MECHANICAL SPECIFICATIONS
TABLE OF CONTENTS
DIVISIONS 23

SECTION 23 07 00 - MECHANICAL INSULATION

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data on the following:
   1. Insulation.
   2. Jackets, coatings and protective finishes.
   3. Sealers, mastics and adhesives.
   4. Fitting covers.
   5. Manufacturer's installation details for fire rated duct wrap.

1.2 FLAME AND SMOKE RATINGS

A. Provide insulation tested on a composite basis (insulation, jacket, covering, sealer, mastic and adhesive) complying with the following:
   1. Flame Spread: 25 or Less
   2. Smoke Developed: 50 or Less
   3. Method: ASTM E84 (NFPA 255)

1.3 PRODUCT DELIVERY

A. Deliver insulation products in factory containers bearing manufacturer's label showing fire hazard rating, density and thickness.

1.4 DEFINITIONS

A. Exposed Location: Located in mechanical rooms or other areas exposed to view.

B. Concealed Location: Located in pipe chases, furred spaces, attics, crawl-spaces, above suspended ceilings, or other locations not exposed to view.

1.5 STANDARDS

A. Comply with the latest edition of National Commercial and Industrial Insulation Standards.

PART 2 - PRODUCTS

2.1 PIPE INSULATION

A. Manufacturers:
   1. 3M
   2. Aeroflex
   3. Armacell
   4. ITW
   5. Johns-Manville
   6. K-Flex
   7. Knauf
   8. Manson Insulation
   9. Owens-Corning
   10. Unifrax

B. Materials:

1. **Type FCCP** - Flexible Closed Cell Pipe Insulation: Armacell AP Armaflex, Aeroflex Aerocel, or K-Flex Insul-Tube. Compliant with ASTM E 84, NFPA 90A, and NFPA 90B.
2. **Type FCCP**-O – UV Resistant Flexible Closed Cell Pipe Insulation: Armacell UT Solaflex, Aerocel AC, K-Flex Insul-Tube with AL Clad System.

Materials indicated are provided as design basis. Equivalent insulation product by manufacturer indicated above is acceptable.

C. Insulation thickness and conductivity: (Thickness and conductivity listed below are minimum required. Provide thickness and conductivity required by Local Building or Energy Codes).
   1. Refrigerant Suction Lines:
      a. 40ºF to 60ºF: (Insulation conductivity: 0.21–0.27 (Btu x in.)/(h x ft^2 x ºF))
         1) Sizes smaller than 1-½": ½"
         2) Sizes 1-½" and larger: 1"
   2. Refrigerant Liquid Lines:
      a. All Sizes: ½"
   3. Refrigerant Hot Gas Lines:
      a. Sizes smaller than 1-½": ½"
      b. Sizes 1-½" and larger: 1"

D. Application: Unless otherwise indicated, use the following:
   1. Refrigerant piping, inside, above ground: **Type FCCP** flexible closed cell insulation.
   2. Refrigerant piping, outside building envelope: **Type FCCP-O** UV resistant flexible closed cell insulation.
   3. Condensate drain piping: **Type FCCP** flexible closed cell insulation.

2.2 DUCT INSULATION

A. Manufacturers:
   1. Aeroflex
   2. Armacell
   3. Certainteed
   4. Johns Manville
   5. K-Flex
   6. Knauf
   7. Owens-Corning

B. Materials:
   1. **Type FDL** – Fiberglass Duct Liner: See Section 23 31 13, for duct liner requirements.
   2. **Type FCCL** – Flexible Closed Cell Duct Liner: See Section 23 31 13, for duct liner requirements.
   3. **Type FDW** - Flexible Faced Fiberglass Ductwork Insulation Wrap: Johns-Manville Microlite, with FSK factory applied foil-scrim-kraft facing. ASTM E 84 compliant.
   4. **Type RDB** - Rigid Fiberglass Ductwork Insulation: Johns-Manville 800 Series, Spin-Glas Type 814, 3 lb. Density rigid board with FSK jacket.
   5. **Type RDB-O** - Rigid Glass Mineral Wool Ductwork Insulation: Knauf Earthwool with all service jacket (ASJ).
   6. **Type FD** - Flexible Plain Fiberglass Ductwork Insulation: Johns-Manville Microlite .75 lb/cu. Ft. unfaced.
   7. **Type FCCD** - Flexible Closed Cell Duct Insulation: Armacell AP Armaflex, Aeroflex Aerocel, or K-Flex Insul-Sheet. ASTM E 84 compliant. Where located outside the building envelope, provide UV resistant paint.
   8. **Type CGD** - Cellular Glass Ductwork Insulation: Owens Corning FOAMGLAS with vapor barrier.
   9. **Type ALJ** - Outdoor Aluminum Jacket: 3M Venturclad 1579 GCW-WME with white finish, Polyguard Alumaguard Cool Wrap with white finish, or MFM Flex Clad 400 with white finish.

10. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, anchors, corner angles, and similar accessories as recommended by the insulation manufacturer for the applications indicated.

Materials indicated are provided as design basis. Equivalent insulation or jacketing product by manufacturer indicated above is acceptable.

C. Application:

SYSTEM	EXPOSED	CONCEALED	OUTDOOR
Supply (Note 7)	½" **Type FDL** duct liner	½" **Type FDL** duct liner	2" Type **RDB-O** external rigid + **Type ALJ** jacket (Note 4)
Return (Note 8)	½" **Type FDL** duct liner	½" **Type FDL** duct liner	2" **Type RDB-O** external rigid + **Type ALJ** jacket (Note 4)
Exhaust (Note 8)	None (Note 6)	None (Note 6)	None (Note 6)
Outside Air (Note 7)	1" **Type RDB** external rigid	1 ½" **Type FDW** duct wrap	2" **Type RDB-O** external rigid + **Type ALJ** jacket (Note 4)

1. Reference 23 07 00/ Duct Insulation and 23 31 13/ Duct Liner.
2. Where energy codes require additional insulation over that listed above, provide insulation in accordance with those codes.
3. Insulate all accessories and components (fire dampers, silencers, air valves, etc.) of the duct systems noted above as requiring insulation. Where lined systems contain components that cannot be lined or have not been provided with liner, insulate them. That insulation shall overlap the lined portion of the system by at least 12 inches.
4. Build up and pitch insulation to prevent water ponding on rectangular ductwork 36" or greater in width.
5. Round ducts concealed above ceilings and serving individual terminal units or diffusers may be wrapped in lieu of liner.
6. Provide insulation of exhaust louver plenums and exhaust ductwork for first 20' from perimeter louvers or from perimeter louver to motorized damper or gravity damper. Provide **Type FDL** duct liner for exposed exhaust louver plenums and ductwork. Provide **Type FDW** duct wrap for concealed exhaust louver plenums and ductwork.
7. Ductwork downstream of 100% outside air units with heating and cooling shall be treated as supply air.
8. All negative pressure ductwork of energy recovery ventilators shall be treated as return air.

PART 3 - EXECUTION

3.1 GENERAL

A. Verify acceptability of all materials which are to be used in air plenums (above ceiling, etc.). Materials must meet all requirements of Local Building Code and Authority having jurisdiction.

3.2 PIPE INSULATION

A. Insulate the following:
   1. Refrigerant hot gas, liquid, and suction lines.
   2. Condensate drain piping.

B. Installation:
   1. Install insulation on pipe system subsequent to testing and acceptance of tests.
   2. Install insulation materials with smooth and even surfaces.
      a. Insulate each continuous run of piping with full length units of insulation, with a single cut piece to complete the run.
      b. Do not use cut pieces or scraps abutting each other.
   3. Clean and dry pipe surfaces prior to insulating.
      a. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.
   4. Extend piping insulation without interruption through pipe clamps, hangers, walls, floors and similar piping penetrations, except where otherwise indicated. **Hangers and supports must be installed outside, not through, insulation.**
   5. Install protective metal shields and saddles where needed to prevent compression of insulation.
   6. Replace existing insulation removed or damaged because of work of this project.
   7. Insulate new pipes and replace insulation on existing pipes to remain where insulation was removed or damaged by demolition or revisions.
   8. Perform all work in a neat and workmanlike manner.

3.3 DUCTWORK INSULATION

A. Install insulation materials with smooth and even surfaces.

B. Clean and dry ductwork prior to insulating.
   1. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

C. Extend ductwork insulation without interruption through walls, floors, and similar ductwork penetrations, except where otherwise indicated. **Hangers and supports must be installed outside, not through, insulation.**

D. Except as otherwise indicated, do not insulate lined ducts. However, extend duct insulation 12" beyond start of lining where lined ductwork meets insulated ductwork.

E. Maintain integrity of vapor-barrier on insulation of ducts carrying cold air, and protect it to prevent puncture and other damage.

F. For Outdoor Insulation:
   1. Stagger joints on multilayer applications.
   2. Locate joints at sides of ducts whenever possible.
   3. Utilize adhesive and vapor retarder as indicated by manufacturer for outdoor applications.
   4. Use full coverage adhesive to adhere external insulation to ductwork. For flexible closed cell insulation, adhesive shall be by insulation manufacturer.
   5. Vapor retarders shall overlap a minimum of 2" at all seams.
   6. Cover flexible connections.
   7. Extend covering to inside face of wall/roof.
   8. Provide all exposed rigid insulation surfaces with protective aluminum jacket. Provide backing and aluminum jacketing tape at all sharp edges and fasteners. Do not puncture aluminum jacket.
   9. Provide all outdoor flexible closed cell insulation with UV resistant painted finish, white in color unless otherwise noted. Paint shall be by same manufacturer as insulation.

