelboard per NEC 408.4(A). Revise directory to reflect circuiting changes required to balance phase loads.

Stub three (3) empty ¾" conduits to accessible location above ceiling or below floor out of each recessed panelboard. Cap these conduits to prevent material from entering them.

FIELD QUALITY CONTROL

If aluminum conductors sized #1/0 and larger (per Section 26 05 19) are to be used as panelboard feeders, it is the responsibility of the contractor to provide panelboards with adequate wire bending space to accommodate the aluminum conductors and terminators to meet allowable code requirements.

The Contractor shall circuit the panelboards as shown on the drawings. Measure steady state load currents at each panelboard feeder. Should the difference at any panelboard between phases exceed 10 percent, rearrange circuits in the panelboard to balance the phase loads within 10 percent.

Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01 or 01 91 02.

AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01 or 01 91 02.

END OF SECTION

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SECTION 26 27 02
EQUIPMENT WIRING SYSTEMS
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23

PART 1 - GENERAL

SCOPE
The work under this section includes electrical connections to equipment specified under other Divisions and/or Sections, or furnished by Owner, including, but not limited to:
-Misc. Equipment
-HVAC and Plumbing motors, VFDs, and panels

Included are the following topics:

PART 1 - GENERAL
Scope
Related Work
Submittals
Coordination
PART 2 - PRODUCTS
Cords and Caps
Other Products
PART 3 - EXECUTION
Inspection
Preparation
Installation
Miscellaneous Connections
HVAC and Plumbing Connections
Equipment Connection Schedule

RELATED WORK
Applicable provisions of Division 1 govern work under this Section.

Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
Section 26 05 33 – Raceway and Boxes for Electrical Systems
Section 01 91 01 or 01 91 02 – Commissioning Process

SUBMITTALS
Product Data: Provide data for cord and wiring devices.

COORDINATION
Coordinate all equipment requirements with the various contractors and the Owner. Review the complete set of drawings and specifications to determine the extent of wiring, starters, devices, etc., required.

Coordinate the available fault current at equipment including control panels and internal components. Equipment shall be listed to interrupt the available fault current at point of connection.

PART 2 - PRODUCTS

CORDS AND CAPS
Straight-blade Attachment Plug: NEMA WD 1.

Locking-blade Attachment Plug: NEMA WD 5.

Attachment Plug Configuration: Match receptacle configuration at outlet provided for equipment.

Cord Construction: Oil-resistant thermoset insulated multi-conductor flexible cord with identified equipment grounding conductor, suitable for hard usage in damp locations.

Cord Size: Suitable for connected load of equipment and rating of branch circuit overcurrent protection.

OTHER PRODUCTS
Refer to related sections for other product requirements.

PART 3 - EXECUTION

INSPECTION

Verify that equipment is ready for electrical connection, wiring, and energizing.

Working space for equipment shall be provided that is likely to require examination, adjustment, servicing or maintenance per NEC 110.26(A)(1) table.

PREPARATION

Review equipment submittals prior to installation and electrical rough-in. Verify location, size, and type of connections. Coordinate details of equipment connections with supplier and installer.

INSTALLATION

Use wire and cable with insulation suitable for temperatures encountered in heat-producing equipment.

Provide a green equipment ground conductor for all installed equipment wiring.

Make conduit connections to equipment using flexible PVC-coated metal conduit.

Requirements of NEC Article 300.22 shall apply for boxes, conduit, conduit connections to equipment, devices and luminaire located in Mechanical Plenum spaces.

Install pre-finished cord set where connection with attachment plug is indicated or specified, or use attachment plug with suitable strain-relief clamps.

Provide suitable strain-relief clamps for cord connections to outlet boxes and equipment connection boxes.

Make wiring connections in control panel or in wiring compartment of pre-wired equipment in accordance with manufacturer's instructions. Provide interconnecting wiring where indicated.

Install disconnect switches, controllers, control stations, and control devices such as limit switches and temperature switches as indicated. Connect with conduit and wiring as indicated.

All 120V single phase motor operated equipment such as fan coil units, unit heaters, door operators, shall be provided with a SSY, 2 gang combination plug fuse holder/ switch mounted adjacent to equipment.

MISCELLANEOUS CONNECTIONS

Hand Dryers: Provide handle lock on source circuit breaker to serve as required lock open disconnect.

Drinking Fountains and Bottle Fill Fountains: Provide GFCI source circuit breaker to serve receptacle at fountain.

HVAC AND PLUMBING CONNECTIONS

Provide all power wiring including all circuitry carrying electrical energy from panelboard or other source through starters, variable frequency drives (VFDs), controller overcurrent protection and disconnects to motors or to packaged control motor protection panels.

Packaged control motor protection panels may include disconnects and starters and overcurrent protection. Provide all wiring between source and packaged control motor protection panel and motors. Install panel on exterior wall or adjacent to AHU’s.

Contractor shall verify with mechanical contractor the electrical requirements including voltages, horsepower, disconnecting means, starters and variable frequency drives for motors and equipment prior to ordering circuit breakers, disconnects, controller overcurrent protection devices and starters.

Provide 120 volts to each temperature control panel. Coordinate quantity and exact locations with HVAC/DDC contractors.

Unless otherwise specified, all electrical control devices such as aqua-stats, float and pressure switches, fan powered VAV boxes, switches, electro-pneumatic switches, solenoid valves and damper motors requiring mechanical connections shall be furnished and installed and wired by the Contractor supplying the devices.

All conduit penetrations to AHU's shall be sealed by electrical contractor. See Casing Penetrations in 23 73 13, 23 73 23 and 23 73 24 for exact requirements.

Each motor terminal box shall be connected with a minimum 12", maximum 36" piece of flexible PVC-coated metal conduit to a fixed junction box. When connections are located in Mechanical Plenum spaces located within Mechanical equipment, flexible metal conduit shall be utilized. Conduit must be installed perpendicular to direction of equipment vibration to allow conduit to freely flex.

All wiring shall be routed in conduit and a minimum of 12 AWG wire shall be used for all luminaires, switches and convenience outlets. All lighting, switches and convenience outlet circuits shall be a minimum of 20 amperes.

Check for proper rotation of each motor.

All heating, air conditioning and refrigeration equipment installed on the exterior of the building or rooftop shall have a 120V, single phase, 20 ampere rated outlet at an accessible location within 25 feet of the equipment.

EQUIPMENT CONNECTION SCHEDULE

As indicated on the drawings.

END OF SECTION

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SECTION 26 27 26
WIRING DEVICES
BASED ON DFD MASTER ELECTRICAL SPEC DATED 09/03/24

PART 1 - GENERAL

SCOPE
This section describes the products and execution requirements relating to furnishing and installing wiring devices and related systems for the project. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Submittals
- Operation and Maintenance Data

PART 2 - PRODUCTS
- Device Colors
- Device Plates and Box Covers
- Modularly Connected (Modular) Devices
- Wall Switches
- Receptacles
- Tamper-Resistant Receptacles
- Corrosion-Resistant Receptacles
- Motion Sensors (Occupancy and Vacancy)

PART 3 - EXECUTION
- Installation
- Field Quality Control
- Motion Sensors
- Adjusting

RELATED WORK
Applicable provisions of Division 1 govern work under this Section.

