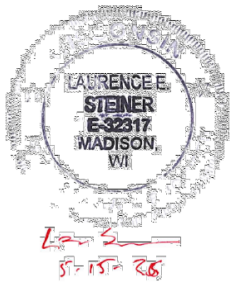
VARIOUS ENERGY UPGRADES
WISCONSIN MILITARY ACADEMY
DEPARTMENT OF MILITARY AFFAIRS
FORT McCOY, WISCONSIN

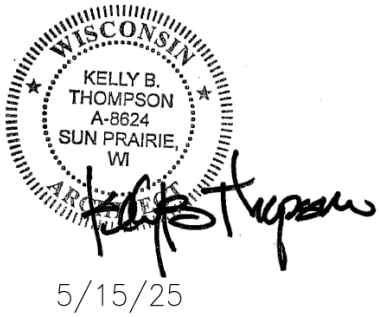
TECHNICAL SPECIFICATIONS VOLUME 2 of 2
BID DOCUMENT

Division Project No. **22L2Q**

MAY 15, 2025

FOR
THE STATE OF WISCONSIN
DEPARTMENT OF ADMINISTRATION
DIVISION OF FACILITIES DEVELOPMENT
STATE OF WISCONSIN ADMINISTRATION BUILDING - 7TH FLOOR
101 EAST WILSON STREET - P.O. BOX 7866
MADISON, WISCONSIN 53707





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ELECTRICAL

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SECTION 02 05 00
COMMON WORK RESULTS FOR EXISTING CONDITIONS
BASED ON DFD MASTER SPECIFICATION DATED 10/01/2012

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

SCOPE

This section provides information common to two or more technical site work specification sections or items that are of a general nature, and not included in other sections. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Referenced Organizations
- Referenced Documents
- Quality Assurance
- Safety
- Permits
- Construction Limits
- Equipment & Materials Furnished by Others
- Provisions for Future Work
- Work by Others
- Submittals
- Off Site Storage
- Codes
- Certificates and Inspections

PART 2 - MATERIALS
- Barricades, Signs, and Warning Devices
- Temporary Plastic Barrier Fencing

PART 3 - EXECUTION
- Maintenance of Site and Building Access/Egress
- Continuity of Existing Traffic/Parking and Traffic Control
- Protection and Continuity of Existing Utilities
- Protection of Existing Work and Facilities
- Stormwater/Excavation Water Management

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

02 41 19 – Selective Structure Demolition

REFERENCED ORGANIZATIONS

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

Abbreviations of organizations referenced in these specifications are as follows:

AASHTO	American Association of State Highway and Transportation Officials
ACPA	American Concrete Pipe Association
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
AWS	American Welding Society
FHA	Federal Highway Administration

EPA	Environmental Protection Agency
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NSF	National Sanitation Foundation
OSHA	Occupational Safety and Health Administration
STI	Steel Tank Institute
UL	Underwriters Laboratories Inc.
WDNR	State of Wisconsin Department of Natural Resources
WISDOT	State of Wisconsin Department of Transportation

REFERENCED DOCUMENTS

Where reference is made to the "SSHSC", it shall mean the pertinent sections of the State of Wisconsin, Department of Transportation, Standard Specifications for Highway and Structure Construction, current edition, and all supplemental and interim supplemental specifications. Where reference is made to the "SSSWC", it shall mean pertinent sections of the Standard Specifications for Sewer and Water Construction in Wisconsin, current edition. Where reference is made to the "BMPH", it shall mean the Wisconsin Construction Site Best Management Practice Handbook, current edition as published by the WDNR. Method of measurement and basis of payment sections in referenced documents shall not apply.

QUALITY ASSURANCE

Provide materials and products as required by individual specification sections. Refer to Section GC - General Conditions of the Contract regarding substitutions.

Provide quality assurance testing and reporting as required by individual specification sections.

SAFETY

Contractor is solely responsible for worksite safety.

Perform all work in accordance with applicable OSHA, state and local safety standards.

PERMITS

Unless otherwise noted in the Contract Documents, Contractor shall be responsible for obtaining and paying for all permits necessary to complete the work.

CONSTRUCTION LIMITS

Construction Limits are indicated on the drawings. In the absence of such a designation on the drawings, confine work to the minimum area reasonably necessary to undertake the work as determined by the DFD Construction Representative. In no case shall construction activities extend beyond state property lines or construction easements.

The Contractor shall restore all disturbed areas in accordance with the drawings and specifications. If plans and specifications do not address restoration of specific areas, these areas will be restored to pre-construction conditions as approved by the DFD Construction Representative.

WORK BY OTHERS

- Direct Digital Control System for HVAC as specified in Section 23 09 24.
- Video Surveillance – Owner furnishing and Owner installing.

Coordinate work under this project with work by Owner and other contractors on the site.

SUBMITTALS
Refer also to Section GC - General Conditions of the Contract and Division 1.
Submit manufacturer's shop drawings, product data, samples, substitutions and operation and maintenance (O&M) data for approval as required by individual specification sections.

Unless otherwise noted, provide 6 copies of each submittal. Submit to project architect/engineer (A/E) unless otherwise directed by DFD Construction Representative at the Pre-Construction Meeting.

OFF SITE STORAGE
Refer to Division 1.

In general, the payments for materials stored off site will only be considered in instances where there is limited space available for storage on the site. Prior approval by the DFD Construction Representative, together with the execution of a Storage Agreement will be required.

CODES
Comply with the requirements of all applicable, local, state and federal codes.

CERTIFICATIONS AND INSPECTIONS
Refer to Section GC - General Conditions.

Obtain and pay for all required sampling, testing, inspections, and certifications except those expressly listed as provided by the A/E or other third party in the Contract Documents. Deliver originals of certificates and documents to the DFD Construction Representative w/I 3 days; provide copies to the A/E. Include copies of the certifications and documents in the O&M Manual.

P A R T 2 - M A T E R I A L S

BARRICADES, SIGNS, AND WARNING DEVICES
Traffic barricades, traffic signs, and warning devices shall meet the requirements of applicable OSHA standards and the FHA Manual of Uniform Traffic Control Devices (MUTCD).

TEMPORARY PLASTIC BARRIER FENCING
UV stabilized high-density polyethylene barrier fence free of holes tears and other defects. Provide 4’ tall fence in diamond or rectangular pattern. Fencing shall be “safety orange” color, unless otherwise noted.

Posts for temporary plastic barrier fencing shall be 5’ tall, minimum 12 gauge, painted metal posts.

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

MAINTENANCE OF SITE AND BUILDING ACCESS/EGRESS
Unless otherwise shown or directed, maintain existing access and egress to the facility throughout construction. Maintain ANSI A117 compliant access for disabled persons, delivery access, emergency vehicle access, and emergency egress. Do not interrupt access and egress without prior written approval from the DFD Construction Representative.

CONTINUITY OF EXISTING TRAFFIC/PARKING AND TRAFFIC CONTROL
Refer also to Section GR - General Requirements.

Do not interrupt or change existing traffic, delivery, or parking without prior written approval from the DFD Construction Representative. When interruption is required, coordinate schedule with the Owner agency to minimize disruptions. When working in public right-of-way, obtain all necessary approvals and permits from applicable municipalities and WISDOT.

When Contractor's activities impede or obstruct traffic flow, Contractor shall provide traffic control devices, signs and flaggers in accordance with other Contract Documents and the current version of the MUTCD, or as shown on the Drawings.

PROTECTION AND CONTINUITY OF EXISTING UTILITIES

Verify the locations of any water, drainage, gas, sewer, electric, drainage, gas, sewer, electric, telephone/communication, fuel, steam lines or other utilities and site features which may be encountered in any excavations or other sitework. All lines shall be properly underpinned and supported to avoid disruption of service.

Do not interrupt or change existing utilities without prior written approval from the DFD Construction Representative, affected utilities and users. Notify all users impacted by outages a minimum of 48 hours in advance of outage. Notification shall be provided in writing and describe the nature and duration of outages and provide the name and number of Contractor's foreman or other contact.

Any service connections encountered which are to be removed shall be cut off at the limits of the excavation and capped in accordance with the requirements of applicable codes and any specifications governing such removals.

PROTECTION OF EXISTING WORK AND FACILITIES

Verify the locations of, and protect, any signs, paved surfaces, buildings, structures, landscaping, streetlights, utilities, and all other such facilities that may be encountered or interfered with during the progress of the work. Take measures necessary to safeguard all existing work and facilities that are outside the limits of the work or items that are within the construction limits but are intended to remain. Report any damage to existing facilities to the DFD Construction Representative immediately. Correct and pay for all damages.

STORMWATER/EXCAVATION WATER MANAGEMENT

Control grading around structures, pitch ground to prevent water running into excavated areas.

Pits, trenches within building lines and other excavations shall be maintained free of water.

Provide trenching, pumping, other facilities required.

Notify Architect/Engineer if springs or running water are encountered in excavation; provide discharge by trenches, drains, pumping to point outside of excavation. Provide information to Architect/Engineer of points and areas that water will be discharged. At the Engineer's option, the Contractor shall drain the spring to the storm sewer system by the use of field tile.

Be responsible for control measures to prevent damage from flooding, erosion, and sedimentation to on-site and off-site areas.

END OF SECTION

SECTION 02 41 19
SELECTIVE STRUCTURE DEMOLITION

PART 1 - GENERAL

SCOPE
Include all materials and labor, services and incidentals for the completion of the following scope of work: Removal of exterior soffits, windows and doors as indicated on drawings.

PART 1 -	GENERAL
	SCOPE
	SECTION REQUIREMENTS
	RELATED WORK
PART 2 -	PRODUCTS (Not Applicable)
PART 3 -	EXECUTION
	DEMOLITION

RELATED WORK
Applicable provisions of Division 1 shall govern work under this section. Refer to General Requirements and DOC-Contractor Site Access and Working Requirements for specific site security requirements.

Section 01 74 19 Construction Waste Management
Section 02 05 00 Common Work Results for Existing Conditions
Section 04 01 20 - Maintenance of Unit Masonry

SECTION REQUIREMENTS
Items if indicated to be removed and salvaged, remain Owner's property. Carefully detach from existing construction, in a manner to prevent damage, and deliver to Owner ready for reuse. Include fasteners or brackets needed for reattachment elsewhere.

Comply with EPA regulations and hauling and disposal regulations of authorities having jurisdiction. Comply with ANSI A10.6 and NFPA 241.

Predemolition Photographs: Show existing conditions of adjoining construction and site improvements, including finish surfaces. Submit before Work begins.

Owner will occupy portions ofbuilding immediately adjacent to selective demolition area during window operations. Conduct selective demolition so Owner's access to buildings and security operations will not be disrupted.

SAFETY
Maintain a clean and orderly site. Remove debris at end of each workday.

Secure all openings at the end of the work day.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

PROTECTION OF EXISTING WORK AND FACILITIES
Take all measures necessary to safeguard all existing work and facilities which are outside the limits of the work.

Report damage of any facilities or items scheduled for salvaging to the DFD Construction Representative.

Explosives shall not be used for demolition.

Protect surrounding area from dust. Control rodents, and other vermin associated with demolition operations.

DEMOLITION

Requirements for Building Reuse:

Maintain existing building structure (including structural floor and roof decking) and envelope (exterior skin and framing, excluding window assemblies and nonstructural roofing material) not indicated to be demolished; do not demolish such existing construction beyond indicated limits.

Maintain existing interior nonstructural elements (interior walls, doors, floor coverings, and ceiling systems) not indicated to be demolished; do not demolish such existing construction beyond indicated limits.

Maintain services/systems indicated to remain and protect them against damage during selective demolition operations. Before proceeding with demolition, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of the building.

Locate, identify, shut off, disconnect, and seal or cap off indicated utility services and mechanical/electrical systems serving areas to be selectively demolished.

Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.

Provide and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.

Provide temporary weather protection to prevent water leakage and damage to structure and interior areas.

Protect walls, ceilings, floors, and fixtures that are to remain. Erect and maintain polyethylene dust barriers where door and window replacements are in rooms open to corridors. Cover and protect furniture, furnishings, and equipment that have not been removed. Keep doors to rooms where doors and windows are being replaced closed during construction.

Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction.

Promptly remove demolition waste materials from Project site and legally dispose of them. Do not burn demolished materials.

Clean adjacent structures and improvements of dust, dirt, and debris caused by demolition operations. Return adjacent areas to condition existing before demolition operations began.

END OF SECTION

SECTION 04 01 20
MAINTENANCE OF UNIT MASONRY

PART 1 - GENERAL

SCOPE
Include all materials and labor, services and incidentals for the completion of the following scope of work: Through Wall Flashing Installation.

PART 1 - GENERAL
SCOPE
RELATED REQUIREMENTS
SUMMARY
DEFINITIONS
SUBMITTALS
QUALITY ASSURANCE
DELIVERY, STORAGE, AND HANDLING
PROJECT CONDITIONS
COORDINATION

PART 2 - PRODUCTS
MASONRY MATERIALS
MORTAR MATERIALS
CLEANING MATERIALS
ACCESSORY MATERIALS
FLASHING MATERIALS AND CLOSURE STRIPS
MORTAR MIXES

PART 3 - EXECUTION
PROTECTION
BRICK REMOVAL AND REPLACEMENT
REPOINTING MASONRY
FINAL CLEANING
FIELD QUALITY CONTROL

RELATED REQUIREMENTS
Applicable provisions of the General Requirements and Division 1 shall govern work under this section.

Section 02 41 19 - Selective Structure Demolition
Section 07 92 00 - Joint Sealants

SUMMARY
Section includes maintenance of unit masonry consisting of masonry restoration and cleaning as follows:

Masonry Opening Construction
Through Wall Flashing Installation
Localized Cleaning

DEFINITIONS

Low-Pressure Spray: 100 to 400 psi (690 to 2750 kPa); 4 to 6 gpm (0.25 to 0.4 L/s).

Saturation Coefficient: Ratio of the weight of water absorbed during immersion in cold water to weight absorbed during immersion in boiling water; used as an indication of resistance of masonry units to freezing and thawing.

SUBMITTALS

Product Data: For each type of product indicated. Include recommendations for application and use. Include test data substantiating that products comply with requirements.

QUALITY ASSURANCE

Mockups: Includes (1) new louver opening. Prepare mockups of restoration and cleaning to demonstrate aesthetic effects and set quality standards for materials and execution and for fabrication and installation.

Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

Preinstallation Conference: Conduct conference at **Project site**.

DELIVERY, STORAGE, AND HANDLING

Deliver masonry units to Project site strapped together in suitable packs or pallets or in heavy-duty cartons.

Deliver other materials to Project site in manufacturer's original and unopened containers, labeled with manufacturer's name and type of products.

Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

Store hydrated lime in manufacturer's original and unopened containers. Discard lime if containers have been damaged or have been opened for more than two days.

Store sand where grading and other required characteristics can be maintained and contamination avoided.

PROJECT CONDITIONS

Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit masonry restoration and cleaning work to be performed according to manufacturers' written instructions and specified requirements.

Repair masonry units and repoint mortar joints only when air temperature is between 40 and 90 deg F (4 and 32 deg C) and is predicted to remain so for at least 7 days after completion of the Work unless otherwise indicated.

Cold-Weather Requirements: Comply with the following procedures for masonry repair and mortar-joint pointing unless otherwise indicated:

When air temperature is below 40 deg F (4 deg C), heat mortar ingredients, masonry repair materials, and existing masonry walls to produce temperatures between 40 and 120 deg F (4 and 49 deg C).

When mean daily air temperature is below 40 deg F (4 deg C), provide enclosure and heat to maintain temperatures above 32 deg F (0 deg C) within the enclosure for 7 days after repair and pointing.

Hot-Weather Requirements: Protect masonry repair and mortar-joint pointing when temperature and humidity conditions produce excessive evaporation of water from mortar and repair materials. Provide artificial shade

and wind breaks and use cooled materials as required to minimize evaporation. Do not apply mortar to substrates with temperatures of 90 deg F (32 deg C) and above unless otherwise indicated.

For manufactured repair materials, perform work within the environmental limits set by each manufacturer.

Extend period in paragraph below if necessary to ensure that masonry does not freeze before it dries out.

Clean masonry surfaces only when air temperature is 40 deg F (4 deg C) and above and is predicted to remain so for at least 7 days after completion of cleaning.

COORDINATION

Coordinate masonry restoration and cleaning with occupant circulation patterns at Project site. Some work is within a security fence and will require phasing and direct coordination with the Owner.

PART 2 - PRODUCTS

MASONRY MATERIALS

Brick Masonry Units: Salvage and reuse existing units

MORTAR MATERIALS

Portland Cement: ASTM C 150, Type I or Type II, **gray** where required for color matching of exposed mortar.

Provide cement containing not more than 0.60 percent total alkali when tested according to ASTM C 114.

Hydrated Lime: ASTM C 207, Type S.

Quicklime: ASTM C 5, pulverized lime.

Mortar Sand: ASTM C 144 unless otherwise indicated.

Color: Provide natural sand of color necessary to produce required mortar color.

For pointing mortar, provide sand with rounded edges.

Match size, texture, and gradation of existing mortar sand as closely as possible. Blend several sands if necessary to achieve suitable match.

Mortar Pigments: Natural and synthetic iron oxides, compounded for mortar mixes. Use only pigments with a record of satisfactory performance in masonry mortars.

Water: Potable.

CLEANING MATERIALS

Water: Potable.

Hot Water: Water heated to a temperature of 140 to 160 deg F (60 to 71 deg C).

Job-Mixed Detergent Solution: Solution prepared by mixing 2 cups (0.5 L) of tetrasodium polyphosphate, 1/2 cup (125 mL) of laundry detergent, and 20 quarts (20 L) of hot water for every 5 gal. (20 L) of solution required.

ACCESSORY MATERIALS

Rigid Insulation: Extruded Polystyrene Board Insulation, Type IV XPS: ASTM C578, Type IV, 25-psi (173-kPa) minimum compressive strength; unfaced.

Steel Lintel: Channels, Angles: ASTM A36/A36M

Finish: Hot-dip or mechanically deposited zinc coating.

Weep Material: 2 ½" x 3 3/8" x 3/8" thick honeycomb polypropylene

FLASHING MATERIALS AND CLOSURE STRIPS

Zinc-Tin Alloy-Coated Stainless Steel: ASTM A 240/A 240M, Type 304, fully annealed stainless-steel sheet, not less than 0.015 inch (0.38 mm) thick, with 0.787-mil (0.020-mm) thickness zinc-tin alloy coating applied to each side.

Embedded Flexible Flashing: Use the following unless otherwise indicated:

Self-Adhering, Stainless Steel Fabric Flashing: Composite, flashing product consisting of 2 mil (0.05 mm) of Type 304 stainless steel sheet, bonded to a layer of polymeric fabric with a butyl adhesive or permanent, clear adhesive, to produce an overall thickness of 40 mil.

Sealant: Butyl-Rubber-Based Joint Sealants: ASTM C1311.

MORTAR MIXES

Measurement and Mixing: Measure cementitious materials and sand in a dry condition by volume or equivalent weight. Do not measure by shovel; use known measure. Mix materials in a clean, mechanical batch mixer.

Mixing Pointing Mortar: Thoroughly mix cementitious materials and sand together before adding any water. Then mix again adding only enough water to produce a damp, unworkable mix that will retain its form when pressed into a ball. Maintain mortar in this dampened condition for 15 to 30 minutes. Add remaining water in small portions until mortar reaches desired consistency. Use mortar within one hour of final mixing; do not retemper or use partially hardened material.

Colored Mortar: Produce mortar of color required by using specified ingredients. Do not alter specified proportions without Architect's approval.

Mortar Pigments: Where mortar pigments are indicated, do not exceed a pigment-to-cement ratio of 1:10 by weight.

Do not use admixtures in mortar unless otherwise indicated.

Mortar Proportions: Mix mortar materials in the following proportions:

Rebuilding (Setting) Mortar: Comply with ASTM C 270, Proportion Specification, Type N unless otherwise indicated; with cementitious material limited to portland cement and lime.

PART 3 – EXECUTION

PROTECTION

Protect persons, motor vehicles, surrounding surfaces of building being restored, building site, plants, and surrounding buildings from harm resulting from masonry restoration work.

Erect temporary protective covers over walkways and at points of pedestrian and vehicular entrance and exit that must remain in service during course of restoration and cleaning work.

Cover adjacent surfaces with materials that are proven to resist chemical cleaners used unless chemical cleaners being used will not damage adjacent surfaces. Use materials that contain only waterproof, UV-resistant adhesives. Apply masking agents to comply with manufacturer's written instructions. Do not apply liquid masking agent to painted or porous surfaces. When no longer needed, promptly remove masking to prevent adhesive staining.

Keep wall wet below area being cleaned to prevent streaking from runoff.

Do not clean masonry during winds of sufficient force to spread cleaning solutions to unprotected surfaces.

Neutralize and collect alkaline and acid wastes for disposal off Owner's property.

Dispose of runoff from cleaning operations by legal means and in a manner that prevents soil erosion, undermining of paving and foundations, damage to landscaping, and water penetration into building interiors.

Prevent mortar from staining face of surrounding masonry and other surfaces.

Cover sills, ledges, and projections to protect from mortar droppings.

Keep wall area wet below rebuilding and pointing work to discourage mortar from adhering.

Immediately remove mortar in contact with exposed masonry and other surfaces.

Clean mortar splatters from scaffolding at end of each day.

BRICK REMOVAL AND REPLACEMENT

At locations indicated, remove bricks that are damaged, spalled, or deteriorated **or are to be reused**. Carefully demolish or remove entire units from joint to joint, without damaging surrounding masonry, in a manner that permits replacement with full-size units.

When removing single bricks, remove material from center of brick and work toward outside edges.

Support and protect remaining masonry that surrounds removal area. Maintain flashing, reinforcement, lintels, and adjoining construction in an undamaged condition.

Notify Architect of unforeseen detrimental conditions including voids, cracks, bulges, and loose units in existing masonry backup, rotted wood, rusted metal, and other deteriorated items.

Remove in an undamaged condition as many whole bricks as possible.

Remove mortar, loose particles, and soil from brick by cleaning with hand chisels, brushes, and water.

Remove sealants by cutting close to brick with utility knife and cleaning with solvents.

Store brick for reuse. Store off ground, on skids, and protected from weather.

Deliver cleaned brick not required for reuse to Owner unless otherwise indicated.

Clean bricks surrounding removal areas by removing mortar, dust, and loose particles in preparation for replacement.

Replace removed damaged brick with other removed brick **and salvaged brick** in good quality, where possible, or with new brick matching existing brick, including size. Do not use broken units unless they can be cut to usable size.

Install embedded flashing and weep holes in masonry at shelf angles, lintels, ledges, other obstructions to downward flow of water in wall, and where indicated on Drawings.

Install flashing as follows unless otherwise indicated:

Prepare masonry surfaces so they are smooth and free from projections that could puncture flashing. Where flashing is within mortar joint, place through-wall flashing on sloping bed of mortar and cover with mortar.

Before covering with mortar, seal penetrations in flashing with adhesive, sealant, or tape as recommended by flashing manufacturer.

Install metal drip edges beneath flexible flashing at exterior face of wall. Stop flexible flashing 1/2 inch (13 mm) back from outside face of wall, and adhere flexible flashing to top of metal drip edge.

Install metal flashing termination beneath flexible flashing at exterior face of wall. Stop flexible flashing 1/2 inch (13 mm) back from outside face of wall, and adhere flexible flashing to top of metal flashing termination.

Install weep holes in exterior wythes and veneers in head joints of first course of masonry immediately above embedded flashing.

Use specified weep/cavity vent products or open-head joints to form weep holes.

Space weep holes 32 inches (610 mm) o.c. unless otherwise indicated.

Install replacement brick into bonding and coursing pattern of existing brick. If cutting is required, use a motor-driven saw designed to cut masonry with clean, sharp, unchipped edges.

Maintain joint width for replacement units to match existing joints.

Use setting buttons or shims to set units accurately spaced with uniform joints.

Lay replacement brick with completely filled bed, head, and collar joints. Butter ends with sufficient mortar to fill head joints and shove into place. Wet both replacement and surrounding bricks that have ASTM C 67 initial rates of absorption (suction) of more than 30 g/30 sq. in. per min. (30 g/194 sq. cm per min.). Use wetting methods that ensure that units are nearly saturated but surface is dry when laid.

Tool exposed mortar joints in repaired areas to match joints of surrounding existing brickwork.

Rake out mortar used for laying brick before mortar sets and point new mortar joints in repaired area to comply with requirements for repointing existing masonry, and at same time as repointing of surrounding area.

When mortar is sufficiently hard to support units, remove shims and other devices interfering with pointing of joints.

CLEANING MASONRY, GENERAL

Localized to brick replacement, brick demolition, and adjacent areas: Proceed with cleaning in an orderly manner; work from **top to bottom** of each scaffold width and from one end of each elevation to the other. Ensure that dirty residues and rinse water will not wash over cleaned, dry surfaces.

Use only those cleaning methods indicated for each masonry material and location.

Use spray equipment that provides controlled application at volume and pressure indicated, measured at spray tip. Adjust pressure and volume to ensure that cleaning methods do not damage masonry.

Equip units with pressure gages.

For water-spray application, use fan-shaped spray tip that disperses water at an angle of 25 to 50 degrees.

For heated water-spray application, use equipment capable of maintaining temperature between 140 and 160 deg F (60 and 71 deg C) at flow rates indicated.

For steam application, use steam generator capable of delivering live steam at nozzle.

Perform each cleaning method indicated in a manner that results in uniform coverage of all surfaces, including corners, moldings, and interstices, and that produces an even effect without streaking or damaging masonry surfaces.

Water Application Methods:

Water-Soak Application: Soak masonry surfaces by applying water continuously and uniformly to limited area for time indicated. Apply water at low pressures and low volumes in multiple fine sprays using perforated hoses or multiple spray nozzles. Erect a protective enclosure constructed of polyethylene sheeting to cover area being sprayed.

After cleaning is complete, remove protection no longer required. Remove tape and adhesive marks.

REPOINTING MASONRY

Rake out and repoint joints as necessary to complete scope of removal and installation.

Do not rake out and repoint joints where not required.

Rake out joints as follows, according to procedures demonstrated in approved mockup:

Remove mortar from joints to depth of **joint width plus 1/8 inch (3 mm)**, but not less than 1/2 inch (13 mm) or not less than that required to expose sound, unweathered mortar.

Remove mortar from masonry surfaces within raked-out joints to provide reveals with square backs and to expose masonry for contact with pointing mortar. Brush, vacuum, or flush joints to remove dirt and loose debris.

Do not spall edges of masonry units or widen joints. Replace or patch damaged masonry units as directed by Architect.

Cut out mortar by hand with chisel and resilient mallet. Do not use power-operated grinders without Architect's written approval based on approved quality-control program.

Cut out center of mortar bed joints using angle grinders with diamond-impregnated metal blades. Remove remaining mortar by hand with chisel and resilient mallet. Strictly adhere to approved quality-control program.

Notify Architect of unforeseen detrimental conditions including voids in mortar joints, cracks, loose masonry units, rotted wood, rusted metal, and other deteriorated items.

Pointing with Mortar:

Rinse joint surfaces with water to remove dust and mortar particles. Time rinsing application so, at time of pointing, joint surfaces are damp but free of standing water. If rinse water dries, dampen joint surfaces before pointing.

Apply pointing mortar first to areas where existing mortar was removed to depths greater than surrounding areas. Apply in layers not greater than 3/8 inch (9 mm) until a uniform depth is formed. Fully compact each layer thoroughly and allow it to become thumbprint hard before applying next layer.

After low areas have been filled to same depth as remaining joints, point all joints by placing mortar in layers not greater than 3/8 inch (9 mm). Fully compact each layer and allow to become thumbprint hard before applying next layer. Where existing masonry units have worn or rounded edges, slightly recess fin-

ished mortar surface below face of masonry to avoid widened joint faces. Take care not to spread mortar beyond joint edges onto exposed masonry surfaces or to featheredge the mortar.

When mortar is thumbprint hard, tool joints to match original appearance of joints as demonstrated in approved mockup. Remove excess mortar from edge of joint by brushing.

Cure mortar by maintaining in thoroughly damp condition for at least 72 consecutive hours including weekends and holidays.

Acceptable curing methods include covering with wet burlap and plastic sheeting, periodic hand misting, and periodic mist spraying using system of pipes, mist heads, and timers.

Adjust curing methods to ensure that pointing mortar is damp throughout its depth without eroding surface mortar.

Hairline cracking within the mortar or mortar separation at edge of a joint is unacceptable. Completely remove such mortar and repoint.

FINAL CLEANING

After mortar has fully hardened, thoroughly clean exposed masonry surfaces of excess mortar and foreign matter; use wood scrapers, stiff-nylon or -fiber brushes, and clean water, spray applied at low pressure.

Wash adjacent nonmasonry surfaces. Use detergent and soft brushes or cloths.

Clean mortar and debris from roof; remove debris from gutters and downspouts. Rinse off roof and flush gutters and downspouts.

Sweep and rake adjacent pavement and grounds to remove mortar and debris. Where necessary, pressure wash pavement surfaces to remove mortar, dust, dirt, and stains.

FIELD QUALITY CONTROL

Architect's Project Representatives: Architect will assign Project representatives to help carry out Architect's responsibilities at the site, including observing progress and quality of portion of the Work completed. Allow Architect's Project representatives use of lift devices and scaffolding, as needed, to observe progress and quality of portion of the Work completed.

END OF SECTION

SECTION 06 10 53.01
MISCELLANEOUS ROUGH CARPENTRY

PART 1 - GENERAL

SCOPE

The work under this section includes all labor, material, equipment and related services necessary to install sheating, rough framing and blocking .

PART 1 - GENERAL
- Scope
- References

PART 2 - PRODUCTS
- Materials

PART 3 - EXECUTION
- Installation

In the event that the Contractor wishes to make improvements in materials and/or techniques, or is required to make improvements by his material manufacturer in order to obtain guarantees, he shall make written request stating in full the nature of the proposed changes and stating that the changes, if approved, will be accomplished at no additional cost to contract.

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

- Section 04 01 20 - Maintenance of Unit Masonry
- Section 07 24 13 - Direct Applied Finish System
- Section 08 44 13 - Glazed Aluminum Curtain Walls
- Section 08 51 13 - Aluminum Windows
- Section 07 59 00 - Roof Maintenance and Repairs
- Section 12 36 61.16 - Solid Surfacing Countertops

REFERENCES

ALSC PS 20 - American Softwood Lumber Standard.
APA - American Plywood Association.

All lumber used on this project shall be graded by an agency certified by ALSC.

PART 2 – PRODUCTS

MATERIALS

Softwood Lumber: ALSC PS20, grade No. 2 or better; 19 percent maximum moisture content, size as detailed or required.

Preservative Treatment by Pressure Process: AWPA U1; Use Category UC2 for interior construction not in contact with ground, Use Category UC3b for exterior construction not in contact with ground, and Use Category UC4a for items in contact with ground.

Paper-Surfaced Gypsum Sheathing: ASTM C1396/C1396M, gypsum sheathing; with water-resistant-treated core and with water-repellent paper bonded to core's face, back, and long edges

Plywood: APA certified; CDX fir plywood.Thickness as detailed or required.

Nail Base Insulation Panel: 1” minimum Polyisocyanurate insulation, total composition thickness 1-1/2”, R-6.5.

Fasteners: Sizes and lengths to suit conditions for wall sheathing, provide fasteners [\with hot-dip zinc coating complying with ASTM A153/A153M

PART 3 - EXECUTION

INSTALLATION

Refer to the detail drawings. Install material as follows for new or corrective work, where required.

Shim, install, provide and securely fasten all wood nailers and blocking as detailed or required. Use longest lengths practical to minimize joints; stagger all joints a minimum of 8". Unless noted otherwise all materials shall be fastened using two rows of fasteners at 24" O.C. staggered.

Fasten new sheathing to existing structural components with appropriate fasteners at 8" O.C. at the edge and 16” O.C. in the field of the sheathing. Gap sheathing 1/16" on all edges prior to fastening.

END OF SECTION

SECTION 07 01 90
MAINTENANCE OF JOINT SEALANTS

PART 1 - GENERAL

SCOPE
Include all materials and labor, services and incidentals for the completion of the following scope of work:

Masonry Opening Perimeter Joints

PART 1 - GENERAL
SCOPE
RELATED WORK
SUBMITTALS
QUALITY ASSURANCE
ENVIRONMENTAL REQUIREMENTS
GUARANTEES, WARRANTIES, CERTIFICATES

PART 2 - PRODUCTS
(Refer to Section 07 92 00)

PART 3 -EXECUTION
EXAMINATION
SEQUENCING/SCHEDULING
SUBSTRATE PREPARATION
SEALANT INSTALLATION

RELATED WORK
Applicable provisions of Division 1 shall govern this section.

Section 07 92 00 Joint Sealants

SUBMITTALS
Product Data: For each type of product indicated.

Color Samples.

Test Reports.

QUALITY ASSURANCE
Restoration Specialist Qualifications: Engage an experienced masonry restorationist. Firm shall have completed work similar in material, design, and extent to that indicated for this Project with a record of successful in-service performance. Masons shall have a minimum of five (5) years experience in this type of work.
Preinstallation Conference: Conduct conference at **Project site per**

Testing: The sealant manufacturer shall test each sample repair for adhesion and submit test reports to the Architect. Two samples of each shall be taken from each façade.

Repair any work, damaged by failure to provide proper and adequate protection, to its original state to the satisfaction of the Owner or remove and replace with new work at the Contractor's expense.

Visible evidence of sealant gassing during curing will be adequate reason for rejection of sealant.

It will be DFD prerogative to forbid the use of tools or methods which do not produce the quality of work which is expected and to insist on the use of methods and tools which will do the work properly.

ENVIRONMENTAL REQUIREMENTS

Sealant shall be applied only when the outside air temperature meets or exceeds 55 degrees Fahrenheit, and the wall is given proper protection from the elements.

During the workday should the weather conditions appear to be changing adversely, the foreman shall take preventive measures to allow work area to be closed to a watertight condition to avoid exposure to building, equipment, and materials.

GUARANTEES, WARRANTIES, CERTIFICATES

Workmanship shall be guaranteed against defect for a period of five (5) years from the date of substantial completion.

Materials shall be guaranteed against defect for a period of ten (10) years from the date of substantial completion.