3.4 PROTECTION AND REPLACEMENT

A. Replace damaged insulation which cannot be repaired satisfactorily. Including units with vapor barrier damage and moisture saturation.

B. Protection: The insulation installer shall advise the Contractor of required protection for the insulation work during the remainder of the construction period, to avoid damage and deterioration.

3.5 ASBESTOS REMOVAL

A. It is understood and agreed that this work does not contemplate handling of, or design including use of, asbestos or any hazardous waste material. Therefore, Owner and Contractor agree to hold harmless, defend and indemnify consultant (A/E) for all claims, lawsuits, expenses or damages arising from or related to the handling, use, treatment, purchase, sale, storage or disposal of asbestos, asbestos products or any hazardous waste materials.

B. In the event asbestos is encountered the Contractor shall immediately cease work in the area of the asbestos shall contact the Engineer and Owner for instructions.

C. Regulations:
   1. Follow Section 1910.1001 Code of Federal Regulations Title 29, Part 1910 (OSHA Asbestos Regulations).
   2. Provide daily sampling during removal instead of at six month intervals.
   3. Stop work and notify Architect immediately if levels exceed those of Subparagraphs b (2) or b (3) of regulations.
   4. Dispose of material containing asbestos using methods approved by EPA at sites approved by EPA.

END OF SECTION 230700

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SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Installer: A firm with at least five years of successful installation experience on projects with refrigerant piping similar to that required for this project.

1.2 REGULATORY/REQUIREMENTS

A. Comply with applicable requirements of the Clean Air Act, State of Missouri, Kansas City and Jackson County Regulations concerning handling of refrigerants.

PART 2 - PRODUCTS

2.1 REFRIGERANT PIPING

A. Type ACR soft drawn copper tube with wrought copper fittings and ½" pre-insulated line sets.

B. End Caps:

1. Provide factory applied plastic end caps on each length of pipe and tube.
2. Maintain end caps through shipping, storage and handling as required to prevent pipe end damage and eliminate dirt and moisture from inside of pipe and tube.

2.2 SHUT-OFF VALVES

A. Manufacturers:

1. Design Basis: Henry
2. Other Acceptable Manufacturers:

    a. Imperial
    b. Mueller
    c. Superior

B. Size 7/8 Inch and Smaller:

1. Model: Series 600.
2. Type: Pack-less diaphragm.
3. Material: Forged bronze.
4. Flow: Non-directional.
5. Servicing: Diaphragm changeable under line pressure.

C. Size 1-1/8 Inch and Larger:

1. Model: Series 200.
2. Type: Wing cap, back seating.
3. Material: Bronze.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Run piping level or plumb, except slope gas piping to compressor with a minimum number of elbows.

B. Size lines for total pressure drop not to exceed 2ºF saturation temperature.

C. Replace air in pipe with dry nitrogen to prevent corrosion during soldering.

3.2 HANGERS

A. For insulated piping, provide hangers of size to fit outside insulation.

B. For non-insulated piping, provide hangers with elastomer insert to prevent damage to piping from vibration.

3.3 TESTING AND DEHYDRATION

A. Use the following procedure to test and hydrate the systems:

1. Isolate any elements which would be damaged by test pressures.
2. Repair or replace leaking elements of system and re-test.
3. After system has been proven to be free of leaks, evacuate it with a high efficiency vacuum pump to 2.5 mm of mercury absolute.
4. Allow the system to stand under vacuum for 2 hours.

    a. Then, if a vacuum of 2.5 mm can be drawn within 30 minutes, the system shall be considered dry.
    b. If not, the procedure shall be repeated.

5. Break the final vacuum by charging with the correct refrigerant.

END OF SECTION 232300

SECTION 233113 - DUCTWORK

PART 1 - GENERAL

1.1 INDUSTRY STANDARDS

A. Construct ductwork to meet all functional criteria defined in Section 11 of the 2005. SMACNA "HVAC Duct Construction Standards, Metal and Flexible", Third Edition. Comply with SMACNA recommendations for fabrication, construction and details, and installation procedures, except as otherwise indicated.

B. Comply with American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), except as otherwise indicated.

1.2 SUBMITTALS

A. Detailed ductwork shop drawings, which include sizes, layouts, and pressure classifications, must be properly submitted. Any ductwork installed without prior written approval by the engineer of record shall be replaced at the expense of the contractor.

B. Shop Drawings: Submit shop drawings for:

1. Transition elbows.
2. Seal and reinforcing schedule for all ductwork fabrication types.
3. Turning vane and turning vane installation.

C. Product Data: Submit manufacturer's product data on the following:

1. Duct lining.
2. Duct lining adhesive.

PART 2 - PRODUCTS

2.1 DUCTWORK MATERIALS

A. All interior ducts shall be constructed with G-90 or better galvanized steel (ASTM A653/653M) LFQ, chem treat. Exterior ductwork or duct exposed to high humidity conditions (i.e. kitchen exhausts) shall also be G-90 or better galvanized steel LFP, chem treat.

B. Ductwork designated for painting (by Others) shall be provided with "Paint Lock" finish to accept primer and paint. See Architectural and mechanical documents for designated locations.

2.2 RECTANGULAR DUCT

A. Construct rectangular ductwork to meet all functional criteria defined in Section 11, of the SMACNA "HVAC Duct Construction Standards Metal and Flexible" 2005 Edition. All ductwork must comply with all local, state and federal code requirements.

B. Pittsburgh lock shall be used on all longitudinal seams. All longitudinal seams will be sealed with mastic sealant. Snaplock is not acceptable.

C. Ductmate or W.D.C.I. proprietary duct connection systems will be accepted. Duct constructed using these systems will refer to the manufacturers guidelines for sheet gauge, intermediate reinforcement size and spacing, and joint reinforcements.

D. Formed on flanges (T.D.C./T.D.F./T-25A/T-25B) shall be constructed as SMACNA T-25 flanges, whose limits are defined on Page 2.76 2005 SMACNA Manual, Third Edition. No other construction pertaining to formed on flanges will be accepted. Formed on flanges shall include the use of corners, bolts and cleat.

E. Ductmate type systems that use a butyl Rubber Gasket which meets Mil-C 18969B, Type II Class B, TT-C-1796 A, Type II Class B, and TTS-S-001657 must also pass UL-723. This material, in addition to the above, shall not contain vegetable oils, fish oils, or any other type vehicle that will support fungal and/or bacterial growth (as defined in 21CFR 177, 1210 closures with sealing gaskets for food containers).

F. Aluminum duct shall be fabricated using the aluminum thickness equivalence table in the standard. Simply increasing the thickness by two gauges is not acceptable.

G. Fittings shall be constructed and reinforced as ductwork according to the longest span.

2.3 ROUND AND OVAL DUCT

A. Round and oval duct shall be galvanized steel, constructed in accordance with Section 11 of the 2005 SMACNA "Duct Construction Standards, Metal and Flexible", except as noted.

1. Lighter gauge factory made duct with an Intermediate standing rod may be used. Submit product data sustaining the equivalency of such duct into SMACNA standard duct.

B. Minimum duct gauge shall be 26 gauge.

2.4 CONTRACTOR FABRICATED CASINGS AND PLENUMS

A. Unless required otherwise by drawings, single wall casings and plenums may either be contractor or factory fabricated where shown on drawings. All double wall casings and plenums shall be factory fabricated.

B. Casings and plenums shall be constructed in accordance with the 2005 SMACNA "HVAC Duct Construction Standards," Third Edition and as specified below.

C. All casings and plenums on the suction side of any fan, including return air outside air, or mixing plenum shall be constructed to 2" negative pressure class.

D. Louver blank-off panels shall be constructed to 2" negative pressure class.

E. All casings and plenums for relief and exhaust air shall be 2" positive or negative pressure class.

F. All casings and plenums on the discharge side of supply fans shall be 4" positive pressure class.

G. Single wall plenums shall be of the standing seam type construction. Submit shop drawings indicating overall dimensions, support details, corner and edge details, penetration details, equipment installation details, and pressure class.

H. Seal all seams, edges, and corners with approved duct sealant.

I. Casing materials shall be the same as that for the connected duct systems.

J. Where automatic dampers may, completely shut off air flow and subject plenum of casing to fan close off pressure, install pressure relief panels, rated to open at 125%.

2.5 MISCELLANEOUS DUCTWORK MATERIALS

A. General: Provide miscellaneous materials and products of the types and sizes indicated, and where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.

B. Single wall splitter and turning vanes shall be custom fabricated as specified below.

C. Ductwork Support Materials: Except as otherwise indicated, provide galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.

D. Type FDL – Fiberglass Duct Liner:

1. Manufacturers:

    a. Certainteed
    b. Johns Manville
    c. Knauf
    d. Owens Corning

2. Model: Johns Manville Linacoustic RC with Permacoat (EPA registered antimicrobial coating), in accordance with UL 181, ASTM C1071, G21 and G22 with no observed growth.
3. Compliances:

    a. FSHH-1-545, Type I
    b. NFPA 90-A

4. Roughness: 0.0008 feet
5. Noise Reduction Coefficient: 0.85 or higher for 1-1/2" liner
6. Round Duct Liner: Spiracoustic Plus "snap-in" type with Permacote.