Section 01 91 01 or 01 91 02 – Commissioning Process

SUBMITTALS
Provide product data showing model numbers, configurations, finishes, dimensions, and manufacturer's instructions.

For motion sensor shop drawings, the manufacturer’s actual layout of motion sensors and the wiring diagrams shall be provided.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

PART 2 - PRODUCTS

DEVICE COLORS:
Device colors shall be selected by project architect’s interior designer and coordinated with Agency representative during shop drawing review.

DEVICE PLATES AND BOX COVERS
Decorative Cover Plate: 302/304 lined stainless steel.

Weatherproof Cover: All receptacles installed in wet locations shall have an enclosure that is weatherproof whether or not the attachment plug is inserted. Covers shall be gasketed metal with hinged “in-use” device covers, powder coat painted. Non-metallic covers are not allowed. Covers shall be latching type and shall be lockable. Covers shall be identified as “extra-duty” type per NEC 406.9(B)(1).

Damp Location Cover: All receptacles installed outdoors in a location protected from the weather or in other damp locations shall have an enclosure that is weatherproof when the receptacle is covered

(attachment plug not inserted and receptacle covers closed). Covers shall be gasketed metal with hinged device covers, powder coat painted. Non-metallic covers are not allowed.

Surface Cover Plate: Raised galvanized steel.

MODULARLY CONNECTED (MODULAR) DEVICES:
Modularly connected devices are allowed, but not required.

Modular Pigtailed Connector: Polarized connector with minimum six-inch stranded copper wire leads, polycarbonate right-angle housing, UL498 listed, with finger-safe connector housing which provides insulation from conductive surfaces. Contacts shall be brass. Connector shall be manufactured so that it provides a secure connection such that it will maintain contact with the device until the device is removed for replacement. Modular connectors shall be provided with covers which protect the contacts from paint, drywall mud, and construction dust and debris. Connectors shall be Hubbell SNAPConnect, Leviton Lev-Lok, Pass & Seymour PlugTail, or approved equal.

WALL SWITCHES
General: Heavy duty use toggle switch, rated 20 amperes and 120/277 volts AC. Switches shall be UL20 Listed and meet Federal Specification WS-896. All switches shall be heavy duty Specification Grade.

Handle: Made of nylon or high impact resistant material.

Wall Switches for Lighting Circuits and Motor Loads Under 1/2 HP: All switches shall be back- and side-wired, screw clamp type, suitable for solid or stranded wire up to #10 AWG, with separate green ground screw. Switches shall be as follows:

Hubbell 1221*,
Leviton 1221-S*,
Pass & Seymour CSB20AC1-*,
or approved equal. (* indicates color selection).

Modular Wall Switches for Lighting Circuits and Motor Loads Under 1/2 HP: Switches shall be as follows:

Hubbell SNAP1221*NA,
Leviton M1221-*,
Pass & Seymour PT20AC1-*,
or approved equal. (* indicates color selection).

RECEPTACLES
General Requirements: NEMA Type 5-20R, Nylon or high impact resistant face. Receptacles shall be UL498 Listed and meet Federal Specification WC-596. All duplex receptacles shall be heavy duty Specification Grade, 20 amp rated.

Generally, all receptacles shall be duplex convenience type unless otherwise noted.

All receptacles installed in bathrooms, kitchens, and within 6 feet of the outside edge of sinks shall be GFCI type.

All receptacles installed in outdoor locations, garages, rooftops, and in other damp or wet locations shall be GFCI type with a weather-resistant (WR) rating.

Convenience and Straight-blade Receptacles: All receptacles shall be back- and side-wired, screw clamp type, suitable for solid or stranded wire up to #10 AWG, with a separate green ground screw. Receptacles shall be as follows:

Hubbell 5362*,
Leviton 5362-S*,
Pass & Seymour 5362*,
or approved equal. (* indicates color selection).

GFCI Receptacles: Duplex convenience receptacle with integral ground fault current interrupter meeting the requirements of UL standard 943 Class A, including self-test functionality and reverse line-load misfire function repeatability. GFCI receptacles shall be as follows:

Hubbell GFR5362SG*,
Leviton GFNT2-*,
Pass & Seymour 2097*,

or approved equal. (* indicates color selection).

GFCI Receptacles with a weather-resistant (WR) rating: Weather-Resistant duplex convenience receptacle with integral ground fault current interrupter meeting the requirements of UL standard 943 Class-A, including self-test functionality and reverse line-load misfire function repeatability. WR GFCI receptacles shall be as follows:
Hubbell GFR5362SG*,
Leviton GFWR2-*,
Pass & Seymour 2097TRWR*,
or approved equal. (* indicates color selection).

Locking-Blade Receptacles: As indicated on drawings.

Specific-use Receptacle Configuration: As indicated on drawings.

Modular Convenience and Straight-blade Receptacles: Receptacles shall be as follows:
Hubbell SNAP5362*A,
Leviton M5362-S*,
Pass & Seymour PT5362*,
or approved equal. (* indicates color selection).

Modular GFCI Receptacles: Duplex convenience receptacle with integral ground fault current interrupter meeting the requirements of UL standard 943 Class A, including self-test functionality and reverse line-load misfire function repeatability. GFCI receptacles shall be as follows:
Hubbell GFRST83SNAP*,
Leviton MGFN2-*,
Pass & Seymour PT2097*,
or approved equal. (* indicates color selection).

Modular GFCI Receptacles with a weather-resistant (WR) rating: Use back- and side-wired devices in lieu of modular weather-resistant rated GFCI receptacles.

TAMPER-RESISTANT RECEPTACLES
Tamper-Resistant Convenience and Straight-blade Receptacles: Tamper-resistant receptacles shall be back- and side-wired, screw clamp type, suitable for solid or stranded wire up to #10 AWG, with a separate green ground screw. Receptacles shall be as follows:
Hubbell 8300*TR,
Leviton T5362-*,
Pass & Seymour TR5362*,
or approved equal. (* indicates color selection).

MOTION SENSORS (OCCUPANCY and VACANCY)
General Requirements:
All motion sensors shall be hardwired type; battery type shall not be permitted.

Sensors shall use either passive infrared, or if dual technology, passive infrared and passive acoustic sensing or passive infrared and ultrasonic sensing for detecting room motion.

Sensitivity shall be user adjustable or self-adjusting type.

The delay timer shall be adjusted within a range of 6 to 30 minutes by the contractor in the field. The sensor shall have a test mode for performance testing.

The test LED shall indicate motion.

Line voltage sensors are acceptable, especially in exposed ceiling areas where all wiring shall be installed in conduit, including low voltage cabling if power packs are used. Provide power pack as required for low voltage sensors.

See drawings for actual types of sensors.

Vacancy sensors shall allow for manual-ON and automatic-ON operation.

Motion sensors and power packs shall have five-year warranties.

Wall Mounted (Wall Switch Type): The unit shall fit in/on a standard single gang switch box.
Rated capacity: 600 watts minimum at 120 volts, 60 Hz; 1000 watts minimum at 277 volts, 60 Hz.
The sensor shall have two switches where dual-level lighting is required. The switch shall have manual override for positive OFF and automatic ON.
The area of coverage shall be approximately 180 degrees by 35-40 feet.