PART 2 – PRODUCTS

Refer to Section 07 92 00.

PART 3 - EXECUTION

EXAMINATION

The Applicator shall have the sole responsibility for the accuracy of all measurements and for the estimate of material quantities required and necessary to satisfy the requirements of these Specifications.

SEQUENCING/SCHEDULING

Expose only as much work as can be restored to a watertight condition each day or before showers commence.

SUBSTRATE PREPARATION

Remove existing sealant by cutting and/or scraping.

The cutting out of joints shall be done with suitable tools, either hand tools or mechanical equipment, in such a manner as will not loosen adjacent joints or injure the edges or corners of the building components. Where the sealant is tightly bonded at one side of the joint, and if the contour permits, the cutting shall be done with portable electric grinders with abrasive wheels in order not to spall at the edges of the masonry units or precast concrete or damage finish of window frames.

After the joint has been cut out, all loose material shall be removed by brush, air jet, or water stream.

Surfaces to be contacted by sealant shall be made free of sanded surfaces or applied coatings that could be detrimental to sealant bond.

Joints shall be totally free of all mortar before any sealant work is begun, and the Owner notified of readiness for inspection.

On porous material the bulk of the existing caulking shall first be cut out and the final caulking substrate shall then be removed by slightly cutting into (grinding) the porous substrate and "peeling" off the residue, without leaving any trace of the caulking on the interfaces. Continue substrate preparation as specified hereinafter.

On nonporous materials the bulk of the existing caulking shall be scraped off without marring of the substrate. Final caulking residue shall be removed by appropriate cleaner/solvent. Contractor may use Hexane or Chlorothene NU. Xylol shall not be used. Continue substrate preparation as specified hereinafter.

SEALANT INSTALLATION

Comply with ASTM C 1193 and section 07 92 00.

END OF SECTION

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SECTION 07 21 19
FOAMED-IN-PLACE INSULATION

PART 1- GENERAL

SCOPE

This section includes closed-cell spray polyurethane foam, and open-cell spray polyurethane foam.

PART 1 - GENERAL
- Scope
- Related Requirements
- Action Submittals
- Informational Submittals

PART 2 – PRODUCTS
- Closed-Cell Spray Polyurethane Foam
- Open-Cell Spray Polyurethane Foam

PART 3 - EXECUTION
- Installation

RELATED REQUIREMENTS:

Applicable provisions of Division 1 shall govern this section.

Section - 06 10 53.01 - Miscellaneous rough carpentry
Section - 08 44 13 Glazed Aluminum Curtain Walls
Section - 08 51 13 - Aluminum Windows

ACTION SUBMITTALS

Product Data: For each type of product.

INFORMATIONAL SUBMITTALS

Product test reports.

Research reports.

PRODUCTS

OPEN-CELL SPRAY POLYURETHANE FOAM

Open-Cell Spray Polyurethane Foam: Spray-applied polyurethane foam using water as a blowing agent. Minimum density of 0.4 lb/cu. ft. (6.4 kg/cu. m) and minimum aged R-value at 1-inch (25.4-mm) thickness of 3.4 deg F x h x sq. ft./Btu at 75 deg F (24 K x sq. m/W at 24 deg C).

Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

Flame-Spread Index: 25 or less.

Smoke-Developed Index: 450 or less.

Fire Propagation Characteristics: Passes NFPA 285 and NFPA 276 testing as part of an approved assembly.

PART 3- EXECUTION

INSTALLATION

Comply with insulation manufacturer's written instructions applicable to products and applications.

Spray insulation to envelop entire area to be insulated and fill voids.

Apply in multiple passes to not exceed maximum thicknesses recommended by manufacturer. Do not spray into rising foam.

END OF SECTION

SECTION 07 24 13
POLYMER-BASED EXTERIOR INSULATION AND FINISH SYSTEM

PART 1 - GENERAL

SCOPE
Include cladding barrier-wall assemblies that are field applied over substrate. (EIFS) Exterior Insulation and Finish System and (DAFS) Direct Applied Finish System.

PART 1 - GENERAL
- Scope
- Related Sections
- Preinstallation Meetings
- Action Submittals
- Quality Assurance
- Warranty

PART 2 - PRODUCTS
- Manufacturers
- Performance Requirements
- Materials
- Accessory Materials

PART 3 - EXECUTION
- Installation

RELATED WORK
Applicable provisions of Division 1 shall govern this section.

Section - 06 10 53.01 - Miscellaneous rough carpentry
Section – 07 92 00 - Joint Sealants
Section - 08 44 13 Glazed Aluminum Curtain Walls
Section - 08 51 13 - Aluminum Windows

PREINSTALLATION MEETINGS
Preinstallation Conference: Conduct conference at Project site.

ACTION SUBMITTALS
Product Data: For each EIFS component, trim, and accessory.

Samples: For each exposed product and for each color and texture specified.

QUALITY ASSURANCE
Installer Qualifications: An installer who is certified in writing by AWCI International as qualified to install Class PB EIFS using trained workers.

Mockups: Includes (24”x24”) as located in field. Prepare mockups of application to demonstrate assembly of materials, aesthetic effects and set quality standards for materials and execution and for fabrication and installation.

Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

WARRANTY

Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of the finish system that fail in materials or workmanship within specified warranty period.

Warranty Period: 10years from date of Substantial Completion.

PART 2- PRODUCTS

MANUFACTURERS

Manufacturers: Parex, Sto, Dryvit

PERFORMANCE REQUIREMENTS

EIFS Performance: Comply with ASTM E2568 and with the following:

Weathertightness: Resistant to water penetration from exterior.

Impact Performance: ASTM E2568, Medium impact resistance unless otherwise indicated.

MATERIALS

Weather Barrier and Flexible-Membrane Flashing: Cold-applied, self-adhering, self-healing, rubberized-asphalt and polyethylene-film composite sheet or tape and primer; EIFS manufacturer's standard or product recommended in writing by EIFS manufacturer.

Insulation Adhesive: manufacturer's standard formulation designed for indicated use; compatible with substrate.
Backer Material

Walls: EIFS - Extruded Polystyrene Board Insulation, Type IV: ASTM C578, Type IV, 25-psi (173-kPa) minimum compressive strength; unfaced.

Flame-Spread Index: Not more than 25 when tested in accordance with ASTM E84.

Smoke-Developed Index: Not more than 450 when tested in accordance with ASTM E84.

Fire Propagation Characteristics: Passes NFPA 285 testing as part of an approved assembly.

Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches (305 mm) and wider in width.

Soffits: DAFS - Cement Board Backer: Cement board complying with ASTM C 1325

Reinforcing Mesh (Impact resistance refers to installation of EPS trim):

Standard Mesh: Weight 4.5 oz. per sq. yd. (153 g/sq m); coated for protection against alkali.
Standard reinforcement or for use with High Impact 358.14 Mesh, or Ultra High Impact 358.20 Mesh.

Short Detail Mesh: Reinforcing mesh used for backwrapping and details, and to embed in the Base Coat & Adhesive Dry.

Primers:

Primer: 100% acrylic based coating to prepare surfaces for finishes.

Finish:

Standard Finish: Factory blended, 100% acrylic polymer based finish, integrally colored. Finish type, texture and color as selected by Project Designer

Water: Clean, potable water

Portland Cement: ASTM C150, Type I or Type I-II.

Trim Accessories: Type as designated or required to suit conditions indicated and to comply with manufacturer's written instructions; manufactured from UV-stabilized PVC; and complying with ASTM D1784 and ASTM C1063.

ACCESSORY MATERIALS

Continuous Soffit Vents: Aluminum (.02inch min thickness) plaster stucco vent, with slots and insect screens. 50% min open area.

Sealants: As specified in Section 07 92 00 - Joint Sealants

PART 3- EXECUTION

INSTALLATION

Comply with ASTM C1397, ASTM E2511, and EIFS manufacturer's written instructions for installation of EIFS as applicable to each type of substrate.

Flexible-Membrane Flashing: Apply and lap to shed water; seal at openings, penetrations, and terminations. Prime substrates with flashing primer if required and install flashing.

Trim: Apply trim accessories at perimeter of EIFS, at expansion joints, at windowsills, and elsewhere as indicated. Coordinate with installation of insulation.

Board Insulation (EIFS): Adhesively attach insulation to substrate in compliance with ASTM C1397.

Rasp or sand flush entire surface of insulation to remove irregularities projecting more than 1/16 inch (1.6 mm) from surface of insulation and to remove yellowed areas due to sun exposure; do not create depressions deeper than 1/16 inch (1.6 mm). Prevent airborne dispersal and immediately collect insulation raspings or sandings.

Coordinate installation of flashing and insulation to produce wall assembly that does not allow water to penetrate behind flashing and EIFS lamina.

Cement Board (DAFS):

The cement board shall be installed in accordance with this specification and the cement board manufacturer’s written instructions.

Cement board shall be fastened to framing by corrosion resistant steel screws.

Locate screws 8" (20.4 m) maximum on center along framing members or closer as required by design loads. Screws at board edges shall be placed 3/8" (0.95 m) in from the edge. Fastener heads are to be driven flush with the face of the cement board.

All vertical joints of the cement board shall be staggered in a running bond pattern and terminate on framing. All cement board joints shall be butted together.

Offset horizontal cement board joints a minimum of 12" (300 mm) from horizontal sheathing joints.

Offset vertical cement board joints a minimum of one stud space from vertical sheathing joints.

Offset cement board joints a minimum of 8" (203 m) from the corners of openings by "L" cutting the cement board around corners of openings

Expansion Joints: Install at locations indicated and where required by finish manufacturer.

Water-Resistant Base Coat: Apply full-thickness coverage to exposed insulation and to exposed surfaces and to other surfaces indicated on Drawings.

Base Coat: Apply full coverage to exposed insulation and foam buildouts with not less than 1/16-inch (1.6-mm) dry-coat thickness.

Reinforcing Mesh: Embed reinforcing mesh in wet base coat to produce wrinkle-free installation with mesh continuous at corners, overlapped not less than 2-1/2 inches (64 mm) or otherwise treated at joints to comply with ASTM C1397. Do not lap reinforcing mesh within 8 inches (200 mm) of corners. Completely embed mesh, applying additional base-coat material if necessary, so reinforcing-mesh color and pattern are invisible.

Double-Layer Reinforcing-Mesh Application: Where indicated or required, apply second base coat and second layer of reinforcing mesh, overlapped not less than 2-1/2 inches (64 mm) or otherwise treated at joints to comply with ASTM C1397 in same manner as first application. Do not apply until first base coat has cured.

Additional Reinforcing Mesh: Apply strip-reinforcing mesh around openings, extending 4 inches (100 mm) beyond perimeter. Apply additional 9-by-12-inch (230-by-300-mm) strip-reinforcing mesh diagonally at corners of openings (re-entrant corners). Apply 8-inch- (200-mm-) wide, strip-reinforcing mesh at both inside and outside corners unless base layer of mesh is lapped not less than 4 inches (100 mm) on each side of corners.

Foam Buildouts: Fully embed reinforcing mesh in base coat.

Double Base-Coat Application: Where indicated, apply second base coat in same manner and thickness as first application, except without reinforcing mesh. Do not apply until first base coat has cured.

Finish Coat: Apply full-thickness coverage over dry primed base coat, maintaining a wet edge at all times for uniform appearance, to produce a uniform finish of color and texture matching approved sample and free of cold joints, shadow lines, and texture variations.

Sealer Coat: Apply over dry finish coat, in number of coats and thickness required by manufacturer.

END OF SECTION

SECTION 07 59 00
ROOF MAINTENANCE AND REPAIRS

PART 1 - GENERAL

SCOPE
Include all materials and labor, services and incidentals for the completion of the following scope of work: Modification to existing ballasted EPDM roofing assembly in order to accommodate new window assemblies.

CLASS 1 NOTICE:
Notice is hereby given in accordance with Section 16.855(10), Wisconsin Statutes, that the Division believes it is in the best interests of the State to contract the work specified herein from only one source, without the usual statutory procedures. – Materials and Labor.

RELATED WORK
Applicable provisions of Division 1 shall govern this section.

Section 06 10 53.01 - Miscellaneous rough carpentry
Section 07 63 00 - Sheet Metal Roofing Specialties
Section 08 51 13 - Aluminum Windows

QUALITY ASSURANCE
Include administration, facilities, materials, labor, and expertise necessary to conform to Contract and ensure quality of roofing and related components.

Manufacturer Requirements

Except as modified and supplemented herein, follow the Roofing Manufacturer's and other material manufacturer's catalogs, general and special requirements, and special application recommendations.

With respect to methods of installation, industry practices apply only when the Contract does not address the matter.

REGULATORY REQUIREMENTS

Materials and construction shall meet the following:

Underwriters Laboratories, Inc. (UL): Class A Fire Hazard Classification.

Factory Mutual Engineering Corporation (FM): Windstorm Resistance Classification, FM Construction Bulletins 1-28 and 1-49; Fire Classification, Class 1 (FM Approval Standards).

SPECIAL REQUIREMENTS

Minimizing Roof Traffic

Keep traffic on partially or fully completed roof surfaces to an absolute minimum after underlayment, insulation, or roofing has been placed.

Where wheeled or other traffic over roofing is unavoidable, use adequate plank or plywood, laid over insulation, to protect the roofing system.

Use only pneumatic-tired vehicles. Do not use steel- or solid rubber-tired vehicles.

SUBMITTALS

Preconstruction Submittals:

Equipment to be used.

Operational plans addressing:

Methods for delivery of material to the job site.

On site handling of materials

Material storage locations.

Material storage methods.

Material protection (particularly moisture control).

Material Safety Data Sheets (MSDSs) for the materials to be used.

Safety Procedures.

Type of roof access to be furnished and locations.

Protection of roofing.

PRODUCT DELIVERY STORAGE AND HANDLING

Materials and Storage: Store and handle materials, except bitumen, metal components, and material in sealed cans, as follows:

Do not expose materials to moisture in any form before, during, or after delivery to the site.

If possible, store materials in a completely enclosed building or trailer.

When out-of-doors:

Store on clean raised platforms at least 4 inches above the ground or roof surface.

Remove manufacturer-supplied plastic covers.

Completely cover materials with waterproof canvas tarpaulins to protect from weather and moisture. Arrange covers to prevent standing water on, and condensation from occurring beneath them. Do not allow covers to extend onto the ground or roof surface.

Store in areas free of standing water.

Store all roll goods on end.

Store all adhesives, roll-goods, and related temperature sensitive materials in enclosures or heated trailers at a minimum temperature of 50 degrees Fahrenheit.

Conspicuously mark unprotected materials. Remove such materials from the site.

ENVIRONMENTAL REQUIREMENTS

Submit and obtain acceptance of at least 14 days prior to implementation, written guideline of procedures and protection methods to be employed if anticipating roofing work at temperatures below 40 degrees F.

Address the following as a minimum:

Monitoring and recording weather conditions.

Method to maintain proper bitumen temperatures.

Method to ensure application of bitumen and membrane at proper temperature.

Method of storing materials in a heated enclosure.

Method of determining suitability of materials for installation.

Schedule and supervise work crews so that the area of work begun one day is completed before leaving the job site that day. Included is the final roof surfacing and bituminous flashings within and adjoining the membrane.

Inclement Weather

Progressively install the work to effect rapid completion and permit timely protection in the event of a change in the weather.

Installation:

Do not install repair materials during snow, rain, fog, mist or other inclement weather.

One exception is that emergency materials may be installed during such weather to protect materials that are already installed.

After installation of emergency materials, inspect building interior for leakage. Stop leaks.

Remove emergency work and wet materials; then install specified materials.

Do not apply roofing materials when moisture in any form (such as dew) can be seen or felt on the surface to which those materials will be applied.

Do not apply materials when foaming, bubbling, or blistering of the hot bitumen occurs.

GUARANTEES, WARRANTIES, CERTIFICATES

The existing ballasted EPDM roof is under warranty. The installation was by Nieman Central Roofing, 608-666-3342, services@niemancwroofing.com. Other Contractors that can perform this scope of work and maintain the existing warranty are acceptable.

Contractors Warranty: Work shall maintain the existing Contractor's Warranty.

Membrane System Manufacturer's Warranty: Work shall maintain the existing Manufacturer's Warranty.

PART 2 - PRODUCTS

ACCEPTABLE MANUFACTURERS

Approved Membrane Manufactures and Membrane Suppliers:

Carlisle SynTec Systems; Manufacturer.

Manufacturer shall have had membrane in production and use on roof systems for a minimum of ten (10) years.

All materials shall be new unless noted otherwise.

MATERIALS

No materials specified or approved shall contain asbestos.

Membrane: ASTM D4637, Type I; Non-reinforced black 60-mil EPDM (Ethylene Propylene Diene Monomer) elastomer.

Uncured Flashing: Uncured black 60-mil EPDM elastomer as recommended by the membrane manufacturer or membrane supplier.

Cured Flashing: ASTM D4637, Type I; Non-reinforced black 60-mil EPDM elastomer as recommended by the membrane manufacturer or membrane supplier.

Bonding Adhesives, Cements, Tapes, Sealants and Accessories: Foam and solvent based adhesives and related prepping and cleaning agents required for the installation of a fully-adhere system membrane, seams, membrane flashing, membrane to insulation, insulation to insulation and deck shall be approved and supplied by the approved membrane provider.

Perimeter Securement Strip: ASTM D4637, Type II; reinforced, 60 mil EPDM elastomer as recommended by the membrane manufacturer or membrane supplier.

Sealant: ASTM C920, Type S, Grade NS, Class 25, Use NT, M, G, A or O; FS TT-S-00230C, Type II, Class A; one-part polyurethane base, elastomeric joint sealing compound such as Sika Chemicals "Sikaflex 1a", Sonneborn-Contech "Sonolastic NP1" or Tremco "Vulkem 116" or "Dymonic".

Miscellaneous materials:

Miscellaneous Lumber for Nailers: **See Section 06 10 53.01**

Other Materials: All other materials, not specifically described but required for a complete and proper installation of the work in this section, shall be as selected by the Contractor subject to approval by the Owner.

PART 3 - EXECUTION

EXAMINATION

The Applicator shall have the sole responsibility for the accuracy of all measurements and for the estimate of material quantities required and necessary to satisfy the requirements of these specifications.

Review the work and equipment to be used with the workers before allowing them on the roof.

Materials and Weight on the Roof

Do not store materials, tools or equipment on roofing surfaces.

Do not load or permit any part of a structure to be loaded, with a weight that will endanger its safety or cause damage.

SEQUENCING/SCHEDULING

Schedule the work to progress from one area to another in a systematic manner. If, in the opinion of DFD or the Architect, the approved schedule lags, take such steps as required to improve progress.

Submit operational plans as may be deemed necessary to demonstrate the manner in which the agreed rate of progress is to be regained, without additional cost to the Owner.

PREPARATION

Remove only existing roofing materials that can be replaced with new materials the same day.

Cleanly cut existing EPDM roof assembly in order to accommodate base flashing replacement.

Install new wood blocking, nail base insulation, and flashings per details and manufacturer’s installation instructions.

END OF SECTION

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SECTION 07 63 00
SHEET METAL ROOFING SPECIALTIES
BASED ON DFD MASTER SPECIFICATION DATED (02/06/17)

PART 1 – GENERAL

SCOPE

The work under this section includes all labor, material, equipment and related services necessary to install all roof related sheet metal. Record documents to include digital photos.

PART 1 - GENERAL
- Scope
- Related Work
- Reference Standards
- Guarantee
- Quality Assurance
- Product Delivery, Storage and Handling
- Submittals - Technical and Other Documents
- Submittals – Final Documents Required Upon Completion of the Work

PART 2 - PRODUCTS
- Sheet Metal Materials
- Other Materials

PART 3 - EXECUTION
- Fabrication
- Workmanship
- Installation
- Cleaning

RELATED WORK

Applicable provisions of Division 01 shall govern work under this Section. The Contractor shall consult these provisions in detail prior to proceeding with work.

Section 07 59 00 - Roof Maintenance and Repairs
Section 06 10 53.01 – Miscellaneous Rough Carpentry

In the event that the Contractor wishes to make improvements in materials and/or techniques, or is required to make improvements by his material manufacturer in order to obtain guarantees/warranties, he shall make written request stating in full the nature of the proposed changes and stating that the changes, if approved, will be accomplished at no additional cost to contract.

REFERENCE STANDARDS

AISI – American Iron and Steel Institute.

ASTM A653 - Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

ASTM C920 – Elastomeric Joint Sealants.

ASTM D2244 – Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates.

ASTM D4214 – Test Methods for Evaluating Degree of Chalking of Exterior Paint Films.

FS TT-S-00230C - Federal Specification.

NRCA - Roofing and Waterproofing Manual.

SMACNA - Architectural Sheet Metal Manual.

GUARANTEE

Manufacturer's Warranty: Provide the sheet metal manufacturer's standard **twenty (20) year** warranty stating at a minimum that the metal finish will not chalk in excess of an eight (8) rating, or fade in excess of a five (5) rating, when tested in accordance with ASTM D2244 and ASTM D4214.

The following information shall be included on all guarantee and warranty documents:
State of Wisconsin (Owner), Agency, city or township, street address where work was performed, building name, Owner Project number, Owner (DOA) building number, all roof areas involved and total sq. ft. area of all roof areas.

QUALITY ASSURANCE

Contractor shall be recognized by the manufacturer of the sheet metal as an "approved" or "authorized" applicator. Within the past five (5) years, the contractor shall be able to document the successful completion of a minimum of three (3) projects of similar size and scope of the work specified in this section.

Provide all equipment recommended by the manufacturer for proper installation of the materials specified.

Prior to the start of construction, it is required that the Contractor's superintendent or foreman attends the preconstruction/pre-installation meeting(s).

PRODUCT DELIVERY, STORAGE AND HANDLING

Store all products in accordance with applicable provisions of Division 1 and Section(s) 07 59 00**.**

Stack preformed material to prevent twisting, bending or abrasion and to provide ventilation.

Prevent contact with materials during storage, which may cause discoloration, staining or damage.

SUBMITTALS - TECHNICAL AND OTHER DOCUMENTS

Contractor shall submit actual samples of pre-finished sheet metal showing the exact color(s), metal type and texture(s) available for selection.

Contractor will be notified of any additional required submittals at the pre-construction meeting.

PART 2 - PRODUCTS

All products used in this installation shall be compatible with materials used in Section(s) 07 59 00**.**

SHEET METAL MATERIALS

Prefinished Aluminum: ASTM B209, Series 3000, Temper H-14; pre-finished aluminum coated with a minimum 70% Kynar (Kynar 500) flouropolymer resin of 0.9-1.1 mil total dry film thickness and primed on the reverse side a wash coat of 0.3-0.4 mil dry film thickness. Color to be chosen from the manufacturer's standard color selection at the preconstruction meeting by AE. Texture shall be smooth.

MATERIALS

Fasteners: Provide materials and types of fasteners, solder, protective coatings, sealants, and other miscellaneous items as required for complete roofing system and as recommended by primary sheet metal manufacturer unless otherwise indicated.

Metal to Wood, at exposed locations: #10 x 1-1/2" stainless steel screws with metal capped neoprene or PVC washers.

Other Metal to Wood (concealed locations): 1-3/4" hot-dipped galvanized roofing nails.

Metal to Metal: #10 x 3/4" stainless steel sheet metal screws with pan or hex heads.

Metal to Concrete or Masonry: Zinc-alloy expansion shields with hardened steel pins.

Sealant: ASTM C920, Type S, Grade NS, Class 25, Use NT, M, G, A or O; FS TT-S-00230C, Type II, Class A; one-part polyurethane base, elastomeric joint sealing compound such as Sika Chemicals “Sikaflex 1a”, Sonneborn-Contech “Sonolastic NP1” or Tremco “Vulkem 116” or “Dymonic”.

Other products, not specifically described, but required for a complete and proper installation of the work in this section shall be selected by the Contractor subject to the approval of Owner.

PART 3 - EXECUTION

Refer to the drawings included with these specifications.

Fabricate and install all material in accordance with the latest edition of SMACNA, the best-accepted practices of the industry and these specifications.

FABRICATION

Fabricate new sections as detailed. Form sections true to shape, accurate in size, square and free from distortion or defects. Do not “punch” metal at brake points.

Form all pieces in lengths of 8'-0" or 10'-0" where practical. Sections less than 3' long are unacceptable unless that section comprises the entire run.

Unless detailed otherwise, hem exposed edges on underside 1/2"; fabricate vertical faces with bottom edge formed outward 3/4" at 45 degrees and hemmed to form drip.

Outside corners shall be prefabricated such that the outside face of section is broken at corner; seam at corner is unacceptable. Miter and seam top of outside and inside corners using rivets and specified polyurethane or manufacturer recommended and approved sealant. Corner pieces shall be a minimum of 18" in length, in both directions from the corner.

WORKMANSHIP

Make all work weather and watertight throughout; provide allowances for material expansion and contraction.

All valley and valley edge/fascia installations shall be recorded from deck to finish by taking digital photo's of the installation as each product is applied over the preceding product. Digital photos shall be properly identified as to their location on the roof and sent to the DFD Project Manager electronically.

Contractors workers shall carry a container or apron to deposit all metal cut offs, droppings or other debris created by the work. Waste shall not be dropped to the roof and ground.

Sections shall be uniform, accurately fitted so as to line up straight and true and rigidly secured in place, without kinks or buckles. Joints at corners and angles shall be smooth, tight and neatly mitered and seamed.
Unless detailed otherwise, lap all vertical joints between adjacent sections a minimum of 2".

Where metal is hooked to a continuous cleat, crimp metal to cleat along entire length.

Installation

Counterflashing:

Fasten counterflashing to receiver with stainless steel sheet metal screws @ 24" O.C.

Notch and lap joints 3" between sections; bayonet joints are unacceptable. Do not fasten joints between sections.

Counterflashing shall be creased longitudinally just enough to provide a spring action that will hold bottom edge firmly against flashing.

CLEANING

The work areas including the roof and ground below shall be inspected on a daily basis for waste/droppings.

Properly dispose of all cut offs, droppings and other debris on a daily basis to avoid damage or injury to others and/or owners property.

***** END OF SECTION *****

SECTION 07 84 00
FIRE STOPPING

BASED ON DFD MASTER SPECIFICATION DATED 12/01/14

PART 1 - GENERAL

SCOPE

The work under this section includes all labor, material, equipment and related services necessary to provide firestop systems consisting of a material, or combination of materials installed to retain the integrity of fire or smoke rated construction in accordance to the Building Code. The fire stopping systems shall maintain an effective barrier against the spread of flame, smoke, and/or hot gases through penetrations, blank openings and construction joints in fire or smoke rated construction, or at perimeter fire containment in or adjacent to fire-rated barriers.

RELATED WORK

Applicable provisions of Division 1 shall govern work under this Section. Contractor shall consult these provisions in detail prior to proceeding with work.

- Section 23 05 00 “Common Work Results for HVAC”
- Section 26 05 00 “Common Work Results for Electrical”

REFERENCES STANDARDS

- ASTM E 84 Test Method for Surface Burning Characteristics of Building Materials.
- ASTM E 119 Test Method for Fire Tests of Building Construction and Materials.
- ASTM E 136 Test Method for Behavior of Materials in a Vertical Tube Furnace at 750F.

ASTM E 814 Fire Tests of Through-Penetration Fire Stops.
ASTM E 1399 Cyclic Movement and Measuring Minimum and Maximum Joint Widths.
ASTM E 1966 Test Method for Resistance of Building Joint.
ASTM E 2174 Standard Practice for On-Site Inspection of Installed Fire Stops.
ASTM E 2393 Standard Practice for On-Site Inspection of Installed Fire Stop Joint Systems.
ASTM E 2307 Standard Test Method for Determining the Fire Endurance of Perimeter Fire Barrier Systems Using the Intermediate-Scale, Multi Story Test Apparatus (ISMA).
ASTM G 21 Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.

NFPA 70 National Electric Code.
NFPA 101 Life Safety Code.
NFPA 221 Standard for High Challenge Firewalls, Firewalls, and Fire Barriers Walls
NFPA 251 Tests of Fire Resistance of Building Construction and Materials.

UL 263 Fire Tests of Building Construction and Materials.
UL 555 Fire Dampers.
UL 723 Surface Burning Characteristics of Building Materials.
UL 1479 Fire-Tests of Through-Penetration Fire Stops.
UL 2079 Tests for Fire Resistance of Building Joint Systems.

International Firestop Council Guideline for Evaluating Firestop System Engineering Judgments.

SYSTEM PERFORMANCE REQUIREMENTS

Fire or Smoke Rated Construction Requirements: Maintain barrier containment and structural floor fire resistance ratings including resistance to smoke at all penetrations, connections with other surfaces or types of construction, at separations required to permit building movement and at other fire or smoke rated construction gaps. Provide fire stopping systems that resist the spread of fire and the passage of smoke and other gases according to the requirements indicated, including but not limited to the following:

Penetrations:

Firestop all penetrations passing through fire resistance rated construction or smoke barriers. Provide and install complete penetration fire stopping systems that have been tested and approved by a third party testing agency.

F - Rated Through-Penetration Firestop Systems: Provide through-penetration firestop systems with F Flame spread ratings indicated, as determined per ASTM E 814, but not less than one hour or the fire-resistance rating of the construction being penetrated.

T - Rated Through-Penetration Firestop Systems: Provide firestop systems with T Thermal Transmission ratings, in addition to F ratings, as determined per ASTM E 814, where required by code and as otherwise indicated.

L – Rated Through-Penetration Firestop Systems: Provide firestop systems with L Air Leakage ratings, in addition to F and T ratings, as determined per UL 1479, where required by code and as otherwise indicated.

W – Rated Through-Penetration Firestop Systems: Provide firestop systems with W Water Resistance ratings, in addition to F, T and L ratings, as determined per UL 1479, where indicated.

Penetration Fire stopping Assembly: Assemblies are specified generally under UL system categories by penetrating item. Manufacturers' product applications shall have specific UL system designations.

UL Through Penetration Classifications

	Fire Stopping System	Construction Penetrated	Type of Construction	System Identification
1	No Penetrating Items	F, W, C	A, B, J, K, L	0001-0999
2	Metallic Pipes, Conduit or Tubing	F, W, C	A, B, J, K, L	1001-1999
3	Nonmetallic Pipe, Conduit or Tubing	F, W, C	A, B, J, K, L	2001-3999
4	Electric Cables	F, W, C	A, B, J, K, L	4001-4999
5	Cable, Trays with Electric Cables:	F, W, C	A, B, J, K, L	5001-5999
8	Mechanical Ductwork Penetrations:	F, W, C	A, B, J, K, L	8001-8999
9	Multiple Penetrations Through Common Openings	F, W, C	A, B, J, K, L	9001-9999

***F** = Floor* — ***A** = concrete floors 5" or less*
***W** = Wall* — ***B** = concrete floors greater than 5"*
***C** = Floor or Wall* — ***J** = concrete or masonry walls 8" or less*
***K** = concrete or masonry walls greater than 9"*
***L** = framed wall*

Joints and Perimeter Systems:

Firestop all connections with other surfaces or types of construction, at separations required to permit building movement and at other fire rated or smoke barrier construction gaps.

Provide and install complete fire stopping systems that have been tested and approved by a third party testing agency.

Provide fire-resistive joint systems with fire and smoke resistance ratings indicated and as determined per ASTM E 1966 or UL 2079, but not less than the fire or smoke resistance rating of the construction in which the joint occurs.

Provide perimeter fire barrier systems with fire and smoke resistance ratings indicated and as determined per ASTM E 2307, but not less than the fire or smoke resistance rating of the floor construction.

UL Joint & Curtainwall Classifications

System Type:	Movement Capability	Joint Width
Floor to Floor (FF):	S, D	0000-0999
Wall to Wall (WW):	S, D	0000-0999
Floor to Wall (FW):	S, D	0000-0999
Head of Wall (HW):	S, D	0000-0999
Floor to Wall (FW):	S, D	0000-0999
Curtain Wall (CW*)	S, D	0000-0999

***S** = Static* — *0000-0999 = less than or equal to 2"*
***D** = Dynamic* — *1000-1999 = greater than 2", less than or equal to 6"*
2000-2999 = greater than 6", less than or equal to 12"
3000-3999 = greater than 12", less than or equal to 24"
4000-4999 = greater than 24"

*Note: If **Intertek Curtain Wall** Classification system is used, nomenclature will be* **CEJ** *or* **HI/BP**

Smoke Partition Penetrations and Joints: Fully seal penetrations and joints to prevent the passage of smoke.

Provide products that upon curing do not re-emulsify, dissolve, break down or deteriorate from exposure to atmospheric moisture or moisture characteristic to construction.

SUBMITTALS

The following information shall be included on all submitted documents:

Building Name and DFD Project Number taken from bidding documents.

Submit Manufacturers Product Data Sheets and material safety data sheets (MSDS) for each type of product selected.

Where there is no specific third party tested and listed, classified firestop system available for a particular firestop configuration, the contractor shall obtain from the firestop manufacturer, an Engineering Judgment (EJ) or Equivalent Fire Resistance Rated Assembly (EFRRA) for submittal following the "Recommended International Firestop Council Guidelines for Evaluating Firestop Systems in Engineering Judgments".

Submit the following:

Firestopping schedule. Listing agency approved installation detail for each type of penetration treatment with drawing reference of where each is used (type of penetration).

Certification that Firestop Material is asbestos free and complies with local regulations.

Certification by fire stopping manufacturer that products supplied comply with specified requirements for volatile organic compounds (VOC's) and are nontoxic to building occupants.

Contractor qualifications as noted in "Quality Assurance" article, including certification of manufacturer's training.

QUALITY ASSURANCE

Provide Fire-resistive System Listing by a testing and inspection agency in accordance with the appropriate ASTM Standard(s) listed. A qualified testing and inspection agency may be UL, FM Research, Intertek Testing Services, Omega Point Laboratories (OPL) or another agency performing testing and follow-up inspection services for fire-resistive system materials that is acceptable to the authority having jurisdiction.

Contractor Qualifications: Acceptable installer firms shall be:

A firm experienced in installing fire stopping systems similar in material, design, and scope to that indicated for this Project, and who has a record of completing past projects. Qualifications include having three years of fire stopping installation experience, staff, and training to install manufacturer's products per specified requirements. Provide statement from manufacturer certifying contractor's staff has successfully completed manufacturer's training on installation requirements of fire stopping systems that will be used on this Project.