E. Duct Liner Adhesive:

1. Manufacturers:

a. Childers CP-127 Chil-Quik
b. CL Ward Duct Liner Adhesive
c. Design Polymerics DP 2500
d. Ductmate Industries, Inc. Gecko Glue
e. Hercules Industries MTA500

2. UL Listings: UL 723/ASTM E84.

F. Duct Sealant:

1. Manufacturers:

a. Childers CP-146 Chil-Flex
b. CL Ward S Seal
c. Design Polymerics 1010
d. Ductmate PROseal
e. Hercules Industries MTS200

2. Description: Non-hardening, water based, liquid or mastic elastic sealant with UV inhibitors for outdoor use
3. UL Listings: UL 181B-M and UL 723/ASTM E84.
4. Sealants shall contain no VOCs.

G. Duct Tape Sealing System:

1. Manufacturers:

a. Design Polymerics
b. Hardcast.
c. Approved equal

2. Model:

a. Tape: Hardcast DT
b. Indoor Adhesive: Hardcast FTA-20
c. Outdoor Adhesive: Hardcast RTA-50

H. Fiberglass ductboard is not accepted.

I. Access doors shall be hinged or Ductmate Sandwich Type Access Doors manufactured by Ductmate Industries, Inc. Doors shall be of adequate size to allow easy access to hardware, which needs to be maintained.

J. Flexible Duct Connector:

1. Flexible duct connector shall be used where ductwork connects to fans of apparatus, or apparatus casing to fans.
2. Connectors will meet NFPA 90A and 90B specifications and provide an airtight and waterproof seal.
3. Indoor installations shall be Neoprene or vinyl coated fabrics.
4. Outdoor installations shall use Hypalon coated fabric.
5. Connector shall be Ductmate PROFlex or approved equal.

2.6 FABRICATION

A. Construct rectangular ductwork to meet all functional criteria defined in Section VII, of the SMACNA "HVAC Duct Construction Standards Metal and Flexible" 2005 Edition. This shall be subsequently referred to as the SMACNA Manual. All ductwork must comply with all local, state, and federal code requirements.

B. All "medium pressure" (systems with external pressures greater than 2" w.c.) duct systems shall be constructed for 4" W.C. positive and 1" W.C. negative static pressure and 3500 FPM velocity.

C. See air handler and fan schedules for external pressure requirements. All pressures above 2" E.S.P. shall be medium pressure.

D. All low-pressure ductwork is to be constructed for 2" W.C. positive and 1" negative static pressure and 2000 FPM.

E. All negative pressure ductwork shall be constructed for a minimum of 2" W.C. negative and 2" W.C. positive static pressure and 2000 FPM velocity.

F. Make all changes in direction using 1.5 radius elbows where possible. Use splitter vanes or mitered rectangular elbows with turning vanes otherwise.

1. Use single thickness splitter vanes for all radius elbows less than 1.5 D = r.

    a. D = diameter of duct or width of duct (in plane of change-in-direction).
    b. r = radius of duct at duct center-line.
    c. Use "Curve Ratios" of 0.45 or greater (as defined by figure 3-7 of the 1989 ASHRAE Fundamentals Handbook).

2. Use single thickness turning vanes with no trailing edges in accordance with SMACNA Standards.

    a. All mitered, rectangular elbows in series.
    b. All mitered, rectangular elbows less than 36" in width (in plane of change-of-direction).

G. All branch duct take-offs shall use 45° laterals or 45° "pants-leg" type fittings.

PART 3 - EXECUTION

3.1 INSTALLATION OF DUCTWORK

A. Assemble and install ductwork in accordance with recognized industry practices, which will achieve air-tight and noiseless systems, capable of performing each indicated service.

B. Install each run with a minimum of joints.

C. Where ducts pass expansion joints or structural elements subject to movement provide flexible connections and supports to allow for movement without adverse effects.

D. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth.

E. Support ducts rigidly with suitable ties, braces, hangers and anchors of the type, which will hold ducts true-to-shape to prevent buckling. This Division is responsible for all duct supports.

F. Seal ducts in accordance with SMACNA requirements for pressure class indicated.

1. Indoor Ducts: Use liquid or mastic sealant, or tape system.
2. Approved manufactured joining systems with gaskets may be used in lieu of transverse sealing.

G. Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible.

H. Hold ducts close to walls, overhead construction, columns, and other structural and permanent-enclosure elements of the building.

1. Limit clearance to 0.5" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any.
2. Where possible, locate insulated ductwork for 1.0" clearance outside of insulation.

I. In finished spaces, conceal ductwork by locating in mechanical shafts, hollow wall construction or above suspended ceilings.

J. Where possible, avoid locating ducts on or near floor.

1. Where ducts must be located low, provide metal trestle to protect duct at places where duct will be climbed over.

K. Coordinate the layout with suspended ceiling and lighting layouts and similar finished work.

L. Install access doors where necessary for inspection and maintenance.

1. Provide additional 12" x 12" access door at each low leakage damper.
2. Arrange access doors so that:

a. They open against the system air pressure wherever feasible.
b. Their latches are operable from either side, except where the duct is too small to be entered.

M. Where ducts pass through non-fire-rated interior partitions below ceiling and exterior walls:

1. Conceal the space between the construction opening and the duct or duct-plus-insulation with sheet metal flanges of the same gauge as the duct.
2. Overlap the opening on all sides by at least 1-1½".

N. Provide volume dampers at branch take-offs (except upstream of VAV boxes which should not have dampers).

O. Provide conical or tapered taps with balancing dampers on all round ductwork takeoffs (except upstream of VAV boxes, which should not have dampers).

P. Where space permits, round or oval ductwork of equivalent diameter may be substituted for unlined rectangular ductwork.

Q. Do not modify ductwork in a manner that will increase external static pressure in the system without written approval from Architect/Engineer.

3.2 DUCT LINER INSTALLATION

A. Ducts Exposed to Weather:

1. Dimensions indicate free area.
2. Seal ducts to three-inch static pressure standards, minimum.

B. Ductwork shall be insulated per Section 23 07 00. See Section 23 07 00 for additional insulation requirements on unlined and/or uninsulated ductwork.

1. Coordinate lined duct and insulated duct prior to bid.

C. Completely remove any loose material from each section of lined ductwork as it is installed.

D. Interrupt duct liner a minimum of 18" upstream and 30 inches downstream of all electric resistance heaters in duct system. If ductwork is used for cooling, wrap that portion of duct which is not lined and extend insulation a minimum of 12" beyond lining in each direction.

3.3 DUCTWORK STORAGE AND CLEANING

A. Cleaning:

1. Interior surfaces shall be free of dust and debris prior to initial startup. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning.
2. Clean external surfaces of foreign substances that might cause corrosion, deterioration of the metal, or where ductwork is to be painted.

B. Ductwork contaminated or damaged above "shop" or "mill" conditions shall be cleaned, repaired or replaced to the Engineer's satisfaction.

1. Ductliner pre-installed in stored duct which has become wet may be installed if first allowed to completely dry out.
2. Ductliner in installed ductwork, which has become wet must be completely removed and replaced.
3. Torn ductliner may be replaced by coating with adhesive if damaged is minor and isolated. Extensively damaged liner shall be replaced back to a straight cut joint.

END OF SECTION 233113

SECTION 237413 - DEDICATED OUTDOOR AIR UNITS (PACKAGED)

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Packaged outdoor air unit.

B. Dehumidification/Cooling.

C. Heating.

D. Electrical Ratings and Connections

E. Unit Controls

F. Powered Exhaust

G. Energy Recovery

H. Roof curb

I. Execution

1.2 RELATED SECTIONS

A. Section 23 05 13 – Motors and Motor Starters.

B. Section 23 05 48 - Vibration Isolation.

C. Section 23 05 00 – Mechanical Insulation.

D. Section 23 40 00 - Air Cleaning.

E. Section 23 09 00 – Building Automation and Automatic Controls

1.3 REFERENCES

(AHRI has introduced Standard 920 "Performance Rating of DX Dedicated Outdoor Air System Units". Testing for rating is next step in implementation of this rating standard.)

A. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration. (all)

B. ANSI/ASHRAE/IESNA 90.1-2013 - Energy Standard for New Buildings Except Low-Rise Residential Buildings.

C. ANSI Z21.47/UL1995 - Unitary Air Conditioning Standard for safety requirements.

D. ANSI/NFPA 70-1995 - National Electric Code. (all)

E. International Fuel Gas Code (g/e)

F. NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems. (all)

1.4 SUBMITTALS

A. Submit unit performance data including: capacity, nominal and operating performance.

B. Submit Mechanical Specifications for unit and accessories describing construction, components and options.

C. Submit drawings indicating overall dimensions as well as installation, operation and services clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.

D. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety and start-up instructions.

E. Drawings submitted for approval shall be accompanied by a copy of the purchase agreement between the Contractor and an authorized service representative of the manufacturer for check, test and start up and first year service.

1.5 DELIVERY, STORAGE and HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units from physical damage. Leave factory shipping covers in place until installation.

C. Units to be secured via base rail tie-down locations.

1.6 WARRANTY

A. Provide parts warranty extending either 12-months from date of unit start-up or a maximum of 18-months from unit ship date.

B. Provide twenty five year heat exchanger limited warranty from unit ship date.

C. 5 year compressor warranty for units 25 tons and below.

D. The manufacturer shall furnish an alternative price for:
1. Extended parts and labor by manufacturer to be provided to the owner for a period up to 5 years.

1.7 MAINTENANCE SERVICE

A. Furnish complete parts and labor service and maintenance of packaged outdoor air units for one year from Date of Substantial Completion by contractor.

B. Provide maintenance service with a two month interval as maximum time period between calls. Provide 24 hour emergency service on breakdowns and malfunctions.