Ceiling Mounted: The unit shall fit in/on a standard octagon box. All ceiling mounted sensors shall be installed to a box with ring and box support.

The coverage area shall be 360 degrees by approximately 15 feet radius when mounted at 9-foot height. The sensor shall have provisions, such as masking, to block out problem areas.

Ceiling/Corner Mounted: The unit shall fit in/on a standard octagon box. All ceiling mounted sensors shall be installed to a box with ring and box support.

The coverage area shall be 90 degrees or greater by approximately 40 feet radius when mounted at 9-foot height. The sensor shall have provisions, such as masking, to block out problem areas.

Power Packs: Provide power packs as required for low voltage sensors. Rated capacity shall be 20 amps at 120 or 277 volts for fluorescent lamps.

The unit shall fit on a standard octagon box. All power packs shall be installed onto a supported box.

Low voltage cabling shall be plenum rated or installed in conduit in plenum-rated areas.

Auxiliary Contacts for HVAC Interlock: Provide auxiliary dry contacts for HVAC BAS interlock when required. Refer to the "Occ Sensor Interlock" column in the Air Terminal Schedule(s) on the HVAC drawings. When required, provide auxiliary contacts regardless if the motion sensors are line- or low-voltage.

The motion sensors and auxiliary contacts shall be wired such that the sensor still detects motion and controls the auxiliary contacts regardless if the light switch(es) are in the OFF position (e.g., the occupant has turned the lights OFF because there is enough daylight, but the occupant is still occupying the space, and the motion sensor senses the occupant and closes the auxiliary contacts for BAS input).

The BAS wiring to the auxiliary contacts shall be by the Division 23 contractor.

PART 3 - EXECUTION

INSTALLATION
Device installations shall be per ADA requirements.

See plans for device mounting heights.

Install wall switches with OFF position down.

Install convenience receptacles with grounding pole **ON TOP**.

Install specific-use receptacles at heights shown on Contract Drawings.
Install decorative plates on switch, receptacle, and blank outlets in finished areas.

Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface-mounted outlets.

Install devices and wall plates flush and level.

Receptacles shall have a bonding conductor from grounding terminal to the metal conduit system. Self-grounding receptacles using mounting screws as bonding means are not approved.

FIELD QUALITY CONTROL
Inspect each wiring device for defects.

Operate each wall switch and sensor with circuit energized, and verify proper operation.

Verify that each receptacle device is energized.

Test each receptacle device for proper polarity.

Test each GFCI receptacle device for proper operation.

The user agency and DFD personnel reserve the right to be present at all tests.

MOTION SENSORS

Provide a minimum of 4' of coiled cable for ceiling-mounted sensors.

Motion sensors shall be installed at locations indicated on the manufacturer's submittal layout drawings. Sensors shall be located to prevent false "ON" tripping of the lights.

Sensitivity Test: After the sensor has been energized for at least 15 minutes, walk to the middle of the room (if conference room), or sit at the normal desk position (if an office). Make no motion for 20 seconds. Move one arm up and down slowly. The test LED should blink.

Time Delay Test: Set the time delay for 10 minutes. Walk into the room to activate the sensor then leave room. Sensor must turn lights off at approximately 10 minutes. Walk into the room again to reactivate the lights. Lights should activate within 1 second.

ADJUSTING

Adjust devices and wall plates to be flush and level.

Mark all conductors with the panel and circuit number serving the device with a machine generated label, at the device, and on the back of the device cover.

TIMECLOCK OPERATION AND SCHEDULE

The timeclock (exhaust fan) will control an exhaust fan provided by the Division 23 contractor. Program the timelock for fan operation as follows:

Spring Season
Fan Dates: April 15th thru the Thursday before Memorial Day Weekend
Weekday Fan Hours (Mon thru Thurs): Fan On: 8am. Fan Off: 9pm
Weekend Fan Hours (Fri, Sat, Sun): Fan On: 7am. Fan Off: 10pm

Summer Season
Fan Dates: Thursday before Memorial Day Weekend thru Monday of Labor Day Weekend
Weekday Fan Hours (Mon thru Thurs): Fan On: 5am. Fan Off: 11pm
Weekend Fan Hours (Fri, Sat, Sun): Fan On: 5am. Fan Off: 11pm

Fall Season
Fan Dates: Tuesday After Labor Day Weekend to Building Close (Estimated Oct 15)
Weekday Fan Hours (Mon thru Thurs): Fan On: 8am. Fan Off: 9pm
Weekend Fan Hours (Fri, Sat, Sun): Fan On: 7am. Fan Off: 10pm

The fan operation schedule (including dates and hours) shall be confirmed with the Agency prior to building turnover.

END OF SECTION

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SECTION 26 27 28
DISCONNECT SWITCHES
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/21/22

PART 1 - GENERAL

SCOPE
The work under this section includes disconnect switches, fuses and enclosures. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- References
- Submittals
- Operation and Maintenance Data
- General

PART 2 - PRODUCTS
- Disconnect Switches
- Fuses

PART 3 - EXECUTION
- Installation
- Construction Verification Items

RELATED WORK
Applicable provisions of Division 1 govern work under this Section.

Section 26 27 02 - Equipment Wiring Systems
Section 26 08 00 - Commissioning of Electrical
Section 01 91 01 or 01 91 02 – Commissioning Process

REFERENCES
NECA (National Electrical Contractors Association) "Standard of Installation"
NEMA ICS 2 – Industrial Control Devices, Controllers, and Assemblies
NEMA KS 1 – Enclosed Switches
UL 50 – Enclosures for Electrical Equipment
UL 98 – Enclosed and Dead-front Switches

SUBMITTALS
Include outline drawings with dimensions, and equipment ratings for voltage, ampacity, horsepower, and short circuit.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

GENERAL
Provide disconnect switches for loads required by code. Review HVAC and Plumbing specifications to determine what equipment is furnished with disconnect switches. Install disconnect switches whether furnished under this contract or not. It is the Electrical Contractors responsibility to determine the need for a disconnect switch for each load. The contractors shall include in their bid the code required disconnect switches whether indicated on the drawings or not.

PART 2 - PRODUCTS

DISCONNECT SWITCHES
Fusible Switch Assemblies: NEMA Type Heavy Duty; quick-make, quick-break, load interrupter, enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Fuse Clips: designed to accommodate Class R, Class J or Class CC (motors) cartridge type fuses.

Nonfusible Switch Assemblies: NEMA Type Heavy Duty; quick-make, quick-break, load interrupter, enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

Enclosure:

Indoor: NEMA 1 code gauge steel with rust inhibiting primer and baked enamel finish.

Outdoors: NEMA 4X, 304 stainless steel with brushed finish, when indicated on drawings.

Corrosive Areas and Interior Damp/Wet locations: NEMA 4X, 304 stainless steel with brushed finish. Provide manufacturer's equipment ground kit in all disconnect switches.

In applications where the switch serves as the service entrance disconnect, provide service ground kit, label as service disconnect and provide UL listing for service disconnect.

FUSES

Fuses 600 Amperes and Less: Dual element, time delay, 250 volt, UL Class RK 1Interrupting Rating: 200,000 rms amperes.