Single Source Responsibility:

Materials made by different manufacturers shall not be intermixed in the same opening.

Tested and listed, classified fire-resistive systems are to be used.

If another manufacturer has a tested and listed system, then that system shall be considered before an Equivalent Fire Resistance Rated Assembly (EFRRA) is considered.

Field Constructed Mockup: Prior to installing fire-resistive systems, erect mockups for each different fire-resistive system indicated to verify product selections and to demonstrate qualities of materials and execution:

1) Duct penetrations between Billet room partitions and walls

Provide mockups complying with the following requirements, using materials indicated for final installations, for the following applications:

Provide mock-up in conjunction with other required mock-ups where fire stopping assemblies will be part of the construction.

Locate mockups on site in locations indicated or, if not indicated, as directed by Architect. Include mockup for each type of system.

Notify Architect in advance of the dates and times when mockups will be installed.
Obtain DFD acceptance of mockups before start of Work.
Retain and maintain mockups during construction in an undisturbed condition as a standard for judging completed unit of Work. Accepted mockups in an undisturbed condition at time of Substantial Completion may become part of completed unit of Work.

DELIVERY, STORAGE, AND HANDLING

Deliver fire stopping products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product and manufacturer.

Store and handle fire-resistive materials in accordance with manufacturer's written instructions.

PROJECT CONDITIONS

Environmental Conditions: Install fire-resistive system in accordance with manufacturer's written instructions.

Ventilation: Ventilate per manufacturers' instructions or Material Safety Data Sheet (MSDS).

PREINSTALLATION COORDINATION

A firestopping specific preinstallation coordination meeting shall be conducted prior to installing any construction affected by or penetrated by firestopping. This meeting shall include the General Prime Contractor and all contractors installing firestopping, as well as DFD. Each type of firestopping shall be discussed, identifying the penetrating component, the building component or system being penetrated, the firestopping system to be utilized and the contractor responsible to install the firestopping. All firestopping submittals should be consistent with the conclusions of this meeting.

PART 2 - PRODUCTS

Where specific manufacturers are named, products by other manufacturers may be considered equal in accordance with the provisions of Article 17 of the General Conditions.

MANUFACTURERS

Systems listed by approved testing agencies may be used providing they conform to the construction type, penetrant type, annular space requirements, and fire rating required for each separate instance.

Manufacturers of fire stopping shall have been successfully producing and supplying these products for a period of not less than 3 years, and shall be able to show evidence of at least 10 projects where similar products have been installed and accepted.

Subject to compliance with requirements, provide products by one of the following manufacturers:
3M Fire Protection Products.
HILTI, Inc.
ProSet Systems, Inc.
Specified Technologies, Inc.
Tremco Construction Division.

PENETRATION FIRE STOPPING

Penetrations in Fire-Resistance-Rated Walls: Provide penetration fire stopping with the following ratings determined per ASTM E 814 or UL 1479:
Fire-resistance-rated walls include fire walls and fire-barrier walls.
F-Rating: Not less than the fire-resistance rating of constructions penetrated.

Penetrations in Horizontal Assemblies: Provide penetration fire stopping with the following ratings determined per ASTM E 814 or UL 1479:

Horizontal assemblies include floor assemblies, floor/ceiling assemblies, roof/ceiling assemblies and roof assemblies.

F-Rating: At least 1 hour, but not less than the fire-resistance rating of constructions penetrated.

T-Rating: At least 1 hour, but not less than the fire-resistance rating of constructions penetrated except for floor penetrations within the cavity of a wall or shaft enclosure above the floor or below the floor.

Penetrations in Smoke Barriers: Provide penetration fire stopping with the following ratings determined per UL 1479 with required "L" rating:

L-Rating: Air leakage rate of the penetration assemblies measured at .30 inches of water column in both the ambient temperature and elevated temperature tests shall not exceed 5.0 cfm/square foot of penetration opening for each through penetration fire stop system or a total cumulative leakage of 50 cfm for any 100 sf of wall or floor area.

Penetrations in Smoke Partitions:

Seal penetrations with mildew resistant water based latex smoke and acoustic sealant with flame-spread smoke-developed rating of less than 25 as tested in accordance with ASTM E84.

Penetrations with Insulated Piping or Ductwork:

Provide penetration fire stop systems designed for continuous insulation except when penetrating piping is constructed of plastic which shall penetrate fire stop without insulation.

Penetrations in Floors with Annular Spaces Exceeding 4" and Exposed to Loading and Traffic:

Provide approved means of supporting floor loads and protecting firestop systems.

Penetrations for Telecom Equipment Rooms or Where Cable Tray is Discontinuous:

Provide a manufactured re-enterable system that features a built-in fire and smoke sealing system that allows cables to be added or removed without the need to remove or reinstall fire stopping materials. Examples of such systems are the STI EZ Path and HILTI Speed Sleeve.

Penetrations for All Other Communication Cabling Applications 2" Diameter and Larger:

Provide a system that utilizes removable and reusable fire stop material. Examples of such systems are the 3M Pass-Through Device, STI FP fire stop plug and HILTI CFS-PL fire stop plug.

Flame Spread and Smoke Developed Ratings:

Provide products with flame-spread and smoke-developed indexes of 25 and 450 or less, respectively, or 25 and 50 or less in air plenums, as determined per ASTM E 84.

VOC Content: Penetration fire stopping sealants and sealant primers shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):

Sealants: 250 g/L.

Sealant Primers for Nonporous Substrates: 250 g/L.

Sealant Primers for Porous Substrates: 775 g/L.

Accessories:

Provide components for each penetration fire stopping system that are needed to install fill materials and to maintain ratings required. Use only those components specified by penetration fire stopping manufacturer and approved by qualified testing and inspecting agency for fire stopping indicated.

Refer to Section Section 23 05 00 “Common Work Results for HVAC” and Section 26 05 00 “Common Work Results for Electrical” for sleeves and openings and for additional requirements at penetrations.

FIRE-RESISTIVE JOINT FIRE STOPPING

Where required, provide fire-resistive joint fire stopping that is produced and installed to resist spread of fire according to code and requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of assemblies in or between which fire-resistive joint stopping is installed. Fire-resistive joint fire stopping shall accommodate building movements without impairing its ability to resist the passage of fire and hot gases.

Joints in or between Fire-Resistance-Rated Construction: Provide fire-resistive joint systems with the following ratings determined per ASTM E 1966 or UL 2079:

Joints include those installed in or between fire-resistance-rated walls, floor or floor/ceiling assemblies, and roofs or roof/ceiling assemblies.

Fire-Resistance Rating: Equal to or exceeding the fire-resistance rating of construction they will join.

Joints at Exterior Curtain Wall/Floor Intersections and Perimeter Fire Barriers: Provide fire-resistive joint systems and perimeter fire barrier systems with the following rating determined by ASTM E 2307.

Fire-Resistance Rating: Equal to or exceeding the fire-resistance rating of the floor assembly.

Joints in Smoke Barriers:

Fire-resistive Rated Construction: Provide fire-resistive joint systems with the following ratings determined per UL 2079 with required “L” rating.

L-Rating: Not exceeding 5.0 cfm/ft (0.00775 cu. m/s x m) of joint at 0.30 inch wg (74.7 Pa) at both ambient and elevated temperatures.

Joints in Smoke Partitions:

Seal joints with mildew resistant water based latex smoke and acoustic sealant with flame-spread smoke-developed rating of less than 25 as tested in accordance with ASTM E84.

Flame Spread and Smoke Developed Ratings:

Provide products with flame-spread and smoke-developed indexes of 25 and 450 or less, respectively, or 25 and 50 or less in air plenums, as determined per ASTM E 84.

VOC Content: Fire-resistive joint system and perimeter fire barrier sealants shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):

Architectural Sealants: 250 g/L.

Sealant Primers for Nonporous Substrates: 250 g/L.

Sealant Primers for Porous Substrates: 775 g/L.

Accessories:

Provide components of fire-resistive joint systems and perimeter fire barrier systems, including primers and forming materials, which are needed to install fill materials and to maintain ratings required. Use only components specified by fire-resistive joint system manufacturer and approved by the qualified testing agency for systems indicated.

PART 3 - EXECUTION

APPLICATION

Fire stopping systems shall be used in applications approved by the manufacturer and in locations including, but not limited to, the following where required by code and as otherwise indicated:

Penetrations through fire-resistance-rated floor assemblies, floor/ceiling assemblies, roof/ceiling assemblies and roof assemblies requiring protected openings including both empty openings and openings that contain penetrations.
Penetrations through fire-resistance-rated wall assemblies including both empty openings and openings that contain penetrations.
Membrane penetrations in fire-resistance-rated wall assemblies where items penetrate one side of the barrier.
Joints in fire-resistance-rated assemblies to allow independent movement.
Perimeter joints between fire-resistance-rated floor assemblies, floor/ceiling assemblies, roof/ceiling assemblies or roofs and exterior wall assemblies.
Joints, through penetrations, and membrane penetrations in Smoke Barriers and Smoke Partitions.

EXAMINATION

Examine substrates and conditions, with installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of fire-resistive system. Notify the Project Representative of any unsatisfactory conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.

PREPARATION

Cleaning and Preparation: Clean and prepare surfaces as recommended by system manufacturer.

Verify system components are clean, dry, and ready for installation.

Verify field dimensions are as shown on the Drawings, are as tested and listed for classified systems, and meet manufacturer requirements and recommendations.

PENETRATION FIRE STOPPING

Comply with the "System Performance Requirements" listed in Part 1 and with the manufacturer's installation instructions and drawings pertaining to products and applications indicated. Protect fire stopping systems, including those raised 2” above surrounding floor, from damage due to construction activities.

SMOKE BARRIERS AND SMOKE PARTITIONS

Comply with the "System Performance Requirements" listed in Part 1 and with the manufacturer's installation instructions and drawings pertaining to products and applications indicated.

FIRE-RESISTIVE JOINT FIRE STOPPING

Comply with the "System Performance Requirements" listed in Part 1 and with the manufacturer's installation instructions and drawings pertaining to products and applications indicated.

Install tested and listed classified systems that result in fire-resistive joint and perimeter fire barrier materials:

Directly contacting and fully wetting joint substrates.
Completely filling recesses provided for each joint configuration,
Providing uniform, cross-sectional shapes and depths relative to joint width that optimize movement capability and meet tested and listed system requirements.

Tool non-sag materials immediately after their application and prior to the time skinning begins. Form smooth, uniform beads of configuration indicated or required to:

Produce fire-resistance rating
To eliminate air pockets
To ensure contact and adhesion with sides of joint.

FIELD QUALITY CONTROL

Inspection: Independent inspection agency may be employed and paid by Owner to examine and photograph fire stopping.

Where deficiencies are found or fire stopping systems are damaged or removed because of testing, repair or replace fire stopping to comply with requirements.

Proceed with enclosing fire stopping with other construction only after inspection reports are issued and installations comply with requirements.

IDENTIFICATION

Identify fire stopping with preprinted labels. Attach labels permanently to surfaces adjacent to and within 6 inches (152 mm) of fire stopping edge so labels will be visible to anyone seeking to remove penetrating items or fire stopping. Use mechanical fasteners or self-adhering-type labels with adhesives capable of permanently bonding labels to surfaces on which labels are placed. Include the following information on labels:

"FIRESTOPPED PENETRATION"
Installed Product
UL System Number
Date of Installation
Installing Contractor and Phone Number

Fire walls, fire barriers, fire partitions, smoke barriers and smoke partitions or any other wall required to have protected openings or penetrations shall be effectively and permanently identified with signs or stenciling which include the hourly rating. Such identification shall:

Be located in accessible concealed floor, floor-ceiling or attic spaces;
Be located within 15 feet of the end of each wall and at intervals not exceeding 30 feet measured horizontally along the wall or partition.
Include lettering not less than 3 inches in height with a minimum 3/8 inch stroke in a contrasting color incorporating the wording.
"FIRE AND/OR SMOKE BARRIER—PROTECT ALL OPENINGS, _ HOURLY RATING"

CLEANING

Clean off excess fill materials and sealants adjacent to openings and joints as work progresses. Use methods and cleaning materials approved by manufacturers of fire stopping products and or assemblies in which openings and joints occur.

***** END OF SECTION *****

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SECTION 07 92 00
JOINT SEALANTS

PART 1 - GENERAL

SCOPE

Include all materials and labor, services and incidentals for the completion of the following scope of work: Replacement of nonsag gunnable joint sealants, joint backings, and accessories. Windows, Curtain Wall Brick Masonry, and EIFS/DAFS.

RELATED WORK

Applicable provisions of Division 1 shall govern this section.

Section - 04 01 20 Maintenance of Unit Masonry
Section - 07 24 13 Polymer-Based Exterior Insulation and Finish System
Section - 08 51 13 Aluminum Windows
Section - 08 44 13 Glazed Aluminum Curtain Walls

SUBMITTALS

Product Data for Sealants: Submit manufacturer's technical data sheets for each product to be used, that includes the following.

Physical characteristics, including movement capability, VOC content, hardness, cure time, and color availability.

List of backing materials approved for use with the specific product.

Substrates that product is known to satisfactorily adhere to and with which it is compatible.

Substrates the product should not be used on.

Color Cards for Selection: Where sealant color is not specified, submit manufacturer's color cards showing standard colors available for selection.

Preinstallation Field Adhesion Test Plan: Submit at least two weeks prior to start of installation.

Preinstallation Field Adhesion Test Reports: Submit filled out Preinstallation Field Adhesion Test

Reports log within 10 days after completion of tests; include bagged test samples and photographic records.

QUALITY ASSURANCE

Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

Installer Qualifications: Company specializing in performing the work of this section and with at least three years of documented experience.

Preconstruction Laboratory Testing: Arrange for sealant manufacturer(s) to test each combination of sealant, substrate, backing, and accessories.

Adhesion Testing: In accordance with ASTM C794.

Compatibility Testing: In accordance with ASTM C1087.

Allow sufficient time for testing to avoid delaying the work.

Deliver to manufacturer sufficient samples for testing.

Report manufacturer's recommended corrective measures, if any, including primers or techniques not indicated in product data submittals.

Testing is not required if sealant manufacturer provides data showing previous testing, not older than 24 months, that shows satisfactory adhesion, lack of staining, and compatibility.

Preinstallation Field Adhesion Test Plan: Include destructive field adhesion testing of one sample of each combination of sealant type and substrate, except interior acrylic latex sealants, and include the following for each tested sample.

Identification of testing agency.

Preinstallation Field Adhesion Test Log Form: Include the following data fields, with known information filled out.

Substrate; if more than one type of substrate is involved in a single joint, provide two entries on form, for testing each sealant substrate side separately.

Test date.

Location on project.

Sealant used.

Stated movement capability of sealant.

Test method used.

Date of installation of field sample to be tested.

Date of test.

Copy of test method documents.

Age of sealant upon date of testing.

Test results, modeled after the sample form in the test method document.
Indicate use of photographic record of test.

Field Quality Control Plan:

Visual inspection of entire length of sealant joints.

Destructive field adhesion testing of sealant joints.

For each different sealant and substrate combination, allow for one test every 100 feet (30 meters) or once per floor on each elevation.

If any failures occur in the first continue testing at frequency of one test at no extra cost to Owner.

Field testing agency's qualifications.

Field Quality Control Log Form: Show same data fields as on Preinstallation Field Adhesion Test Log, with known information filled out and lines for multiple tests per sealant/substrate combinations; include visual inspection and specified field testing; allow for possibility that more tests than minimum specified may be necessary.

Field Adhesion Test Procedures:

Allow sealants to fully cure as recommended by manufacturer before testing.

Have a copy of the test method document available during tests.

Take photographs or make video records of each test, with joint identification provided in the photos/videos; for example, provide small erasable whiteboard positioned next to joint.

Record the type of failure that occurred, other information required by test method, and the information required on the Field Quality Control Log.

When performing destructive tests, also inspect the opened joint for proper installation characteristics recommended by manufacturer, and report any deficiencies.

Deliver the samples removed during destructive tests in separate sealed plastic bags, identified with project, location, test date, and test results, to Owner.

If any combination of sealant type and substrate does not show evidence of minimum adhesion or shows cohesion failure before minimum adhesion, report results to Architect.

Destructive Field Adhesion Test: Test for adhesion in accordance with ASTM C1521, using Destructive Tail Procedure.

Sample: At least 18 inch (457 mm) long.

Minimum Elongation Without Adhesive Failure: Consider the tail at rest, not under any elongation stress; multiply the stated movement capability of the sealant in percent by two; then multiply 1 inch (25 mm) by that percentage; if adhesion failure occurs before the "1 inch mark" is that distance from the substrate, the test has failed.

If either adhesive or cohesive failure occurs prior to minimum elongation, take necessary measures to correct conditions and re-test; record each modification to products or installation procedures.

Record results on Field Quality Control Log.

Repair failed portions of joints.

WARRANTY

Correct defective work within a five year period after Date of Substantial Completion.

Warranty: Include coverage for installed sealants and accessories that fail to achieve watertight seal , exhibit loss of adhesion or cohesion, or do not cure.

PART 2 - PRODUCTS

JOINT SEALANTS

Compatibility: Provide joint sealants, joint fillers, and other related materials that are compatible with one another and with joint substrates under service and application conditions.

Sealant for Exterior Use Type S - Non-Staining Silicone Sealant: ASTM C920, Grade NS, Uses M and A; not expected to withstand continuous water immersion or traffic.

Movement Capability: Plus and minus 50 percent, minimum.

Non-Staining To Porous Stone: Non-staining to light-colored natural stone when tested in accordance with ASTM C1248.

Dirt Pick-Up: Reduced dirt pick-up compared to other silicone sealants.

Color: To be selected by Architect from manufacturer's standard range.

Cure Type: neutral.

Service Temperature Range: Minus 20 to 180 degrees F (Minus 29 to 82 degrees C).

Manufacturers:

Basis of Design: Tremco Commercial Sealants & Waterproofing; Spectrem 3: www.tremcosealants.com/#sle.

Dow Chemical Company; DOWSIL 791 Silicone Weatherproofing Sealant: consumer.dow.com/en-us/industry/ind-building-construction.html/#sle.

Sealant for Interior Use at Perimeters of Door and Window Frames: Acrylic latex or siliconized acrylic latex, ASTM C 834, Type OP, Grade NF.

MISCELLANEOUS MATERIALS

Backer Rod: Cylindrical cellular foam rod with surface that sealant will not adhere to, compatible with specific sealant used, and recommended by backing and sealant manufacturers for specific application.

Type for Joints Not Subject to Pedestrian or Vehicular Traffic: ASTM C1330; Type C - Closed Cell Polyethylene.

Closed Cell and Bi-Cellular: 25 to 33 percent larger in diameter than joint width.

Backing Tape: Self-adhesive polyethylene tape with surface that sealant will not adhere to and recommended by tape and sealant manufacturers for specific application.

Joint Cleaner: Non-corrosive and non-staining type, type recommended by sealant manufacturer; compatible with joint forming materials.

Primers: Type recommended by sealant manufacturer to suit application; non-staining.

PART 3 - EXECUTION

EXAMINATION

Verify that joints are ready to receive work.

Verify that backing materials are compatible with sealants.

Verify that backer rods are of the correct size.

PREPARATION

Remove loose materials and foreign matter that could impair adhesion of sealant.

Clean joints, and prime as necessary, in accordance with manufacturer's instructions.

Perform preparation in accordance with manufacturer's instructions and ASTM C1193.

Mask elements and surfaces adjacent to joints from damage and disfigurement due to sealant work; be aware that sealant drips and smears may not be completely removable.

INSTALLATION

Perform work in accordance with sealant manufacturer's requirements for preparation of surfaces and material installation instructions.

Perform installation in accordance with ASTM C1193.

Measure joint dimensions and size joint backers to achieve width-to-depth ratio, neck dimension, and surface bond area as recommended by manufacturer, except where specific dimensions are indicated.
Install bond breaker backing tape where backer rod cannot be used.

Install sealant free of air pockets, foreign embedded matter, ridges, and sags, and without getting sealant on adjacent surfaces.

Do not install sealant when ambient temperature is outside manufacturer's recommended temperature range, or will be outside that range during the entire curing period, unless manufacturer's approval is obtained and instructions are followed.

Nonsag Sealants: Tool surface concave, unless otherwise indicated; remove masking tape immediately after tooling sealant surface.

END OF SECTION 07 92 00

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SECTION 08 08 00
COMMISSIONING OF EXTERIOR BUILDING ENVELOPE
BASED ON DFD MASTER SPECIFICATION DATED 02/27/15

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-08 51 13 Metal Windows

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.

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CV-08 51 13 – Metal Windows

Identification/Tag: _____
Location:_____

Group/Item	Group/Task Description			Submitted	Delivered
A	*MODEL VERIFICATION*				
1	Manufacturer				
2	Model				
3	Width / Height (in / in)			/	/
4	Material / Gauge			/	/
5	Finish				
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
B	*PHYSICAL CHECKS*				
1	All components are free from physical damage.			YES	NO
2	All components present.			YES	NO
3	Hardware provided per window schedule.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
C	*INSTALLATION*				
1	Opening square, true and plumb.			YES	NO
2	Opening prepared for installation.			YES	NO
3	Imbeds and anchors installed.			YES	NO
4	Head and sill flashing installed.			YES	NO
5	Vapor barrier is properly sealed to frame.			YES	NO
6	Windows set plumb and level.			YES	NO
7	Weep holes directed down and away from window.			YES	NO
8	Caulking and backer rod installed with proper tolerances.			YES	NO
9	All components undamaged and cleaned.			YES	NO
10	Factory seal of window is undamaged.			YES	NO
11	Window and hardware operation verified and free from restrictions of movement (if applicable).				
❑ **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		

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SECTION 08 51 13
ALUMINUM WINDOWS
BASED ON DFD MASTER SPECIFICATION DATED 10/01/2012

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

SCOPE
This section provides information common to two or more technical site work specification sections or items that are of a general nature, and not included in other sections. This section applies to ALL site work, as applicable. Included are the following topics: aluminum windows for exterior locations.

PART 1 - GENERAL
- Scope
- Action Submittals
- Informational Submittals
- Quality Assurance
- Warranty

PART 2 – PRODUCTS
- Window Performance Requirements
- Aluminum Windows
- Accessories
- Fabrication
- Aluminum Finishes

PART 3 - EXECUTION
- Installation

PREINSTALLATION MEETINGS
Preinstallation Conference: Conduct conference at Project site.

ACTION SUBMITTALS
Product Data: For each type of product.

Shop Drawings: Include plans, elevations, sections, hardware, accessories, insect screens, operational clearances, and details of installation, including anchor, flashing, and sealant installation.

Samples: For each exposed product and for each color specified.

INFORMATIONAL SUBMITTALS
Product test reports.

Sample warranties.

QUAITY ASSURANCE
Mockups: Prepare mockups of window installation to demonstrate aesthetic effects and set quality standards for materials and execution and for fabrication and installation.

Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

Preinstallation Conference: Conduct conference at **Project site**.

GUARANTEE and WARRANTY

Provide written two (2) year guarantee warranting Curtain Wall Systems required under contract, to be watertight, airtight and free from defects in materials or workmanship for period of time, as stipulated in guarantee form.

Products: Submit a written warranty, executed by the window manufacturer, for a period of 10 years from the date of manufacture, against defective materials or workmanship, including substantial non-compliance with applicable specification requirements and industry standards, which result in premature failure of the windows, finish, factory-glazed glass, or parts, outside of normal wear.

In the event that windows or components are found defective, manufacturer will repair or provide replacement material without charge at manufacturer's option.

Warranty for all components must be direct from the manufacturer (non pass-through) and non pro-rated for the entire term. Warranty must be assignable to the non-residential owner, and transferable to subsequent owners through its length.

Manufacturer's Warranty: Manufacturer agrees to repair or replace aluminum windows that fail in materials or workmanship within specified warranty period.

Warranty Period:

Window: 10 years from date of Substantial Completion.

Glazing Units: 10 years from date of Substantial Completion.

Aluminum Finish: 10 years from date of Substantial Completion.

PART 2 – PRODUCTS

WINDOW PERFORMANCE REQUIREMENTS

Product Standard: Comply with AAMA/WDMA/CSA 101/I.S.2/A440 for definitions and minimum standards of performance, materials, components, accessories, and fabrication unless more stringent requirements are indicated.

Window Certification: AAMA certified with label attached to each window.

Performance Class and Grade: AAMA/WDMA/CSA 101/I.S.2/A440 as follows:

Minimum Performance Class: AW.

Minimum Performance Grade: 80.

Thermal Transmittance: NFRC 100 maximum whole-window U-factor of 0.55 Btu/sq. ft. x h x deg F

Solar Heat-Gain Coefficient (SHGC): NFRC 200 maximum whole-window SHGC of 0.51

Condensation-Resistance Factor (CRF): Provide aluminum windows tested for thermal performance according to AAMA 1503, showing a CRF of 52.

Thermal Movements: Provide aluminum windows, including anchorage, that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

Temperature Change: 120 deg F (67 deg C) ambient; 180 deg F (100 deg C) material surfaces.

ALUMINUM WINDOWS

Manufacturer:

Basis of Design: Manko 4527i with Grid
Other Acceptable Manufacturer: Wausau Windows, EFCO, DeSCo, Kawneer

Types: As indicated on Drawings

Frames and Sashes: Aluminum extrusions complying with AAMA/WDMA/CSA 101/I.S.2/A440.

Thermally Improved Construction: Fabricate frames, sashes, and muntins with an integral, concealed, low-conductance thermal barrier located between exterior materials and window members exposed on interior side in a manner that eliminates direct metal-to-metal contact.

Glass: See Section 08 80 00 - Glazing

Glazing System: Manufacturer's standard factory-glazing system that produces weathertight seal and compatible with the glazing specified elswhere.

Hardware, General: Provide manufacturer's standard corrosion-resistant hardware sized to accommodate sash weight and dimensions.

Exposed Hardware Color and Finish: Clear Anodized Aluminum.

Fasteners: Noncorrosive and compatible with window members, trim, hardware, anchors, and other components.

Exposed Fasteners: Do not use exposed fasteners to greatest extent possible. For application of hardware, use fasteners that match finish hardware being fastened.

ACCESSORIES

BY MANUFACTURER.

Receptor System: Two-piece, snap-together, thermally broken, extruded-aluminum receptor system that anchors windows in place.

Subsills: Thermally broken extruded-aluminum subsills in configurations indicated on Drawings.

Interior Snap Trim: Extruded-aluminum profiles in sizes and configurations indicated on Drawings.

Outside Stap Trim: Extruded-aluminum profiles in sizes and configurations indicated on Drawings.

OTHER:

Prefinished Aluminum: ASTM B209, Series 3000, Temper H-14; pre-finished aluminum coated with a minimum 70% Kynar (Kynar 500) flouropolymer resin of 0.9-1.1 mil total dry film thickness and primed on the reverse side a wash coat of 0.3-0.4 mil dry film thickness. Color to be chosen from the manufacturer's standard color selection at the preconstruction meeting. Texture shall be smooth.

FABRICATION

Fabricate aluminum windows in sizes indicated. Include a complete system for assembling components and anchoring windows.

Glaze aluminum windows in the factory.

Weather strip each operable sash to provide weathertight installation.

Weep Holes: Provide weep holes and internal passages to conduct infiltrating water to exterior.

Provide water-shed members above side-hinged sashes and similar lines of natural water penetration.

Mullions: Provide mullions and cover plates, matching window units, complete with anchors for support to structure and installation of window units. Allow for erection tolerances and provide for movement of window units due to thermal expansion and building deflections. Provide mullions and cover plates capable of withstanding design wind loads of window units.

Complete fabrication, assembly, finishing, hardware application, and other work in the factory to greatest extent possible. Disassemble components only as necessary for shipment and installation.

ALUMINUM FINISHES

Color Anodic Finish: AA-M12C22A32/A34, Class II, 0.010 mm or thicker. Medium bronze.

PART 3 – EXECUTION

INSTALLATION

Comply with manufacturer's written instructions for installing windows, hardware, accessories, and other components. For installation procedures and requirements not addressed in manufacturer's written instructions, comply with installation requirements in ASTM E2112.

Install windows level, plumb, square, true to line, without distortion or impeding thermal movement, anchored securely in place to structural support, and in proper relation to wall flashing and other adjacent construction to produce weathertight construction.

Install windows and components to drain condensation, water penetrating joints, and moisture migrating within windows to the exterior.

Separate aluminum and other corrodible surfaces from sources of corrosion or electrolytic action at points of contact with other materials.

Adjust operating sashes and hardware for a tight fit at contact points and weather stripping for smooth operation and weathertight closure.

Clean exposed surfaces immediately after installing windows. Avoid damaging protective coatings and finishes. Remove excess sealants, glazing materials, dirt, and other substances.

Remove and replace glass that has been broken, chipped, cracked, abraded, or damaged during construction period.

END OF SECTION

SECTION 08 80 00
GLAZING

PART 1- GENERAL

SCOPE
This section includes glass products, laminated glass, insulating glass, glazing sealants, glazing tapes, and miscellaneous glazing materials.

COORDINATION
Coordinate glazing channel dimensions to provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances to achieve proper safety margins for glazing retention under each design load case, load case combination, and service condition.

PREINSTALLATION MEETINGS
Preinstallation Conference: Conduct conference at Project site.

ACTION SUBMITTALS
Product Data: For each type of product.

Glass Samples: For each type of glass product other than clear monolithic vision glass; 12 inches (300 mm) square.

Delegated Design Submittal: For glass indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by qualified professional engineer responsible for their preparation.

INFORMATIONAL SUBMITTALS
Product Certificates: For glass.

Product test reports.

Preconstruction adhesion and compatibility test report.

Sample warranties.

QUALITY ASSURANCE
Sealant Testing Agency Qualifications: An independent testing agency qualified according to ASTM C1021 to conduct the testing indicated.

WARRANTY
Manufacturer's Special Warranty for Glass Products: Manufacturer agrees to replace glass units that deteriorate within specified warranty period. Deterioration of glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning coated glass contrary to manufacturer's written instructions.

Warranty Period: 10 years from date of Substantial Completion.

PART 2- PRODUCTS

PERFORMANCE REQUIREMENTS
Thermal Loads: Design glazing to resist thermal stress breakage induced by differential temperature conditions and limited air circulation within individual glass lites and insulated glazing units.

Safety Glazing: Where safety glazing is indicated, provide glazing that complies with 16 CFR 1201, Category II.

GLASS PRODUCTS, GENERAL
Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below unless more stringent requirements are indicated. See these publications for glazing terms not otherwise defined in this Section or in referenced standards.

NGA Publications:"Glazing Manual."

Safety Glazing Labeling: Where safety glazing is indicated, permanently mark glazing with certification label of manufacturer. Label shall indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.

Thickness: Where glass thickness is indicated, it is a minimum. Provide glass that complies with performance requirements and is not less than thickness indicated.

Strength:

Where heat-strengthened float glass is indicated, provide fully tempered float glass. Where fully tempered float glass is indicated, provide fully tempered float glass.

GLASS PRODUCTS
Fully Tempered Float Glass: ASTM C1048, Kind FT (fully tempered), Condition A (uncoated) unless otherwise indicated, Type I, Class 1 (clear).

Heat-Strengthened Float Glass: ASTM C1048, Kind HS (heat strengthened), Type I, Condition A (uncoated) unless otherwise indicated, Type I, Class 1 (clear) or Class 2 (tinted) as indicated, Quality-Q3.

Reflective- and Low-E-Coated Vision Glass: ASTM C1376.

Ceramic-Coated Vision Glass: ASTM C1048, Condition C, Type I, Class 1 (clear) or Class 2 (tinted) as indicated, Quality-Q3; and complying with Specification No. 95-1-31 in NGA's "Engineering Standards Manual."

Ceramic-Coated Spandrel Glass: ASTM C1048, Type I, Condition B, Quality-Q3.

GLAZING SEALANTS

General:

Compatibility: Compatible with one another and with other materials they contact, including glass products, seals of insulating-glass units, and glazing channel substrates, under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.

Suitability: Comply with sealant and glass manufacturers' written instructions for selecting glazing sealants suitable for applications indicated and for conditions existing at time of installation.

Colors of Exposed Glazing Sealants: As indicated by manufacturer's designations.

GLAZING TAPES

Back-Bedding Mastic Glazing Tapes: Preformed, butyl-based, 100 percent solids elastomeric tape; nonstaining and nonmigrating in contact with nonporous surfaces; with or without spacer rod as recommended in writing by tape and glass manufacturers for application indicated; and complying with ASTM C1281 and AAMA 800 for products indicated below:

AAMA 804.3 tape, where indicated.

AAMA 806.3 tape, for glazing applications in which tape is subject to continuous pressure.

AAMA 807.3 tape, for glazing applications in which tape is not subject to continuous pressure.

Expanded Cellular Glazing Tapes: Closed-cell, PVC foam tapes; factory coated with adhesive on both surfaces; and complying with AAMA 800 for the following types:

AAMA 810.1, Type 1, for glazing applications in which tape acts as primary sealant.

AAMA 810.1, Type 2, for glazing applications in which tape is used in combination with a full bead of liquid sealant.

MISCELLANEOUS GLAZING MATERIALS

Cleaners, Primers, and Sealers: Types recommended by sealant or gasket manufacturer.

Setting Blocks:

Silicone with Shore A durometer hardness of 85, plus or minus 5.

Type recommended in writing by sealant or glass manufacturer.

Spacers:

Neoprene blocks or continuous extrusions of hardness required by glass manufacturer to maintain glass lites in place for installation indicated.

Type recommended in writing by sealant or glass manufacturer.

Edge Blocks:

Silicone with Shore A durometer hardness per manufacturer's written instructions.

Type recommended in writing by sealant or glass manufacturer.

Cylindrical Glazing Sealant Backing: ASTM C1330, Type O (open-cell material), of size and density to control glazing sealant depth and otherwise produce optimum glazing sealant performance.

PART 3- EXECUTION

GLAZING, GENERAL

Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.

Protect glass and panel edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass includes glass with edge damage or other imperfections that, when installed, could weaken glass, impair performance, or impair appearance.

Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction testing.

Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.

Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.

Provide spacers for glass lites where length plus width is larger than 50 inches (1270 mm).

Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and in accordance with requirements in referenced glazing publications.