C. Include maintenance items as outlined in manufacturer's operating and maintenance data.

D. Submit copy of service call work order or report and include description of work performed.

E. Must have twenty factory-certified and factory-trained technicians within a four-hour radius of the jobsite.

1.8 REGULATORY REQUIREMENTS

A. Unit shall conform to the appropriate standards listed in Section 103 as well as be listed and labeled by a Nationally Recognized Testing Laboratory (NRTL) for compliance with the following applicable standards.
   1. Standard for Safety Heating and Cooling Equipment-Fourth Edition, UL 1995/CSA C22.2#236 Issue: 2011/10/14
   2. Standard for Gas Unit Heaters And Gas-Fired Duct Furnaces ANSI Z83.8-2013, CSA 2.6-2013, Third Edition – 2006 (indirect gas-fired/e)
   3. Standard for Non-Recirculating Direct Gas-Fired Industrial Air Heaters, ANSI Z83.4 / CSA 3.7 - Issued: 2013/03/01 Ed: 3
   4. In the event the unit is not approved by an NRTL for compliance with the appropriate standards, the manufacturer shall, at manufacturer's expense, provide for a field certification and labeling of unit by an NRTL to the appropriate standards. Manufacturer shall, at manufacturer's cost, complete any and all modifications required by NRTL prior to certification and field labeling. Manufacturer shall include coverage of all modifications in unit warranty.

1.9 EXTRA MATERIALS

A. Provide one set of filters.

PART 2 - PRODUCTS

2.1 SUMMARY

A. The contractor shall furnish and install packaged outdoor air unit(s) as shown and scheduled on the contract documents. The unit(s) shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

B. APPROVED MANUFACTURERS
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Lennox , or approved equal.

2.2 GENERAL UNIT DESCRIPTION

A. Unit(s) furnished and installed shall be packaged outdoor air unit(s) as scheduled on contract documents and described in these specifications. Unit(s) shall be designed for dehumidification, cooling and/or heating of 100% Outdoor Air. For dehumidification and cooling modes the evaporator temperature shall be monitored, reported at unit controller. Compressor controls shall modulate capacity to maintain evaporator leaving set point. Hot Gas Bypass shall not be used to control compressor capacity. Compressor Hot Gas Reheat (HGRH) shall be factory installed. To prevent rehydration of evaporator condensate the reheat coil face shall be located a minimum of 6" downstream from the leaving face of the evaporator coil. Heating system shall include modulating controls. Compressor on-off only or primary heating on-off only controls shall not be acceptable control strategies.

B. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

C. Unit discharge airflow configuration shall be:
1. Vertical discharge thru unit base.

2.3 CABINET

A. Cabinet panels: 2" double-wall foamed panel construction throughout the indoor section of unit to provide nonporous, cleanable interior surfaces. All interior seams exposed to airflow shall be sealed.

B. Insulation: 2" polyisocyanurate foam metal encapsulated with no exposed edges. Initial R value of 6.6 per inch of thickness.

C. Cabinet base shall be double wall construction designed to prevent trapping or ponding of water within the unit base. Cabinet base pan shall be insulated with 2" thick polyisocyanurate foam. Foam insulation shall be fully enclosed with galvanized steel insulation cover. Insulation shall not be applied to underside of unit base.

D. Cabinet Base Rails: Side and end base rails shall include openings for forklift and tie-down access. To protect unit base from fork damage side rails shall include removable heavy gauge fork pockets.

E. Shipping anchors attach to and/or through unit base rails. Straps over unit shall not be used to secure unit for shipping.

F. Cabinet material interior and base rails: shall be G-90 zinc-coated galvanized steel. Material gauge shall be a minimum of 14-gauge for base rails, 16-gauge for structural members and 20-gauge for access doors and cabinet panels.

G. Exterior Corrosion Protection: Exterior cabinet panels shall be a base coat of G-90 galvanized steel with both exterior and interior surfaces cleaned, phosphatized and finished with a weather-resistant baked enamel finish. Unit's surface shall be in compliance with ASTM B45 salt spray testing at a minimum of 672 hour duration.

H. Cabinet construction shall provide hinged panels providing easy access for all parts requiring routine service.

I. Cabinet top cover shall be one piece construction or where seams exist, it shall be double-hemmed and gasket-sealed.

J. Hinged Access Panels: Water- and air-tight hinged access panels shall provide access to all areas requiring routine service including air filters, heating section, electrical and control cabinet sections, optional ERV and power exhaust fan section, supply air fan section, evaporator and reheat coil sections. Insulated doors shall be constructed to allow the hinges to be reversed in the field.
   1. Hold-open devices shall be factory installed on all hinged access doors. Chains shall not be used as hold-open devices.

   2. Latches with locking hasp or tool operated closure devices shall be factory installed on all hinged access panels.

K. Drain Pan material shall be Type 430 Stainless steel drain and constructed to sloped in two directions to ensure positive drainage with corners exposed to standing water and drain fittings welded liquid tight to prevent leaks. Pan shall have a minimum depth of 2". Base of drain pan shall be insulated with 1" thick foam insulation.

L. Provide openings either on side of unit or thru the base for power, control and gas connections.

M. Unit shall be equipped with a 6" filter rack upstream of the evaporator. Frame shall be field-adjustable to match any filter combination specified in the following section.

2.4 FANS AND MOTORS

A. Indoor fans shall be high efficiency backward curved impeller.

B. The indoor fan motor shall be an electronic commutated motor with integrated power electronics for variable motor speed.

C. Outdoor fans shall be direct drive with premium efficiency motors, statically and dynamically balanced, draw through in the vertical discharge position.

D. Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

2.5 AIR FILTERS

A. Evaporator Inlet shall include a full compliment of pleated media air filters. Filters shall be:
   1. 2" deep MERV 8

2.6 DAMPERS

A. Unit shall include a motor operated outdoor air damper constructed of galvanized steel.

B. Damper blades shall be air foil design with rubber edge seals designed not to exceed a 4 CFM/SQ FT leakage rate exceeding ASHRAE 90.1 damper leakage requirements.

C. Damper actuator shall be factory mounted and wired sealed spring return and either two-position or fully modulating.

D. Dampers air velocity shall not exceed 2000 fpm.

2.7 DEHUMIDIFICATION/COOLING

A. Compressors
1. All units shall have direct-drive, scroll type compressors including a digital scroll compressor on circuit one.
2. Motor shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate voltage.
3. Internal overloads shall be provided with the scroll compressors.
4. Each compressor shall have a crankcase heater to minimize the amount of liquid refrigerant present in the oil sump during off cycles.
5. Each compressor shall be mounted on rubber vibration isolators, to reduce the transmission of noise.
6. Provide each unit with hermetically sealed refrigerant circuit(s) factory-supplied completely piped with liquid line filter-drier, liquid line charging port, suction and liquid line pressure ports, sight glass, and thermal expansion valve.
7. Provide each circuit with automatic reset high and low pressure and high temperature switches for safety control.

B. Coils
1. Evaporator, Condenser and Hot Gas Reheat coils shall be constructed with copper tubes mechanically bonded to configured aluminum plate fins.
2. Coils shall be factory leak tested in accordance ANSI/ASHRAE 15-1992 at a minimum pressure of 500 PSIG.
3. The condenser coil shall have a fin designed for ease of cleaning.
4. Evaporator coil shall include (six / four) rows of cooling interlaced for superior sensible and latent cooling with a maximum of 12 FPI for ease of cleaning.
5. Reheat coil shall be fully integrated into the supply airstream and be capable of delivering design supply air temperature.
6. To prevent re-hydration of condensate from evaporator coil, the evaporator coil face and the hot gas reheat coil face shall be separated by a minimum of six inches.
7. Condenser coil hail guards shall be factory installed.

C. Condenser Section
1. Outdoor Fans: Shall be direct drive vertical discharge design with low-noise corrosion resistant glass reinforced polypropylene props, powder coated wire discharge guards and electro-plated motor mounting brackets.
2. Fans shall be statically and dynamically balanced.

D. Compressor Capacity Control
1. Compressor output capacity shall be controlled by the Main Control Module.

2.8 HEATING

A. Modulating Indirect Gas Fired Heating System
1. Completely assembled and factory installed heating system shall be located in the primary heating position located downstream of the indoor fan assembly and be integral to unit and approved for use downstream from refrigerant cooling coils in units mounted outdoors. Threaded gas connection shall terminate at manual shut-off valve. Provide capability for sidewall or thru-base gas piping.
2. Heaters shall include high turn-down burners firing into individual stainless steel tubular

heat exchangers. Heat exchangers shall be constructed of type 439 stainless steel and be a high efficiency dimpled tubular design capable of draining internal condensate. Units with multiple heaters shall include one fully modulating high turndown heater with additional on-off heater sections. Total heater turndown shall be based on heater gas input capacity 5:1 when ≤150 MBH or a minimum of 10:1 when >150 MBH.

3. Heater outdoor air inlet shall be hooded and include internal baffle system to prevent rain blow thru. To prevent recirculation of flue gas and to prevent flue gas condensate from draining onto and obstructing the heater air inlet the inlet shall be hooded and shall be located a minimum of 11" beneath the flue outlet. Inlet hood shall include bird screen.
4. Heater flue outlet(s) shall include hooded outlet with wire cloth all constructed of Type 430 stainless steel. Hooded outlet shall be sealed to prevent flue gas recirculation.
5. Gas Burner Safety Controls: Provide safety controls for the proving of combustion air prior to ignition, continuous air proving monitoring following ignition and continuous electronic flame supervision.
6. Unit controls shall monitor heat output and shall discontinue all heating attempts and or unit operation in the event the heating section fails to ignite or fails to maintain programmed supply air temperature/time.
7. Inducer fan shall be direct drive high pressure centrifugal type with two speeds and shall include built- in thermal overload protection.
8. Limit controls: High temperature automatic reset limits shall be located on blower wall and in indoor fan chamber to shut off gas flow in the event of excessive temperatures resulting from restricted indoor airflow, or loss of indoor airflow.
9. Flame roll-out safeties shall provide continuous monitoring of proper burner operation.