Fuses 30 Amperes and less: Time-Delay, 600 volt, UL Class CC. Interrupting rating: 200,000 rms amperes.

Provide three (3) spares of each size and type fuse.

Provide cabinet/enclosure for spare fuses sized to accommodate all required spare fuses for entire facility. Cabinet shall have hinged and latched cover. Label cabinet "Spare Fuses". Locate cabinet in main electrical room.

PART 3 - EXECUTION

INSTALLATION

Install disconnect switches where indicated on Drawings or required by NEC.

Provide identification as specified in Section 26 05 53.

Provide label on inside of disconnect cover identifying the type and size of fuse to be utilized.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01 or 01 91 02.

END OF SECTION

SECTION 26 51 00
INTERIOR LIGHTING
BASED ON DFD MASTER ELECTRICAL SPEC DATED 09/03/24

PART 1 – GENERAL

SCOPE
The work under this section includes interior luminaires and accessories, exit signs, and building-mounted exterior lighting. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference Standards
- Submittals
- Operation and Maintenance Data
- Extra Materials
- Definitions

PART 2 - PRODUCTS
- Interior Luminaires and Accessories
- Prohibited Lamp Types
- LED Luminaires
- LED Drivers

PART 3 - EXECUTION
- Installation
- Adjusting and Cleaning
- Interface with Other Products
- Field Quality Control
- Luminaire Connections
- Construction Verification Items
- Agency Training

RELATED WORK
Applicable provisions of Division 1 govern work under this Section.

Section 01 91 01 or 01 91 02 – Commissioning Process
Section 26 08 00 – Commissioning of Electrical
Section 26 27 26 – Wiring Devices

REFERENCE STANDARDS
IEEE 1789 – Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers.
RoHS – Restriction of Hazardous Substances. Council of the European Union (EC) Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment.
LM-79-08 (or latest) – IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.
LM-80-08 (or latest) – IES Approved Method for Measuring Lumen Maintenance of LED Light Sources.
TM-21-11 (or latest) – IES Technical Memorandum on Projecting Long Term Lumen Maintenance of LED Light Sources.
NEMA SSL 1-2010 (or latest) – Electronic Drivers for LED Devices, Arrays, or Systems.

SUBMITTALS
Include outline drawings, lamp and ballast data, support points, weights, accessory information and performance data for each luminaire type.

For each luminaire type, submit luminaire information including catalog cuts with highlighted catalog numbers and required accessories:

- Luminaire:
  - Manufacturer and catalog number,
  - Type (identification) as indicated on the plans and schedule,

    - Delivered lumens,
    - Input watts,
    - Efficacy,
    - Color rendering index.
- Driver:
    - Manufacturer and catalog number,
    - Type (Non-Dimming, Step-dimming, Continuous dimming, etc.),
    - Power Factor, Crest Factor, THD, etc.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

EXTRA MATERIALS
Provide one (1) of each type of luminaire.

Provide one (1) LED driver of each type.

DEFINITIONS
Driver: The power supply used to power LED luminaires, modules, or arrays.

L70, $L_{70,}$ or $L_{70\%}$: The reported life of an LED component or system to reach 70% lumen maintenance, or 70% of the LED's original light output.

LED's: Broadly defined as complete luminaire with light emitting diode (LED) packages, modules, light bars or arrays, complete with driver.

LED luminaire failure: Negligible light output from more than 10 percent of the LEDs, or less than 70 percent of the listed lumen output constitutes luminaire failure.

PART 2 - PRODUCTS

INTERIOR LUMINAIRES AND ACCESSORIES
See the Luminaire Schedule on the drawings for types of luminaires and catalog numbers. Catalog numbers are shown on the drawings for quality and performance requirements only. Luminaires manufactured by others are equally acceptable provided they meet or exceed the performance of the indicated luminaires and meet the intent of the design.

Luminaire shall be listed by a NRTL (Nationally Recognized Testing Laboratory: e.g. UL, ETL, etc.).

Provide luminaires with quick-connect disconnecting means similar to Thomas & Betts Sta-Kon.

PROHIBITED LAMP TYPES
Fluorescent, metal halide, high-pressure sodium, low-pressure sodium, mercury vapor, halogen, and incandescent lamp types are prohibited.

General Use Incandescent Lamps and Incandescent Reflector Lamps are also prohibited. Use LED retrofit lamps or LED luminaires in lieu of fluorescent, incandescent, or halogen lamps. LED fluorescent replacement lamps shall be line-voltage compatible or compatible with the existing ballast type as coordinate with facility staff and DFD.

LED retrofit lamps shall be:
- Rated for the voltage of the incandescent lamp/luminaire they are replacing.
- Dimmable where required as indicated on the plans.
- Rated for the luminaire in which they are being installed. Verify whether the luminaire is enclosed and whether the LED retrofit lamp is rated for enclosed luminaires and the temperatures that will be encountered.
- LED lamps/luminaires shall provide delivered footcandles equal to or greater than the footcandles provided by an equivalent incandescent lamp/luminaire.
- LED retrofit lamps shall have an average rated life of 25,000 hours, minimum.
- Lamp color temperature shall be nearly equal to the incandescent lamp it is replacing.

All lamps shall be new.

LED LUMINAIRES

- LED Luminaires shall meet all DesignLights Consortium® (DesignLights.org) Product Qualification Criteria. This does not require that the luminaire be listed on the DesignLights Consortium's® Qualified Products List, but they must meet the Product Qualification Criteria. The technical requirements that the luminaire shall meet for each Application Category are:
    - Minimum Light Output.
    - Zonal Lumen Requirements.
    - Minimum Luminaire Efficacy.
    - Minimum CRI.
    - L70 Lumen Maintenance.
    - Minimum Luminaire Warranty of 5 years (not pro-rated) to include LED driver and all LED components.

Additional requirements:

- Color Temperature of 3000K-4100K for interior luminaires as listed in the Luminaire Schedule on the plans. The color temperature of exterior LED luminaires should not exceed 4100K (nominal).
- Color Consistency: LED manufacturer shall use a maximum 3-step MacAdam Ellipse binning process to achieve consistent luminaire-to-luminaire color for interior luminaires. Exterior luminaires shall use a maximum 5-step MacAdam Ellipse binning process.
- Glare Control: Exterior luminaires shall meet DesignLights Consortium's® criteria for Zonal Lumen Distribution requirements or Backlight-Uplight-Glare (BUG) standards for exterior luminaires.
- Luminaire shall be mercury-free, lead-free, and RoHS compliant.
- Luminaire shall comply with FCC 47 CFR part 15 non-consumer RFI/EMI standards.
- Light output of the LED system shall be measured using the absolute photometry method following IES LM-79 and IES LM-80 requirements and guidelines.
- Luminaire shall maintain 70% lumen output (L70) for a minimum of 50,000 hours.
- Lumen output shall not depreciate more than 20% after 10,000 hours of use.
- Luminaire and driver shall be furnished from a single manufacturer to ensure compatibility.
- Luminaire Color Rendering Index (CRI) shall be a minimum of 80 for interior luminaires, and a minimum of 70 for exterior luminaires.
- LED luminaire shall be thermally designed as to not exceed the maximum junction temperature of the LED for the ambient temperature of the location the luminaire is to be installed. Rated case temperature shall be suitable for operation in the ambient temperatures typically found for the intended installation. Exterior luminaires to operate in ambient temperatures of -40°F to 104°F (-40°C to 40°C).
- Luminaire shall operate normally for input voltage fluctuations of plus or minus 10 percent.
- Luminaire shall have a maximum Total Harmonic Distortion (THD) of $\leq$20% at full input power and across specified voltage range.
- All connections to luminaires shall be reverse polarity protected and provide high voltage protection in the event connections are reversed or shorted during the installation process.
- All luminaires shall be provided with knockouts for conduit connections.
- The LED luminaire shall carry a limited 5-year warranty minimum for LED light engine(s)/board array, and driver(s).
- Provide all of the following data on submittals:
    - Delivered lumens
    - Input watts
    - Efficacy
    - Color rendering index.