TAPE GLAZING

Position tapes on fixed stops so that, when compressed by glass, their exposed edges are flush with or protrude slightly above sightline of stops.

Install tapes continuously, but not necessarily in one continuous length. Do not stretch tapes to make them fit opening.

Cover vertical framing joints by applying tapes to heads and sills first, then to jambs. Cover horizontal framing joints by applying tapes to jambs, then to heads and sills.

Place joints in tapes at corners of opening with adjoining lengths butted together, not lapped. Seal joints in tapes with compatible sealant approved by tape manufacturer.

Apply heel bead of elastomeric sealant.

Center glass lites in openings on setting blocks, and press firmly against tape by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings.

Apply cap bead of elastomeric sealant over exposed edge of tape.

GASKET GLAZING (DRY)

Cut compression gaskets to lengths recommended by gasket manufacturer to fit openings exactly, with allowance for stretch during installation.

Insert soft compression gasket between glass and frame or fixed stop so it is securely in place with joints miter cut and bonded together at corners.

Installation with Drive-in Wedge Gaskets: Center glass lites in openings on setting blocks, and press firmly against soft compression gasket by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings. Compress gaskets to produce a weathertight seal without developing bending stresses in glass.

Seal gasket joints with sealant recommended in writing by gasket manufacturer.

Installation with Pressure-Glazing Stops: Center glass lites in openings on setting blocks, and press firmly against soft compression gasket. Install dense compression gaskets and pressure-glazing stops, applying pressure uniformly to compression gaskets. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended in writing by gasket manufacturer.

Install gaskets so they protrude past face of glazing stops.

SEALANT GLAZING (WET)

Install continuous spacers, or spacers combined with cylindrical sealant backing, between glass lites and glazing stops to maintain glass face clearances and to prevent sealant from extruding into glass channel and blocking weep systems until sealants cure. Secure spacers or spacers and backings in place and in position to control depth of installed sealant relative to edge clearance for optimum sealant performance.

Force sealants into glazing channels to eliminate voids and to ensure complete wetting or bond of sealant to glass and channel surfaces.

Tool exposed surfaces of sealants to provide a substantial wash away from glass.

CLEANING AND PROTECTION

Immediately after installation, remove nonpermanent labels and clean surfaces.

Protect glass from contact with contaminating substances resulting from construction operations. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains.

If, despite such protection, contaminating substances do contact with glass, remove substances immediately as recommended in writing by glass manufacturer. Remove and replace glass that cannot be cleaned without damage to coatings.

Remove and replace glass that is damaged during construction period.

INSULATING GLASS SCHEDULE

Low-E-Coated, Clear Insulating Glass Type:

Overall Unit Thickness: 1 inch (25 mm).

Minimum Thickness of Each Glass Lite: .25 inch 5 mm.

Outdoor Lite: Fully tempered float glass.

Interspace Content: Air.

Indoor Lite: Fully tempered float glass .

Low-E Coating: Pyrolytic or sputtered on second or third surface.

Ceramic-Coated, Insulating Spandrel Glass Type:

Overall Unit Thickness: 1 inch (25 mm).

Minimum Thickness of Each Glass Lite: .25 inch (5 mm).

Interspace Content: Air.

Coating Location: Fourth surface.

END OF SECTION

SECTION 08 91 19
FIXED LOUVERS

PART 1- GENERAL

SCOPE
This section includes fixed **extruded-aluminum** louvers.

PART 1 - GENERAL
- Scope
- Related Requirements
- Action Submittals
- Informational Submittals
- Quality Assurance
- Warranty

PART 2 – PRODUCTS
- Performance Requirements
- Fixed Extruded-Aluminum Louvers
- Fixed Formed Metal Louvers
- Louver Screens
- Materials
- Fabrication
- Aluminum Finishes

PART 3 - EXECUTION
- Installation
- Adjusting

RELATED REQUIREMENTS:
Applicable provisions of the General Requirements and Division 1 shall govern work under this section.

Section 04 01 20 Maintenance of Unit Masonry
Division 23

ACTION SUBMITTALS
Product Data: For each type of product.

For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.

Samples: For each type of metal finish required.

INFORMATIONAL SUBMITTALS
Product Test Reports: Based on tests performed according to AMCA 500-L.

Sample warranties.

QUALITY ASSURANCE

Welding Qualifications: Qualify procedures and personnel according to the following:

AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."

AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

WARRANTY

Special Finish Warranty: Manufacturer agrees to repair or replace components on which finishes fail in materials or workmanship within specified warranty period.

Warranty Period: 10 years from date of Substantial Completion.

PART 2- PRODUCTS

PERFORMANCE REQUIREMENTS

Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width according to AMCA 500-L.

FIXED EXTRUDED-ALUMINUM LOUVERS

Horizontal Drainable-Blade Louver See Sheet A600:

Louver Depth: 4 inches (100 mm).

Blade Profile: Blade with center baffle.

Frame and Blade Nominal Thickness: Not less than 0.080 inch (2.03 mm) for blades and 0.080 inch (2.03 mm) for frames].

Louver Performance Ratings:

Free Area: See Louver Schedule on Sheet A600.

Point of Beginning Water Penetration: Not less than 900 fpm (4.6 m/s).

Air Performance: Not more than 0.10-inch wg (25-Pa) velocity.

AMCA Seal: Mark units with AMCA Certified Ratings Seal.

LOUVER SCREENS

General: Provide screen at each exterior louver

Screen Location for Fixed Louvers: Interior face.

Screening Type: Insect screening, Stainless steel, 18-by-18 (1.4-by-1.4-mm) mesh, 0.009-inch (0.23-mm) wire.

MATERIALS

Aluminum Extrusions: ASTM B221 (ASTM B221M), Alloy 6063-T5, T-52, or T6.

Aluminum Sheet: ASTM B209 (ASTM B209M), Alloy 3003 or 5005, with temper as required for forming, or as otherwise recommended by metal producer for required finish.

Galvanized-Steel Sheet: ASTM A653/A653M, [G60 (Z180)] [G90 (Z275)] zinc coating, mill phosphatized.

Stainless-Steel Sheet: ASTM A240/A240M, Type 304, [No. 2B finish] [No. 2D finish] [No. 4 finish, with grain running parallel to length of blades and frame members] [No. 4 finish, with grain running perpendicular to length of blades and frame members] [No. 4 finish, with grain running perpendicular to length of blades and parallel to length of frame members] [No. 6 finish].

Fasteners: Use types and sizes to suit unit installation conditions.

Use hex-head or Phillips pan-headscrews for exposed fasteners unless otherwise indicated.

For fastening aluminum, use aluminum or 300 series stainless-steel fasteners.

For fastening galvanized steel, use hot-dip-galvanized-steel or 300 series stainless-steel fasteners.

For fastening stainless steel, use 300 series stainless-steel fasteners.

For color-finished louvers, use fasteners with heads that match color of louvers.

Postinstalled Fasteners for Concrete and Masonry: Torque-controlled expansion anchors, fabricated from stainless-steel components, with allowable load or strength design capacities calculated according to ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing according to ASTM E488/E488M conducted by a qualified testing agency.

Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

FABRICATION

Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

Join frame members to each other and to fixed louver blades with fillet welds [concealed from view] [, threaded fasteners, or both, as standard with louver manufacturer] unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

ALUMINUM FINISHES

Color Anodic Finish: AA-M12C22A32/A34, Class II, 0.010 mm or thicker. Medium bronze.

GALVANIZED-STEEL SHEET FINISHES

Finish louvers after assembly.

Surface Preparation: Clean surfaces with nonpetroleum solvent, so surfaces are free of oil and other contaminants. After cleaning, apply a conversion coating compatible with the organic coating to be applied over it. Clean welds, mechanical connections, and abraded areas and repair according to ASTM A780/A780M.

Baked-Enamel or Powder-Coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 2 mils (0.05 mm).

Color and Gloss: [As indicated by manufacturer's designations] [Match Architect's sample] [As selected by Architect from manufacturer's full range] <Insert color and gloss>.

STAINLESS-STEEL SHEET FINISHES

Repair sheet finish by grinding and polishing irregularities, weld spatter, scratches, and forming marks to match surrounding finish.

PART 3- EXECUTION

INSTALLATION

Locate and place louvers level, plumb, and at indicated alignment with adjacent work.

Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

Protect unpainted galvanized- and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.

ADJUSTING

Restore louvers damaged during installation and construction, so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

END OF SECTION 08 91 19

SECTION 09 01 90.52
MAINTENANCE REPAINTING

PART 1- GENERAL

SCOPE
This section includes maintenance repainting as follows: Removing existing paint, patching substrates, surface preparation and repainting steel lintels.

PART 1 - GENERAL
- Scope
- Related Requirements
- Informational Submittals

PART 2 – PRODUCTS
- Preparatory Cleaning Materials
- High Performance Coating

PART 3 - EXECUTION
- Maintenance, General
- Examination
- Preparatory Cleaning
- Paint and High Performance, General
- Cleaning and Protection
- Coating Application

RELATED REQUIREMENTS:
Applicable provisions of the General Requirements and Division 1 shall govern work under this section.

Section 04 01 20 - Maintenance of Unit Masonry

ACTION SUBMITTALS
Product Data: For each type of product.

Samples: For each type of paint system and each pattern, color, and gloss.

For each painted color being matched to a standardized color-coding system, include the color chips from the color-coding-system company with Samples.

Label each Sample for location and application.

Product List: Printout of current “MPI Approved Products List” for each MPI-product category specified in paint systems, with the proposed product highlighted.

INFORMATIONAL SUBMITTALS
Color Matching Certificate: For computer-matched colors.

QUALITY ASSURANCE
Mockups: Include (1) existing steel lintel. Prepare a mockup of maintenance repainting processes for each type of coating system and substrate indicated and each color and finish required to demonstrate aesthetic effects and to set quality standards for materials and execution. Duplicate appearance of approved Sample submittals.

Surface-preparation mockups using applicable specified methods of cleaning and other surface preparation.

Coating mockups to represent surfaces and conditions for application of each type of coating system.

PART 2- PRODUCTS

PREPARATORY CLEANING MATERIALS

Abrasives for Ferrous Metal Cleaning: Aluminum oxide paper, emery paper, fine steel wool, steel scrapers, and steel-wire brushes of various sizes.

Rust Remover: Manufacturer's standard phosphoric acid-based gel formulation, also called "naval jelly," for removing corrosion from iron and steel.

HIGH-PERFORMANCE COATINGS

Manufacturers:

Steel Coating:

PPG
Tnemic
Sherwin Williams
Carboline

Material Compatibility: Provide materials that are compatible with one another and with substrates.

For each coat in a system, provide products recommended in writing by manufacturers of topcoat for use in system and on substrate indicated.

Steel Coating: Semigloss Water-Based, Light-Industrial Coating System: Two coats over primer: MPI EXT 5.1M.

Color: Dark Base to closely match existing and color sample provided by Owner.

PART 3- EXECUTION

MAINTENANCE, GENERAL

Execution of the Work: In repainting surfaces, disturb them as minimally as possible and as follows:

Remove failed coatings and corrosion and repaint.

Verify that substrate surface conditions are suitable for repainting.

Allow other trades to repair items in place before repainting.

Mechanical Abrasion: Where mechanical abrasion is needed for the work, use gentle methods, such as scraping and lightly hand sanding, that will not abrade softer substrates, reducing clarity of detail.

EXAMINATION

Examine substrates and conditions, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of painting work. Comply with paint manufacturer’s written instructions for inspection.

Alkalinity: Do not begin application of coatings unless surface alkalinity is within range recommended in writing by paint manufacturer. Conduct alkali testing with litmus paper on exposed plaster, cementitious, and masonry surfaces.

PREPARATORY CLEANING

General: Use the gentlest, appropriate method necessary to clean surfaces in preparation for painting. Clean all surfaces, corners, contours, and interstices.

Mechanical Rust Removal:

Remove rust with specified abrasives for ferrous-metal cleaning. Clean to bright metal.

Wipe off residue with mineral spirits and either steel wool or soft rags.

Dry immediately with clean, soft cloths. Follow direction of grain in metal.

Prime immediately to prevent rust. Do not touch cleaned metal surface until primed.

CLEANING AND PROTECTION

At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

SURFACE-PREPARATION SCHEDULE

General: Before painting, prepare surfaces as field conditions dictate and apply per the requirements of this schedule.

Examine surfaces to evaluate each surface condition according to paragraphs below.

Where existing degree of soiling prevents examination, preclean surface and allow it to dry before making an evaluation.

Repair substrate defects according to "Substrate Repair" Article.

Surface Preparation for MPI DSD 0 Degree of Surface Degradation:

Surface Condition: Existing paint film in good condition and tightly adhered.

Paint Removal: Not required.

Preparation for Painting: Wash surface by detergent cleaning; use solvent cleaning where needed.

Roughen or degloss cleaned surfaces to ensure paint adhesion according to paint manufacturer's written instructions.

Surface Preparation for MPI DSD 1 Degree of Surface Degradation:

Surface Condition: Paint film cracked or broken but adhered.

Paint Removal: Scrape by hand-tool cleaning methods to remove loose paint until only tightly adhered paint remains.

Preparation for Painting: Wash surface by detergent cleaning; use other cleaning methods for small areas of bare substrate if required. Roughen, degloss, and sand the cleaned surfaces to ensure paint adhesion and a smooth finish according to paint manufacturer's written instructions.

Surface Preparation for MPI DSD 3 Degree of Surface Degradation:

Surface Condition: Paint film indicated to have paint completely removed.

Paint Removal: Completely remove paint film by hand-tool or chemical paint-removal methods. Remove rust.

Preparation for Painting: Prepare bare cleaned surface according to paint manufacturer's written instructions for substrate construction materials.

Surface Preparation for MPI DSD 4 Degree of Surface Degradation:

Surface Condition: corroded substrate.

Preparation for Painting: Sand substrate surfaces to smooth remaining paint film edges and prepare according to paint manufacturer’s written instructions for substrate construction materials. Remove rust.

COATING APPLICATION

Comply with recommendations in MPI's "MPI Architectural Painting Specification Manual" applicable to substrates indicated.

Coat exposed surfaces, as shown on Drawings unless otherwise indicated.

Do not coat prefinished items, items with an integral finish, operating parts, and labels unless otherwise indicated.

Apply high-performance coatings according to manufacturer's written instructions.

Use brushes only where the use of other applicators is not practical.

Apply high-performance coatings to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform finish, color, and appearance.

END OF SECTION

SECTION 09 22 16
NON-STRUCTURAL METAL FRAMING

PART 1- GENERAL

SCOPE
This section includes non-load bearing steel framing systems for interior partitions.

PART 1 - GENERAL
- Scope
- Related Work
- Action Submittals
- Quality Assurance

PART 2 – PRODUCTS
- Performance Requirements
- Framing System
- Auxiliary Materials

PART 3 - EXECUTION
- Installation, General
- Installing Framed Assemblies
- Sound Mitigation

RELATED WORK
Applicable provisions of the General Conditions and Division 1 shall govern work under this section.

Section 09 29 00 - Gypsum Board

ACTION SUBMITTALS
Product Data: For each type of product.

QUALITY ASSURANCE
Code-Compliance Certification of Studs and Tracks: Provide documentation that framing members are certified according to the product-certification program of the Certified Steel Stud Association, the Steel Framing Industry Association or the Steel Stud Manufacturers Association.

PART 2- PRODUCTS

PERFORMANCE REQUIREMENTS
STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated on Drawings, according to ASTM E90 and classified according to ASTM E413 by an independent testing agency.

FRAMING SYSTEMS
Framing Members, General: Comply with ASTM C754 for conditions indicated.

Steel Sheet Components: Comply with ASTM C645 requirements for steel unless otherwise indicated.

Protective Coating: ASTM A653/A653M, G40 (Z120).

Studs and Tracks: ASTM C645. Use either conventional steel studs and tracks or embossed, high-strength steel studs and tracks.

Minimum Base-Steel Thickness: As indicated on Drawings.

Resilient Furring Channels: 1/2-inch- (13-mm-) deep, steel sheet members designed to reduce sound transmission.

Configuration: Asymmetrical.

AUXILIARY MATERIALS

General: Provide auxiliary materials that comply with referenced installation standards.

Fasteners for Steel Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.

Isolation Strip at Exterior Walls: Provide one of the following:

Asphalt-Saturated Organic Felt: ASTM D226/D226M, Type I (No. 15 asphalt felt), nonperforated.

Foam Gasket: Adhesive-backed, closed-cell vinyl foam strips that allow fastener penetration without foam displacement, 1/8 inch (3.2 mm) thick, in width to suit steel stud size.

Sound Attenuation Batts: Comply with ASTM C1104, ASTM C1304, and ASTM C665 – Basis of Design Owens Corning PINK Next Gen Sound Attenuation Batts (SABs)

Acoustical Sealant: Meet or Exceeds the Requirements of ASTM E90; ASTM E84; ASTM C834.

PART 3- EXECUTION

INSTALLATION, GENERAL

Installation Standard: ASTM C754.

Gypsum Plaster Assemblies: Also comply with requirements in ASTM C841 that apply to framing installation.

Portland Cement Plaster Assemblies: Also comply with requirements in ASTM C1063 that apply to framing installation.

Gypsum Veneer Plaster Assemblies: Also comply with requirements in ASTM C844 that apply to framing installation.

Gypsum Board Assemblies: Also comply with requirements in ASTM C840 that apply to framing installation.

Install framing and accessories plumb, square, and true to line, with connections securely fastened.

Install supplementary framing, and blocking to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction.

Install bracing at terminations in assemblies.
Do not bridge building control and expansion joints with non-load-bearing steel framing members. Frame both sides of joints independently.

INSTALLING FRAMED ASSEMBLIES
Install framing system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.

Where studs are installed directly against exterior masonry walls or dissimilar metals at exterior walls, install isolation strip between studs and exterior wall.

Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch (3 mm) from the plane formed by faces of adjacent framing.

SOUND MITIGATION

Accessory Materials: Install sound attenuation batts and perimeter acoustical sealants per manufacturer's requirements.,

END OF SECTION

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SECTION 09 29 00
GYPSUM BOARD

PART 1- GENERAL

SCOPE
This section includes: Interior gypsum board panels and liner.

PART 1 - GENERAL
Scope
Action Submittals
Related Work

PART 2 – PRODUCTS
Performance Requirements
Gypsum Board, General
Interior Gypsum Board
Trim Accessories
Joint Treatment Materials
Auxiliary Materials

PART 3 - EXECUTION
Installation and Finishing of Panels
Protection

ACTION SUBMITTALS

Product Data:
Gypsum wallboard
Interior trim.
Joint treatment materials.

RELATED WORK
Applicable provisions of Division 1 shall govern this section.

PART 2- PRODUCTS

PERFORMANCE REQUIREMENTS
Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E119 by an independent testing agency.

GYPSUM BOARD, GENERAL
Size: Provide maximum lengths and widths available that will minimize joints in each area and that correspond with support system indicated.

INTERIOR GYPSUM BOARD
ABUSE-, MOISTURE- AND- MOLD-RESISTANT TYPE X GYPSUM PANEL

ASTM C1658, Standard Specification for Glass Mat Gypsum Panels, for 5/8 in. (15.9 mm), Type X and glass mat water-resistant gypsum panel.

UL Type Designation: “AR”
ASTM E136 Noncombustibility: Meets
ASTM E84 Surface-Burning Characteristics
Flame Spread: 0

Smoke Developed: 0
Class A (Flame spread not greater than 25 and smoke developed not greater than 450): Meets

ASTM C473, Standard Test Methods for Physical Testing of Gypsum Panels Products
Core Hardness
Field: Not less than 15 lbf (67 N)
End: Not less than 15 lbf (67 N)
Edge: Not less than 15 lbf (67 N)
Flexural Strength
Parallel: Not less than 100 lbf (445 N)
Perpendicular: Not less than 140 lbf (623 N)
Nail Pull Resistance: Not less than 90 lbf (400 N)
Humidified Deflection: Not greater than 1/4 in. (6 mm)

Average Water Absorption (Not greater than 5% by weight after two-hour immersion): Meets
ASTM D3273, Standard Test Method for Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber: 10

Dimensions:

Thickness: 5/8 in. (15.9 mm)
Length: 8-12 ft. (2438-3658 mm)
Width: 4 ft. (1219 mm)
Weight: 2.8 lb./sq. ft. (13.7 kg/sq. m)
Edge: Tapered

TRIM ACCESSORIES
Interior Trim: ASTM C1047.

Material: Galvanized or aluminum-coated steel sheet or rolled zinc

Shapes:

Cornerbead.

Bullnose bead.

LC-Bead: J-shaped; exposed long flange receives joint compound.

L-Bead: L-shaped; exposed long flange receives joint compound.
U-Bead: J-shaped; exposed short flange does not receive joint compound.

Curved-Edge Cornerbead: With notched or flexible flanges.

JOINT TREATMENT MATERIALS
General: Comply with ASTM C475/C475M.

Joint Tape:

Interior Gypsum Board: Paper.

Joint Compound for Interior Gypsum Board: For each coat, use formulation that is compatible with other compounds applied on previous or for successive coats.

Prefilling: At open joints, rounded or beveled panel edges, and damaged surface areas, use setting-type taping compound.

Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use setting-type, sandable topping or drying-type, all-purpose compound as dictated by job site conditions and project schedule.

Use setting-type compound for installing paper-faced metal trim accessories.

Fill Coat: For second coat, use setting-type, sandable topping OR drying-type, all-purpose compound as dictated by job site conditions and project schedule.

Finish Coat: For third coat, use setting-type, sandable topping OR drying-type, all-purpose compound as dictated by job site conditions and project schedule.

Provide trowel (smooth) finish.

AUXILIARY MATERIALS

Provide auxiliary materials that comply with referenced installation standards and manufacturer's written instructions.

Steel Drill Screws: ASTM C1002 unless otherwise indicated.

Use screws complying with ASTM C954 for fastening panels to steel members from 0.033 to 0.112 inch (0.84 to 2.84 mm) thick.

For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.

Sound-Attenuation Blankets: ASTM C665, Type I (blankets without membrane facing) produced by combining thermosetting resins with mineral fibers manufactured from glass, slag wool, or rock wool.

Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.

PART 3- EXECUTION

INSTALLATION AND FINISHING OF PANELS

Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.
Comply with ASTM C840.

Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments. Provide 1/4- to 1/2-inch- (6.4- to 12.7-mm-) wide spaces at these locations and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.

For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.

Prefill open joints, rounded or beveled edges, and damaged surface areas.

Apply joint tape over gypsum board joints, except for trim products specifically indicated as not intended to receive tape.

Gypsum Board Finish Levels: Finish panels to levels indicated below and according to ASTM C840:

Level 1: Ceiling plenum areas, concealed areas, and where indicated.

Level 2: Panels that are substrate for tile where indicated on drawings.

Level 4: At panel surfaces that will be exposed to view unless otherwise indicated

PROTECTION

Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.

Remove and replace panels that are wet, moisture damaged, and mold damaged.

END OF SECTION

SECTION 09 91 24
INTERIOR PAINTING

PART 1 - GENERAL

SCOPE
The work under this section shall consist of providing all work, materials, labor, equipment, and supervision necessary to provide for the work. Included are the following topics: surface preparation and the application of paint systems on interior substrates.

Gypsum board.

PART1 - GENERAL
- Scope
- Related Work
- Definitions
- Submittals

PART 2 - MATERIALS
- Equipment

PART 3 - EXECUTION
- Protection of Existing Work and Facilities
- Demolition
- Transportation and Disposal of Demolition Waste

RELATED WORK
Applicable provisions of the General Conditions and Division 1 shall govern work under this section.

Section 09 01 90.52 – Maintenance Repainting
Section 09 29 00 - Gypsum Board

DEFINITIONS
"MPI" Master Painters Institute.

ACTION SUBMITTALS
Product Data: For each type of product. Include preparation requirements and application instructions.
Include printout of current "MPI Approved Products List" for each product category specified, with the proposed product highlighted.

Samples: For each type of topcoat product.
Product List: Use same designations indicated on Drawings and in the Interior Painting Schedule to cross-reference paint systems specified in this Section. Include color designations.

PART 2 - PRODUCTS

MANUFACTURERS
Benjamin Moore
PPG Paints
Sherwin Williams
Kelly-Moore
Hallman Lindsay

Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to products listed in the Interior Painting Schedule for the paint category indicated.

PAINT, GENERAL

MPI Standards: Products shall comply with MPI standards indicated and shall be listed in its "MPI Approved Products List."

Material Compatibility:

Materials for use within each paint system shall be compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.

For each coat in a paint system, products shall be recommended in writing by topcoat manufacturers for use in paint system and on substrate indicated.

Colors: Match on-site samples of existing paint colors.

Ten percent of surface area will be painted with deep tones.

PART 3-EXECUTION

EXAMINATION

Verify suitability of substrates, including surface conditions and compatibility, with existing finishes and primers.

Proceed with coating application only after unsatisfactory conditions have been corrected.

Application of coating indicates acceptance of surfaces and conditions.

PREPARATION

Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates and paint systems indicated.

Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.

After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.

INSTALLATION

Apply paints according to manufacturer's written instructions and to recommendations in "MPI Manual."

Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

Paint portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets that are visible from occupied spaces.

FIELD QUALITY CONTROL

Dry-Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry-film thickness.

Contractor shall touch up and restore painted surfaces damaged by testing.

If test results show that dry-film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry-film thickness that complies with paint manufacturer's written recommendations.

CLEANING AND PROTECTION

At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.

At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

INTERIOR PAINTING SCHEDULE

Gypsum Board Substrates:

Institutional Low-Odor/VOC Latex System, MPI INT 9.2M:

Prime Coat: Primer sealer, interior, institutional low odor/VOC, MPI #149.

Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.

Topcoat: Latex, interior, institutional low odor/VOC (MPI Gloss Level 3), MPI #145.

END OF SECTION

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SECTION 12 36 61.16
SOLID SURFACING COUNTERTOPS

PART 1- GENERAL

SCOPE
This section includes solid surface material for window sills.

PART 1 - GENERAL
Scope
Related Work
Action Submittals

PART 2 – PRODUCTS
Solid Surface Countertop Materials
Countertop Fabrication
Installation Materials

PART 3 - EXECUTION
Installation

RELATED WORK
Applicable provisions of the General Conditions and Division 1 shall govern work under this section.
rk under this section.
tion.

Section 06 10 53.01 –Miscellaneous Rough Carpentry
Section 07 92 00 – Joint Sealants

ACTION SUBMITTALS
Product Data: For countertop materials and sinks.

Shop Drawings: For countertops. Show materials, finishes, edge and backsplash profiles, methods of joining, and cutouts for plumbing fixtures.

Samples: For each type of material exposed to view.

PART 2- PRODUCTS

SOLID SURFACE COUNTERTOP MATERIALS
Solid Surface Material: Homogeneous-filled plastic resin complying with ICPA SS-1.

Manufacturers: Subject to compliance with requirements, provide products by one of the following:
Corian
Wilsonart
Or approved equal.

Type: Provide Standard type unless Special Purpose type is indicated.

Colors and Patterns: As selected by Architect from manufacturer's full range.

Particleboard: ANSI A208.1, Grade M-2-Exterior Glue.

Plywood: Exterior softwood plywood complying with DOC PS 1, Grade C-C Plugged, touch sanded.

COUNTERTOP FABRICATION
Fabricate countertops according to solid surface material manufacturer's written instructions and to the AWI/AWMAC/WI's "Architectural Woodwork Standards."

Grade: Premium

Configuration:

Countertops: 1/2-inch- thick, solid surface material with front edge built up with same material.

Joints: Fabricate countertops without joints.

INSTALLATION MATERIALS
Adhesive: Product recommended by solid surface material manufacturer.

Sealant for Countertops: Comply with applicable requirements in Section 07 92 00 "Joint Sealants."

PART 3- EXECUTION

INSTALLATION
Fasten countertops by screwing through steel support into underside of countertop.

Shim as needed to align tops in a level plane.

Bond joints with adhesive and draw tight as countertops are set. Mask areas of countertops adjacent to joints to prevent adhesive smears.

Apply sealant to gaps at walls, jambs and windows; comply with Section 07 92 00 "Joint Sealants."

END OF SECTION 12 36 61.16

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 and Fire Stopping
- Submittals
- Off Site Storage
- Certificates and Inspections
- Operating and Maintenance Data
- Training of Owner Personnel
- Record Drawings

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

PART 3 - EXECUTION
- Demolition
- Cutting and Patching
- Building Access
- Equipment Access
- Coordination
- Identification
- Lubrication
- Sealing and Fire Stopping
- Agency Training

RELATED WORK

Section 01 91 01 – Commissioning Process
Section 07 84 00 - Fire Stopping
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
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
AWWA	American Water Works Association
AWS	American Welding Society
EPA	Environmental Protection Agency

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.

SEALING AND FIRE STOPPING

Sealing and fire stopping 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. Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with section 07 84 00 Fire Stopping.

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.

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 __8__ 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

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 Section 09500 are sufficient; no additional access provisions are required unless specifically indicated.

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 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 is 12" by 12".

IDENTIFICATION

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, Setonply Style 2060 by Seton Name Plate Company or Emedolite- Style EIP by EMED Co., or equal by 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 AND FIRE STOPPING

FIRE AND/OR SMOKE RATED PENETRATIONS:
Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with section 07 84 00 “Fire Stopping”.

NON-RATED PENETRATIONS:
Duct Penetrations:
For exposed non-rated duct penetrations: Where shown or specified, annular space between duct and non-rated wall shall be patched to match existing construction to within 0.25” around the duct. Fill annular space with fiberglass batt insulation or mineral wool insulation. Provide urethane caulk in annular space between wall construction and duct work on both sides of wall. Install per caulk manufacturer instructions utilizing backer rod where required. Paint to match adjacent construction. See drawings for additional requirements.

For non-rated concealed duct penetrations or non-rate duct penetrations above ceilings or in mechanical or utility spaces: Where shown or specified, pack annular space with fiberglass batt insulation or mineral wool insulation. Provide 4" sheet metal escutcheon around duct on both sides of partition or floor to cover annular space. Provide urethane caulk where metal escutcheon contacts duct on both sides of partition or floor. Install per caulk manufacturer instructions utilizing backer rod where required.

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.

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.

For equipment that is accessed above acoustical lay in ceilings or access doors, label the ceiling tile grid at the ceiling tile that is to be removed for access to the equipment or the access door. 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. Label shall match equipment tag designation used on mechanical plans.

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.

Label fire, smoke and combination fire smoke dampers on the exterior surface of ductwork directly adjacent to access doors using a minimum of 0.5 inch height lettering reading, “SMOKE DAMPER” or “FIRE DAMPER”. Smoke and combination fire smoke dampers shall also include a second line listing the individual damper tag. The tags must be coordinated with the mechanical schedules. Utilize stencils or manufactured labels. All other forms of identification are unacceptable. All labels shall be clearly visible from the ceiling access point. For dampers that are accessed above acoustical lay in ceilings, label the ceiling tile grid at the ceiling tile that is to be removed for access to the damper and use an arrow to point at the tile to be removed for access. 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. Ceiling tile label shall match damper tag designation used on mechanical plans.

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.

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 AND FIRE STOPPING

FIRE AND/OR SMOKE RATED PENETRATIONS

Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with section 07 84 00 Fire Stopping.

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.

Duct penetrations through non-rated partitions shall require sheet metal escutcheons with fiberglass or mineral wool insulation fill for spaces that include janitor closets, toilet rooms, mechanical rooms, where ducts are exposed and where noted on drawings elsewhere.

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
- Three Phase, Single Speed Motors
- Single Phase, Single Speed Motors
- Motors Used on Variable Frequency Drives

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
Section 23 05 14 - Variable Frequency Drives
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

THREE PHASE, SINGLE SPEED MOTORS

Use NEMA rated 480 volt, three phase, 60 hertz motors for all motors 1/2 HP and larger unless specifically indicated.

Use NEMA general purpose, continuous duty, Design B , normal starting torque, T-frame or U-frame motors with Class B or better insulation unless the manufacturer of the equipment on which the motor is being used has different requirements. Use open drip-proof motors unless totally enclosed fan-cooled, totally enclosed non-ventilated, explosion-proof, or encapsulated motors are specified in the equipment sections.

Use grease lubricated anti-friction ball bearings with housings equipped with plugged/capped provision for relubrication, rated for minimum AFBMA 9, L-10 life of 20,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at the end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

All open drip-proof motors to have a 1.15 service factor. Other motor types may have minimum 1.0 service factors.

All motors 1 HP and larger, except specially wound motors and inline pump motors 56 frame and smaller, to be high efficiency design with full load efficiencies which meet or exceed the values listed below when tested in accordance with NEMA MG 1.

FULL LOAD NOMINAL MOTOR EFFICIENCY BY MOTOR SIZE AND SPEED

	-----Open Drip-Proof Motors------		
MOTOR	-------Nominal Motor Speed-------		
HP	1200 rpm	1800 rpm	3600 rpm
1	82.5	85.5	77.0
1-1/2	86.5	86.5	84.0
2	87.5	86.5	85.5
3	88.5	89.5	85.5
5	89.5	89.5	86.5
7-1/2	90.2	91.0	88.5

10	91.7	91.7	89.5
15	91.7	93.0	90.2
20	92.4	93.0	91.0

	----Totally Enclosed Fan-Cooled----		
MOTOR	-------Nominal Motor Speed------		
HP	1200 rpm	1800 rpm	3600 rpm
1	82.5	85.5	77.0
1-1/2	87.5	86.5	84.0
2	88.5	86.5	85.5
3	89.5	89.5	86.5
5	89.5	89.5	88.5
7-1/2	91.0	91.7	89.5
10	91.0	91.7	90.2
15	91.7	92.4	91.0
20	91.7	93.0	91.0

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.

Provide adjustable speed ECM motors where shown on plans. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted on the motor. Motor shall be a minimum of 85% efficient at all speeds.

MOTORS USED ON VARIABLE FREQUENCY DRIVES

In addition to the requirements specified above, the motor must be suitable for use with the drive specified in Section 23 05 14, including but not limited to motor cooling. Motor shall comply with NEMA MG1 Part 31 to provide windings capable to withstand up to 1600 peak Volts with a rise time of 0.1 µs. Provide brush style bearing protection to bleed current from the motor shaft to the motor casing to suit motor application. Brushes shall be field replaceable. Manufacturers: Shaft Grounding Systems (SGS), Helwig Carbon Bearing Protection Kits (BPK), or equal.