2.9 ELECTRICAL RATINGS AND CONNECTIONS

A. All high voltage power components such as fuses, switches and contactors shall include a service personnel protection barrier or shall be a listed as touch-safe design.

B. Field wiring access to be provided thru unit base into isolated enclosure with removable cover.

C. Power wiring to be single point connection.

D. Wiring internal to the unit shall be colored and numbered for identification.

E. Unit shall be factory wired to field wiring terminal block mounted in isolated enclosure.

F. Factory wired main power disconnect and overcurrent device shall be rated for total unit connected power

G. Unit SCCR rating shall be a minimum of 5kA

H. Factory wired Voltage/Phase monitor shall be included as standard. In the event of any of the following, the units will be shut down and a fault code will be stored in the monitor for the most recent 25 faults. Upon correction of the fault condition the unit will reset and restart automatically.
   1. Phase Unbalance Protection: Factory set 2%
   2. Over/Under/Brown Out Voltage Protection: +/-10% of nameplate voltage
   3. Phase Loss/Reversal

B. All low voltage field wiring connections shall be made at factory installed low voltage terminal strip.

2.10 UNIT CONTROLS

A. Main Unit Controller (MCM) shall be a microprocessor based controller with resident control logic. Controller program logic shall include
   1. Include single program with field selectable
      a. Discharge Air control with unit conditioning modes enabled based on outdoor air conditions and controlled to maintain discharge air setpoints.

B. MCM shall:
   1. Prevent simultaneous operation of any conditioning modes.
   2. Accept separate setpoints for Occupied and Unoccupied states.
   3. Call for Dehumidification based on dew point setpoints. When no call for Dehumidification is present MCM shall control calls for Cooling, Heating and Economizer modes based on sensible or enthalpy temperature setpoints. MCM shall have onboard clock and scheduling function for occupancy.
   4. Include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
   5. Enable HGRH dehumidification and cooling modes and control modulation to maintain (discharge air temperature / space temperature).
   6. Unit shall include minimum discharge air control.

2.11 SYSTEM CONTROLS

A. System controls shall include:
   1. Anti-cycle timing
   2. Minimum compressor run/off-times.

2.12 ROOF CURB

A. Contractor shall provide factory supplied 14" tall roof curb, 18 gauge perimeter made of zinc coated steel with supply and return air gasketing and wood nailer strips. Ship knocked down and provided with instructions for easy assembly.

B. Curb shall be manufactured in accordance with the National Roofing Contractors Association guidelines.

PART 3 – EXECUTION

2.1 EXAMINATION

A. Contractor shall verify that roof is ready to receive work.

B. Installation
   1. Contractor shall install in accordance with manufacturer's instructions.
   2. Mount unit on factory built roof mounting frame providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.

2.2 MANUFACTURER'S FIELD SERVICES

A. Unit start-up and commissioning shall be completed by a Factory-trained and factory-certified technician.
   1. Manufacturer must have twenty factory-authorized and factory-trained technicians within a 50 mile radius of job site.

B. The contractor shall furnish manufacturer complete submittal wiring diagrams of the package unit as applicable for field maintenance and service.

END OF SECTION 237413

SECTION 238129 - VARIABLE REFRIGERANT FLOW HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Bidders shall provide the minimum system as indicated on drawing, including Heat Recovery or Heat Pump systems as defined by model and family numbers. All systems shall be capable of providing the scheduled capacity at the location of the indoor unit regardless of pipe length. Nominal or catalog capacities will not be accepted.

B. Heat Recovery systems shall be capable of simultaneous cooling and heating.

C. Heat Recovery systems shall be capable of transferring heat between individual indoor units and between individual Mode Control Units.

D. Heat Recovery systems shall have a space temperature controller for each connected indoor unit. Each individual space temperature controller shall be capable of automatically satisfying heating or cooling regardless of time of day, occupancy, or season without inhibiting or affecting other space temperature controllers.

E. Heat pump systems that do not allow for simultaneous heating and cooling are not acceptable.

F. VRF System Controls, and integration shall be provided by the manufacturer of the VRF system. Graphics shall include floor plan layout.

1.3 SUBMITTALS

A. Product data for each product.

B. Dimensional data for each product.

C. Manufacturer's selection reports indicating design conditions, load profile, actual capacity, altitude corrections, and relative equipment locations.

D. Manufacturer's piping and wiring layout indicating piping, wire sizes, equipment quantities, piping length estimates, and refrigerant charge.

E. Performance report for each product.

F. Control system wiring diagrams and network architecture.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VRF HVAC systems to include in emergency, operation, and maintenance manuals. Service and installation manuals must be readily available on the manufacturer's website without entering a username and password.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.5 QUALITY ASSURANCE

A. System efficiencies (SEER and HSPF) for units less than 65,000 BTUH shall be certified by AHRI standard 210-240, and shall be published for public review at www.ahrinet.org. Equipment that is "rated" in accordance with AHRI Standard 210-240, but not published for public review by AHRI shall not be accepted.

B. System efficiencies (IEER and SCHE) for units greater than 65,000 BTUH shall be certified by AHRI standard 1230, and shall be published for public review at www.ahrinet.org. Equipment that is "rated" in accordance with AHRI Standard 1230, but not published for public review by AHRI shall not be accepted.

C. The units shall be listed by Electrical Laboratories (ETL) and bear the ETL label.

D. All wiring shall be in accordance with the National Electrical Code (N.E.C.).

E. Project shall comply with the applicable version of ASHRAE standard 15.

F. Project shall comply with the applicable version of ASHRAE 90.1

G. The VRF manufacturing facility shall be registered to ISO 9001 and ISO14001.

H. All components shall be provided by one manufacturer including but not limited to:

1. Outdoor Units
2. Indoor Units
3. Mode Control Units as required
4. All necessary and applicable controls for the VRF System
5. Factory refrigerant charge for outdoor unit(s) only
6. Factory Wye -Branch(s) as required
7. Condensate Lift Pump(s) as shown on the contract documents
8. Refrigerant Ball Valves as shown on the contract documents
9. Service Software

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in a clean and dry place.

B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.

C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.

D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.

1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remover coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.

E. Replace installed products damaged during construction.

1.7 WARRANTY

A. The units shall be covered by the manufacturer's standard limited warranty for a period of 12 months from date of installation. If during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer.

B. The IDU units, MS Boxes and compressors shall carry an extended manufacturer's parts warranty for a period of 5 years from date of installation. The following steps shall be taken by the contractor to ensure systems are eligible for extended warranty.

1. System is designed and submitted using the approved application tool.
2. Upon completion of installation and prior to final commissioning, contractor shall provide revised piping layout reflecting actual installation conditions to VRF manufacturer.
3. Provide a verified and submitted commissioning report to manufacturer.

C. The contractor shall provide labor warranty as specified in the general conditions for this project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Lennox air-cooled VRF system with simultaneous heating and cooling, or approved equal.

B. Source Limitations: Obtain products from single source from single manufacturer including, but not limited to, the following:

1. Indoor and outdoor units, including accessories.
2. Controls and software.
3. Refrigerant energy recovery units (refer to system design if applicable)
4. Expansion valves.
5. Specialty refrigerant pipe fittings.

2.2 SYSTEM DESCRIPTION

A. Direct-expansion (DX) VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, refrigerant energy recovery units, outdoor units, piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.

1. System shall include heat recovery at zone level refrigerant energy recovery units.
2. Common refrigerant circuit shared by all indoor units connected to each system.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. AHRI Compliance: System and equipment performance certified according to AHRI 1230.

D. ASHRAE Compliance:

1. ASHRAE 15: For safety code for mechanical refrigeration.
2. ASHRAE 62.1: For indoor air quality.
3. ASHRAE 135: For control network protocol with remote communication.
4. ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.

E. UL Compliance: Comply with UL 1995.

2.3 EXPOSED, WALL-MOUNTED INDOOR UNIT

A. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, internal piping, the electronic modulating linear expansion device, control circuit board, and fan motor. The unit shall have a self-diagnostic function, time delay mechanism, an auto restart function. The unit shall be provided with a face mounted infrared receiver for use with a handheld wireless remote controller. The unit shall have an integral return air sensor.

B. The unit casing shall have a white finish, with multi directional drain and refrigerant piping offering multiple directions for condensate drainage. The unit shall be secured firmly to the wall with factory mounting plate.

C. The indoor fan shall consist of a cross-flow fan with a single direct drive motor. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings. A manual adjustable guide vane shall be provided to change the airflow from side to side (left to right) as desired. A motorized air sweep louver shall provide an automatic change in airflow by directing the air up and down to provide uniform air distribution. The indoor fan shall have multiple speeds.

D. Return air shall be filtered by means of an easily removable, washable filter.

E. The indoor coil shall be constructed as follows:

1. The indoor coil shall be of nonferrous construction with slit fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.
6. The coil fins shall be coated with hydrophilic paints.

7. The optional field installed condensate lift mechanism shall be able to raise drain water 29.5 inches water column above the condensate pan.
8. Both refrigerant lines to the indoor units shall be insulated.

F. Use 18-2 stranded and shielded wire for communications wiring. Splicing of communication wiring shall not be permitted.