LED DRIVERS

General:

- Provide driver type (non-dimmed, step-dimmed, continuous-dimming, etc.) as indicated on the luminaire schedule on the drawings.
- Minimum Warranty of 5 years (not pro-rated) to include LED driver and all LED components.
- Driver shall have a rated life of 50,000 hours, minimum.
- Driver and LEDs shall be furnished from a single manufacturer to ensure compatibility.
- Driver shall modulate current at high frequencies.
- Driver shall have a minimum power factor (pf) of 0.9 and a maximum crest factor (cf) of 1.5 at full input power and across specified voltage range.
- Driver shall operate normally for input voltage fluctuations of plus or minus 10 percent.

- Driver shall have a maximum Total Harmonic Distortion (THD) of ≤20% at full input power and across specified voltage range.
- Wiring connections to LED drivers shall utilize polarized quick-disconnects for field maintenance.
- Fuse Protections: All luminaires shall have built-in fuse protection. All power supply outputs shall be either fuse protected or be Polymeric Positive Temperature Coefficient (PTC)-protected as per Class 2 UL listing.
- Provide all of the following data on submittals:
    - Input watts
    - Power Factor (pf)
    - Crest Factor (cf) at full input power
    - Total Harmonic Distortion (THD).

PART 3 - EXECUTION

INSTALLATION

Verify ceiling types with Architectural plans or with existing ceilings. Verify specified luminaires are compatible with specified ceiling type(s) prior to ordering luminaires.

Install in accordance with manufacturer's instructions.

Install suspended luminaires using aircraft cable, or pendants supported from swivel hangers. Heavy duty chain supports may be used where indicated on the luminaire schedule. Provide aircraft cable, pendants, or chain lengths required to suspend luminaire at indicated height. All aircraft cables or pendant supported luminaires shall have an independent support to structure at all cable or pendant support locations. When chain is used, tie-wrap the luminaire wiring method to the chain.

Support luminaires larger than 2 x 4 foot (600 x 1200 mm) size independent of ceiling framing.

Provide independent support for all luminaires over 50 lbs.

Locate ceiling luminaires as indicated on reflected ceiling plan.

Install surface mounted luminaires and exit signs plumb and adjust to align with building lines and with each other. Secure to prohibit movement.

The Contractor shall install luminaire supports as required. Luminaire installations with luminaires supported only by insecure boxes will be rejected. It shall be the Contractor's responsibility to support all luminaires adequately, providing extra steel work for the support of luminaires if required. Any components necessary for mounting luminaires shall be provided by the Contractor. No plastic, composition or wood type anchors shall be used.

Install recessed luminaires to permit removal from below.

Install recessed luminaires using accessories and firestopping materials to meet regulatory requirements for fire rating.

Install code required hardware to secure recessed grid-supported luminaires in place.

Install wall mounted luminaires and exit signs at height as scheduled. Use pendants supported from swivel hangers in exposed ceiling/structure locations where necessary to mount exit signs at the specified height.

Install accessories furnished with each luminaire.

Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within luminaire.

Bond luminaires and metal accessories to branch circuit equipment grounding conductor.

Install specified lamps in each luminaire and exit sign.

All new luminaires shall be operational at the Substantial Completion of the project.

ADJUSTING AND CLEANING
Align luminaires and clean lenses and diffusers at completion of Work. Clean paint splatters, dirt, and debris from installed luminaires.

Aim and adjust luminaires as indicated on Drawings or as directed by the A/E.

Touch up luminaire finish at completion of work.

INTERFACE WITH OTHER PRODUCTS
Interface with air handling accessories furnished and installed under Division 23.

Provide controls as indicated on the plans. Refer to section 26 27 26 - Wiring Devices. Controls shall be compatible with the luminaires/drivers being installed.

FIELD QUALITY CONTROL
Operate each luminaire after installation and connection. Inspect for proper connection and operation.

LUMINAIRE CONNECTIONS
METAL-CLAD (MC) CABLE WHIPS
Metal-Clad (MC) type cable that combines power and Class 2 circuits into a single cable may be used for luminaire whips where 0-10V dimming control wiring is required. Whips may not exceed six (6) feet in length. Examples of such products are Encore Wire® MC-LED™ or Southwire® MC-PCS Duo™. Manufacturer's names and catalog numbers are used for quality and performance only. MC Cables manufactured by others shall be equally acceptable provided they meet or exceed in performance and quality as specified.

Recessed, including Master-Satellite connections:

- Use a luminaire fixture whip from a J-box for recessed lay-in luminaires. Luminaire fixture whips shall be aluminum or steel AC Cable (Armored Cable) or Flexible Metal Conduit (FMC). Metal Clad (MC) cable that combines power and Class 2 circuits (for 0-10V dimming control) into a single cable may be used as a whip for luminaires that are dimmed.
- Cable/Conduit whips shall be 3/8" (10 mm) minimum diameter, six feet (1.8 m) maximum length.
- Flexible whips or pre-wired systems between master and satellite luminaires may be supported by the ceiling grid wires.
- The flexible connectors shall be steel, galvanized, clamp type with locknut, snap-in type with locknut, or snap-in connector type, including those used on the master-satellite units.

Chain or Cable Hung (unfinished spaces):

- Use manufacturer’s SO cord or a luminaire fixture whip from a J-box. Luminaire fixture whips shall be aluminum or steel AC Cable (Armored Cable) or Flexible Metal Conduit (FMC). Metal Clad (MC) cable that combines power and Class 2 circuits (for 0-10V dimming control) into a single cable may be used as a whip for luminaires that are dimmed.
- Conduit whips shall be 3/8" (10 mm) minimum diameter. Conduit whip or SO cord shall be cut to length (six feet (1.8 m) maximum) and shall allow movement of the chain/cable/luminaire, but shall not be long enough to “loop” and shall present a neat and workmanlike appearance.
- Luminaire field wired flexible cord installations shall be connected per NEC 410.62.
- The flexible connectors shall be steel, galvanized, clamp type with locknut, snap-in type with locknut, or snap-in connector type, including those used on the master-satellite units.
- Conduit whip slack shall be tie-wrapped to the chain supports. Tie-wraps shall be UL listed for UV resistance.