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.

Verify the proper rotation of each three-phase motor as it is being wired or before the motor is energized for any reason.

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

END OF SECTION

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SECTION 23 05 14
VARIABLE FREQUENCY DRIVES
BASED ON DFD MASTER ELECTRICAL SPEC DATED 7/2/2024

PART 1 GENERAL

Applicable provisions of Division 1 shall govern all work under this Section

SCOPE

This section includes variable frequency drives, bypass starters, and line reactors. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Standards
- Submittals
- Operating and Maintenance Data
- Equipment Startup
- Warranty

PART 2 - PRODUCTS
- Manufacturers
- Design and Construction
- Performance Requirements
- Control Features
- Protection Features
- Diagnostics
- Quality Assurance Tests
- AC Input Line Reactors

PART 3 - EXECUTION
- Variable Frequency Drives (VFD)
- 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 34 00 - HVAC Fans

REFERENCE

Applicable provisions of Division 1 govern work under this section.

STANDARDS

ANSI/IEEE 519-2014 Guide for Harmonic Control and Reactive Compensation of Static Power Converters

SUBMITTALS

Submit shop drawings and product data under provisions of Division 1, General Conditions of the Contract.

Include physical, electrical, and performance characteristics of each variable frequency drive and associated components, including dimensions; weight; input and output performance; voltage, phase, current and overcurrent characteristics; installation instructions; protective features; wiring and block diagrams indicating specified options; electrical noise attenuation equipment where required to meet the criteria specified; line side voltage notch wave form and line side current harmonics; certified efficiency versus load and speed curves; and required operating environment.

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

EQUIPMENT STARTUP AND AGENCY TRAINING
Provide the services of a factory trained and certified technician to approve the installation; start-up, test, and adjust for proper operation of the unit(s). Upon completion of the equipment startup, submit a complete manufacturer's field report, including startup and test log, signed by the factory trained technician. Coordinate with the Temperature Control Contractor and the Balancing Contractor. The startup shall be coordinated with Division 26. Electrical and shall be completed within ten (10) working days from the startup date as set by the DFD representative.

WARRANTY
The warranty shall be for a period of twenty-four (24) months from the date of project Substantial Completion. Further, the warranty shall include all parts, labor, travel time, administrative costs, overhead, travel expenses, technical support and any and all other costs to provide the warranty service.

PART 2 PRODUCTS

MANUFACTURERS
ABB, Yaskawa

DESIGN AND CONSTRUCTION
The unit shall be variable torque, modular design for control of the motors as specified in Division 23 and rated at the motor full load nameplate amps.

The unit shall be U.L. listed, solid state, microprocessor based with a pulse width modulated (PWM) output wave form (none others are acceptable).

The VFD package shall have a short circuit current rating (SCCR) of 65 kA.

The VFD shall employ a full wave bridge rectifier and capacitors to minimize the ripple of the rectified voltage to maintain near constant DC voltage. Insulated gate bipolar transistors (IGBT's) shall be employed as the output switching device.

The VFD package shall contain the equivalent of 5% impedance to reduce harmonic distortion. The 5% equivalent impedance shall be provided in the form of a DC choke, an input AC line reactor in each phase, or a combination of the two methods.

Control circuitry shall be plug-in, plug-out modular basis with a corrosion resistant coating on printed circuit boards.

Units to be suitable for an operating environment from 0°C to 40°C temperature and humidity up to 90% non-condensing.

Electrically and physically isolate control circuitry and conductors from power circuitry and power conductors. Control conductors and power conductors shall not be run in the same pathway.

The unit enclosure shall be NEMA 1 as required for the application minimum and all components shall be fully factory assembled and tested prior to leaving the manufacturing facility.

Include the following operating and monitoring devices mounted on the front cover:

A fused disconnect switch to de-energize the drive with door interlocked handle and lock-open padlocking provisions.

Operating mode selector switch marked "hand-off-auto".
Manual speed adjustment via keypad, mounted on the door.

PERFORMANCE REQUIREMENTS

Units shall be suitable for input power of electrical system as scheduled on the drawings ±10%, 3 phase, 60 Hertz nominal.

Use a current limiting control device to limit output current to 110% continuous for one minute; also refer to Protection Features in this section. Full load output current available from drive shall not be less than motor nameplate amperage. The full load amp rating of the VFD shall not be less than the values indicated in the NEC Table 430-150.

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Output power shall be suitable for driving standard NEMA B design, three phase alternating current induction motors at full rated speed with capability of 6:1 turndown.

Additional performance capabilities to include the following:

Ride through a momentary power outage of 15 cycles,
Start into a rotating load without damage to drive components or motor,
Capable of automatic restart into a rotating load after a preset, adjustable time delay following a power outage
Input power factor: Min 0.95 throughout the speed range
Minimum efficiency: 95% at 100% speed, 85% at 50% speed

CONTROL FEATURES

Use control circuits compatible with input signal from temperature control system in the automatic mode and from manual speed control in the manual mode. Vary motor speed in response to the input control signal. Include components necessary to accept the signal from the temperature control system in the form that it is sent. Refer to Division 23 00 00.

Include the following additional control features:

- Hand-Off-Automatic (HOA) selector switch to select local or remote start/stop and speed control
- Local speed control at the VFD.
- Manual transfer bypass circuit when bypass starter is provided.
- VFD shall have (2) analog inputs, (2) analog outputs, (6) digital inputs, and (2) form "C" dry contact digital outputs. Open collector digital outputs are not acceptable unless pilot relays are used to provide from "C" dry contacts.
- One analog input, shall be programmed for automatic control from the temperature control system where specified in Section 23 09 15 and be selectable 0-10v or 4-20 mA.
- One (1) N.O. dry contact output shall be programmed for proving motor status where specified in Section 23 09 15. This output shall be programmed to detect belt or coupling break that would remove the load from the motor by using sensed torque of the motor. The dry contact shall open on loss of load, motor being disconnected from the power source by wire fault, or disconnect, or VFD being off.
- One (1) input shall be programmed for a N.O. dry contact type input for a 2-wire remote start/stop (run) where specified in Section 23 09 15.
- One (1) input shall be programmed for a N.C. dry contact type input for external faults: (freezestats, fire alarm, static pressure safety switches, etc). This input shall be factory wired to prevent both the VFD and bypass starter operation when external fault is present.
- PID control loop capable of VFD control from an external device connected to a VFD analog input.
- When specified in the 23 09 93 sequence of operations, program a VFD input and output for shutoff damper control that shall operate as follows: When the fan is remotely or locally commanded to start, VFD digital output contact shall energize the shutoff damper actuator to open the damper. The damper position end switch shall be wired to a run permissive digital input on the VFD and enable the VFD to start when the damper end switch proves the damper is open. This feature shall be provided for both inverter and bypass operation (if bypass option is provided).

- Where VFD's are used in code required smoke control systems, the start/stop (run) input shall be programmed so that the start/stop (run) contact closure shall override the control interface on the face of the VFD to cause the fan to run regardless of any commands from the VFD control interface.
- Adjustable acceleration and deceleration rate so that the time period from start to full speed and from full speed to stop can be field adjusted.
- Adjustable minimum and maximum speed settings for both automatic and manual modes of operation.
- Field adjustment of minimum and maximum output frequency.
- Illuminated display keypad.
- External Fault indicator.

PROTECTION FEATURES

Use electronic protection circuitry in the power circuits to provide an orderly shutdown of the drive without blowing fuses and prevent component loss under the following abnormal conditions:

Activation of any safety device;
Instantaneous overcurrent and/or over voltage of output;
Power line overvoltage and undervoltage protection;
Phase loss;
Single and three phase short circuiting;
Ground faults;
Control circuit malfunction;
Overtemperature; and
Output current over limit.

Provide the following additional protective features:

- Input transient overvoltage protection up to 3000 volts per ANSI 37.90A;
- DC bus fusing which limit the rate of rise of the DC bus current and de-energizes the drive at a predetermined current level;
- Fusing for the control circuit transformer;
- Grounded control chassis; and
- Devices and/or control circuitry to ensure that the variable frequency drive and bypass starter are not both energized and driving motor simultaneously.

DIAGNOSTICS

Provide an English character display (no error codes) with indicators for the following:

Phase loss
Ground fault
Overcurrent
Overvoltage
Undervoltage
Over temperature
Overload
DC bus status

QUALITY ASSURANCE TESTS

Use a factory heat stress test to verify proper operation of all functions and components under full load.

Field performance test of variable frequency drives to determine compliance with this specification will be performed at the DFD's discretion and may include any specified feature, including operation of protective devices through a simulated fault. Contractor will pay for initial testing. Should drive be found deficient by this testing, drive manufacturer will be required to make any and all changes necessary to bring unit(s) into compliance with the specified performance and demonstrate this performance by retesting. Cost of changes and retest will be by this contractor.

Variable frequency drive manufacturer or designated representative to perform a field test of each drive, in the presence of the DFD's representative, for the following items:

- Provide general inspection to verify proper installation;
- Demonstrate drive reaction to simulated power interruptions of two seconds and sixty seconds;
- Demonstrate adequate protection during switching from variable frequency drive operation to bypass starter operation and back again;

AC INPUT LINE REACTORS

When needed to comply with the requirement for 5% equivalent impedance, furnish and factory install AC input line reactors.

Line reactors shall be installed in each phase of the AC input side of the VFD and mounted within a common enclosure with the VFD.

Line reactor shall be a three phase inductor, iron core, 600V, Class H insulation, 115 degree C rise, copper windings with screw type terminal blocks.

PART 3 EXECUTION

VARIABLE FREQUENCY DRIVES

Install where indicated on drawings and in accordance with approved submittals and manufacturer's published recommendations. Installation to be by the Division 26 00 00 - Electrical contractor.

Input power wiring shall be installed in a separate conduit, output power wiring shall be installed in a separate conduit and control wiring shall be installed in a separate conduit. Do not mix input power, output power, or control wiring in a common conduit. Separate conduits for input and output power wiring shall be provided for each motor. Input and output power wiring for more than one motor shall not share a common conduit. Power wiring shall be furnished and installed by the Div. 26 contractor. If provided, do not mount output line filter above the drive.

Motor status relay shall be programmed to detect belt or coupling loss for fans. This shall use motor torque to determine when the load is lost and shall be set to show status loss whenever the VFD is at the lowest programmed speed and the belt or coupling loss occurs. This shall be tested by the VFD setup technician in conjunction with the Division 23 control contractor and commissioning agent.

Control signal for drive will be provided under Division 23.

Temperature Control Contractor will furnish and install the required temperature control wiring in metal conduit and in accordance with Division 26 00 00 - Electrical of this specification.

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.

FUNCTIONAL PERFORMANCE TESTING

Contractor is responsible for utilizing the functional performance test procedures 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 4hours.

END OF SECTION

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SECTION 23 05 29
HANGERS AND SUPPORTS FOR HVAC 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:

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

PART 2 - PRODUCTS
- Equipment Hanger and Support Manufacturers
- Structural Supports
- Equipment Hangers and Supports
- Concrete Inserts

PART 3 - EXECUTION
- Installation
- Construction Verification

RELATED WORK
Section 01 91 01 – Commissioning Process
Section 23 05 48 - Vibration and Seismic Controls for HVAC Equipment
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.

Support apparatus and material under all conditions of operation, accounting for variations in installed and operating weight of equipment 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 attachment methods and type of device for each piece of equipment. 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 supports shall be in accordance with MSS Standard Practice SP-58 unless noted otherwise.

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

EQUIPMENT 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.

EQUIPMENT HANGERS AND SUPPORTS

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

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

Total weight of equipment is 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.

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

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

INSTALLATION
Install supports to provide for free expansion of the duct system.

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.

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 05 48
VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT
BASED ON DFD MASTER SPECIFICATION DATED 11/09/2023

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

SCOPE

This section includes specifications for vibration isolation material for equipment, piping systems, and duct systems. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Quality Assurance
- Design Criteria
- Shop Drawings

PART 2 - PRODUCTS
- Materials
- Vibration Isolation Manufacturers
- Type 5: Spring Hanger with Neoprene
- Type T: Horizontal Thrust Restraint
- Performance
- Blower Minimum Deflection Guide

PART 3 - EXECUTION
- Installation

Centrifugal Fans

RELATED WORK

Section 01 91 01 - Commissioning Process
Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment
Section 23 34 00 - HVAC Fans
Section 23 33 00 - Air Duct Accessories

REFERENCE

Applicable provisions of Division 1 govern work under this section.

QUALITY ASSURANCE

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

DESIGN CRITERIA

Isolate all motor driven mechanical equipment from the building structure and from the systems in which they serve to prevent equipment vibrations from being transmitted to the structure. Consider equipment weight distribution to provide uniform isolator deflections.

For equipment with variable speed capability, select vibration isolation devices based on the lowest speed.

Provide flexible piping connections for all piping to rotating or reciprocating equipment mounted on vibration isolators except do not use flexible piping connectors on any type of gas piping or with inline pumps. Piping connected to a coil which is in an assembly mounted on vibration isolators is to have flexible piping connections and piping vibration hangers as specified below. Piping connected to a coil which is in an assembly where the fan is separately isolated by means of vibration isolators and duct flexible connections does not require flexible piping connectors or piping vibration hangers.

Credit will be given for the inherent flexibility and vibration absorption characteristics of mechanical grooved pipe connections providing that supporting calculations are submitted for approval.

Coordinate the selection of devices with the isolator and equipment manufacturers.

SHOP DRAWINGS

Refer to division 1, General Conditions, Submittals.

Include isolator type, materials of construction, isolator free and operating heights, and isolation efficiency based on the lowest operating speed of the equipment supported.

PART 2 - PRODUCTS

MATERIALS

Use materials that will retain their isolation characteristics for the life of the equipment served. Use industrial grade neoprene for elastomeric materials.

Treat all isolators to resist corrosion. For isolation devices exposed to the weather or used in high humidity areas, hot dip galvanize steel parts, apply a neoprene coating on all steel parts, or use stainless steel parts; include limit stops to resist wind.

Provide pairs of neoprene side snubbers or restraining springs where side torque or thrust may develop.

Use isolators with a ratio of lateral to vertical stiffness not less than 1.0 or greater than 2.0.

VIBRATION ISOLATOR MANUFACTURERS

Mason Industries, Amber/Booth Co., Vibration Mounting & Controls, Kinetics Noise Control, or approved equal.

TYPE 5: SPRING HANGER WITH NEOPRENE

Vibration hanger with a steel spring and 0.3" deflection neoprene element in series. Use neoprene element molded with a rod isolation bushing that passes through the hanger box. Select spring diameters and size hanger box lower holes large enough to permit the hanger rod to swing through a 30-degree arc before contacting the hole and short circuiting the spring. Select springs so they have a minimum additional travel to solid equal to 50% of the rated deflection.

TYPE T: HORIZONTAL THRUST RESTRAINT

Spring element in series with a neoprene pad as described for Type 3 mount with the same deflection as specified for the mounting or hanger. Design the assembly so the spring element is contained within a steel frame, so it can be preset for thrust at the factory and adjusted in the field for a maximum of 1/4" movement at start and stop. Include threaded rod and angle brackets for attachment to both equipment and ductwork or equipment and structure.

PERFORMANCE

Select vibration isolation devices as indicated below or to provide not less than 95% isolation efficiency, whichever is greater.

Centrifugal Blowers:

Suspended	Use type 5-T hangers with deflection from blower minimum deflection guide. Type T needed only when air thrust exceeds 10% of equipment weight

BLOWER MINIMUM DEFLECTION GUIDE

	Required Deflection (Inches)			
Fan Speed (RPM)	On Grade	20' Floor Span	30’ Floor Span	40’ Floor Span
175-224	0.35	3.50	4.50	4.50
225-299	0.35	3.50	3.50	3.50
300-374	0.35	2.50	2.50	3.50
375-499	0.35	1.50	2.50	3.50
500 and over	0.35	0.75	1.50	2.50

PART 3 - EXECUTION

INSTALLATION

Install vibration isolation devices for motor driven equipment in accordance with the manufacturer's installation instructions.

Set steel and inertia bases for one inch clearance between the concrete floor or housekeeping pad and the base.

Do not allow installation practices to short circuit any isolation device.

CENTRIFUGAL FANS

Attach horizontal thrust restraints at the centerline of thrust and symmetrically on either side of the unit. Thrust restraints are not required when the fan section in not isolated from the remainder of the air handling unit by means of duct flexible connections.

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
Section 23 09 23 Direct Digital Control System 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 and hydronic 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 and water 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 and hydronic 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
- Hydronic Systems
- Special 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.

EXISTING EQUIPMENT
Test and balance all supply outlets served by existing AHU-6 and AHU-7. AHU-6 and AHU-7 will be retrofitted with VFDs as part of the scope of this project. Test and balance all new exhaust fans and automatic balance dampers served by new exhaust fans.

Set duct static pressure setpoint for AHU-6 and AHU-7 supply fan with temperature control contractor.

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 and/or pump 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/piping 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, 02) including providing all required sampling date necessary for the commissioning process.
Verify and record, in the T&B Report, “K” factors for allair flow stations.

Verify and record, in the T&B Report, values of damper positions and fan speeds for all characterization curves required in the 23 09 93 control sequences.

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 3/27/2024

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 31 00 - HVAC Ducts and Casings

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 C303	Density of Preformed Block Insulation
ASTM C355	Test Methods for Test for Water Vapor Transmission of Thick Materials
ASTM C518	Heat Flux and Thermal Transmission Properties
ASTM C578	Preformed, Block Type Cellular Polystyrene Thermal Insulation
ASTM C921	Properties of Jacketing Materials for Thermal Insulation
ASTM C1136	Flexible Low Permeance Vapor Retarders for Thermal Insulation
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
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:

- Duct 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.

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, Halstead, Foster, Imcoa, ITW, Johns Manville, Knauf Insulation, Owens-Corning, Pittsburgh 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:

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.

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.

EXTRUDED POLYSTYRENE INSULATION:
Rigid closed cell, minimum nominal density of 1.6 lbs. per cu. ft., thermal conductivity of not more than 0.26 at 75 degrees F mean temperature, minimum compressive strength of 20 psi, maximum water vapor permeability of 1.5 perm inch, maximum water absorption of 0.5 % by volume (ASTM C272), rated for service temperature range of -290 degrees F to 165 degrees F.

MASS LOADED SOUND ATTENUATING SOUND SEAL B20 WRAP:
Vinyl noise barrier, minimum nominal density of 2.0 lbs. per cu. ft., STC value of at least 32.

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 insulated ductwork, 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.

JACKETS

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.

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.

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.

Tack fasteners to be stainless steel ring grooved shank tacks.

Staples to be clinch style.

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 ductwork is 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 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:

- Insulated Duct

PROTECTIVE JACKET INSTALLATION

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.

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.

DUCT INSULATION

GENERAL:
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.

DUCTWORK PROTECTIVE COVERINGS:
In addition to the jackets specified in the duct insulation schedule below the following protective coverings are required:

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

- Louver blank-off panels

DUCT INSULATION SCHEDULE:

Provide duct insulation on new and existing remodeled ductwork in the following schedule:

SERVICE	INSULATION TYPE	JACKET	THICKNESS
Exhaust and relief ducts downstream of motorized backdraft dampers	Rigid Fiberglass	FSK	2"
Louver blank-off panels ****	Ext. Polystyrene	SAJ	4"

**** Insulating value of any louver or curb blank off panel needs to meet the building envelope insulating value required by current building code.

EQUIPMENT INSULATION SCHEDULE:

Provide equipment insulation as follows:

EQUIPMENT	INSULATION TYPE	JACKET	THICKNESS
Exhaust Fans	Sound Seal B20 Wrap or Equivalent	FSK	1”

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

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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 05 14	Variable Frequency Drives
CV-23 07 00	HVAC Ductwork Insulation
CV-23 09 14	Control Wiring and Devices
CV-23 09 24	Local Control Panels
CV-23 31 00	Ductwork and Casings
CV-23 33 00	Control Dampers
CV-23 34 00	Centrifugal Fans
CV-23 37 13	Diffuser, Grilles and Registers

Functional Performance Test Forms

FPT-23 05 14	Variable Frequency Drives
FPT-23 05 93	Testing Adjusting and Balancing
FPT-23 09 24	BAS Communication/Calibration
FPT-23 34 00	HVAC Fans

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 R O 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 05 14 – Variable Frequency Drives

Equipment Identification/Tag: _____
Location: _____

Group/Item	Group/Task Description			Submitted	Delivered
A	*MODEL VERIFICATION*				
1	Manufacturer				
2	Model				
3	Serial Number				
4	Associated Motor				
5	Associated Motor Power (hp)				
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	All components and accessories present.			YES	NO
3	All penetrations sealed properly.			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	Adequate clearance around unit for service.			YES	NO
3	All components accessible for maintenance.			YES	NO
4	Unit labeled and is easy to see.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
D	*ELECTRICAL-INCOMING*				
1	Local disconnect installed in accessible and visible location.			YES	NO
2	Conductors run in conduit separate from outgoing and control conductors.			YES	NO
2	Wires are bundled, trained, and supported in enclosure.			YES	NO
3	Unit is properly grounded to a resistance of 10 ohms to ground.			YES	NO
4	Incoming supply line is connected to drive input terminals and permanently labeled.			YES	NO
5	Bypass circuit or starter installed and wired per manufacturer instructions (if applicable).			YES	NO
6	AC line reactor installed and wired per manufacturer instructions (if applicable).			YES	NO
7	All electrical connections are tight.			YES	NO
8	All electrical components are grounded.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
E	*ELECTRICAL-OUTGOING*				
1	Conductors run in conduit separate from incoming and control conductors.			YES	NO
2	Wires are bundled, trained, and supported in enclosure.			YES	NO
3	Outgoing supply line is connected to drive output terminals and permanently labeled.			YES	NO
4	Bypass circuit or starter installed and wired per manufacturer instructions (if applicable).			YES	NO
5	Output line filter installed and wired per manufacturer instructions for all 460 VAC applications with conductor lengths >120' (if applicable).			YES	NO
6	All electrical connections are tight.			YES	NO
7	All electrical components are grounded.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
F	*CONTROLS INSTALLATION*				
1	Conductors run in conduit separate from incoming and outgoing conductors.			YES	NO
2	Remote start and stop wiring installed and communication verified.			YES	NO
3	Remote status wiring installed and communication verified.			YES	NO
4	Remote alarm wiring installed and communication verified.			YES	NO
5	Status, start/stop and safety interlock wiring has been wired to permit operation and monitoring of unit in bypass mode.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
G	*ELECTRICAL STARTUP*				
1	Unit has been cleaned of all debris and dirt on interior of unit.			YES	NO
2	All switches and circuit breakers have been manually tested.			YES	NO
3	Motor circuit protector has been adjusted to the full load amperes of the motor it serves.			YES	NO
4	All wiring connections verified for proper torques values and are acceptable.			YES	NO
5	Phase-to-phase, phase-to-ground, and neutral-to-ground, and dielectric tests have been accomplished and results are acceptable.			YES	NO
6	Insulation megger test accomplished and results acceptable.			YES	NO
7	Voltages for each phase tested and within acceptable ranges for unit.			YES	NO
8	Unit energized by authorized personnel.			YES	NO
9	Motor rotation in the proper direction for associated motor.			YES	NO
10	Motor overload verified for associated motor.			YES	NO
11	Motor voltage and amps verified for each phase for associated motor and are acceptable.			YES	NO
12	Motor overload verified for associated motor.			YES	NO
13	Maximum full load amps (FLA) acceptable for associated motor.			YES	NO
14	Deceleration occurs without causing a bus overload condition.			YES	NO
15	There are no motor/drive vibrations at any speed, with any frequencies which result in motor drive vibrations locked out.			YES	NO
16	Bypass circuit or starter tested and operation acceptable.			YES	NO
17	Power interruptions of two (2) and thirty (30) seconds tested and unit operation acceptable.			YES	NO
18	All damage to unit finish is repaired			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
H	*CONTROLS STARTUP*				
1	Unit minimum speed set per associated motor.			YES	NO
2	Status monitor adjusted to account for belt loss or coupling failure.			YES	NO
3	All safeties and alarms verified and acceptable.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Negative Responses

Construction Verification Checklist
23 05 14 – Variable Frequency Drives

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 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 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 09 24 – Local Control Panels

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)			/ /	/ /
5	# of Controllers				
6	UPS Manufacturer				
7	UPS Model				
8	UPS Serial Number				
❑ **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
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
C	*INSTALLATION*				
1	Unit secured as required by manufacture and specifications requirements.			YES	NO
2	Unit display located 60" above finished floor level.			YES	NO
3	Adequate clearance around unit for service.			YES	NO
4	Conduit feeds are aligned with openings and accommodate seismic motion.			YES	NO
5	Panel mounted near controlled equipment/system on vibration free wall or free-standing support.			YES	NO
6	Unit is level, plumb and square.			YES	NO
7	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	Circuit breaker for panel installed and labeled within panel.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____
E	*WIRING-DEVICES*				
1	All connections are terminated properly.			YES	NO
2	A minimum of 5' spare cabling and/or tubing provided for all controller terminations to panel.			YES	NO
3	All electrical connections are tight.			YES	NO
4	Shutdown toggle switch provide for each air handling unit controller contained within panel (if applicable).			YES	NO
5	All cables are permanently labeled relative to use.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
F	*STARTUP*				
1	All points given address and list provided in panel.			YES	NO
2	All switches and circuit breakers have been manually tested.			YES	NO
3	Fuses have been installed in all controllers and switches (if applicable).			YES	NO
4	All toggle and HOA switches checked and fully operational.			YES	NO
5	Point-to-point communication test conducted and all points found to be acceptable.			YES	NO
6	Record drawings and instructions noted within specifications provided in panel enclosure.			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 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 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 37 13 – Diffuser, Grilles and Registers

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)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	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) Diffusers, grilles and registers installed as shown in contract documents.
2) Where it is not possible to maintain minimum 2 duct diameter straight duct into diffuser, equalizing grids are furnished.
3) Connections between ductwork drops and diffusers, grilles and registers sealed airtight.
4) Unused portions of linear slot diffusers and linear bar diffusers and grilles are blanked off.
5) Where diffusers, registers and grilles cannot be installed to avoid seeing inside duct, inside of duct is painted with flat black paint to reduce visibility.
6) In clean rooms and animal holding rooms, space between diffusers, registers and grilles and ceiling or wall to be air and watertight using clear, non-hardening, microbiological resistant silicone sealant compatible with ceiling or wall surfaces.
7) All diffusers, grilles and registers temporary sealed at end of work day to maintain duct system cleanliness.
8) All mars and blemishes are repaired.
9) Throw pattern and direction adjusted per contract document 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		

FUNCTIONAL PERFORMANCE TEST FORMS

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FPT-23 05 14 - Variable Frequency Drives

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 a variable frequency drive.

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. Remote Start/Stop
    a. Verify unit 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. Place unit into bypass mode via bypass circuit or starter.
    f. Command unit to "off".
    g. Verify unit de-energizes.
    h. Return system to normal operation.
2. Speed Control – Differential Pressure (if applicable)
    a. Verify unit and associated motor are in occupied mode. If not override system into occupied mode.
    b. Verify differential pressure setpoint for associated system is set to [XX] psi.
    c. Record current differential pressure for associated system.
    d. Record current output capacity or frequency of unit.
    e. Override differential pressure setpoint to be 2 psi above current differential pressure.
    f. Verify output capacity or frequency of unit increases.
    g. Allow associated system to stabilize for 10 minutes.
    h. Return system to normal operation.
    i. Verify output capacity or frequency of unit decreases to original readings.
3. Speed Control – Static Pressure (if applicable)
    a. Verify unit and associated motor are in occupied mode. If not override system into occupied mode.
    b. Verify static pressure setpoint for associated system is set to [XX] psi.
    c. Record current static pressure for associated system.
    d. Record current output capacity or frequency of unit.
    e. Override static pressure setpoint to be 2 psi above current static pressure.
    f. Verify output capacity or frequency of unit increases.
    g. Allow associated system to stabilize for 10 minutes.
    h. Return system to normal operation.
    i. Verify output capacity or frequency of unit decreases to original readings.

5. Speed Control – Differential Temperature (if applicable)
    a. Verify unit and associated motor are in occupied mode. If not override system into occupied mode.
    b. Verify differential temperature setpoint for associated system is set to [XXºF].
    c. Record current differential temperature for associated system.
    d. Record current output capacity or frequency of unit.
    e. Override differential temperature setpoint to be 5º above current differential temperature.
    f. Verify output capacity or frequency of unit decreases.
    g. Allow associated system to stabilize for 10 minutes.
    h. Return system to normal operation.
    i. Verify output capacity or frequency of unit increases to original readings.
6. Speed Control – CHW Temperature (if applicable)
    a. Verify unit and associated motor are in occupied mode. If not override system into occupied mode.
    b. Verify CHW temperature setpoint for associated system is set to [XXºF].
    c. Record current CHW temperature for associated system.
    d. Record current output capacity or frequency of unit.
    e. Override CHW temperature setpoint to be 5º above current CHW temperature.
    f. Verify output capacity or frequency of unit increases.
    g. Allow associated system to stabilize for 10 minutes.
    h. Return system to normal operation.
    i. Verify output capacity or frequency of unit decreases to original readings.

Results

Remote Start/Stop:

Unit is energized and de-energized when commanded by BAS?	YES	NO
Unit is de-energized when commanded by BAS, when in bypass mode?	YES	NO

Speed Control – Differential Pressure (if applicable):

Differential Pressure Setpoint:	_____
Differential Pressure:	_____
Unit Output Capacity or Frequency:	**Y / N**
Unit increases and decreases output capacity or frequency in response to decreases and increases of differential pressure, respectively?	**Y / N**

Speed Control – Static Pressure (if applicable):

Static Pressure Setpoint:	_____
Static Pressure:	_____
Unit Output Capacity or Frequency:	**Y / N**
Unit increases and decreases output capacity or frequency in response to decreases and increases of static pressure, respectively?	**Y / N**

Speed Control – Differential Temperature (if applicable):

Differential Temperature Setpoint:	_____
Differential Temperature:	_____
Unit Output Capacity or Frequency:	**Y / N**
Unit increases and decreases output capacity or frequency in response to increases and decreases of differential temperature, respectively?	**Y / N**

Speed Control – CHW Temperature (if applicable):

CHW Temperature Setpoint:	_____
CHW Temperature:	_____
Unit Output Capacity or Frequency:	**Y / N**
Unit increases and decreases output capacity or frequency in response to decreases and increases of CHW temperature, respectively?	**Y / N**

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, differential pressure setpoint, differential pressure, static pressure setpoint, static pressure, differential temperature setpoint, differential temperature, temperature setpoint, temperature

Witnesses

Name	**Signature**

FPT-23 05 93 – Testing, Adjusting and Balancing Verification Test

Equipment Identification/Tag: _____
Location: _____

Test Duration
Date: _____ Start Time: _____ End Time _____

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

Objectives
This test is performed to verify the accuracy of the testing, adjusting and balancing completed for the facility.

Instrumentation
AABC or NEBB specified equipment with specified accuracies.

Sampling Methodology
1. Major equipment air flow (i.e. AHU's, fans, etc.): Sample air flow performance of 100 % of all major equipment shown in the construction documents for all sample points indicated.
2. Major equipment water flow (i.e. AHU's, Chillers, Boilers, pumps, etc.): Sample water flow performance of 100 % of all major equipment shown in the construction documents for all sample points indicated.
3. Terminal devices air flow (i.e. terminal units, fan coil units, grilles, etc.): Sample air flow performance of 10% of all terminal units shown in the construction documents, with at least one sample for each terminal type for all sample points indicated.
4. Terminal and balancing devices water flow (i.e. Fan Coils, Terminal Units, Balancing valves, etc.): Sample water flow performance of 10% of all terminal units and all balance valves shown in the construction documents, with at least one sample for each terminal or valve type for all sample points indicated.
5. Critical terminal devices for Labs and Vivariums (VAV boxes, air valves, etc.): Sample air flow performance of (50%)(100 %) of all Critical terminal devices shown in the construction documents for all sample points indicated.

Note: Fume hoods will be tested by the Contractor furnishing the fume hood when they conduct the ASHRAE 110 test and calibrate the fume hood monitor.

Procedure
For each of the sample points listed under the results section, re-test the point in accordance with the procedures detailed within specification section 23 05 93. Verify procedures utilized concur with these documents and record findings in the results section below. In addition, for each point tested record the measured value and verify the result is within 10% of the original value recorded and within the specified tolerances of the design setting for the point.

Sample 100% of Terminal devices if 20% of devices sampled fall outside of either specified tolerance range of the completed Testing, Adjusting and Balancing Verification Test Results Table found in form FPT – 23 05 93, located in section 01 91 01.

Sample 100% Lab and Vivarium devices if 20% of devices sampled fall outside of either specified tolerance range of the completed Testing, Adjusting and Balancing Verification Test Results Table found in form FPT – 23 05 93, located in section 01 91 01

Results

Sample Point Name	Procedure Compliant	Design	T&B Report Final Reading	Commission Test	Tolerance Within 10% of T & B Report Final Reading	Within Tolerance Specified in 23 05 93	Notes
AHU – CFM Min	YES NO				YES NO	YES NO	
AHU – CFM Max	YES NO				YES NO	YES NO	
AHU – CFM OA-Min	YES NO				YES NO	YES NO	
AHU – CFM OA-Max	YES NO				YES NO	YES NO	
AHU – CFM RA-Min	YES NO				YES NO	YES NO	
AHU – CFM RA-Max	YES NO				YES NO	YES NO	
AHU – GPM Coil	YES NO				YES NO	YES NO	
AHU – GPM Coil	YES NO				YES NO	YES NO	
Fan – CFM	YES NO				YES NO	YES NO	
Fan - ESP	YES NO				YES NO	YES NO	
Grille – CFM	YES NO				YES NO	YES NO	
Grille – CFM	YES NO				YES NO	YES NO	
Offset – CFM-Pressurization	YES NO				YES NO	YES NO	
Pump – GPM	YES NO				YES NO	YES NO	
Pump – GPM	YES NO				YES NO	YES NO	
VAV – CFM Min	YES NO				YES NO	YES NO	
VAV – CFM Max	YES NO				YES NO	YES NO	

Triple duty valves for pumps operated by VFD are 100% open? YES NO
Diffusers and grilles with adjustable throw patterns adjusted to match contract documents? YES NO
Final ductwork control static pressure setpoint recorded? YES NO
Final hydronic control differential pressure setpoint recorded? YES NO
VAV box “k” factors recorded YES NO
Pump impeller required trimming completed YES NO

Conclusion
Acceptable Criteria: All points listed are within listed tolerances of design and original recordings and were recorded in accordance with TAB plan and/or NEBB standards.