G. This unit shall use controls provided by the original equipment manufacturer to perform functions necessary to operate the system.

2.4 CONCEALED, CEILING-MOUNTED, DUCTED INDOOR UNIT

A. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, the electronic modulating linear expansion device, control circuit board, and fan motor. The unit shall have a self-diagnostic function, time delay mechanism, and an auto restart function. The unit shall have integral return air sensor, integral discharge air sensor, and integral contacts to interface with an external auxiliary heat source.

B. The unit cabinet shall be a space saving, ceiling-concealed, ducted unit. The cabinet panel shall have provisions for a field installed filtered outside air intake.

C. The indoor unit fan shall consist of two or three fans, direct driven by a single motor. The indoor fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. The indoor fan shall have high, medium, and low fan speeds. The fan speed shall be adjustable by an optional remote controller. The airflow may also be adjusted based on static pressure.

D. The return air shall be filtered by means of a standard factory installed return air filter. For Ducted units, an optional return filter box (rear placement) with high-efficiency filter shall be available. If using the optional return filter box, verify the filter/filter box performance is within the bounds of the unit's external pressure performance.

E. The indoor coil shall be constructed as follows:

1. The indoor coil shall be of nonferrous construction with slit fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.
6. The coil fins shall be coated with hydrophilic paints.
7. The integral condensate lift mechanism shall be able to raise drain water 12 inches water column above the condensate pan.
8. Both refrigerant lines to the indoor units shall be insulated.

F. Use 18-2 strand shielded wire for communications wiring. Splicing of communication wiring shall not be permitted.

G. This unit shall use controls provided by the original equipment manufacturer to perform functions necessary to operate the system.

2.5 OUTDOOR, AIR-SOURCE HEAT RECOVERY UNITS (6 TO 36 TONS NOMINAL CAPACITY)

A. Basis-of-Design Product: Lennox VRF Heat Recovery Air Source outdoor units.

B. The Heat Recovery Air Source unit shall be used specifically with OEM Heat Recovery systems (simultaneous heating and cooling). Units shall have weather tight construction for outdoor installation, (outdoor unit).

C. Each zone shall have a dedicated space temperature controller. The Heat Recovery system shall provide simultaneous heating and cooling without the use of reheat.

D. Heat Recovery outdoor units shall be equipped with multiple circuit boards. These boards shall perform all functions necessary for operation of the outdoor units.

E. The outdoor unit shall be completely factory assembled, internally piped and wired. Each unit shall be run tested at the factory.

1. The combination ratio of the nominal indoor cooling capacity versus the nominal outdoor rated cooling capacity shall range from 50% to 130%.
2. Outdoor unit shall have a sound rating no higher than 68 dB(A)
3. Unit shall have a night quiet setting to reduce nighttime sound levels.
4. All refrigerant lines from the outdoor unit to the MCU (Mode Change Unit), and or from MCUs to IDUs (Indoor Units,) shall be field insulated with a minimum insulation as referenced in the VRF manufacturer's IOM.
5. The outdoor unit shall have an accumulator with crank case heater and controls.
6. The outdoor unit shall have a high pressure safety switch, fuse, over-current protection and crank case heater.
7. If the outdoor unit is above the indoor unit, the outdoor unit shall have the ability to operate with a maximum height difference of 360ft
8. If the outdoor unit is below the indoor unit, the outdoor unit shall have the ability to operate with a maximum height difference of 230 ft.
9. The system shall have a maximum total refrigerant tubing length of 3280 ft.
10. The maximum length between first branch and the furthest indoor units is not to exceed 295 ft.
11. The maximum height difference between MCU boxes on the same system shall be 98 ft.
12. The maximum height difference between indoor units on the same system shall be 98 ft.
13. The outdoor unit shall be capable of operating in cooling mode from 5°F to 125°F.
14. The outdoor unit shall be capable of operating from -13°F to 125°F if the system is installed and configured per manufacturers guidelines.
15. The outdoor unit shall be capable of operating in heating mode from 80°F to -13°F ambient temperatures without additional low ambient controls, additional modules, or low ambient accessories.
16. The outdoor unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained. Oil return sequences must be enabled only during extended periods of reduced refrigerant flow to ensure no disruption to correct refrigerant flow to individual zones during peak loads. Systems which might engage oil return during inopportune periods are not allowed.
17. The outdoor units shall provide continuous heating during oil return and the defrost cycle through the use of rotational defrost. (multiple module systems). Unit must defrost all circuits simultaneously in order to resume full heating more quickly during extreme low ambient temperatures (below 23F). Partial defrost, also known as hot gas defrost which allows reduced heating output during defrost, is permissible only when ambient temperature is above 23F.
18. While in hot gas defrost the system shall slow the indoor unit fan speed down to maintain a high discharge air temperature, systems that keep fan running in same state shall not be allowed as they provide an uncomfortable draft to the indoor zone due to lower discharge air temperatures.

19. In reverse defrost all refrigerant shall be bypassed in the main branch controller and shall not be sent out to the indoor units, systems that flow refrigerant through indoor units during reverse defrost shall not be allowed.

F. The unit casing(s) shall be fabricated of galvanized steel, bonderized and finished with a powder coated baked enamel.

G. The outdoor condenser fan shall be furnished with direct drive motors(s). All fan motors shall have inherent motor protection, and permanently lubricated bearings. All fan motors shall be mounted for quiet operation. All fans shall be provided with a raised guard to prevent contact with moving parts. The fans shall have vertical discharge airflow.

H. R410A refrigerant shall be required for VRF outdoor unit systems.

I. System shall use Polyvinylether (PVE) oil. Due to the increased risk of hydrolysis and formation of acids, Polyolester (POE) oil shall not be acceptable.

J. The outdoor condenser coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing. The condenser coil shall have Blue Fin anti-corrosion protection as a standard feature. The coil shall be protected with an integral metal guard. The coil fins shall be coated with hydrophilic paints. Coil shall be capable of withstanding 1000 hour salt spray test.

K. The outdoor units shall be equipped with inverter driven scroll compressor(s).

1. The outdoor unit compressor shall utilize inverter driven technology to modulate capacity. The compressors shall also utilize advanced technology adaptive sine wave control for reduced harmonics and faster frequency acceleration.
2. The compressor shall be capable of 1/60th second advanced micro-control.
3. The outdoor unit compressor shall utilize vapor injection technology which shall increase the mass flow rate of refrigerant, resulting in improved performance for low temperature conditions.
4. The compressor will be equipped with an internal thermal overload protection.
5. The compressor shall be mounted to avoid the transmission of vibrations.

L. Use 18-2 stranded and shielded wire for communications wiring. Splicing of communication wiring shall not be permitted.

2.6 BRANCH REFRIGERANT CONTROL BOXES (MS BOX)

A. The MS Box shall be used for applications requiring simultaneous heating and cooling.

B. MS Boxes require they be used in conjunction with VRF Heat Recovery air source units. These units shall be equipped with a circuit board that shall perform all functions necessary for operation.

C. The MS Box shall be completely factory assembled, internally piped and wired. Unit shall be run tested. This unit shall be mounted indoors.

D. Each MS Box shall be capable of transferring heat to connected associated indoor units, and to the connected air source unit. This shall allow simultaneous heating and cooling without the need for reheat.

E. Isolation valves with access ports shall be provided on the entering and leaving refrigerant circuits when shown on the drawings.

F. Additional subcooling shall be provided at the MS Box. The additional subcooling ~~is~~ shall mitigate losses due to pipe length and heat gain and ensure scheduled capacity at the indoor unit.

G. The MS Box casing shall be fabricated of galvanized steel. Each cabinet shall house multiple refrigeration control valves. The unit shall house tube-in-tube heat exchangers (sub cooling) to ensure heating and cooling capacity at the indoor unit.

H. The MS Box shall be furnished with multiple two position refrigerant valves. Linear electronic expansion valves shall be used to control the variable refrigerant flow.

I. An integral MS Box condensate pan and drain connection shall be provided as required. The MS Box shall be connected with a field installed drain line.

J. Use 18-2 stranded a wire for communications wiring. Splicing of communication wiring shall not be permitted.

K. The control circuit between the indoor units and outdoor units shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

2.7 SYSTEM ACCESSORIES

A. Wye-Joint Kits – are a required component for basis of design VRF systems capable of operating multiple outdoor modules on a single system. T-Joints are not acceptable. Wye-Joints shall be provided with polystyrene insulation. Wye-Branches shall facilitate different pipe sizes. Field fabrication or substitution of joints shall void warranty. Kits shall be installed per manufacturer guidelines. Requires field installation. Requires manufacturer inspection.

B. EEV KITs- the EEV (Electronic Expansion Valve) are internally provided in all systems by the VRF manufacturer.

C. Condensate Drain Pumps shall be provided for field installation as required for efficient condensate management. Remote Condensate pumps shall be capable of 29.5" of lift to allow condensate to reach the closest gravity drain line. Condensate pumps shall include a check valve to prevent water form flowing back into the indoor unit. Internal Condensate Pump shall be mounted in the chassis of the indoor unit. Pump shall draw on required power from the associated indoor unit Refrigerant Isolation Ball Valves - shall be provided for field installation as specified by the contract documents. Valves shall utilize a uni-body full port design to minimize leaks and internal pressure drops. Valves shall be rated for 700PSIG, Valves shall require polytetrafluoroethylene (PTFE) seals and gaskets. No synthetic O-rings are allowed. Design shall permit valve operation without removal of seal cap. Valves shall have a temperature operation range of -40°F to 300°F. Valves 5/8" and smaller can be flare fittings. Valves larger than 5/8" shall be sweat fittings. Valves shall be provided with formed and fitted insulated jacket. Requires field installation.