Cable Hung (finished spaces):

- Use manufacturer’s SO cord from luminaire to a J-box.
- SO cord shall be cut to length (six feet (1.8 m) maximum) and shall allow movement of the cable/luminaire, but shall not be long enough to “loop” and shall present a neat and workmanlike appearance.
- SO cord slack may be tie-wrapped to the cable supports. Tie-wraps shall be UL listed for UV resistance.
- Luminaire field wired flexible cord installations shall be connected per NEC 410.62.

Surface Mounted (unfinished spaces):

- Provide direct conduit and box connection.

Surface Mounted (finished spaces):

- Provide direct conduit and box connection. Use surface metal raceway where indicated on drawings. Conceal box and conduit where appropriate. Flexible metal conduit shall not be used where the conduit is exposed.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01 or 01 91 02.

AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01 or 01 91 02.

END OF SECTION

SECTION 26 56 29
SITE LIGHTING
BASED ON DFD MASTER ELECTRICAL SPEC DATED 09/03/24

PART 1 - GENERAL

SCOPE

The work under this section includes exterior luminaires and accessories, poles, and foundations. Also included are the following topics:

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

Section 01 91 01 or 01 91 02 – Commissioning Process
Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
Section 26 08 00 – Commissioning of Electrical

REFERENCE STANDARDS

Wisconsin Administrative Code SPS 362.1807 Shallow Post Foundations.
International Building Code IBC 1807.3 Embedded Posts and Poles.
IEEE 1789 – Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers.
RoHS – Restriction of Hazardous Substances. Council of the European Union (EC) Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment.
LM-79-08 (or latest) – IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.
LM-80-08 (or latest) – IES Approved Method for Measuring Lumen Maintenance of LED Light Sources.
TM-21-11 (or latest) – IES Technical Memorandum on Projecting Long Term Lumen Maintenance of LED Light Sources.
NEMA SSL 1-2010 (or latest) – Electronic Drivers for LED Devices, Arrays, or Systems.

DEFINITIONS

Driver: The power supply used to power LED luminaires, modules, or arrays.

L70, $L_{70,}$ or $L_{70\%}$: The reported life of an LED component or system to reach 70% lumen maintenance, or 70% of the LEDs original light output.

LEDs: Broadly defined as complete luminaire with light emitting diode (LED) packages, modules, light bars, or arrays, complete with driver.

LED luminaire failure: Negligible light output from more than 10 percent of the LEDs, or less than 70 percent of the listed lumen output constitutes luminaire failure.

SUBMITTALS

Shop Drawings: Indicate dimensions and components for each luminaire, pole, and base.

Product Data:

For each luminaire type, submit luminaire information including catalog cuts with highlighted catalog numbers, and required accessories:

- Luminaire:
  - Manufacturer and catalog number,
  - Type (identification) as indicated on the plans and schedule,
  - Delivered lumens,
  - Input watts,
  - Efficacy,
  - Color rendering index,
  - Performance data, and
  - Effective Projected Area (EPA).
- Driver:
  - Manufacturer and catalog number,
  - Type (Non-Dimming, Step-dimming, Continuous dimming, etc.),
  - Power Factor, Crest Factor, THD, etc.
- Pole (if applicable):
  - Diameter
  - Height
  - Pole thickness
  - Weight

Manufacturer's Instructions:

Indicate application conditions and limitations of use stipulated by product testing agency specified under "Regulatory Requirements".

Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

Light Layout: Provide a computer-generated factory point-by-point foot-candle layout of the project for each area involved.

Post Installation Report: Provide to the Engineer and DFD the results of the measured foot-candle level for each area involved. Use a measuring device pre-approved by DFD.

PROJECT RECORD DOCUMENTS

Accurately record actual locations of each luminaire, pole, and underground circuit.

Provide record drawings of the final, as installed and measured, point-by-point foot-candle layout for each area involved.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

COORDINATION

Use bolt templates and pole mounting accessories to install anchor bolts in pole base.

EXTRA MATERIALS

Provide one (1) of each type of LED module, light bar, or array (if applicable). If the LEDs are integrated into the luminaire and are not separate components, then provide one (1) of each of these types of luminaires.

Provide one (1) LED driver of each type.

Provide five (5) percent of total fuses provided for each size, but not less than one (1) of each size.

PART 2 - PRODUCTS

LUMINAIRES

See the Luminaire Schedule on the drawings for type of luminaires and catalog numbers. Catalog numbers are shown on the drawings for quality and performance requirements only. Luminaires manufactured by others are equally acceptable provided they meet or exceed the performance of the indicated luminaires and meet the intent of the design.

Luminaire shall be certified by a Nationally Recognized Testing Laboratory (UL, ETL, or IEC).

Provide luminaires with quick-connect disconnecting means, similar to Thomas & Betts Sta-Kon.

LED LUMINAIRES

- LED Luminaires shall meet all DesignLights Consortium® (DesignLights.org) Product Qualification Criteria. This does not require that the luminaire be listed on the DesignLights Consortium's® Qualified Products List, but they must meet the Product Qualification Criteria. The technical requirements that the luminaire shall meet for each Application Category are:
    - Minimum Light Output.
    - Zonal Lumen Requirements.
    - Minimum Luminaire Efficacy.
    - Minimum CRI.
    - L70 Lumen Maintenance.
    - Minimum Luminaire Warranty of 5 years (not pro-rated) to include LED driver and all LED components.

Additional requirements:

- Color Temperature of 3000K-4100K for interior luminaires as listed in the Luminaire Schedule on the plans. The color temperature of exterior LED luminaires should not exceed 4100K (nominal).
- Color Consistency: LED manufacturer shall use a maximum 3-step MacAdam Ellipse binning process to achieve consistent luminaire-to-luminaire color for interior luminaires. Exterior luminaires shall use a maximum 5-step MacAdam Ellipse binning process.
- Glare Control: Exterior luminaires shall meet DesignLights Consortium's® criteria for Zonal Lumen Distribution requirements or Backlight-Uplight-Glare (BUG) standards for exterior luminaires.
- Luminaire shall be mercury-free, lead-free, and RoHS compliant.
- Luminaire shall comply with FCC 47 CFR part 15 non-consumer RFI/EMI standards.
- Light output of the LED system shall be measured using the absolute photometry method following IES LM-79 and IES LM-80 requirements and guidelines.
- Luminaire shall maintain 70% lumen output (L70) for a minimum of 50,000 hours.
- Lumen output shall not depreciate more than 20% after 10,000 hours of use.
- Luminaire and driver shall be furnished from a single manufacturer to ensure compatibility.
- Luminaire Color Rendering Index (CRI) shall be a minimum of 80 for interior luminaires, and a minimum of 70 for exterior luminaires.
- LED luminaire shall be thermally designed as to not exceed the maximum junction temperature of the LED for the ambient temperature of the location the luminaire is to be installed. Rated case temperature shall be suitable for operation in the ambient temperatures typically found for the intended installation. Exterior luminaires to operate in ambient temperatures of -40°F to 104°F (-40°C to 40°C).
- Luminaire shall operate normally for input voltage fluctuations of plus or minus 10 percent.
- Luminaire shall have a maximum Total Harmonic Distortion (THD) of $\leq$20% at full input power and across specified voltage range.
- All connections to luminaires shall be reverse polarity protected and provide high voltage protection in the event connections are reversed or shorted during the installation process.
- All luminaires shall be provided with knockouts for conduit connections.
- The LED luminaire shall carry a limited 5-year warranty minimum for LED light engine(s)/board array, and driver(s).
- Provide all of the following data on submittals:
    - Delivered lumens
    - Input watts
    - Efficacy

- Color rendering index.