Comments:

Observations:

Final Status: ❑ Accepted ❑ Not Accepted

Relevant Trend Data
Static Pressure Setpoint (VFD fans ONLY), Hydronic Loop Differential Setpoint (VFD pumps ONLY).

Witnesses

Name	**Signature**

FPT-23 09 24 - BAS Communication/Calibration

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 communication within BAS system, associated sensors, actuators and relays and the calibration of these devices.

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
A minimum of 20% of total points monitored or controlled by BAS system is to be sampled. However, areas specified as critical in nature or associated with critical or major components (i.e. chiller, AHU, etc.) are to be sampled at a rate of 50% of total points associated with given area or equipment.

Procedure
1. For each of the points listed under the results section related to monitoring run status of equipment or responsible for actuation or control of equipment, manually override the equipment to start or actuate. Verify equipment is started and status concurs with BAS head end.
2. For each of the points listed under the results section related to monitoring temperature, pressure, humidity, etc. record the readings registered at the BAS head end and measure the conditions present at the sensor. Verify BAS and measured readings agree within scheduled tolerances listed under the results section.
3. For each of the points listed under the results section related to alarms and safeties, verify proper communication of alarm conditions for each point by manually overriding the alarm point by one of the following methods:
    a. Disconnect relay contacts.
    b. Force alarm condition by running a diagnostic protocol on the local control panel.
    c. Force alarm condition by presenting a simulated alarm condition (i.e. shutting off gas to each boiler to produce a flame failure).

Results
Status & Actuation Points:

Point Name	Communication Verified	Notes
	❑ YES ❑ NO	

Temperature, Pressure, Humidity Sensors:

Point Name	BAS Value	Measured Value	Tolerance	Accepted
				❑ YES ❑ NO

Alarms and Safeties

Point Name	Communication Verified	Notes
	❑ YES ❑ NO	

Conclusion

Acceptable Criteria: All points listed have proper communication with BAS head end and are calibrated to meet tolerances specified.

Comments:

Observations:

Final Status: ❑ Accepted ❑ Not Accepted

Relevant Trend Data

N/A

Witnesses

Name	**Signature**

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

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**

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:

POINT LIST (Section 23 09 15)

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 15 - Direct Digital Control Input/Output Point Summary Tables
Section 23 09 24 - Direct Digital Control System for HVAC (Informational purposes only)
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.

WORK NOT INCLUDED
Direct digital controls and energy management interface, as specified in Section 23 09 24.

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
New work on system is to be electric/electronic. Some existing equipment utilizes pneumatic actuation.

All pneumatic tubing and electrical wiring are 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.

Schedule of control valves indicating system in which the device is to be used, rated capacity, flow coefficient, flow required by device served, actual pressure drop at design flow, size of operator required, close-off pressure, and locations where valves are to be installed.

A complete description of each control sequence for equipment that is not controlled by direct digital controls. Direct digital controlled equipment control sequences will be provided by the DDC control contractor.

Calculations completed to determine size of control air compressor(s) and dryer (s).

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.
Provide a complete set of Submittal Drawings to the 23 09 24 DDC Contractor to enable them to coordinate the interfacing of the 23 09 14 controls with the 23 09 24 supplied controls. The 23 09 24 contractor is also required to provide any information regarding their supplied control equipment to the 23 09 14 contractor so that the 23 09 14 contractor can complete his engineered Submittal Drawings.

Provide a complete set of control Record Drawings to the 23 09 24 DDC Contractor to enable them to provide a complete composite set of drawings incorporating DDC and electric/pneumatic controls as specified. Where communication and/or power wiring is specified to be provided under this Section, ppoint to point routing of communication trunks and power wiring between DDC controllers, DDC communication devices, control panels, and Ethernet switches shall be documented in the control Record Drawings.

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.

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

AIR PIPING
ASTM B75 seamless, hard drawn, or annealed copper tubing with ANSI B16.22 wrought copper fittings, except final connections to apparatus may be made with brass compression-type fittings. Use ANSI/ASTM B32, 95/5 tin antimony solder.

Virgin polyethylene plastic tubing classified as flame retardant under UL 94 and conforming to ASTM D1693 stress-crack test.

CONTROL AIR SUPPLY
Extend existing air supply for new work.

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 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.

CONTROL SYSTEM INSTRUMENTATION

Manufacturers: Bulb Type - Johnson Controls, Ashcroft, Marshall, Weksler
Solar Digital Type – Trerice, Palmer, or equal.

TEMPERATURE CONTROL PANELS

Constructed of steel or extruded aluminum, with hinged door, keyed lock, and baked enamel finish. Install controls, relays, transducers, and automatic switches inside panels. Label devices with permanent printed labels and provide asbuilt wiring/piping diagram within enclosure. Provide raceways for wiring and poly within panel for neat appearance. Provide termination blocks for all wiring terminations. Label outside of panel with panel number corresponding to plan tags and asbuilt control drawings as well as building system(s) served.

Control panels that have devices or terminations that are fed or switch 50V or higher shall enclose the devices, terminations, and wiring so that Personal Protective Equipment (PPE) is not required to service the under 50V devices and terminations within the control panel. As an alternative, a separate panel for only the 50V and higher devices may be provided and mounted adjacent to the under 50V control panel.

For panels that have 120VAC power feeds provide a resettable circuit breaker. Provide label within the panel indicating circuit number of 120VAC serving panel

TEMPERATURE SENSORS

Thermistor temperature sensor manufacturers: PreCon, BAPI, and ACI

Use thermistor or RTD type temperature sensing elements constructed so accuracy and life expectancy is not affected by moisture, physical vibration, or other conditions that exist in each application.
RTD's shall be of nickel or platinum construction and have a base resistance of 1000Ω at 70°F and 32°F respectively. 100Ω platinum RTD's are acceptable if used with temperature transmitters.

The temperature sensing device used must be compatible with the DDC controllers used on the project.

RTD

Accuracy (Averaging)	minimum ± 1.2°F
Accuracy (Other than Room Sensor or Averaging)	minimum ± 0.65°F

Thermistor

Accuracy (All)	minimum ± 0.36°F
Range (Averaging)	minimum -30 – 200°F
Heat Dissipation Constant	minimum 2.7 mW/°C

Provide limited range or extended range sensors if required to sense the range expected for a respective point. Use RTD type sensors for extended ranges beyond -30 to 230°F. If RTD's are incompatible with DDC controller direct temperature input, use temperature transmitters in conjunction with RTD's.

Use wire size appropriate to limit temperature offset due to wire resistance to 1.0°F. If offset is greater than 1.0°F due to wire resistance, use temperature transmitter. If feature is available in DDC controller, compensate for wire resistance in software input definition.

Use averaging elements on AHU/duct sensorsProvide coverage of the coil to be one foot of coverage for 2 ft^2 of air plenum or coil size with a +25% variance allowable for the coverage, with a maximum of one 24' averaging element distributed evenly across the coil face.,

HUMIDITY SENSORS

Use capacitive thin-film polymer sensor types with a range of 0-100% RH. Accuracy to be no less than **±2%** in the range of 20% RH to 80% RH with a response time of 120 seconds or less. Provide covers for room humidity sensors as specified for temperature sensors.

For outside air applications, use sensor designed for outside air use along with weather enclosure. Provide sensor equal to Vaisala Model HMD60UO w/ DTR503B enclosure and weather resistant mounting hardware.

PRESSURE TRANSDUCERS (AIR)

Provide pressure transducers specified below for the following applications:

- Duct static pressure applications where setpoints are specified to control at greater than 0.1" w.c.
- Pitot type fan inlet air flow stations.
- Air filtration in fan powered equipment.

Manufacturers: Mamac Systems, Setra, and Veris Industries.

Provide a transmitter that operates on the capacitance principle and is capable of sensing low positive, negative or differential pressures. Transmitter shall have a minimum of three pressure ranges adjustable by an onboard switch or jumper. Size the transmitter where the middle or high range is suitable for the application. Use a bi-directional transmitter for applications that may have both positive and negative pressure excursions. Transmitter shall be provided with an integral four-digit display of the pressure sensed.

Accuracy (including non-linearity and hysteresis)	± 1% FS
Compensated Temperature Range	32°-140° F
Temperature Effect	0-1"wc Range .09% FS/°F
	>1"wc Range .02% FS/°F
Output	4-20 MA
Load Impedance (smallest maximum acceptable)	800 Ω max.
Operating Temperature	32°-140° F

For air filtration monitoring, size differential pressure transducers to provide for the following ranges:

Filter Type	**Scale Range (inch W.G.)**
Panel filters	0.0 to 0.5
MERV 7	0.0 to 1.0
MERV 11	0.0 to 2.0
MERV 14	0.0 to 2.0
HEPA filters	0.0 to 4.0
Roll filters	0.0 to 1.0
Activated carbon filters	0.0 to 2.0

Provide pressure transducers specified below for the following applications:

- Duct static pressure applications where setpoints are specified to control at 0.1" w.c. or lower.
- All duct mounted pitot type air flow stations.
- Space/building static control or monitoring.

Manufacturers: Paragon Controls MicroTrans, Air Monitor Veltron DPT2500 Plus, or approved equal.
The airflow transducer shall provide noise filtration and automatic auto-zeroing. The automatic zeroing circuit shall be capable of maintaining the transducer output to within ±0.25% of operating span. The transducer output shall be locked and maintained at the last given output value during the automatic zeroing period so as not to interrupt the automatic control process. Use a bi-directional transmitter for applications that may have both positive and negative pressure excursions. Transmitter shall be provided with an integral four-digit display of the pressure sensed.

Transducer Span: <2 times the design velocity pressure at maximum flow, single range
Accuracy: ±0.25% of full scale, including non-linearity, hysteresis, deadband, and non-repeatability
Temperature Effect: ±0.15% of full scale/°F
Response: 0.5 sec. for 98% of full span change
Overpressure: 5 PSIG Proof
Power: 24VAC/VDC
Analog Output: 0-5VDC, 0-10VDC, or 4-20mA field adjustable
Auto Zero Frequency: every 1 to 24 hours on 1 hour intervals

For space or building static pressure monitoring, use Vaisala model SPH10 Static Pressure Head, or approved equal for outside air reference and Mamac A-523 or equal for space reference. For fan housing or duct static or differential pressure sensing, use gasketed metal static pressure sensors. Mamac A-520 or equal. Mount in location shown on plans or approved by AE.

CURRENT STATUS SWITCHES
Provide a current sensor with adjustable threshold and digital output with LED display, equal to a Veris model H-708/H-904. Threshold adjustment must be by a multi-turn potentiometer or set by multiprocessor that will automatically compensate for frequency and amperage changes associated with variable frequency drives. When used on variable speed motor applications, use a current sensor that will not change state due to varying speeds. Current switches with integral relays shall not be used for start/stop and status motor applications.

Current sensor to be compatible with ECM motor provided with exhaust fans.

ELECTRIC TO PNEUMATIC TRANSDUCERS
Electric to pressure transducers shall have internal pressure feedback to compare actual commanded pressure value and will compensate for leakage or drift. Provide with manual override. Output of transducer shall bleed to zero PSI on power fail.

High air capacity	500 SCIM at 20 psig
Low air consumption	15 SCIM at 20 psig
Input	4-20 MA / 0-10VDC
Output	0-20 psig
Linearity	1% of span
Hysteresis	1% of span

This contractor shall be responsible for verifying that the input of electric to pneumatic transducers is compatible with the output of the DDC controller provided under 23 09 24 or 23 09 23.

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. All cables to the electronic input/output devices, sensors, relays, and interlocking wiring (all of which shall be supplied and installed under this section of specification) interfaced with the Direct Digital Control System shall be extended into the 23 09 24 DDC panel with a minimum of 5 ft. of cable to allow for termination by the 23 09 24 DDC Contractor. This contractor shall provide a technician to inspect and validate all tubing, wiring, and field devices associated with the DDC interface in coordination with and under direction of the 23 09 24 DDC Contractor to ensure that each device is operating per the control sequences 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.

- At HVAC terminal units only, where the wiring serves a specific device; e.g., controller, actuator, transmitter, etc. associated with the unit, the j-hooks or Bridal rings required to support the wiring, may be secured to the rods or straps that support the ductwork or piping that serves the unit. Wall penetrations shall be sleeved.

- 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.

Control panels serving equipment fed by emergency power shall also be served by emergency power. This contractor shall be responsible for all 120VAC power, not provided in the Division 26 specifications, required for equipment provided under this section. Power shown for temperature control panels on plans may be utilized by the 23 09 24 and/or 23 09 23, and 23 09 14 contractors.

Provide communication trunk wiring to integrated devices (i.e., VFD's, Flow Meters, Chillers, Lighting Panels, Electrical Meters, etc.) and terminal unit controllers that are specified to be connected to the building automation system. Communication trunk wiring shall be as required by the equipment specified under the 23 09 23 or 23 09 24 Sections and shall be routed to the DDC panel designated for that equipment as shown on the plans or the closest DDC panel if not designated. If communication trunks require daisy chained style wiring, provide two communication cables to the DDC panel so that the communication trunk is not dead ended.

This contractor shall provide all 24VAC power transformers and wiring for DDC terminal unit and exhaust fan controls. This contractor shall provide all communication wiring to the DDC supervisory controller for the terminal units provided under 23 09 23 or 23 09 24. Provide all power and communication wiring type and installation as required by the DDC controller manufacturer for the terminal units. Tag all terminal units with printed labels to match the terminal unit room schedules. This contractor shall terminate wiring for all terminal unit controllers and perform end to end point checkout of all inputs and outputs to the terminal unit controllers. This contractor shall verify the communication trunk and controller addressing.

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.
If terminal unit controllers are furnished under Section 23 09 24, the 23 09 24 contractor shall provide a laptop or other tools and training to the 23 09 14 contractor on how to perform the communication trunk testing and end to end point checkout as described above. Terminal unit room schedules are to be provided under this Section and supplied to the 23 09 24 contractor. The 23 09 24 contractor shall provide engineered control drawings for installation of the terminal unit controllers and deliver these to the 23 09 14 contractor in time to meet the project schedule for the installation of these terminals. Communication trunk wiring for the DDC control panels provided under Section 23 09 24 shall be provided by the 23 09 24 contractor unless otherwise specified.

Install "hand/off/auto" selector switches on systems where automatic interlock controls are specified and "hand/off/auto" selector switches are not supplied with the equipment controlled. Control panel power will not be required for "hand" switch to operate. When switch is in "hand" position, allow manual operation of the selected device without operating the interlocked motors but allowing all unit safety devices to stay in the circuit.

Install all shutdown switches furnished under this Section where specified or shown on the plans. Boiler kill switches shall be wired to each boiler safety circuit and an auxiliary contact shall be wired to a DDC binary input. Emergency HVAC shutdown switches shall be wired to DDC binary inputs for shutdown of all HVAC equipment serving the building.

All wiring in control panels shall be terminated on a terminal strip. Wire nuts are not acceptable. A maximum of two wires shall be terminated under any one terminal.

Utilizing a control panel as a raceway for wiring to another control panel is prohibited.

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.

AIR PIPING

Conceal piping whenever possible. Exposed piping may be run only in mechanical rooms, storage rooms, or other areas where mechanical systems piping is exposed.

Mechanically attach tubing to supporting surfaces. Sleeve through concrete surfaces in minimum one-inch sleeves, extended 6 inches above floors and one inch below bottom surface of slabs. Fire stop any open space in the sleeve after the air piping is installed if the sleeve is in a fire rated surface.

Isolate air supply from compressor assembly with wire braid reinforced rubber hose or polyethylene tubing.

Take-offs shall enter top of main air piping wherever possible. Install a shut-off valve at each PRV connection to high-pressure air main.

Purge tubing with dry, oil free compressed air before connecting control instruments.

Install all polyethylene tubing in conduit as scheduled below unless specified otherwise hereafter. Exposed polyethylene tubing not exceeding 18 inches may be used for connection to an instrument or operator without being installed in conduit. All Conduit to be independently supported, all boxes must be supported, all conduit ends to have bushings for protection of tubing.

Conduit shall be a minimum of 1/2 " for poly tubing provided the pipe fill does not exceed 40%.

Minimum poly tubing size allowed is ¼” OD. If an instrument has a barbed fitting that will only accept 5/32” tubing, connection to the device can be made with 5/32” tubing that is as short as is practical. Couplings are acceptable in this instance.

Install all exposed piping and conduit parallel to or at right angles to the building structure and support adequately at uniform intervals. Use only tool made bends in copper air pipe.

Tubing must be installed and supported in a manner as specified for exposed locations and acceptable to DFD.

Where polyethylene tubing is installed free-air, installation shall consider the following:

- Tubing shall run at right angles and be kept clear of other trades work.
- Tubing shall be supported utilizing "J-" or "Bridal-type" mounting rings anchored to ceiling concrete, piping supports or structural steel beams. Rings shall be designed to maintain tubing bend to larger than the minimum bend radius (typically 4 x tubing diameter).
- Supports shall be spaced at a maximum 4-foot interval unless limited by building construction. If tubing "sag" at mid-span exceeds 6-inches, another support shall be used.
- Tubing shall never be laid directly on the ceiling grid or attached in any manner to the ceiling grid wires.
- Air piping may be routed with Class 2 control wiring in J-hooks.

Tubing shall not be attached to existing cabling, existing tubing, plumbing or steam piping, ductwork, ceiling supports or electrical or communications conduit.

Tubing connected to air terminal unit devices shall be attached to the terminal unit device to prevent tubing from becoming kinked or becoming disconnected. Tubing serving air terminals may be routed on top of ductwork serving that terminal unit for a maximum distance of eight feet.

Tubing directly connected to steam valve actuators shall be copper tubing for a minimum of six inches.

Where tubing is connected to ductwork at an exterior location for sensing purposes, the tubing shall be sloped to a heated interior location without sags or traps in the tubing to prevent condensation to be trapped in the tubing and prevent accurate sensing. Install drip leg at low point at interior location and note location on control record drawings.

Number code all polyethylene tubing and install neatly with no concealed splices.

Test entire piping system by pressurizing it to 20 psig for 24 hours. Pressure drop during this period shall not exceed 3 pounds.

Low-pressure air mains shall be designed so that the pressure at any point in the main shall not vary by more than 1 PSI from the pressure at the air pressure regulator.

Piping material used shall be as follows:

Use hard copper tubing for all main air lines, above 30 psi.

All exposed copper to be hard drawn.

Use only polyethylene tubing inside panels.

In concealed locations (other than noted below) hard copper, soft copper, or polyethylene tubing in conduit shall be used.

Polyethylene tubing in block, stud. or concrete walls must be in conduit and associated boxes to be of steel.

Where air piping is within concrete slab or under grade use only polyethylene tubing in conduit

For exposed outdoor locations, use hard copper or polyethylene tubing in conduit. Provide shielding for polyethylene tubing that is used for final device connection that will be exposed to direct sunlight.

For static sensing lines connected to ductwork located in exposed outdoor locations, slope piping from connection into building to a location that will be above freezing so any condensation will run into the building and not freeze in piping. Piping tap shall not be on the bottom of the ductwork. Provide a drip leg of 3/8" tubing a minimum of one foot in length in an accessible location inside the building that will collect condensation from the sensing line.

Polyethylene tubing may be used in exposed areas if run in a fully enclosed rigid metal raceway or metal conduit and ambient temperature is less than 150°F.

Use copper tubing, where subject to temperatures in excess of 150°F or where adjacent to heating pipes passing through a common sleeve.

When polyethylene tubing is used above accessible lay-in acoustical panel ceilings it must be fire resistance "FR" rated pass the UL 94 vertical flame test with a rating of V2, be rated as self-extinguishing under ASTM D 635, and may be run without conduit.

High pressure rated polyethylene tubing in conduit may be used for branch lines to high-pressure actuators. Compression fittings must be used for high-pressure (above 30 PSI) applications.

For pneumatic actuated dampers that are involved in a smoke control system, all air piping shall be hard copper, except within control panels and shall be isolated from the non-smoke control system controls by automatic isolation valves in the event of a smoke control event. Installation shall conform to applicable International Building Code Section 909 requirements.

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.

Underground Installations within Five Feet (1.5 m) of Foundation Wall: Rigid steel conduit.

Underground Installations More than Five Feet (1.5 m) From Foundation Wall: Rigid steel conduit. Plastic-coated rigid steel conduit. Schedule 40 PVC conduit.

Under Slab on Grade Installations: Schedule 40 PVC conduit.

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.

CONTROL VALVES

All temperature control valves 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.

Steam valve actuators shall be mounted between 45 and 90 degrees from upright vertical to prevent over heating of the actuator unless this orientation is specifically prohibited by the manufacturer. All other valves shall be mounted in the upright vertical position. If upright vertical mounting is not possible due to lack of space, obtain approval from the mechanical engineer of record on the project for alternate mounting that meet

the manufacturers recommended installation. Radiation control valves shall not be located in the convective air flow above the heating element.

Provide pilot positioners on all valves where more than one pneumatic operator is controlled in sequence, for all valves 3" and larger, or where required to provide sufficient power. Where two or more valves are operated in sequence, pilot positioners to have adjustable start point (2-12 psig) and span (5-13 psig).

CONTROL SYSTEM INSTRUMENTATION

For pneumatically actuated systems install pressure gauges as follows: for indication of supply air pressure in each temperature control panel; at the output of pneumatic/electric transducers; the output of each pneumatic controller; the output of each solenoid air valve; the input of each PE switch; at each modulated damper and valve except terminal devices; other points where the visible indication of air pressure is required for operating and maintenance purposes. On dampers and valves with pilot positioners, locate gauge in the output of positioner to controlled device. Mount gauges so they are visible when looking at the monitored device. At each receiver controller input port, install a 1-1/2" diameter dial indicator with scale to match input range (in degrees F., % R.H., in. w.c., etc.). Equip control air output line with a 1-1/2" diameter air pressure gauge.

Install thermometer on the discharge of the AHU after the supply fan, all coils, and humidifiers but before any booster coils. Install thermometer to permit easy reading from the floor or operating platform. Adjust swiveled mounting for easy reading from floor.

TEMPERATURE CONTROL PANELS

Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. All control panel openings shall be plugged. Conduits and other penetrations on the top of the cabinets shall be sealed on the exterior of the cabinet with silicone caulk to resist water penetration. Provide a separate control panel for each major mechanical system, i.e. AHU, hot water system, chilled water system, etc. as outlined in the point charts and shown on the plans. One control panel may accommodate more than one major mechanical system in same equipment room only where specifically stated in the contract documents. Provide permanent printed labeling for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.

Provide as-built control drawings of all systems served by each local panel in a location adjacent to or inside of panel cover. Provide a protective cover or envelope for drawings.

CURRENT STATUS SWITCHES

Provide for each fan or pump specified or shown on point list. Set threshold adjustment to indicate belt or coupling loss. Readjust threshold for proper operation after final balancing is completed. Use the variable frequency drive (VFD) integrated relay output for motor status, if provided on the VFD, in lieu of a discrete current switch. A separate current switch provided under this Section shall be wired 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. When a VFD serves more than one fan, provide a separate current switch for each fan served.

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.

The GPC shall schedule the meeting after the final control submittals from all 23 09 xx specifications Sections have been completed and submitted to the AE.

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

DDC INPUT / OUTPUT SUMMARY TABLE

DFD PROJECT NO: 22L2Q — **DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 24**

PROJECT:

UPGRADE VARIOUS SYSTEMS

LOCATION:

DSF PROJECT NO: 11X1X

SYSTEM: AHU-6 (100% OA VAV pneumatically actuated)

POINT DESCRIPTION	HARDWARE: OUTPUT – DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	HARDWARE: OUTPUT – ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT – DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	HARDWARE: INPUT – ANALOG: Temperature	Relative Humidity	Differential Pressure	Gauge Pressure	Static Pressure	Flow	SOFTWARE: ALARMS – DIGITAL: Equipment Status	Maintenance	Pressure	SOFTWARE: ALARMS – ANALOG: High Limit	Low Limit	Maintenance		SOFTWARE: ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend	Redundancy Control	Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	CFM Offset	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Supply Air Temperature															X																														Existing I/O point to remain
Outside Air Temperature															X																														Existing I/O point to remain
Corridor W-235 Space Temp															X																														Existing I/O point to remain
Billet room space temp															X																														Existing I/O point to remain
Supply Fan Start/Stop	X																																											Wire new VFD to existing point
Supply Fan Status													X																																Wire new VFD to existing point
Exhaust fans start/stop	X																																											Existing I/O point to remain
Heating/Cooling Coil Control valve						X																																							Existing I/O point to remain
Heating coil control valve								X																																					Existing I/O point to remain
Summer/Winter Mode										X																																			Existing I/O point to remain
Occupied/Unoccupied Mode										X																																			Existing I/O point to remain
West Wing 1st Floor FCU's enable/disable	X																																											Existing I/O point to remain
West Wing 2nd Floor FCU's enable/disable	X																																											Existing I/O point to remain
West Wing 3rd Floor FCU's enable/disable	X																																											Existing I/O point to remain
Boiler enable	X																																												Existing I/O point to remain
Boiler fault												X																																	Existing I/O point to remain
HW supply temp															X																														Existing I/O point to remain
HW return temp															X																														Existing I/O point to remain
1st floor space humidity																X																														Provide new input point
2nd floor space humidity																X																														Provide new input point
3rd floor space humidity																X																														Provide new input point
Supply fan speed command							X																																							Provide new output point
Duct static pressure																	X																														Provide new input point

DDC INPUT / OUTPUT SUMMARY TABLE

DFD PROJECT NO: 22L2Q

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 24

PROJECT: UPGRADE VARIOUS SYSTEMS	HARDWARE																				SOFTWARE																									
LOCATION: MILITARY ACADEMY, FORT MCCOY	OUTPUT								INPUT												ALARMS																									
	DIGITAL				ANALOG				DIGITAL						ANALOG						DIGITAL			ANALOG			ENERGY MANAGEMENT SYSTEM FUNCTIONS																			
SYSTEM: **AHU-7** (100% OA VAV pneumatically actuated) POINT DESCRIPTION	Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	Temperature	Relative Humidity	Differential Pressure	Gauge Pressure	Static Pressure	Flow	Equipment Status	Maintenance	Pressure	High Limit	Low Limit	Maintenance	Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend	Redundancy Control	Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	CFM Offset	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Supply Air Temperature															X																															Existing I/O point to remain
Outside Air Temperature															X																															Existing I/O point to remain
Corridor N-271 Space Temp															X																															Existing I/O point to remain
Billet room space temp															X																															Existing I/O point to remain
Supply Fan Start/Stop	X																																													Wire new VFD to existing point
Supply Fan Status													X																																	Wire new VFD to existing point
Exhaust fans start/stop	X																																													Existing I/O point to remain
Heating/Cooling Coil Control valve						X																																								Existing I/O point to remain
Heating coil control valve								X																																						Existing I/O point to remain
Summer/Winter Mode										X																																				Existing I/O point to remain
Occupied/Unoccupied Mode										X																																				Existing I/O point to remain
North Wing 1st Floor FCU's enable/disable	X																																													Existing I/O point to remain
North Wing 2nd Floor FCU's enable/disable	X																																													Existing I/O point to remain
North Wing 3rd Floor FCU's enable/disable	X																																													Existing I/O point to remain
Boiler enable	X																																													Existing I/O point to remain
Boiler fault												X																																		Existing I/O point to remain
HW supply temp															X																															Existing I/O point to remain
HW return temp															X																															Existing I/O point to remain
1st floor space humidity																X																														Provide new input point
2nd floor space humidity																X																														Provide new input point
3rd floor space humidity																X																														Provide new input point
Supply fan speed command							X																																							Provide new output point
Duct static pressure																	X																													Provide new input point

DDC INPUT / OUTPUT SUMMARY TABLE

DFD PROJECT NO: 22L2Q — **DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 24**

PROJECT: UPGRADE VARIOUS SYSTEMS

LOCATION: MILITARY ACADEMY, FORT MCCOY

SYSTEM: Miscellaneous Points

POINT DESCRIPTION	HARDWARE: OUTPUT – DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Actuator	OUTPUT – ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT – DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	INPUT – ANALOG: Temperature	Relative Humidity	Differential Pressure	Gauge Pressure	Static Pressure	Flow	SOFTWARE: ALARMS – DIGITAL: Equipment Status	Maintenance	Pressure	ALARMS – ANALOG: High Limit	Low Limit			ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Lighting Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
New Billet Rm Exhaust Fans (19 fans)																																											
EF-XX Start/stop	X																																										NEW I/O POINT QTY 19
EF-XX Status									X												X																						NEW I/O POINT QTY 19
EF-XX Damper				X																																							PROVIDE NEW OUTPUT AND ACTUATOR

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SECTION 23 09 24
DIRECT DIGITAL CONTROL SYSTEM FOR HVAC
(INFORMATIONAL PURPOSES ONLY)
BASED ON DFD MASTER SPECIFICATION DATED 10/15/2024

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

SCOPE

The work associated with this section WILL NOT be bid as part of the Division 23 scope of work.

Work in this section includes Direct Digital Control (DDC) panels, main communication trunk, software programming, and other equipment and accessories necessary to constitute a completely coordinated extension of the existing campus or building Direct Digital Control (DDC) system. This system interfaced with pneumatic/electric controls (Section 23 09 14) utilizing Direct Digital Control signals to operate actuated control devices will meet, in every respect, all operational and quality standards specified herein, a fully coordinated modification and extension via DDC of the existing Central Campus Automation System.

RELATED WORK

Section 01 91 01 – Commissioning Process
Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC - Coordination
Section 23 08 00 – Commissioning of HVAC

Section 23 09 14 - Pneumatic and Electric Instrumentation and Control Devices for HVAC
Section 23 09 15 - Direct Digital Control Input/Output Point Summary Tables
Section 23 09 93 - Control Sequences

Division 23 - HVAC - Equipment provided to be controlled or monitored
Division 26 - Electrical - Equipment provided to be controlled or monitored

REFERENCE

Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS
FCC Part 15, Subpart J, Class A - Digital Electronic Equipment to Radio Communication Interference

WORK NOT INCLUDED
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.

QUALITY ASSURANCE

MANUFACTURERS:
Johnson Controls, Inc..

INSTALLER:
A firm specializing and experienced in DDC control system installation for no less than 3 years. All engineering and commissioning work shall be done by qualified personnel in the direct employ of this manufacturer, or of an Authorized Representative of that manufacturer that provides engineering and commissioning of the manufacturers control equipment. Where installing contractor is an authorized representative of the control equipment manufacturer, submit written confirmation of such authorization. Indicate in letter of authorization that the installing contractor has successfully completed all necessary training required for the engineering, installation, and commissioning of equipment and systems to be provided for the project, and that such authorization has been in effect for a period of not less than three years. The letter of authorization should also indicate that the installing contractor is authorized to install the manufacturer's DDC equipment at the project location at the time the project is bid. Installation of the equipment shall be done by qualified mechanics and/or electricians in the direct employ or be directly subcontracted and under the supervision of the manufacturer or Authorized Representative.

RESPONSE TIME:
During warrantee period, four (4) hours or less, 24-hours/day, 7 days/week.

ELECTRICAL STANDARDS:
Provide electrical products, which have been tested, listed, and labeled by Underwriters' Laboratories (UL) and comply with NEMA standards.

DDC Standards: DDC manufacturer shall provide written proof with shop drawings that the equipment being provided is in compliance with FCC rules governing the control of interference caused by Digital Electronic Equipment to Radio Communications (Part 15, Subpart J, Class A).

SUBMITTALS
Include the following information:

Details of construction, layout, and location of each temperature control panel within the building, including instruments location in panel and labeling. Indicate which piece of mechanical equipment is associated with each controller and what area within the building is being served by that equipment. For terminal unit control, provide a room schedule that lists mechanical equipment tag, room number of space served, address of DDC controller, and any other pertinent information required for service.

PRODUCT DATA:
Submit manufacturer's specifications for each control device furnished, including installation instructions and startup instructions. General catalog sheets showing a series of the same device is not acceptable unless the specific model is clearly marked. Annotated software program documentation shall be submitted for system sequences, along with descriptive narratives of the sequence of operation of the entire system involved. Submit wiring diagram for each electrical control device along with other details required to demonstrate that the system has been coordinated and will function as a system.

MAINTENANCE DATA:
Submit maintenance data and spare parts lists for each control device. Include this data in maintenance manual.

RECORD DRAWINGS:
Prior to request for final payment provide complete composite record drawings to incorporate the DDC and Pneumatic/Electric fieldwork. Accurate Section 23 09 14 record drawings to be supplied by the Section 23 09 14 contractor with the accuracy of these drawings being the responsibility of the 23 09 14 contractor. If changes are required to the 23 09 14 supplied record drawings after they have been compiled by the 23 09 24 contractor, it shall be the 23 09 14 contractor's responsibility to provide updated composite record drawings incorporating the 23 09 24 record drawings. All software addressing for device communication shall be noted for all devices provided under this section and the communication addressing required for devices provided by others that are integrated into the direct digital control system provided under this section. Point to point routing of communication trunks and power wiring between DDC controllers, DDC communication devices, control panels, and Ethernet switches shall be documented. For systems that have additions to existing communication networks, provide complete DDC network diagrams for the entire building with new work clearly delineated. Coordinate with the supplier of the equipment specified to be interfaced through digital communications for communication addressing. Provide circuit number of 120VAC panel power circuit(s) feeding each control panel on record drawings. Label circuit number(s) inside the panel served.

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

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

GENERAL
Provide DDC control products in sizes and of capacities as required, conforming to manufacturer's standard materials and components as published in their product information, designed, and constructed as recommended by the manufacturer and as required for application indicate.

System shall be capable of operating with 120 VAC power supply, fully protected with a shutdown-restart circuit, and associated hardware and software.

DDC controllers shall not use Power over Ethernet (PoE) for powering the controller unless specified.

All DDC controllers shall use screw terminals for termination of individual wires. Spade lugs are not acceptable.