D. Wired Remote Temperature Controller shall be used with all VRF Indoor Units. Remote shall utilize a multi-function LCD display and shall possess the following functionality:

1. Power on/off setting
2. Digital Display
3. Temperature set point control

4. Built-in room temperature sensor
5. Operation mode: Auto-Cool-Dry-Fan-Heat
6. Fan speed: Auto-Low-Med-High
7. Filter alarm reset (timer)
8. Real-time clock includes current time, day display
9. Daylight savings time adjustment (program in the date)
10. Weekly operating scheduling
11. Error display
12. Service Mode provides configuration settings
13. Security lock code

2.8 SYSTEM CONTROLS

A. The VRF system network controls shall consist of individual controllers, system controllers, and an integrated management system. Network Controls shall support operation monitoring, scheduling, error monitor, power distribution, personal browsers, , online maintenance support, and integration with Building Management Systems (BMS) using BACnet® interfaces.

B. The VRF system network controls shall be capable of supporting remote controllers, system controllers, centralized controllers, an integrated web-based interface, graphical user workstation, and system integration to Building Management Systems via BACnet®.

C. The VRF system network controls shall operate at 12VDC. Controller power and communications shall be via a common communications bus.

D. Control wiring shall be installed in a system daisy chain configuration from the wired remote controller to the indoor unit, to the and to outdoor unit. Control wiring to wired remote controllers shall be run from the indoor unit terminal block to the controller associated with that unit.

E. Control wiring for system controllers, and centralized controllers shall be installed in a daisy chain configuration from interface module to interface module, to system controllers, to the power supply.

F. For communication wiring between ODUs, IDUs, BC's and system controller use 18-2 for remote controllers use 18-3 stranded and shielded wire. Splicing of communication wiring shall not be permitted.

G. The VRF web user interface shall be capable of being networked with all connected system controllers for web based control.

2.9 VRF CENTRAL SYSTEM CONTROLLER WHEN REQUIRED

A. The VRF System Controller is an intelligent field panel that communicates with VRF Outdoor Unit(s), Indoor Unit(s) and other VRF controllers. The VRF System Controller shall scan all controllers to update information and coordinate building control. The VRF System Controller shall connect to associated indoor and outdoor units utilizing a dedicated control network, and over a local area network (LAN) to provide a web page-based user interface available wherever the building's network access is available. The VRF System Controller shall be housed in a protective enclosure suitable for wall-mounting in a mechanical or electrical equipment room.

B. The VRF System Controller shall allow a building operator to view the system using a PC with a standard web browser.

C. The VRF System Controller shall include a user interface that includes control and monitoring of each Indoor unit through a standard graphical display with convenient pop-up controller screen to adjust comfort settings for each zone.

D. The VRF System Controller shall be capable of controlling a maximum of 256 indoor units via a PC. The VRF System Controller shall support operation superseding that of the remote controllers, system configuration, 1-day/daily/weekly scheduling, monitoring of operation status, error email notification and malfunction monitoring.

E. Provide an operator workstation for use in hosting the VRF system controller software. Refer to Division 230900 for operator workstation requirements.

F. The VRF System Controller shall have a basic set of operation controls which can be applied to an individual indoor unit, a group of indoor units (up to 256 indoor units), or all indoor units (collective batch operation).

G. The basic set of operation controls for the VRF System Controller shall include on/off, operation mode selection (auto, cool, heat, dry, and fan), temperature setting, fan speed setting, airflow direction setting, error email notification.

H. Since the VRF System Controller provides centralized control, it shall be able to enable or disable operation of local remote controllers via the operator workstation. In terms of scheduling, the VRF SC shall allow the user to define 1-day, daily, and annual schedules with operations consisting of ON/OFF, mode selection, temperature setting, permit/prohibit of wireless/wired remote controllers.

I. The system shall detect and store alarms in the Alarm Log. The Alarm Log shall display critical data about the alarm, including the location of the device, and the time of occurrence. Alarms shall be routed by e-mail to stationary or mobile devices. Capacity to store up to 1024 alarm events on time specific basis shall be required.

J. Database changes made by other users shall automatically be reflected in the VRF System Controller without the need for a central server. The system database be capable of archiving or backing up data for local or offsite storage. This is desirable in the event the date is ever needed for restoring the system. A built-in SD card slot provides for on-board but removable data backup storage.

K. A password shall protect the VRF control system from unauthorized access. Each operator is assigned a role. Roles are defined by access rights. Pre-defined roles shall be selected from the VRF System Controller interface. Operators shall have access only to those features which define their roles. Roles may also be customized. An operator with administrative-level security shall access all information on the system, and shall have the ability to alter passwords and create new security roles.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine products before installation. Reject products that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.

D. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.

E. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.

F. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.

G. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

H. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION, GENERAL

A. Clearance:

1. Maintain manufacturer's recommended clearances for service and maintenance.
2. Maintain clearances required by governing code.

B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.

3.3 INSTALLATION OF INDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch.

C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.

D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.

E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.

F. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.

G. Provide lateral bracing if needed to limit movement of suspended units to not more than 0.25 inch.

H. For wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.

I. Attachment: Install hardware for proper attachment to supported equipment.

J. Grouting: Place grout under equipment supports and make bearing surface smooth.

3.4 INSTALLATION OF OUTDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Install outdoor units on support structures indicated on Drawings.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage VRF HVAC system manufacturer's service representative to advise and assist installers; witness testing; and observe and inspect components, assemblies, and equipment installations, including controls and connections.

1. Field service shall be performed by a factory trained and authorized service representative of VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.

    a. Additional factory-authorized representatives may assist with completion of certain activities only if supervised by manufacturer's employee. A factory-authorized representative shall not provide assistance without manufacturer's employee supervision.

2. Manufacturer shall provide on-site visits during the course of construction at installation milestones indicated. System Installer shall coordinate each visit in advance to give manufacturer sufficient notice to plan the visit.

    a. First Visit: Kick-off meeting.
    b. Second Visit: At approximately 50 percent completion of system(s).
    c. Third Visit: Final inspection before system startup.

3. Kick-off Meeting:

    a. Meeting shall include system Installer and other related trades with sole purpose of reviewing VRF HVAC system installation requirements and close coordination required to make a successful installation.
    b. Meeting shall be held at Project site and scheduled at a mutually agreed to time that occurs before the start of any part of system installation.
    c. Meeting shall cover the following as a minimum requirement:

        1) Review of latest issue of Contract Documents, Drawings, and Specifications, relevant to VRF HVAC systems.
        2) Manufacturer's installation requirements specific to systems being installed.
        3) Review of all relevant VRF HVAC system submittals, including delegated-design submittals.
        4) Required field activities related installation of VRF HVAC system.
        5) Project team communication protocol, contact information, and exchange of responsibilities for each party involved, including manufacturer, supplier, system Installer, and other related trades.

4. Site Visits: Activities for each site visit shall include the following:

a. Meet with VRF HVAC system Installer to discuss field activities, issues, and suggested methods to result in a successful installation.
b. Offer technical support to Installer and related trades as related to VRF system(s) being installed.
c. Review progress of VRF HVAC system(s) installation for strict compliance with manufacturer's requirements.
d. Advise and, if necessary, assist Installer with updating related refrigerant calculations and system documentation.
e. Issue a report for each visit, documenting the visit.

1) Report to include name and contact information of individual making the visit.
2) Date(s) and time frames while on-site.
3) Names and contact information of people meeting with while on-site.
4) Clearly identify and list each separate issue that requires resolution. For each issue, provide a unique identification number, relevant importance, specific location or equipment identification, description of issue, recommended corrective action, and follow-up requirements needed. Include a digital photo for clarification if deemed to be beneficial.

5. Final Inspection before Startup:

a. Before inspection, Installer to provide written request to manufacturer stating the system is fully installed according manufacturer's requirements and ready for final inspection.
b. All system equipment and operating components shall be inspected. If components are inaccessible for inspection, they shall be made accessible before the final inspection can be completed.
c. Manufacturer shall provide a comprehensive inspection of all equipment and each operating component that comprise the complete system(s). Inspection shall follow a detailed checklist specific to each equipment and operating component.
d. Inspection reports for indoor units shall include, but not be limited to, the following:

1) Unit designation on Drawings.
2) Manufacturer model number.
3) Serial number.
4) Network address, if applicable.
5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.
11) Low-voltage reading(s) within an acceptable range.
12) Controller type and model controlling unit.
13) Controller location.
14) Temperature settings and readings within an acceptable range.
15) Humidity settings and readings within an acceptable range.
16) Condensate removal acceptable.
17) Fan settings and readings within an acceptable range.
18) Unit airflow direction within an acceptable range.
19) If applicable, fan external static pressure setting.
20) Filter type and condition acceptable.
21) Noise level within an acceptable range.
22) Refrigerant piping properly connected and insulated.
23) Condensate drain piping properly connected and insulated.