LED Luminaires used for Emergency Egress Lighting:

- The failure of one LED shall not affect the operation of the remaining LEDs.

LED DRIVERS

General:

- Provide driver type (non-dimmed, step-dimmed, continuous-dimming, etc.) as indicated on the luminaire schedule on the drawings.
- Minimum Warranty of 5 years (not pro-rated) to include LED driver and all LED components.
- Driver shall have a rated life of 50,000 hours, minimum.
- Driver and LEDs shall be furnished from a single manufacturer to ensure compatibility.
- Driver shall modulate current at high frequencies.
- Driver shall have a minimum power factor (pf) of 0.9 and a maximum crest factor (cf) of 1.5 at full input power and across specified voltage range.
- Driver shall operate normally for input voltage fluctuations of plus or minus 10 percent.
- Driver shall have a maximum Total Harmonic Distortion (THD) of $\leq$20% at full input power and across specified voltage range.
- Wiring connections to LED drivers shall utilize polarized quick-disconnects for field maintenance.
- Fuse Protections: All luminaires shall have built-in fuse protection. All power supply outputs shall be either fuse protected or be Polymeric Positive Temperature Coefficient (PTC)-protected as per Class 2 UL listing.
- Provide all of the following data on submittals:
  - Input watts
  - Power Factor (pf)
  - Crest Factor (cf) at full input power
  - Total Harmonic Distortion (THD).

WIRING CONNECTORS

Wiring Connectors shall meet the requirements of Section 26 05 19 Low-Voltage Electrical Power Conductors and Cables.

Twist-On Wire Connectors: Solderless twist-on spring connectors (wire-nuts) with insulating covers for copper wire splices and taps. All wire connectors used in site lighting applications shall be silicone gel-filled twist connectors or connectors designed for damp and wet locations. Gel-filled twist-on connectors may be used for copper conductor sizes 6 AWG and smaller for site lighting applications. The manufacturer's wire fill capacity must be followed.

POLES

Furnish products as specified in schedule on Drawings.

Handhole: With removable weatherproof cover.

Anchor Bolts: As recommended by pole manufacturer. Provide template, flat washers, lock washers, and hex nuts for each pole.

FOUNDATIONS

Provide foundations for poles, bollards, and ground-mounted flood and accent lighting. Construct from reinforced concrete in sizes as shown on drawings and to meet the minimum structural requirements of SPS 362.1807 Shallow Post Foundations, and IBC 1807.3 Embedded Posts and Poles.

Place the anchor bolts in pole bases so that the luminaire will be oriented perpendicular to the curb/street/sidewalk/parking lot or as indicated on the plan.

Provide a concrete-encased electrode (UFER) grounding system for grounding the foundation, luminaire, and pole:

1. Provide twenty-five (25) feet of #4 bare stranded copper grounding electrode conductor.
2. Extend three (3) feet of the grounding electrode conductor out the top of the foundation for connection to the luminaire/pole.
3. Clamp the grounding electrode conductor to the top of the rebar cage. Use a clamp rated for such use such as an Erico EK16 or similar.
4. Spiral a minimum of ten (10) feet of the grounding electrode conductor around the outside of the rebar cage.

5. Loop the remaining conductor around the rebar cage at the bottom of the foundation in direct contact with earth.

The exposed surface area of the foundation shall have the forms removed and the concrete rubbed out to a smooth finish.

Pole Base J-Boxes
For pole bases with multiple conduits to other poles/locations, the contractor may provide a non-metallic j-box with a curved cover mounted in the side of the exposed part of the base to accommodate the multiple conduits. Boxes shall be NEMA 3R Carlon Nonmetallic Curved Lid J-Boxes or equal. Mount j-box centered at 20" above grade. Use only in poles 18" in diameter and larger. Locate boxes 90-degrees or 180-degrees from traffic. Install boxes per manufacturer's recommendations.

PART 3 - EXECUTION

INSTALLATION
Install in accordance with manufacturers' instructions.

Minimum underground conduit size is 1 inch.

Underground and exterior wire shall be minimum #10 AWG conductors, type XHHW-2 or USE-2. Number 10 AWG conductors shall be utilized for vertical wire installed within pole and for overall circuit lengths of less than 100 LF.

Protect anchor bolts 2 inches (50 mm) minimum above base.

Install all anchor bolts and handhole fasteners with anti-seize compound.

Install poles plumb. Provide shims or double nuts to adjust plumb.

Use belt slings or non-chafing ropes to raise and set pre-finished luminaire poles.

Bond each luminaire, each metal accessory, the UFER ground conductor and the pole to the branch circuit equipment ground conductor with a separate ground wire sized per NEC or as shown on the drawings.

Dimmed luminaire circuits shall have separate neutrals.

Dimmed luminaires shall have a positive OFF, which requires turning off the circuit to the luminaire so that the luminaires don't "glow" at the lowest dimmed setting. This shall be accomplished using a switch, relay, or some other means acceptable to DFD.

FIELD QUALITY CONTROL
Operate each luminaire after installation and connection. Inspect for improper connections and operation.

ADJUSTING
Aim and adjust luminaires as indicated on Drawings or as directed by the A/E.

All new luminaires shall be operational at the Substantial Completion of the project.

CLEANING
Clean photometric control surfaces.

Clean finishes and touch up damage.

CONSTRUCTION VERIFICATION
Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01 or 01 91 02.

AGENCY TRAINING
All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01 or 01 91 02.

END OF SECTION

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SECTION 26 60 00
ELECTRIC HEATING CABLES

PART 1 - GENERAL

SCOPE
The work under this section includes electric heating cables and accessories. Included are the following topics:

SECTION INCLUDES
Heating cable.

PERFORMANCE REQUIREMENTS
Pipe Trace Heating: Freeze protection with outside temperature at 32 degrees F, zero degrees C.

Basis of design is Raychem Icestop GM-XT.

SUBMITTALS
Shop Drawings: Indicate heating cable layout, locations of terminations, thermostats, and branch circuit connections.

Product Data: Provide data for heating cable and control components.

Manufacturer's Installation Instructions: Indicate installation instructions.

PROJECT RECORD DOCUMENTS
Submit under provisions of Section 01 70 00.

Accurately record actual locations of heating cable, temperature sensors, thermostats, and branch circuit connections.

OPERATION AND MAINTENANCE DATA
Submit under provisions of Section 01 70 00.

Operation Data: Include description of operating controls.

Maintenance Data: Include repair methods and parts list of components.

QUALIFICATIONS
Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years experience.

PRE-INSTALLATION CONFERENCE
Convene one week prior to commencing work of this Section, under provisions of

Require attendance of parties directly affecting the work of this Section.

Review sequencing of installation, protection from damage of finished installation, location of expansion and control joints in building and methods used for covering installations with insulation.

COORDINATION
Coordinate Work under provisions of Section 01 30 00.

Coordinate installation of heating cable with installation of roofing and gutters, piping, and piping insulation.