LOCAL CONTROL PANELS
Use control panels with suitable mounting brackets for each supply fan system. Locate panel adjacent to system served.

Fabricate panels of 14 gauge furniture grade steel or 6063-T5 extruded aluminum alloy, totally enclosed on six sides, hinged door, and keyed lock, with manufacturer's standard shop painted finish and color.

Provide UL listed cabinets for use with line voltage devices.

Control panels that have devices or terminations that are fed or switch 50V or higher shall enclose the devices, terminations, and wiring so that Personal Protective Equipment (PPE) is not required to service the under 50V devices and terminations within the control panel. As an alternative, a separate panel for only the 50V and higher devices may be provided and mounted adjacent to the under 50V control panel. For DDC controllers that are directly fed by 120VAC, provide an externally mounted 120VAC, 5A fast blow fuse to feed these controllers.

Plastic control enclosures will be approved provided all conduits are bonded and grounded.

Provide control panels for all DDC Controllers, ASC's, and associated function modules. All controls to be in control panels provided under this Section except for the following:

- Terminal unit controllers mounted within the terminal unit equipment enclosure as specified under Section 23 09 14.

- Above accessible lay-in tile ceilings where VAV box controllers designed to be directly mounted on air terminals.
- Above accessible lay-in tile ceilings where additional controllers are required for air terminal unit control. Where additional controllers are required, they shall not be mounted directly to the ductwork but be mounted on din rail or back panel in an accessible location as close as possible to the terminal unit(s) being controlled.
- Any devices other than DDC controllers, i.e., relays, pressure switches, etc. shall be installed in an enclosure.

All wiring for controllers shall be managed in a neat and workmanlike manner.

All 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.

DIRECT DIGITAL CONTROLS

System to be capable of integrating multiple building functions, including equipment supervision and control, alarm management, energy management, and trend data collection.

DDC to consist of Supervisory Controllers, Programmable Controllers, stand-alone Application Specific Controllers (ASC's), Operators Terminals, Operator Workstations, DDC system servers, and other operator interface devices.

The vendor of the system provided under this Section shall provide all software and communication interface hardware necessary to program and upload/download programmable and application specific controllers from a laptop computer and make additional copies and future software revisions available for sale directly to the user Agency.

The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, ASC's, and operator devices.

The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

The existing DDC controllers for AHU-6 and AHU-7 may be utilized if suitable for use in new work. Provide additional networked controllers as needed to execute the point list and sequence of operations.

NETWORKING/COMMUNICATIONS

The design of the DDC shall be networked. The highest-level networking shall use Ethernet and the sub-level networking shall use serial or Ethernet communications. Inherent in the system's design shall be the ability to expand or modify the highest network either via a local area network (LAN), wide area network (WAN), or a combination of the two schemes.

The highest level DDC communications network shall be capable of direct connection to and communication with a high-speed LAN or WAN utilizing an Ethernet connection.

A supervisory controller may be used to directly oversee a local network such that communications may be executed directly to and between programmable controllers and ASC's. All operator devices shall have the ability to access all points and application reports on the network.

Provide serial or Ethernet communication ports on all ASC's for operator's terminal communications with the DDC Controller.

Access to system data shall not be restricted by the hardware configuration of the DDC system.

Global data sharing or global point broadcasting shall allow point data to be shared between programmable controllers and ASC's when it would be impractical to locate multiple sensors.

Network design shall include the following provisions:

- Data transfer rates for alarm reporting and quick point status from multiple programmable controllers and ASC's. The minimum baud rate for serial communications shall be 9600 baud.

- Support of any combination of programmable controllers and ASC's. A minimum of 32 programmable controllers and ASC's shall be supported on a single local serial network. The serial communication buss shall be addressable for up to 32 ASC's.

- Detection of single or multiple failures of programmable controllers and ASC's or the network media.

- Error detection, correction, and re-transmission to guarantee data integrity.

- Use commonly available, multiple-sourced, networking components.

- Use of an industry standard communication transport, such as ARCNET, Ethernet, and IEEE RS-485 communications interface.

- Provide all necessary communication devices and components to provide all communications required for a complete DDC system.

- When using Ethernet programmable controllers and ASC's in control panels provide for a direct connection to an Ethernet switch (Star topology). Controllers within the panel may be daisy chained.

- Ethernet ASC's used for terminal units shall have fail-over relays for Ethernet communications that shall allow continuous Ethernet communications in the event of a controller failure or loss of power. If the controllers do not have fail-over relays, an Ethernet switch that allows for ring (spanning tree) communications shall be provided under this Section and the Ethernet trunks shall be connected in a ring topology.

BACNET REQUIREMENTS

BACnet of highest level network communications shall be capable of BACnet/IP over Ethernet and field level communications shall utilize BACnet MSTP or BACnet/IP.

Supervisory controllers shall provide a Protocol Implementation Conformance Statement (PICS) and BACnet Interoperability Building Blocks (BIBB"S) as required by the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ANSI/ASHRAE) Standard 135-2001, BACnet protocol.

In general, all highest level networked supervisory devices shall support the following:

Segmentation Capability
Segmentation requests supported
Segmentation responses supported

Standard Object Types Supported

- Analog input
- Analog output
- Analog value
- Binary input
- Binary output
- Binary value
- Calendar
- Device
- Event enrollment
- Group
- Multistate input
- Multistate output
- Multistate value
- Notification class
- Schedule

Data Link Layer Option

- BACnet Internet Protocol (IP) (Annex J)

Networking Options

BACnet/IP Broadcast Management Device (BBDM)

Character Sets supported

- ANSI X3.4
- ISO 10646 Universal Character Set-2

BACnet object name and description shall match the existing naming conventions used by the state Agency for their existing Building Automation System. Coordinate with Agency control personnel to establish the naming conventions prior to programming of any controllers provided under this specification section. All controllers shall have object names, descriptions, and engineering units that are writable at the controller level and shall be programmed so that the object names, descriptions, and engineering units match the desired naming standards as specified above. Ensure that the BACnet object attributes for object name, object description, engineering units and other required attributes will be transferred through to the Supervisory Controller when the auto-discovery function is executed.

Coordinate BACnet device instance numbering with the agency facility personnel for controllers provided under this Section that are being connected to an existing building automation system. This contractor shall be responsible for correcting any conflicts with existing devices that may occur or changing the device instance numbers to comply to follow the agency BACnet device instance numbering scheme.

The following table indicates the minimum VAV terminal unit objects, the associated naming, and the object values that are required to be writable that shall be provided for all VAV terminals. If the agency does not have a convention for VAV terminal object names and descriptions that it prefers, use the naming standards as listed below. Provide similar naming and descriptions that are approved by the agency for other types of terminal units and mechanical systems.

Object Type	Object Name	Object Description	Units
	Writeable		
BV	DEVICE-S	DEVICE STATUS - SERVED BY AHU#	ONLINE/OFFLINE
MV	OCC-MODE	OCCUPIED MODE	OCC/UNOCC/STNDBY
BV	OCC-SCHED	OCCUPIED SCHEDULE Xam-Xpm	OCC/UNOCC
	Yes		
DI	OCC-S	OCCUPANCY SENSOR STATUS	OCC/UNOCC
AV	ZN-SP	ZONE TEMPERATURE SETPOINT	DEG F
	Yes		
AI	RM#-T	ROOM #### TEMPERATURE	DEG F
AI	DA-T	DISCHARGE AIR TEMPERATURE	DEG F
AO	HTG-VLV	HEATING VALVE	% OPEN
	Yes		
AO	RAD-VLV	RADIATION VALVE	% OPEN
	Yes		
AO	SA-DPR	SUPPLY AIR DAMPER	% OPEN
	Yes		
AV	CFM-SP	ACTUAL FLOW SETPOINT	CFM
AI	CFM-FLOW	SUPPLY AIR FLOW	CFM
AV	HTG-SP	HEATING TEMPERATURE SETPOINT	DEG F
	Yes		
AV	CLG-SP	COOLING TEMPERATURE SETPOINT	DEG F
	Yes		
AV	OCC-C-CFM-MIN	OCCUPIED CLG CFM MIN SETPOINT	CFM
	Yes		
AV	OCC-C-CFM-MAX	OCCUPIED CLG CFM MAX SETPOINT	CFM
	Yes		

SYSTEM SOFTWARE FEATURES

All necessary software to form a complete operating system, as described in this specification, shall be provided as an integral part of the supervisory controller, and shall not be dependent upon higher level computer for execution.

Programming tools for programmable and application specific controllers that utilize the Niagara Framework shall not be restricted to any specific brand of Jace. Tools and controllers shall be able to connect to any brand of Jace that are provided under this specification Section. Vendor of the system provided under this Section shall provide all software and hardware necessary to program programmable and application specific controllers and make additional copies and future software revisions available for sale directly to the user Agency.

Control software shall include a provision for limiting the number of times that each piece of equipment may be cycled within any one-hour period.

The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.

Supervisory controllers shall have the ability to perform any or all the following energy management routines:

- Time of day scheduling
- Calendar based scheduling
- Holiday scheduling
- Optimal start
- Optimal stop
- Demand limiting
- Load rolling
- Heating/cooling interlock

All programs to be executed automatically without the need for operator intervention and be flexible enough to allow user customization. Programs shall be applied to building equipment described in Section 23 09 93 of this specification.

Supervisory controllers shall be able to execute configured processes defined by the user to automatically perform calculations and control routines.

It shall be possible to use any of the following in a configured process:

- Any system-measured point data or status
- Any calculated data
- Any results from other processes
- Boolean logic operators (and, or)

Configured processes may be triggered based on any combination of the following:

- Time of day
- Calendar date
- Other processes
- Events (e.g., point alarms)

A single process shall be able to incorporate measured or calculated data from all other ASC's.

A single process shall be able to issue commands to points in all other programmable controllers and ASC's on the local network.

Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each supervisory controller shall perform distributed; independent alarm analysis and filtering to minimize network traffic and prevent alarms from being lost. At no time shall the ability of supervisory controllers to report alarms be affected by either operator activity at the local I/O device or communications with other ASC's on the network.

All alarm or point change reports shall include the English language description of each point and the time and date of the occurrence.

The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three priority levels shall be provided. Users shall have the ability to manually inhibit alarm reporting for each point.

The user shall also be able to define conditions under which point changes need to be acknowledged by an operator and/or logged for analysis later.

Alarms reports and messages shall be directed to an operator device.

In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 60-character alarm message to describe the alarm condition or direct operator response more fully.

Each supervisory controller shall be capable of storing a library of at least 100 messages. Each message may be assignable to any number of points in the panel.

A data collection utility shall be provided to automatically sample, store, and display system data.

Measured and calculated analog and binary data shall be assignable to user definable trends for the purpose of collecting operator specified performance data over extended periods of time. Sample intervals of 1 minute to 24 hours, in one minute or one hour intervals, shall be provided. Each supervisory controller shall have a dedicated buffer for trend data and shall be capable of storing 16 trend logs. Each trend log shall have up to four points trended at 48 data samples each. Data shall be stored at the supervisory controller and up-loaded to the DDC system server when archiving is desired.

Supervisory controllers shall automatically accumulate and store runtime hours for binary input and output points specified in Section 23 09 14 of this specification.

Supervisory controllers shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis, user defined, for user-selected analog and binary pulse input type points.

Totalization shall provide calculation and storage accumulations of up to 9,999,999 units (e.g., KWH, gallons KBTU, tons, etc.).

The totalization routine shall have a sampling resolution of one minute.

The user shall have the ability to define a warning limit. Unique, user specified messages shall be generated when the limit is reached.

The information available from pulse totalization shall include, but not be limited to, the following:

- Peak demand, with date and time stamp
- 24-hour demand log
- Accumulated KWH for day
- Sunday through Saturday KWH usage
- Demand KW annual history for past 12 periods
- KWH annual history for past periods

Supervisory controllers shall have the ability to count events, such as the number of times a pump or fan system is cycled on and off.

The event totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.

PROGRAMMABLE CONTROLLERS

Programmable controllers shall be provided with a software program that shall allow the user to design flexible software algorithms for the control sequences as described in Sections 23 09 14 and 23 09 93 portions of this specification.

Each programmable controller shall have the latest firmware available from the manufacturer installed at the time the controller is loaded with project specific software algorithms. If there are defects in the controller firmware that causes detrimental operation to the control system installed under this Section, the controllers shall have updated firmware installed at no cost by this contractor through the warranty period.
Programmable controllers shall support all necessary point inputs and outputs to perform the specified control sequence in a totally stand-alone fashion.

Each programmable controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

Each programmable controller shall support the use of a locally mounted status and adjust panel interface to allow for the local adjustment of all setpoints, temporary override of any input or output points and status of all points directly at the controller. The capabilities of the locally mounted status and adjust panel shall include, but not be limited to, the following information for the programmable controllers to which:

- Display temperatures
- Display status
- Display setpoints
- Display control parameters
- Override binary output control
- Override analog output control
- Override analog setpoints
- Modification of gain and offset constants

All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the programmable controller.

Programmable controllers shall support, but not be limited to, the following configurations of systems to address current requirements as described in Sections 23 09 14 and 23 09 93 portions of this specification, and for future expansion of air handling units:

- Mixed air handling units
- 100 percent outside air handling units
- Boiler or chiller plants with pump logic
- Hot water heat exchangers
- Cooling towers
- Zone pressurization of labs
- Smoke control systems
- Generic system interlocking through hardware

OPERATOR INTERFACE REQUIREMENTS

COMMAND ENTRY/MENU SELECTION PROCESS:

Operator interface software shall minimize operator training using English language prompting and English language point identification.

TEXT-BASED DISPLAYS:

The operator interface shall provide consistent text-based displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application-naming conventions shall be the same at all operator devices.

GRAPHIC-BASED DISPLAYS:

The operator interface shall include graphic based displays of each system on DDC systems that currently employ graphic based displays. The point data associated with each system shall dynamically update at a minimum of every 30 seconds. Graphic displays shall have the ability to be linked to each other to provide a “drill down” capability from main graphic displays to more specific system based displays. Provide a building level graphic display that links to system graphics. For systems that have ASC controlled terminal unit controls, provide a building floor plan with dynamic temperatures shown on the graphic that can be drilled into for more specific terminal information. Points provided in the graphic shall have the override and adjust capability specified under operator commands.

PASSWORD PROTECTION:

Multiple-level password access protection shall be provided to allow the user/manager to limit control, display, and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password.

Passwords shall be the same for all operator devices.

A minimum of three levels of access shall be supported:

- Level 1: Data access and display
- Level 2 = Level 1 + operator overrides and commands
- Level 3 = Level 2 + database generation and modification

A minimum of 4 passwords shall be supported at each supervisory controller.

Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device shall be limited to only those items defined for the access level of the password used to log-on.

Provide user definable, automatic log-off timers of from 1 to 60 minutes to prevent operators from inadvertently leaving devices on-line.

OPERATOR COMMANDS:

The operator interface shall allow the operator to perform commands including, but not limited to, the following:

- Start-up or shutdown selected equipment
- Adjust setpoints
- Override analog and binary outputs
- Add/modify/delete time programming
- Enable/disable process execution
- Lock/unlock alarm reporting for each point
- Enable/disable totalization for each point
- Enable/disable trending
- Enter temporary override schedules
- Define holiday schedules
- Change time/date
- Enter/modify analog alarm limits
- Enable/disable analog alarm limits
- Enable/disable demand limiting
- Enable/disable duty cycle

LOGS AND SUMMMARIES:

Reports shall be generated manually and directed to the displays. As a minimum, the system shall allow the user to easily obtain the following general listing of all points in the system, which shall include, but not be limited to:

- Points currently in alarm
- Off-line points
- Points currently in override status
- Points in weekly schedules
- Holiday programming

Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration on the facility management system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.

SYSTEM CONFIGURATION AND DEFINITION:

All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

The system shall be provided complete with all equipment, software, and documentation necessary to allow an operator to independently perform the following functions:

- Add/delete/modify application specific controllers
- Add/delete/modify points of any type, and all associated point parameters, and tuning constants
- Add/delete/modify alarm reporting definition for each point
- Add/delete/modify energy management applications
- Add/delete/modify time and calendar-based programming
- Add/delete/modify totalization for every point
- Add/delete/modify historical data trending for every point
- Add/delete/modify configured control processes
- Add/delete/modify dial-up telecommunication definition
- Add/delete/modify all operator passwords
- Add/delete/modify alarm messages

NETWORK WIDE STRATEGY DEVELOPMENT:

Inputs and outputs for any process shall not be restricted to a single programmable controller or ASC but shall be able to include data from all other programmable controller or ASC's to allow the development of network-wide control strategies.

SYSTEM DEFINITION/CONTROL SEQUENCE:
All portions of system definition shall be self-documenting and capable of providing hardcopy printouts of all configuration and application data.

DATA BASE SAVE/RESTORE/BACK-UP:
Backup copies of all programmable controller, ASC and supervisory controller databases shall be stored in at least one personal computer or laptop. Users shall also have the ability to manually execute downloading of a programmable controller, ASC or supervisory controller database.

PART 3 - EXECUTION

GENERAL
All electronic work required as an integral part of the central campus automation system work is the responsibility of this section unless specifically indicated otherwise in this section, Section 23 09 14, or in Division 26.

This contractor shall provide all labor, materials, engineering, software permits, tools, check-out, and certificates required to install a complete DDC expansion to the existing central campus automation system as herein specified. This system expansion shall be compatible with and interfaced to the existing computer driven automation center on campus and shall operate through all the existing I/O devices, central processing unit (CPU), and digital communication trunks. This connection to the digital communications trunk shall be true bi-directional analog and digital communications with the existing central campus automation system.

All points added with this project shall be properly interfaced into the existing central campus automation system format and grouped for display purposes into the system such that all points associated with a new or existing DDC system can appear together on the CRT display or printed log. Assignment of points to a group shall not be restricted by hardware configuration of the points of direct digital control. It shall be possible to assign a point to appear in more than one system. An English descriptor and an alpha/numeric identifier shall identify each system.

This central campus automation system expansion as herein specified shall be fully integrated and completely installed by this section. Include the engineering, installation, supervision, calibration, software programming, and checkout necessary for a fully operational system.

INSTALLATION
All work and materials are to conform in every detail to the rules and requirements of the National Electrical Code and present manufacturing standards. All wiring and cable installation shall conform with the wiring installation as specified in the installation section of Section 23 09 14. All material shall be UL approved.

The addition of this specified system expansion shall in no way impair the future capabilities of any existing functions of the computer driven central campus automation system. A system expansion with lessor capabilities will not be accepted. Further, this contractor will not put in jeopardy the normal, uninterruptable operation of the entire campus automation system the time it is interfaced through the completion of this project.

Install system and materials in accordance with manufacturer's instructions, rough-in drawings, and details on drawings.

Line voltage wiring to power the DDC Controllers, not provided by the Division 26 contractor, to be by this contractor.

Control panels serving equipment fed by emergency power shall also be served by emergency power.

Provide uninterruptable power supplies where necessary to provide proper startup of equipment or to accomplish power restart control sequences specified.

Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide printed plastic tags for instruments and controls inside cabinet and on engraved plastic nameplates cabinet face.

Provide as-built control drawings of all systems served by each local panel in a location adjacent to or inside of panel cover. Provide a protective cover or envelope for drawings.

Cable tray routing of the communication trunks is acceptable.

Where a new system is required to be extended to an existing agency Building Automation Network (BAN) (typically connected via the agency Local Area Network (LAN) or Wide Area Network (WAN)), extension of the data-net between DDC Controllers and to the BAN to be by this contractor unless specified to be provided by the division 27 contractor. All wiring and cable installation shall conform to the wiring installation as specified in the installation section of Section 23 09 14 and division 27. Where Ethernet cabling is provided by this contractor, preconfigured cabling may be used or if cable ends are terminated by this contractor, testing as specified in Division 27 shall be performed.

If division 27 is not specified in this project specifications, the state master specification 27 00 00 located on the DFD Master Specification website should be used as reference.
https://doa.wi.gov/Pages/DoingBusiness/MasterSpecsDesignGuide.aspx

Provide all necessary routers and or repeaters to accomplish connection to the LAN via the panel-mounted port provided.

Provide two data jacks in control panels housing supervisory controllers or Ethernet programmable controllers and allocate 6”x6” for each data jack in the panel. The first jack will be used for connecting the supervisory controller or programmable controllers to the Building Automation Network (BAN). The second jack will be used as a spare for connecting to the BAN by service personnel.

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 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

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 .

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.
- Final user interface shall be complete. This includes all graphics, trending, and agency defined user names and grouping.

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 3 hours.

Provide two follow-up visits for troubleshooting and instruction, one six months after substantial completion and the other at the end of the warranty period. Length of each visit to be not less than 3 hours or the time

necessary to provide required information and complete troubleshooting and inspection activity for all controls installed under this section. Coordinate the visit with the owner/Agency and provide an inspection report to the owner of any deficiencies found.

END OF SECTION

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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
- Constant Volume Mixed Air Handling Unit Control
- Exhaust 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 24 - Direct Digital Controls (DDC)
Section 23 09 14 - Pneumatic and Electric Controls
Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC – Coordination

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
The A/E must properly coordinate the necessary power wiring.
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, with adequate lead length for termination within the appropriate control panel being provided under Section [23 09 24 or 23 09 23].

Sequences for equipment controlled by Direct Digital Controls (DDC) as specified are accomplished by hardware and software provided under Section [23 09 24 or 23 09 23]. Sequences for equipment controlled by pneumatic or 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 Sections [23 09 24 or 23 09 23], and 23 09 14 for descriptions of what should be included in the submittals.

Shop drawings shall be provided by contractor(s) providing equipment under Sections [23 09 24 or 23 09 23] and 23 09 14. The contractor providing the DDC equipment shall provide a complete narrative of the sequence of operations for equipment that is controlled through the DDC system. 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 (without control logic through the DDC system). 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.

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

1. All final setpoints shall be documented on the as-built control drawings as determined by working in conjunction with the balancing contractor.

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 Sections 23 09 24 and 23 09 14 for product descriptions.

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

GENERAL:

BACNET OBJECTS:
All hardwired points listed in 23 09 15 and any setpoints, timers, or other control elements that are specified to be adjustable (adj.) in the following control sequences shall be mapped as BACnet objects and be available on the user interface to be adjusted. Consult with the user agency HVAC and/or DDC personnel prior to programming to determine if there are any items that they do not want to have mapped as BACnet objects. This is especially important for DDC controlled items that are duplicative, i.e., air terminal units.

BACNET ADDRESSING:
BACnet instance ID's shall be coordinated with the agencies established BACnet instance ID addressing scheme. If there is not such a scheme in place, the contractor(s) providing BACnet DDC controllers shall work with the agency to establish such a scheme and document this in the asbuilt control drawings. BACnet/IP addressing shall be coordinated with the agency prior to installation. BACnet MSTP addressing shall be addressed to provide for consecutive addressing to provide for the best speed of response. Max Master address shall be set appropriately for speed of response.

USER INTERFACE/FEATURE SOFTWARE:
Consult with the user agency HVAC and/or DDC personnel prior to programming to determine BACnet object naming conventions, user views, graphic layout, security matrix, alarming, trending, and scheduling preferences desired by the agency. Failure to consult and come to agreement prior to programming shall require the DDC contractor to make changes in the above listed items as desired by the user agency to the system at no cost. Section 23 09 15 feature software checkmarks are guides only and are not specific to what is required by the user agency.

SETPOINTS:
All setpoints indicated in the control specification are to be adjustable. The setpoints shall be readily available to be modified in the mechanical system software system summary (either textual or graphic based) and under the same software level as hardware points. Some less used setpoints may be provided on a lower software level, if requested by the user Agency for clarity. 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.

ALARMS:
Provide all alarmed points with adjustable time delays to prevent nuisance tripping under normal operation and on equipment start-up. For all commanded outputs that have status feedback, provide an alarm that shall indicate the commanded output is not in its commanded state. Provide alarms on all points as indicated on point charts. For existing campus automations systems, add/delete what is called on the point charts for after consultation with user Agency to provide consistent alarming throughout the automation system.

For devices that have form “C” contacts available for alarm monitoring, use closed contacts for the Normal condition and open contacts on Alarm condition. This shall provide a level of supervision by detecting a break in the wiring.

TREND DATA:
Trends shall be provided for all hardware I/O points and integrated points listed as having trending in Section 23 09 15 point charts and for analog and binary data points mapped to the user interface as specified below. Interval trending with sample intervals of 10 minutes shall be provided on analog process variables (this includes both analog inputs and calculated process variables) and process outputs. In addition, provide Change of Value (CoV) trending for all binary input and output points, binary data points mapped to the user interface, and for all analog inputs and process variables. Analog inputs and process variables and setpoints shall be set at 5% CoV of setpoint. Analog process outputs shall have CoV set at 5% of the output range. Other analog data points mapped to the user interface shall have CoV trends of 5% of their range. Consult with the user agency specific standard values for interval and CoV trends for different points and control types. Data shall be stored at the supervisory controller or in the field controller and up-loaded to the DDC

system server when archiving is desired. Consult with the user agency to determine which trends should be archived. Trending shall be in place for a minimum of 24 hours prior to functional testing by the commissioning provider.

EQUIPMENT START/STOP FAILURE STATES:
All start/stop points for equipment shall utilize normally open contacts unless called out specifically in the individual control sequences.

RESTART DELAYS:
Provide restart delays for all large loads (15 HP or greater) to be invoked on emergency power and after normal power is restored. Manifolded air and water system loads shall be started simultaneously, if required. Timers shall be embedded in individual controllers and staggered by five seconds (adj.). Systems shall be restarted in a logical manner so systems serving other systems are started first, i.e., hot water systems started before AHU's served. Adjust timers as needed to have systems fully operational if serving other systems. If specific start-up sequences are specified below, these shall take precedence over this sequence.

LEAD/LAG/STANDBY SEQUENCING:
For sequences that call for lead/lag/standby control of equipment connected to building automation systems, the lead device shall be able to be chosen through a selectable day of the week and time of day through the building automation system. Coordinate with the user Agency for scheduling switchover and frequency. Unless otherwise directed, switchover shall occur at 10AM Tuesday and shall rotate the lead device on a weekly cycle rotating through all devices sequentially. For standalone lead/lag/standby sequence controllers (non-DDC), the lead device shall be selected by a switch on the panel face.

VARIABLE FREQUENCY DRIVE (VFD) MOTOR RUN STATUS:
Use the VFD programmable relay dry contact output specified to be provided with the VFD under Section 23 05 14 to prove motor run status and detect belt loss or coupling break. If a bypass contactor is provided with the VFD, provide an adjustable current switch and wire it in parallel with the VFD output for proving motor status. For multiple fan units that have multiple fans powered by a single VFD, provide current sensors that shall provide status to the DDC system for each motor as well as the VFD run status.

VFD BYPASS & SAFETY INTERLOCKS:
VFD's equipped with bypass starters shall be interlocked so that the start/stop and safety circuits that are called out for VFD operation shall be functional when the VFD is indexed to the bypass starter mode. Unless otherwise specified in the sequence below, the switch from inverter to bypass starter modes shall be through a manual switch provided on the VFD/bypass starter package.

VFD MINIMUM SPEED & RAMP TIMERS:
The VFD start-up technician shall work with the DDC Temperature Control Contractor determine the minimum speed required for the motor controlled by the VFD to provide cooling of the motor as installed to prevent heat related problems. This minimum speed shall be set in the VFD controller. Unless otherwise noted in the following control sequences or needed for lower turndown for volume matching, minimum speeds for fans shall be set at 15 Hz. If a lower minimum speed is required for volume matching of fans, the minimum speed shall never be set below 6 Hz to prevent overheating of the motor. Pump minimum speeds shall be 20 Hz for 1750 RPM motors and 25 Hz for 1150 RPM motors to ensure seals stay lubricated. For splash-lubricated cooling tower fans and submersible pumps, minimum speed shall be 30 Hz. The controlled motor shall ramp linearly in speed between the minimum Hz and the maximum Hz required for the application (may not be 60 Hz) as the control speed signal increases from 0% to 100% speed. The VFD start-up technician shall work with the DDC Temperature Control Contractor to set the acceleration and deceleration timers in the VFD controller at 30 seconds for motors less than 40 HP and 60 seconds for motors 40 HP and greater.

CURRENT STATUS SWITCHES:
When current switches are used for proving fan or pump status, they shall be set up so that they will detect belt or coupling loss by the reduction in current draw on loss of coupled load. The current switch calibration shall be repeated by the 23 09 14 contractor after the balancer is complete. Current switches shall be provided for each motor on multiple fan air handling units and status provided individually to the DDC system for each motor.

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.

SERVICE SHUTDOWN SWITCHES

Provide a switch for servicing each AHU and each lab exhaust fan and a software switch in the DDC system that will provide the same function. If either the hardware or software switch is in the off position, the associated AHU or exhaust fan shall be shut down in an orderly fashion following the specific sequences below. When the both the hardware and software switches are on, the AHU or exhaust fan shall be restarted in an orderly fashion following the specific sequences below. For systems that have more than one AHU or exhaust fan manifolded together and if multiple switches are turned off, only the first service switch shall be active to turn off the associated AHU or exhaust fan and the other switches shall be ignored. Multiple AHU's or exhaust fans shall be allowed to be turned off from the DDC workstation through software overrides on the DDC system. If a switch is turned off, an alarm will be annunciated through the DDC system for all switches in the off position. The switches shall be located inside the associated control panel.

AUTO-TUNING CONTROL LOOPS

For systems that have auto-tuning for PID control loops, contact the user agency for preferences on how the auto-tuning shall be implemented prior to programming. If the agency is not contacted on preferences, the control contractor responsible for programming shall adjust the loops as desired by the user agency at no additional cost. Typically, autotuning for control loops on major mechanical equipment that have services that can be lost, i.e., chilled water, steam, hot water, should be turned off so if there is a loss in service, the control loops do not adjust gain and integral to values that will cause the control loops to not function properly.

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.

ORIGINAL EQUIPMENT MANUFACTURER (OEM) CONTROLLER DDC INTEGRATION:

Provide DDC programming to define all equipment integral input/output points, setpoints, data points, calculations, etc. that are available through the manufacturer's communication interface. Consult with the Agency DDC operations personnel to determine if some of the points should be omitted (for clarity or lack of value). The following equipment shall be integrated into the DDC system:

- Chillers
- Chilled Water BTU Meters
- Variable Frequency Drives
- Laboratory Fume Hood Control
- Computer Room Air Conditioners
- Lighting Control (furnished by Div. 26)
- Power Quality Meters (furnished by Div. 26)

WATCH DOG TIMER

Where the integrated system consists of programmable DDC controllers with BACnet objects mapped to an enterprise level Building Automation System (BAS) and it is shown that the BACnet objects do not indicate when they are offline on the enterprise level BAS when communication is lost between the two systems, software algorithms shall be provided to alarm when communication is lost. The integrated system shall program a binary data object that is toggled on and off at an adjustable rate (initially one minute) that shall be monitored by the enterprise level BAS which shall alarm if the toggling ceases.

WEEKLY SCHEDULING

Provide scheduling of DDC terminal units in groups based on occupancy. Work with the user Agency to determine how many groups are required and which zones should be included. Individual terminal units shall be able to receive temporary schedules that shall override the group schedules. Temporary override buttons at the zone sensor (where specified on point charts) shall override the scheduling to occupied. When groups that consist of more than 20% of terminal units are indexed to occupied, the associated air handling unit shall start if not already running.

DDC CONTROLLER COMMUNICATION BUS CONFIGURATION

The actively controlled primary mechanical equipment (AHU's, hot water, chilled water, boilers, etc.) DDC controllers shall be configured to be located on the same supervisory controller BACnet MSTP communication trunk unless the supervisory controller capacity prevents it. If this is the case, the primary mechanical equipment DDC controllers shall be separated onto supervisory controllers in such a way that the systems that need to share information for operation and interlocking shall reside on the same supervisory controllers. When AHU systems have associated exhaust fan systems that are interlocked and designed to operate together as a combined air system within a building, these must be on the same BACnet MSTP trunk.

Peer to peer communication shall be used for interlocks and data sharing between the AHU and exhaust fans systems when possible to limit air system disruptions in the event of a supervisory controller failure. Other critical building systems that require communication between DDC controllers to operate shall be on the same BACnet MSTP communication trunk. Terminal unit controllers shall be located on a separate BACnet MSTP trunks if necessary, to allow for primary equipment to reside on the same BACnet MSTP trunk. If the DDC controllers used for control of primary mechanical equipment and interlocks or point information is required for proper operation as described above do not use BACnet MSTP communication but use Ethernet communication, the DDC controllers shall be connected to the same Ethernet switch. If the controllers cannot be connected to the same switch, hardwired points between controllers shall be used to share information.

CONTROLLED VARIABLE REQUIREMENTS
All controlled variables, i.e., static pressure, differential pressure, temperature, humidity, etc., shall be wired directly to the DDC controller in which the software PID loop or other similar software loop resides unless the control sequence specifically allows the controlled variable to be routed over the network. Where a controlled variable is used for reset of a PID loop, the controlled variable shall be allowed to be shared over the network unless specified to be directly wired to the DDC controller.

CONSTANT VOLUME MIXED AIR HANDLING UNIT CONTROL (AHU-6):

EXISTING CONTROL SEQUENCE:

GENERAL:
The Air Handling unit is constant air volume, indoor air unit (existing).
The Air Handling unit is controlled by direct digital controller (DDC) (existing).
The Air Handling unit is equipped with the following:

- Supply fan (existing) with VFD (new)..
- Associated Exhaust fans with starters (existing).
- 2 Position 100% Outside Air Damper (existing).
- Hot/Chilled water coil for cooling and heating (2-pipe distribution system) (existing).
- Hot Water Reheat Coil (existing).
- 30% filter bank.
- Pneumatic Damper Actuator for OAD (existing).
- Pneumatic Valve Actuator for Hot/Chilled water coil (existing).
- Electronic Valve & Actuator for Hot Water Reheat Coil (existing).

FAN CONTROL:
Start/Stop: The DDC system shall start and stop the supply fan. The supply fan runs continuously.

DISCHARGE AIR TEMPERATURE CONTROL – (EXISTING FOR REFERENCE)
Water Coil Pump Control: The AHU coil pump shall run continuously.

Discharge Air Temperature Setpoint Reset from Outside Air Temperature: Reset the discharge air temperature setpoint based on the outside temperature as follows. All setpoints shall be adjustable.

Discharge Air Setpoint	Outside Air Temperature
55º F	70º F
65º F	40º F

An existing strap-on aquastat on the supply water pipe to the AHU coil provides an input to the DDC controller to indicate whether the 2-pipe water system is in the heating or cooling mode.

The DDC controller shall modulate the coil control valve for hot water and for chilled water to maintain discharge air temperature at setpoint. Provide separate space heating and cooling setpoints. When the 2-pipe water system is in the heating mode (as determined by coil aquastat) and the discharge air temperature is below the heating setpoint, the DDC controller shall modulate the coil water valve open to maintain the heating setpoint. When the discharge air temperature is above the heating setpoint but below the cooling setpoint, the DDC controller shall modulate the coil water valve closed. When the 2-pipe water system is in he cooling mode (as determined by coil aquastat) and the discharge air temperature is above the cooling setpoint, the DDC controller shall modulate the coil water valve open to maintain the cooling setpoint.

DISCHARGE AIR TEMPERATURE CONTROL – NEW HOT WATER HEATING COIL
Enable the new hot water heating coil valve for discharge air temperature heating control when the 2-pipe water system is still in the cooling mode but outside air temperature is below 60F.

Discharge Air Temperature Setpoint: The discharge air temperature setpoint shall be fixed at 60F.

When outside air temperature is below 60F and the 2-pipe water system is still in the cooling mode, the AHU-6 hot water boiler will be started (see Boiler Control sequence).

The DDC controller shall modulate the hot water coil control valve to maintain discharge air temperature at setpoint. Provide separate discharge air temperature heating setpoint for hot water coil valve control. When the discharge air temperature is below the heating setpoint, the DDC controller shall modulate the hot water coil valve open to maintain the heating setpoint. When the discharge air temperature is above the heating setpoint the DDC controller shall modulate the hot water coil valve closed. When the hot water coil valve control is enabled, the 2-pipe system coil water valve shall be closed.

SAFETIES:
Existing safeties shall remain in place and function as is.

UNIT SHUTDOWN:
Whenever the air handling unit is indexed off, the supply and exhaust fans shall stop. On a failure of the supply fan, an alarm will be sent through the DDC system. Whenever the supply fan is off for any reason the following shall occur:

The outside air dampers shall close.

The hot water coil control valve shall close.

The 2-pipe coil control valve shall close.

Freezestat shall override both coil control valve open.

The 2-pipe water coil pump shall run.

Modify the supply fan control to the following:

SUPPLY FAN CONTROL
The DDC system shall start and stop the supply fan through the supply fan VFD. The supply fan runs continuously. The supply fan speed shall modulate to maintain a constant duct static pressure. Static pressure shall be set at the design outlet airflow by the TAB and control contractor. This will maintain duct flow as filter loading changes.

Add the following dehumidification sequence:

DEHUMIDIFICATION
When outside air temperature is >55F and average of space humidity sensors are >60% RH, the heating/cooling coil shall operate in cooling mode to maintain a heating/cooling coil leaving air temperature (new sensor) of 55F. Reheat coil shall maintain a discharge air temperature of 72F (adj.) System will revert to normal operation when space humidity is <59% for 2 hours.

CONSTANT VOLUME MIXED AIR HANDLING UNIT CONTROL (AHU-7):

GENERAL:
The Air Handling unit is constant air volume, indoor air unit (existing).
The Air Handling unit is controlled by direct digital controller (DDC) (existing).
The Air Handling unit is equipped with the following:

- Supply fan (existing) with VFD (new).
- Associated Exhaust fans with starters (existing).
- 2-Position 100% Outside air damper (existing).
- Hot/Chilled water coil for cooling and heating (2-pipe distribution system) (existing).
- Hot Water Reheat Coil (existing).
- 30% filter bank.
- Pneumatic Damper Actuator for OAD (existing).
- Pneumatic Valve Actuator for Hot/Chilled water coil valve (existing).
- Electronic Valve & Actuator for Hot water reheat coil (existing).

FAN CONTROL:
Start/Stop: The DDC system shall start and stop the supply fan. The supply fan runs continuously.

DISCHARGE AIR TEMPERATURE CONTROL – (EXISTING FOR REFERENCE)
Water Coil Pump Control: The AHU coil pump shall run continuously.

Discharge Air Temperature Setpoint Reset from Outside Air Temperature: Reset the discharge air temperature setpoint based on the outside temperature as follows. All setpoints shall be adjustable.

Discharge Air Setpoint	Outside Air Temperature
55º F	70º F
65º F	40º F

An existing strap-on aquastat on the supply water pipe to the AHU coil provides an input to the DDC controller to indicate whether the 2-pipe water system is in the heating or cooling mode.

The DDC controller shall modulate the coil control valve for hot water and for chilled water to maintain discharge air temperature at setpoint. Provide separate space heating and cooling setpoints. When the 2-pipe water system is in the heating mode (as determined by coil aquastat) and the discharge air temperature is below the heating setpoint, the DDC controller shall modulate the coil water valve open to maintain the heating setpoint. When the discharge air temperature is above the heating setpoint but below the cooling setpoint, the DDC controller shall modulate the coil water valve closed. When the 2-pipe water system is in the cooling mode (as determined by coil aquastat) and the discharge air temperature is above the cooling setpoint, the DDC controller shall modulate the coil water valve open to maintain the cooling setpoint.

DISCHARGE AIR TEMPERATURE CONTROL – NEW HOT WATER HEATING COIL
Enable the new hot water heating coil valve for discharge air temperature heating control when the 2-pipe water system is still in the cooling mode but outside air temperature is below 60F.

Discharge Air Temperature Setpoint: The discharge air temperature setpoint shall be fixed at 60F.

When outside air temperature is below 60F, the AHU-7 hot water boiler will be started (see Boiler Control sequence).

The DDC controller shall modulate the hot water coil control valve to maintain discharge air temperature at setpoint. Provide separate discharge air temperature heating setpoint for hot water coil valve control. When the discharge air temperature is below the heating setpoint, the DDC controller shall modulate the hot water coil valve open to maintain the heating setpoint. When the discharge air temperature is above the heating setpoint the DDC controller shall modulate the hot water coil valve closed. When the hot water coil valve control is enabled, the 2-pipe system coil water valve shall be closed.

SAFETIES:
Existing safeties shall remain in place and function as is.

UNIT SHUTDOWN:
Whenever the air handling unit is indexed off, the supply and exhaust fans shall stop. On a failure of the supply fan, an alarm will be sent through the DDC system. Whenever the supply fan is off for any reason the following shall occur:

The outside air dampers shall close.

The hot water coil control valve shall close.

The 2-pipe coil control valve shall close.

Freezestat shall override both coil control valve open.

The 2-pipe water coil pump shall run.

Modify the supply fan control to the following:

SUPPLY FAN CONTROL
The DDC system shall start and stop the supply fan through the supply fan VFD. The supply fan runs continuously. The supply fan speed shall modulate to maintain a constant duct static pressure. Static pressure

shall be set at the design outlet airflow by the TAB and control contractor. This will maintain duct flow as filter loading changes.

Add the following dehumidification sequence:

DEHUMIDIFICATION
When outside air temperature is >55F and average of space humidity sensors are >60% RH, the heating/cooling coil shall operate in cooling mode to maintain a heating/cooling coil leaving air temperature (new sensor) of 55F. Reheat coil shall maintain a discharge air temperature of 72F (adj.) System will revert to normal operation when space humidity is <59% for 2 hours.

EXHAUST FAN CONTROL EF-XX (Typ. For 19 New Exhaust Fans):
GENERAL:
The exhaust system is a constant volume exhaust fan system.
The exhaust system is controlled by direct digital controller (DDC).
The ventilation system is equipped with the following:
Constant speed exhaust fan.
Isolation air dampers furnished by ATC. (Refer to specification 23 09 14)
Damper actuators furnished by ATC. (Refer to specification 23 09 14)

FAN CONTROL:
Current Status Switch:
Provide for all exhaust fans and set up as described under GENERAL, Current Switch Setup, in this Section.

Start/Stop:
The DDC system shall start and stop the exhaust fans.

Exhaust Fan Start/Stop Sequencing:
Fans shall run when AHU-6 is on.
Exhaust fans shall shut off if the AHU-6 is off.
When exhaust fan is started, isolation damper shall open and fan shall start after 1 minute delay.
When exhaust fan is off, isolation damper shall close.
If exhaust fan fails (no status from current switch) alarm through DDC, shut off fan and close damper.

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 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:

RELATED WORK
Section 23 01 30.51 – HVAC Air Duct Cleaning
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 C 1071	Specification for Fibrous Glass Duct Lining Insulation
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 G 21	Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi
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.
NAIMA	Fibrous Glass Duct Liner Standard

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.
- Duct liner including data on thermal conductivity, air friction correction factor, and limitation on temperature and velocity.

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

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. Duct system pressure classes not indicated on the drawings to be as follows:

	Calc. S.P. in	Pressure Class in
Exhaust air ducts	0.53”	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.

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.

Rectangular ducts may be substituted for round ducts if sized in accordance with ASHRAE table of equivalent rectangular and round ducts. No variation of duct configuration or sizes permitted except by written permission of the Architect/Engineer.

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.

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

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.

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.

Exposed ductwork in billeting rooms to be suspended by flat strap supports. Roll or file edges to prevent sharp edges. Conceal ceiling anchor fasteners above the new ductwork. Conventional and wire hangers will not be acceptable for exposed ductwork in resident rooms.

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.

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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

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:

RELATED WORK

Section 23 05 29 – Hanger and Supports for HVAC Piping and Equipment
Section 23 05 48 – Vibration and Seismic Controls 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.

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

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.

FIRE DAMPERS
Manufacturers: Air Balance, Advanced Air, American Warming and Ventilating, Greenheck, Phillips-Aire, Prefco, Ruskin, Safe-Air or approved equal.
STATIC FIRE DAMPERS
Static fire damper assemblies must be UL 555 (6^{th} edition) listed and labeled for static applications (where air systems do not operate during a fire) and meet requirements of NFPA 90A. Damper must be type B curtain type with blades out of the air stream; dampers with blades in the air stream will not be accepted. Damper fire rating to be compatible with the rating of the building assembly in which the damper is used.

CONTROL DAMPERS
Control dampers are specified in section 23 09 14.

AUTOMATIC BALANCING DAMPERS
Manufacturers: American Aldes, Greenheck, Ruskin, or approved equal.

Pressure Independent Automatic Balancing Dampers shall maintain a constant airflow volume in HVAC applications. The engineered damper blade is calibrated to automatically adjust to varying pressures without the need for an external actuator or power supply. Each unit is laboratory calibrated to allow a specific volume of air at a specific static pressure. Unit shall operate within 10% of setpoint through the specified pressure range.

Dampers to be tested in accordance to published data sheets. Test set up and orientation to be per AMCA 500-D. Leakage and pressure drop will be recorded and submitted for review and acceptance. Dampers shall be licensed to bear the AMCA Certified Ratings Seal. Ratings based on tests and procedures performed in accordance with AMCA 511 and comply with AMCA Certified Ratings Program. Flow ranges shall be tested

using AMCA Standard 500-D Figure 1. Each unit shall be classified per UL 2043 for heat and visible smoke release and carry the UL mark indicating compliance.
Each unit shall be rated for use in air temperature ranging from 25°F to 150°F.

Pressure: 0.2 in. w.g. to 2.0 in. w.g.
Frame and Blades: Thermoplastic resins with non-caustic antimicrobial preventing organic growth. Passes UL2043 test for heat and smoke emissions.
Seals: Full circumference outer rubber gasket-type.

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.

Billet Room Exhaust Fan Access Doors:
Basis of design product: J. L. Industries, Inc. STC Series. Subject to compliance with requirements, provide product indicated or a comparable product by one of the following:

Acudor Products Inc.
The Williams Bros. Corporation of America
Best Access Doors

Description: Acoustical STC-60 sound rated access panel for walls and ceilings.
Locations: Ceiling (underside of exhaust fan soffits).
Door Material: 20 ga CRS steel or gypsum board.
Frame Material: 16 ga cold rolled steel or gypsum board.
Door Gaskets: EPDM foam seal on frame or manufacturer recommended seal.
Hinges: Continuous steel rod hinge. Opens to 170° or lay-in.
Latch and Lock: Lockable compression paddle or screwdriver operated latch.

DUCT LINING
Manufacturer: Manville, Owens-Corning, Knauf, or approved equal.

1 inch thick, flexible, mat faced insulation made from inorganic glass fibers bonded with a thermosetting resin with thermal conductivity of .25 Btu inch / hour sq.ft. deg F.
Meet erosion testing per UL 181 or ASTM C 1071 for 5000 fpm maximum air velocity. ASTM C 411 maximum operating temperature rating of 250 deg F. ASTM E84 flame spread less than 25 and smoke developed less than 50.

Meet requirements of ASTM C 1338 and ASTM G21 for fungi resistance.

Install liner using adhesive conforming to ASTM C 916.

FLASHINGS
Provide flashing to completely weatherproof connection of ductwork to louvers. Flashing to be constructed of material similar to louver material.

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.

LOUVERS

Louvers Provided by GPC:
Louvers are specified in the architectural section of these specifications.

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.

FIRE DAMPERS
Install dampers in strict accordance with manufacturer's installation instructions. Install damper sleeves with retaining angles on both sides of rated partition. Connections of ductwork to fire damper assemblies to be as specified on the installation instructions. 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 replacing the fusible link.

Manually test each fire damper for proper operation by removing the fusible link. Repair or replace any fire damper that does not close completely. Re-install fusible link after test.

The A/E must coordinate the location of all fire dampers, smoke dampers and combination fire smoke dampers. All dampers must be installed in accessible locations and access to these dampers must be coordinated. The dampers must have adequate access to allow for servicing and testing of the dampers.

CONTROL DAMPERS
Install dampers in locations indicated on the drawings, as detailed, and according to the manufacturer's instructions. Install blank-off plates or transitions where required for proper mixing of airstreams in mixing plenums. Provide adequate operating clearance and access to the operator. Install an access door adjacent to each control damper for inspection and maintenance.

AUTOMATIC BALANCING DAMPERS
Install dampers in locations indicated on the drawings, as detailed, and according to the manufacturer’s instructions. Do not compress or stretch damper frame into duct or opening. Handle damper using sleeve or frame. Do not lift damper using blades.

If dampers are installed in a continuous duct run, a duct access door should be provided for inspection and maintenance. If damper is installed such that it is adjacent to a removable grille, a duct access door is not required.

ACCESS DOORS
Access doors shall be installed by GPC.

DUCT LINING
Apply lining to the following ductwork:

- Where shown on drawings.

Install liner in compliance with the latest edition of NAIMA's Fibrous Glass Duct Liner Standard. Locate longitudinal joints at the corners of duct only. Cut and fit to assure lapped, compressed joints. Coat all transverse and longitudinal joints and edges with adhesive. Provide metal nosing on leading edge where lined duct is preceded by unlined duct. Adhere liner to duct with full coverage area of adhesive. Additionally secure liner to duct using mechanical fasteners spaced as recommended by the liner manufacturer without compressing liner more than 1/8" with the fasteners.

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.

LOUVERS
Louvers are furnished and installed by others.

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 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:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Quality Assurance
- Shop Drawings
- Operation and Maintenance Data
- Design Criteria

PART 2 - PRODUCTS
- General
- In-line Centrifugal Fans

PART 3 - EXECUTION
- Installation
- Construction verification Items
- Functional performance Testing
- Agency Training

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 05 48 - Vibration and Seismic Controls for HVAC Piping and 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

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.

For variable air volume application, include data which indicates the effect of capacity control devices on performance.

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.

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.

Statically and dynamically balance all fans so they operate without objectionable noise or vibration.

IN-LINE CENTRIFUGAL FANS
Manufacturers: Cook, Greenheck, or approved equal.

Fans to be direct drive with adjustable speed ECM motor. 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.

Fan breakout noise level not to exceed NC30 in the room where fan is installed.

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.

Coordinate construction of enclosing soffit with GPC where enclosure is shown on drawings. Provide access door sized to accommodate fan replacement.

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.

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.

END OF SECTION

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SECTION 23 37 13
DIFFUSERS, REGISTERS & GRILLES
BASED ON DFD MASTER SPECIFICATION DATED 7/11/2023

PART 1 - GENERAL

SCOPE

This section includes specifications for air terminal equipment. Included are the following topics:

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

PART 2 - PRODUCTS
- Manufacturers
- Sidewall Registers and Grilles

PART 3 - EXECUTION
- Installation
- Construction Verification Items

RELATED WORK

Section 01 91 01 - Commissioning Process
Section 23 08 00 - Commissioning of HVAC
Section 23 31 00 - HVAC Ducts and Casings
Section 23 33 00 - Air Duct Accessories
Section 23 05 93 - Testing, Adjusting and Balancing for HVAC

REFERENCE

Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
UL 181 - Factory-Made Air Ducts and Connectors.
ARI-ADC Standard 880.

QUALITY ASSURANCE

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

SUBMITTALS

Refer to division 1, General Conditions, Submittals.

Furnish submittal information including, but not limited to, the following:
- Manufacturer's name and model number
- Identification as referenced in the documents
- Capacities/ratings
- Materials of construction
- Sound ratings
- Dimensions
- Finish
- Color selection charts where applicable
- Manufacturer's installation instructions
- All other appropriate data

DESIGN CRITERIA

All performance data shall be based on tests conducted in accordance with Air Diffusion Council (ADC) Test Code 1062 GRD 84.

PART 2 - PRODUCTS

MANUFACTURERS
Acceptable manufacturers for specific products are listed under each item.

SIDEWALL REGISTERS AND GRILLES
Carnes R, Greenheck XG-4000, Krueger 880, Metal Aire 4000, Nailor 51DH, Price 530, Shoemaker 900, Titus 350.

Steel unless otherwise indicated, with frame type appropriate to installation.

Register and grille sizes as shown on drawings and/or as scheduled.

White, baked enamel finish or powder coat finish, unless otherwise indicated.

Screw holes on surface counter sunk to accept recessed type screws.

Fixed blade (0 or 45 degree) core return and exhaust registers and grilles.

PART 3 - EXECUTION

INSTALLATION
Install grilles, registers and diffusers as shown on drawings and according to manufacturer's instructions.

Furnish diffusers with equalizing grids where it is not possible to maintain minimum 2 duct diameter straight duct into diffuser. Equalizing grids shall consist of individually adjustable vanes designed for equalizing airflow into diffuser neck and providing directional control of airflow.

Unless otherwise indicated, size ductwork drops to diffusers or grilles to match unit collar size.

Seal connections between ductwork drops and diffusers/grilles airtight.

Blank off unused portion of linear slot diffusers and linear bar diffusers and grilles.

Where diffusers, registers and grilles cannot be installed to avoid seeing inside duct, paint inside of duct with flat black paint to reduce visibility.

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 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

Electrical work for this project includes providing power to new exhaust fans installed on floors 1-3 and extending the existing circuits for removed AH-6 and AH-7 to new motors SF-6 and SF-7 and associated VFD.

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 and Fire Stopping
- Work by State and/or User Agency
- Intent
- Omissions
- Submittals
- Project/Site Conditions
- Work Sequence and Scheduling
- Work by Other Trades
- Offsite Storage
- Salvage Materials
- Certificates and Inspections
- Operating and Maintenance Data
- Record Drawings

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

PART 3 - EXECUTION
- Cutting and Patching
- Building Access
- Equipment Access
- Coordination
- Sleeves and Openings
- Sealing and Fire Stopping
- Housekeeping and Clean Up
- 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 07 84 00 – Fire Stopping

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 AND FIRE STOPPING
Sealing and fire stopping 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. Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with section 07 84 00 Fire Stopping.

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.

Concealed Spline Ceilings:
Removable sections of ceiling tile held in position with metal slats or tabs compatible with the ceiling system used will be provided under other divisions.

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.

SEALING AND FIRE STOPPING

FIRE AND/OR SMOKE RATED PENETRATIONS:
Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with section 07 84 00 “Fire Stopping”.

NON-RATED PENETRATIONS:
Conduit Penetrations Below Grade:
In exterior wall openings below grade, use a modular mechanical type seal consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the uninsulated conduit and the cored opening or water-stop type wall sleeve.

Conduit and Cable Tray Penetrations Above Grade:
At through-wall conduit and cable tray penetrations of non-rated interior and exterior walls, and floors, use urethane caulk in annular space between conduit and sleeve, or the core drilled opening.

PART 3 - EXECUTION

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.

Conduit penetrations in existing concrete floors: Core drill openings.

Conduit 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.

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

SEALING AND FIRE STOPPING

FIRE AND/OR SMOKE RATED PENETRATIONS:
Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with section 07 84 00 Fire Stopping.

NON-RATED PENETRATIONS:
In exterior wall openings below grade, assemble rubber links of mechanical seal to the proper size for the conduit and tighten in place, in accordance with the manufacturer's instructions. Install so that the bolts used to tighten the seal are accessible from the interior of the building or vault.

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

PENETRATIONS SUBJECT TO WATER INTRUSION:
For penetrations (both rated and non-rated) in floors subject to water intrusion or in rooms housing electrical equipment (but not within walls) provide one of the following:

- Conduit penetration where steel pipe sleeve is used extend steel sleeve 2" above the floor.
- Conduit penetration where cast in place fire stopping device/sleeve is used, extend device/sleeve 2" above the floor (provided it meets the device's UL listing).
- Conduit penetration where there is no steel sleeve or cast in place fire stopping device/sleeve, provide 2"x 2" x 1/8" galvanized steel angles fastened to floor surrounding the penetration or group of penetrations to prevent water from getting to penetration. Provide urethane caulk between angles and floor and fasten angles to floor minimum 8"on center. Seal corners water tight with urethane caulk.

Floors subject to water intrusion or rooms housing electrical equipment include the following locations:

- Mechanical/Plumbing Equipment Rooms
- Data/Telecommunications Rooms
- Electrical Equipment Rooms

Provide waterproof caulk sealant top coating on fire stopping system (or other approved means to protect the fire stopping system from water) in areas subject to wash down such as Food Service and Dish Washing Areas.

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 1 hour.

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
The work under this section includes disconnecting power to existing units AH-6 and AH-7 for new motor replacement by Division 23**.** Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work

PART 2 - PRODUCTS
- Materials and Equipment

PART 3 - EXECUTION
- Examination
- Preparation
- Demolition and Extension of the Existing Electrical Work

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.

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.

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.

Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.

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.

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
- Panelboards Motor Starters and Motor Control Centers
- Cables

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.

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.

MOTOR STARTERS AND MOTOR CONTROL CENTERS

Verify the control circuits. Confirm the fusing and the grounding of the control transformers. Torque all of the connections. Confirm the overload elements and the circuit breakers (fuse) for proper sizing. Verify all grounding. Operate and test each motor starter for proper operation.

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.

Perform a 1000 Vdc megger test on all secondary cables from the substation transformers to the secondary switchboards and on all switchboard feeders.

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:

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.

VARIABLE FREQUENCY DRIVE (VFD) WIRE
All power wiring from the VFD output to the motor shall be type XHHW-2 insulation, single conductor wire.

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.

VFD Installations: Install VFD input wiring and output wiring in separate conduit systems. Do not mix VFD input power and output power, or control wiring in a common raceway.

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.

Additional testing as follows shall be performed if aluminum conductors are used:

Feeders terminated with aluminum conductors shall be tested with a thermal imager and recorded.

Conductors shall be closely checked for loose or poor connections, and for signs of overheating or corrosion.

Test procedures shall meet NETA guidelines.

Test results and report shall be provided to the engineer and included in O&M manual under AL conductors/ tests.

Contractor shall correct all deficiencies reported in the test report.

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.

Neutral Conductors: White for 120/208V and 120/240V systems, Gray for 277/480V 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 and Communications systems. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- References
- Submittals
- Project Record Documents
- Regulatory Requirements

PART 2 - PRODUCTS
- Mechanical Connectors
- Compression Connectors
- Conductors

PART 3 - EXECUTION
- 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.

PROJECT RECORD DOCUMENTS

Record locations of all electrical grounding conductors as installed including recorded ground resistance test results.

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

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).

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.

PART 3 - EXECUTION

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.

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

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.

FIELD QUALITY CONTROL

Inspect grounding and bonding system conductors and connections for tightness and proper installation.

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 grounding conductors as installed including recorded ground resistance test results.

WARRANTY

See Division 1, General Conditions, and General Requirements.

END OF SECTION

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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
- Nylon Anchors
- 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.

NYLON ANCHORS
Nylon anchors may only be used in limited applications with the pre-approval of the State of Wisconsin DFD Electrical Inspector. See Part 3 – Execution for examples of applications of where nylon anchors may be allowed.

Nylon wall plugs shall be designed for 2-way expansion, providing rapid fixing with high pull-out values. Nylon wall plugs shall be molded with protruding side fins which restrict rotation and prevent fall out from overhead holes. Examples of these include Mungo types MN or MU, or Fischer type S nylon plugs.

Nylon one-piece self-drilling anchors designed for use in hollow gypsum wallboard for light duty loads. Anchors shall be engineered nylon or Zamac alloy. Examples of these are the Zip-It ® or Zip-It Jr. ® self-drilling anchors.

Manufacturer's names and catalog numbers are used for quality and performance only. Anchors manufactured by others shall be equally acceptable provided they meet or exceed in performance and quality as specified.

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.

Nylon anchor applications

Nylon anchors may only be used in limited light duty applications with the pre-approval of the State of Wisconsin DFD Electrical Inspector.

Nylon anchors shall be designed for the construction material in which they are intended to be installed and shall be designed for the weight in which the anchors are intended to support.

Nylon wall plug applications may include attaching 4” square boxes or conduit straps to plaster-covered clay tile, drywall, or hollow concrete block. Screws used with nylon wall plugs shall be #10 minimum and shall be longer than the anchor.

Nylon one-piece self-drilling anchor applications may include attaching 4” square boxes or conduit straps to hollow gypsum wallboard for light duty loads. Use No. 8 screws with one-piece self-drilling anchors designed for 3/8” to 1” thick wallboard. Use No. 6 screws with anchors designed for 3/8” to 5/8” wallboard.

END OF SECTION

SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS
BASED ON DFD MASTER ELECTRICAL SPEC DATED 11/18/24

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, communications, 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
- Flexible Metal Conduit (FMC) 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

PART 3 - EXECUTION
- Conduit Sizing, Arrangement, and Support
- Conduit Installation
- Conduit Installation Schedule
- Coordination of Box Locations
- Pull and Junction 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 27 05 33.41 – Raceway and Boxes for Audio-Video Systems
Section 26 27 02 – Equipment Wiring Systems.

REFERENCES

Wisconsin Administrative Code SPS 316 - Electrical
ANSI/TIA-569-C-Telecommunications Pathways and Spaces
ANSI/SCTE 77-2017 – Specifications for Underground Enclosure Integrity

SUBMITTALS

Boxes - provide product data showing configurations, finishes, dimensions, and manufacturer's instructions.

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.

Aluminum conduits shall not be in direct contact with concrete.

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.

FLEXIBLE METAL CONDUIT (FMC) AND FITTINGS
Conduit: steel, galvanized, spiral strip.

Fittings and Conduit Bodies: All steel, galvanized or malleable iron (except as allowed in specification 26 51 13).

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.

ELECTRICAL NONMETALLIC TUBING (ENT) AND FITTINGS
Conduit: ENT (smurf tube), UL listed and NEC recognized.

Fittings: One piece quick connect fittings for 1/2 inch to 1 inch size and schedule 40 cemented fittings for larger size. When installed in concrete, fittings shall be suitable for damp locations and shall be concrete–tight, stub-ups and stub-downs kits shall meet manufacturer's recommendations.

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.

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.

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.

Provide one raceway from each communications outlet box [to above accessible ceiling] [to cable tray].

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.

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.

Where communication cabling is to be installed in conduit to the wiring hub (e.g. Telecom Room), multiple conduits may be consolidated into fewer, larger conduits. Capacity of shared conduits shall equal the capacity of the individual conduits unless otherwise noted.

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.

Identify conduit under provisions of Section 26 05 53.

All Aluminum conduits shall not be in direct contact with concrete.

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.

- 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, Flexible Metal Conduit (FMC). For FMC installations, 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 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.

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.

Size pull boxes for communications per ANSI/TIA-568-C

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.

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
- Support Wire Identification
- Nameplate Engraving for Electrical Equipment

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 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 – 480Y/277V	Brown
Secondary Power – 208Y/120V	White

Other Systems	**Color(s)**
Fire Alarm	Red
Temperature Control	Green
Door Access Control	Orange
Sound and Intercom Systems	Gray
Video Surveillance System	Yellow
Communications	Blue

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 – 480Y/277V	White letters on Brown background
Secondary Power – 208Y/120V	Black letters on White background

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.

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

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.

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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		

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

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 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.

PART 2 - PRODUCTS

BRANCH CIRCUIT PANELBOARDS
The panelboard and overcurrent devices contained within shall be **fully-rated.**

Provide updated typewritten panel directories for all panels modified under this project. Provide metal directory holders with clear plastic covers. Holder to be factory mounted.

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.

PART 3 - EXECUTION

INSTALLATION

See section 26 05 29 for support requirements.

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.

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.

FIELD QUALITY CONTROL

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

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:
-HVAC motors, VFDs, and panels

Included are the following topics:

PART 1 - GENERAL
Scope
Related Work
Submittals
Coordination
PART 2 - PRODUCTS
Other Products
PART 3 - EXECUTION
Inspection
Preparation
Installation
HVAC 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

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.

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.

HVAC 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.

VFD Installations: Input power wiring shall be installed in a separate conduit, output power wiring shall be installed in a separate conduit and control wiring shall be installed in a separate conduit. Do not mix input power, output power, or control wiring in a common conduit. Separate conduits for input and output power wiring shall be provided for each motor.

VFD Installations: Output power wiring for more than one motor shall not share a common conduit.

VFD installations: Provide aux contact in local disconnect to de energize VFD when opening local disconnect.

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.

Provide separate junction box for each engineered supply, return/relief/exhaust system at exterior of air handling unit for 480V, 3-phase source.

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.

EQUIPMENT CONNECTION SCHEDULE

As indicated on the drawings.

END OF SECTION

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SECTION 26 29 00
LOW-VOLTAGE CONTROLLERS
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/21

PART 1 - GENERAL

SCOPE

The work under this section includes Low-Voltage Controllers (starters) for motors: Manual motor starters, magnetic motor starters, combination magnetic motor starters, and/or motor control centers. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- References
- Submittals
- Operation and Maintenance Data
- Coordination with Other Trades
- Delivery, Storage, and Handling

PART 2 - PRODUCTS
- Motor Control Center

PART 3 - EXECUTION
- Installation
- Construction Verification Items

RELATED WORK

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

Section 01 91 01 or 01 91 02 – Commissioning Process
Section 26 05 29 – Hangers and Supports for Electrical Systems
Section 26 08 00 – Commissioning of Electrical

REFERENCES

ANSI/NEMA ICS 6 – Industrial Control and Systems: Enclosures.
ANSI/UL 248-8 – Low-Voltage Fuses – Part 8: Class J Fuses.
NEMA AB 1 – Molded-case Circuit Breakers, Molded Case Switches, and Circuit-breaker Enclosures.
NEMA ICS 2 – Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts.
NEMA ICS 18 – Motor Control Centers.
NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches.
NEMA PB 1 – Panelboards.
NEMA PB 1.1 – General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less.

SUBMITTALS

Provide product data on motor starters and combination motor starters, relays, pilot devices, and switching and overcurrent protective devices.

OPERATION AND MAINTENANCE DATA

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

COORDINATION WITH OTHER TRADES

Motors: In general, all electric motors required for this installation will be supplied with equipment, apparatus and/or appliances covered under other sections of the specifications.

For the sake of consistency and conformity of manufacturer, design and construction, all motors shall conform to the following description unless otherwise noted or required.

- Motors 1/3 HP and smaller shall be wound for operation on single phase, 60 Hz. service unless otherwise noted.

- Motors 1/2 HP and above shall be wound for operation on 3 phase, 60 Hz service unless otherwise noted.

- Refer to drawings in each case in order to verify voltage characteristics required.

Equipment:
All building utility motors such as fans, pumps, overhead doors, etc., together with certain "controlling equipment" for same, except motor starters and related apparatus, will be furnished under other sections of the specifications and delivered to the building site unless specifically noted otherwise. The above mentioned "controlling equipment" pertains to electrical thermostats, electro-pneumatic and pneumatic-electric and detection devices, or any other device not purely electrically operating in nature.
The starters for these motors shall be furnished and installed by the Electrical Trade unless noted otherwise (See Motor Schedule on Drawings).

The Electrical Trade shall set and connect all specified starting equipment, install all power conduits and wiring and shall furnish and make all connections from starting equipment to motors as required to leave the apparatus in running condition.

Wiring Connections:
Furnish branch circuits for all motors to the starting equipment and then to the motors, complete with all control wiring for automatic and remote control where required or noted. Conduits to motors shall terminate in the conduit fittings on the motors, the final connection being made with flexible, PVC-coated metal conduit.

Provide all necessary labor and material to completely connect all electrical motors and controls (where required) in connection with the building utility equipment, including fans, pumps, overhead door operators, etc.

All conduits and wiring required for control work from the holding coil circuit of the starter, including the furnishing and installation of control devices such as auxiliary contacts, control relays, time delay relays, pilot lights, selector switches, alternators, etc., shall be provided and installed by other trades unless otherwise indicated.

Power Branch Circuits:
Wire sizes for branch circuits not specifically called for on drawings or in specifications shall be based on 125 percent of the full load current of the motor unless the voltage drop of motor branch circuits exceeds 1-1/2 percent from the distribution panel to the motor; in which case, voltage drop shall govern wire sizes. A power factor of 80 percent shall be used for motors in such calculations.

DELIVERY, STORAGE, AND HANDLING
Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to components, enclosure, and finish.

PART 2 - PRODUCTS

MOTOR CONTROL CENTER
Feeder Tap Units: Molded case thermal-magnetic circuit breakers or as scheduled.

Integrated Equipment Short Circuit Rating: As scheduled on the drawings.

PART 3 - EXECUTION

INSTALLATION
Install motor control equipment in accordance with manufacturer's instructions.

Set overload protection in motor starters to match installed motor characteristics.

Motor Data: Provide neatly typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.

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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