PART 2 - PRODUCTS

MANUFACTURERS
Raychem
Chromalox
Danfoss

Substitutions: Under provisions of Section 01 63 00.

HEATING CABLE
Pipe Heating and Roof Drains: XLTrace 5, 8, 12 watts per foot

Roof and Gutter: Icestop GM-XT 12 watts per foot

Self-Regulating Conductive Core.

Thermoplastic inner Elastomer jacket, Metal braid and outer over jacket.

Rating: 120-277V

ACCESSORIES
Thermostat: Digitrace ECW-GF.

Power connection kit: Rayclic-PC

End seal kit: Rayclic-E

Downspout hangers: GMK-RAKE

Roof Clips: GMK-RC

Application tape for pipes: GT66

Labels: ETL –English (required every 10’ by NEC) and other items required by the manufacturer for installation.

PART 3 – EXECUTION

EXAMINATION
Verify that piping is ready to receive work.

Verify field measurements are as shown on shop drawings.

Verify that required utilities are available, in proper location, and ready for use.

Beginning of installation means installer accepts conditions.

INSTALLATION

Install in accordance with manufacturer's instructions.

Bending Radius: Six times cable diameter, minimum.

Avoid pinching and making sharp bends in cable.

Prevent damage by sharp rocks, metal, or other objects during installation.

Do not install heating cable across expansion or construction joints.

Installation on Roof: Do not begin until roofing work is complete. Route and fasten cable in accordance with manufacturer's instructions. Select and install cable based on maximum safe temperature for materials used.

FIELD QUALITY CONTROL

Field inspection and testing will be performed under provisions of Section 01 40 00.

Test continuity of heating cable.

Measure insulation resistance to manufacturer's recommended values. When delivered prior to installation, after installation. Test at 500, 100, 2500V DC

Measure voltage and current at each unit.

Submit written test report showing values measured on each test for each cable.

DEMONSTRATION

Provide systems demonstration under provisions of Section 01 79 00.

Demonstrate operation of heating cable controls.

END OF SECTION

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SECTION 32 31 29
WOOD FENCES AND GATES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Wood fencing.

B. Wood gate.

C. Excavation for posts.

1.02 RELATED SECTIONS

A. Section 03 30 00 - Cast-in-Place Concrete.

1.03 REFERENCES

A. ASTM C 94 - Standard Specification for Ready-Mixed Concrete.

B. ASTM C 177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.

C. ASTM D 143 - Standard Test Methods for Small Clear Specimens of Timber.

D. ASTM D 198 - Standard Test Methods of Static Tests of Lumber in Structural Sizes.

E. ASTM D 1037 - Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials.

F. ASTM D 1413 - Standard Test Method for Wood Preservatives by Laboratory Soil-Block Cultures.

G. ASTM D 1761 - Standard Test Methods for Mechanical Fasteners in Wood.

H. ASTM D1929 - Standard Test Method for Determining Ignition Temperature of Plastics.

I. ASTM D 2047 - Standard Test Method for Static Coefficient of Friction of Polish-Coated Flooring Surfaces as Measured by the James Machine.

J. ASTM D2394 - Standard Methods for Simulated Service Testing of Wood and Wood-Base Finish Flooring.

K. ASTM D 2395 - Standard Test Methods for Specific Gravity of Wood and Wood-Based Materials.

L. ASTM D 4761 - Standard Test Methods for Mechanical Properties of Lumber and Wood-Base Structural Material.

M. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

N. ASTM F 1679 - Standard Test Method for Using a Variable Incidence Tribometer (VIT).

O. American Wood Preservers Association (AWPA) E1-06 - Standard Method for Laboratory Evaluation to Determine Resistance to Subterranean Termites.

1.04 SUBMITTALS

A. Product Data: Manufacturer's data sheets on each product to be used indicating sizes, profiles, surface finishes, and performance characteristics, and including:
   1. Preparation instructions and recommendations.
   2. Storage and handling requirements and recommendations.
   3. Installation methods.
   4. Instructions on care and cleaning of composite wood products.

B. Verification Samples: For each finish product specified, two samples, minimum size 9 inches square, representing actual product, color, and patterns.

C. Manufacturer's Certificates: Certify products meet or exceed specified requirements.

D. Closeout Submittals: Provide manufacturer's maintenance instructions that include recommendations for cleaning and maintenance.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store and handle products in accordance with the manufacturer's instructions.

B. Store level and flat, off ground or floor, with supports at each end and maximum 24 inches on center.

C. Do not stack wood composite over 8 feet high.

D. Cover wood composite with waterproof covering, vented to prevent moisture buildup.

1.06 WARRANTY

A. Provide manufacturer's 25 year residential warranty / 10 year commercial warranty providing coverage against checking, splitting, splintering, rotting, structural damage from termites, and fungal decay of wood composite.

PART 2 PRODUCTS

2.01 COMPONENTS

A. Fence System: See detail in the A80? series of drawings.
   1. Components:
      a. Fence posts: Redwood. Straight grain and true to line within 1/4 inch over the length of the post.
      b. Wood Slats: Cedar, Grade 1, Rough sawn.

2.02 ACCESSORLES

A. Hardware:
   1. Finish: Galvanized with Black Coating.
   2. Basis of design products:
      a. Manufacturer: Hoover Fence Company.
         1) Hinge Assembly: 24 inch long strap with hinge slot, 8 inch L bolt, post mounting plate for L bolt. Item # 8324-S24P.
            (a) Carriage Bolt Fasteners, Black.
         2) Horizontal Latch: Padlockable Cane Bolt and Keeper Item # 5000-12SP & 5000-00SP.
         3) Vertical Cane Bolt: Canebolt that latches gate to ground. Item # 5000-36SP.
   3. Comparable, listed by manufacturer for 6 foot long gate, by:
      a. National Hardware: www.national-hardware.com.
      b. Crown Industrial: www.crown-industrial.com.

B. Fasteners: 1-5/8 inch galvanized or corrosion-resistant coated steel. Provide finish nails where applicable.

C. Concrete: Bagged Post Mix, minimum 2500 PSI compressive strength at 28 days, with a 3 to 5 inch slump.

D. Gate Hardware:
   1. Provide two Trex hinges per gate leaf minimum, and size to gate weight and conditions.
   2. Provide center gate stop.
   3. Latching hardware as scheduled in 08 71 00.

PART 3 EXECUTION

3.01 EXAMINATION

A. Do not begin installation until substrates have been properly prepared.

B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.02 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.03 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Cut and drill wood composite using carbide tipped blades.

C. Space posts maximum 8 feet on center.

D. Drill post holes into undisturbed or compacted soil; excavate deeper in soft or loose soils and for posts with heavy lateral loads.

E. Drill posts to 12 inch diameter. Locate bottom of post 30 inches below grade or below frost line whichever is greater.

F. Place top of concrete flush with finished grade.

G. Assemble to match detail on drawings.

3.04 CLEANING

A. Clean wood composite to remove stains:

1. Mold, mildew, and berry and leaf stains: Clean surfaces with conventional deck wash containing detergent or sodium hypochlorite.
2. Rust and ground-in dirt: Clean surfaces with cleaner containing oxalic or phosphoric acid.
3. Oil and grease: Clean surfaces with detergent containing degreasing agent.

3.05 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION

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