24) If applicable, ductwork properly connected.
25) If applicable, external interlocks properly connected.
26) Remarks.

e. Inspection reports for outdoor units shall include, but not be limited to, the following:

1) Unit designation on Drawings.
2) Manufacturer model number.
3) Serial number.
4) Network address, if applicable.
5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.
11) Low-voltage reading(s) within an acceptable range.
12) Condensate removal acceptable.
13) Noise level within an acceptable range.
14) Refrigerant piping properly connected and insulated.
15) Condensate drain piping properly connected and insulated.
16) Remarks.

f. Inspection reports for indoor, dedicated outdoor air ventilation units shall include, but not be limited to, the following:

1) Unit designation on Drawings.
2) Manufacturer model number.
3) Serial number.
4) Network address, if applicable.
5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.
11) Low-voltage reading(s) within an acceptable range.
12) Controller type and model controlling unit.
13) Controller location.
14) Temperature settings and readings within an acceptable range.
15) Humidity settings and readings within an acceptable range.
16) Condensate removal acceptable.
17) Fan settings and readings within an acceptable range.
18) Fan external static pressure setting.
19) Filter type and condition acceptable.
20) Noise level within an acceptable range.
21) Refrigerant piping properly connected and insulated.
22) Condensate drain piping properly connected and insulated.
23) Automatic dampers properly installed and operating.
24) Ductwork properly connected.
25) If applicable, external interlocks properly connected.
26) Remarks.

g. Inspection reports for energy recovery ventilators shall include, but not be limited to, the following:

1) Unit designation on Drawings.
2) Manufacturer model number.
3) Serial number.
4) Network address, if applicable.
5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.
11) Low-voltage reading(s) within an acceptable range.
12) Controller type and model controlling unit.
13) Controller location.
14) Temperature settings and readings within an acceptable range.
15) Humidity readings.
16) Condensate removal acceptable.
17) Fan settings and readings within an acceptable range.
18) Fan external static pressure setting.
19) Filter type and condition acceptable.
20) Noise level within an acceptable range.
21) Automatic dampers properly installed and operating.
22) Ductwork properly connected.
23) If applicable, external interlocks properly connected.
24) Remarks.

h. Installer shall provide manufacturer with the requested documentation and technical support during inspection.
i. Installer shall correct observed deficiencies found by the inspection.
j. Upon completing the on-site inspection, manufacturer shall provide a written report with complete documentation describing each inspection step, the result, and any corrective action required.
k. If corrective action is required by Installer that cannot be completed during the same visit, provide additional visits, as required, until deficiencies are resolved and systems are deemed ready for startup.
l. Final report shall indicate the system(s) inspected are installed according to manufacturer's requirements and are ready for startup.

B. Perform the following tests and inspections with the assistance of manufacturer's service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Refrigerant Tubing Positive Pressure Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.

2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.5 times VRF HVAC system operating pressure, but not less than 650 psig, for 1 hour using dry nitrogen.
3. Successful testing shall maintain a test pressure of 470 psig for a continuous and uninterrupted period of 24 hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.
4. Prepare test report to record the following information for each test:

    a. Name of person starting test, company name, phone number, and e-mail address.
    b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
    c. Detailed description of extent of tubing tested.
    d. Date and time at start of test.
    e. Test pressure at start of test.
    f. Outdoor temperature at start of test.
    g. Name of person ending test, company name, phone number, and e-mail address.
    h. Date and time at end of test.
    i. Test pressure at end of test.
    j. Outdoor temperature at end of test.
    k. Remarks:

5. Submit test reports for Project record.

D. Refrigerant Tubing Evacuation Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of 500 microns.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of four hour(s) with no change.
4. Prepare test report to record the following information for each test:

    a. Name of person starting test, company name, phone number, and e-mail address.
    b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
    c. Detailed description of extent of tubing tested.
    d. Date and time at start of test.
    e. Test pressure at start of test.
    f. Outdoor temperature at start of test.
    g. Name of person ending test, company name, phone number, and e-mail address.
    h. Date and time at end of test.
    i. Test pressure at end of test.
    j. Outdoor temperature at end of test.
    k. Remarks:

5. Submit test reports for Project record.
6. Upon successful completion of evacuation testing, system shall be charged with refrigerant.

E. System Refrigerant Charge:

1. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.

2. Installer shall charge system following VRF HVAC system manufacturer's written instructions.
3. System refrigerant charging shall be witnessed by system manufacturer's representative.
4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.

F. Products will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.

1. Service representative shall be a factory trained and authorized service representative of VRF HVAC system manufacturer.
2. Complete startup service of each separate system.
3. Complete system startup service according to manufacturer's written instructions.

B. Startup checks shall include, but not be limited to, the following:

1. Check control communications of equipment and each operating component in system(s).
2. Check each indoor unit's response to demand for cooling and heating.
3. Check each indoor unit's response to changes in airflow settings.
4. Check each indoor unit, MCU, and outdoor unit for proper condensate removal.
5. Check sound levels of each indoor and outdoor unit.

C. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service.

1. Installer shall correct deficiencies found during startup service for reverification.

D. System Operation Report:

1. After completion of startup service, manufacturer shall issue a report for each separate system.
2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
3. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference.

    a. All available system operating parameters shall be included in the information submitted.

E. Witness:

1. Invite Architect, Owner, and Commissioning Agent to witness startup service procedures.
2. Provide written notice not less than 20 business days before start of startup service.

3.7 ADJUSTING

A. Adjust equipment and components to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.

C. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.

D. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 PROTECTION

A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.

B. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections shall be grounds for removal and replacement.

C. Protect equipment from electrical damage. Replace equipment suffering electrical damage.

D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

END OF SECTION 238129

ELECTRICAL SPECIFICATIONS
TABLE OF CONTENTS
DIVISIONS 26

SECTION 26 05 02 - ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. This Section supplements Division 1, General Requirements.

B. Where contradictions occur between this Section and Division 1, the more stringent of the two shall apply. Architect shall decide which is most stringent.

C. Provisions of Divisions 21, 22, 23, 27 and 28 shall also apply to the work of this section as if fully repeated here.

D. Provision indicate Section 23 05 01/26 05 01 "Mechanical and Electrical Coordination" shall also apply to the work of this section as if fully repeated here.

1.2 REGULATORY REQUIREMENTS

A. All materials shall conform to the current applicable industry standards. Workmanship and neat appearance shall be as important as electrical and mechanical operation. Defective or damaged materials shall be replaced or repaired prior to final acceptance in a manner meeting approval of the Architect and at no additional cost to the Owner.

B. The latest editions of the following standards are minimum requirements.
1. Underwriters' Laboratories, Inc. (UL)
2. National Electrical Manufacturer's Assoc. (NEMA)
3. American National Standards Institute (ANSI)
4. Institute of Electrical and Electronic Engineers (IEEE)
5. International Electrical Testing Association (NETA)
6. Insulated Cable Engineer's Association (ICEA)

C. All work and materials shall comply with latest rules, codes and regulations including, but not limited to the following:
1. OSHA.
2. National Fire Codes of National Fire Protection Assoc. (NFPA)
3. National Electrical Safety Code (NESC, ANSI C2)
4. National Electrical Code (2017 Edition) with city, county and state Amendments.
5. International Building Code (2018 Edition) with city, county and state Amendments.
6. Americans with Disabilities Act (ADA).
7. All applicable Federal, state and local laws, code amendments and regulations.

D. Code compliance is mandatory. Nothing in these drawings and specifications permits work not conforming to these codes.

E. No work shall be concealed until after inspection and approval by proper authorities. If work is concealed without inspection and approval, Contractor shall be responsible for all work required to open and restore the concealed area including all required modifications.

F. Contradictions: Where Codes are contradictory, follow the most stringent. Architect/Engineer shall determine which is most stringent.

1.3 CONTRACT DOCUMENTS

A. Drawings indicate general arrangement of circuits and locations of outlets, conduit, and other work. Information shown on drawings is as accurate as planning can determine, but not guaranteed and field verification of all dimensions, locations, levels, etc., to suit field conditions

is directed. Review all architectural, structural and mechanical drawings, and adjust all work to conform to all conditions shown therein. Architectural drawings shall take precedence over all other drawings. Discrepancies between different drawings or between drawings and specifications or regulations and codes governing installation shall be brought to attention of the Architect.

B. Where the Drawings and Specifications do not comply with the minimum requirements of the Codes, either notify the Architect/Engineer in writing during the Bidding Period of the revisions required to meet Code requirements, or provide an installation which complies with the Code requirements. After entering into contract, Contractor will be held to complete all work necessary to meet these requirements without additional expense to the Owner.

C. Follow Drawings and Specifications where they are superior to Code requirements. The more stringent of plans and drawing shall apply.

1.4 COORDINATION DRAWINGS

A. Prepare coordination drawings in accordance with Division 1 "Submittals" to a scale of ¼" = 1'-0" or larger; detailing major elements, components, and systems of electrical equipment (i.e., all transformer vaults, switchgear rooms, generator rooms, electrical rooms and technology rooms) and materials in relationship with other systems, installations, and building components. Where equipment is located outdoors, prepare shop drawings indicating electrical equipment locations and exterior elements in the equipment areas. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are important to the efficient flow of the work, including (but not necessarily limited to) the following:
   1. Indicate the proposed locations of major raceway systems, and materials. Include the following:
      a. Exterior wall and foundation penetrations.
      b. Fire-rated wall and floor penetrations.
      c. Support details.
      d. Sizes and location of required concrete pads and bases.
   2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
   3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installation.

1.5 RECORD DRAWINGS

A. Refer to Division 1 for additional requirements.

B. Maintain a blue-line set of Electrical Contract Drawings in clean, undamaged condition, for mark-up of installations which vary from the Contract Drawings. These drawings shall be a separate set of drawings, not used for construction purposes, and shall be kept up to date as the job progresses. This set shall be made available for inspection by the Engineer or Architect at all times. Upon completion of the contract a set of computerized "as builts" capable of interfacing with AutoCAD software, shall be delivered to the Architect.

C. Prepare record documents in accordance with the requirements in Division 1 Section "Project Closeout." In addition to the requirements specified in Division 1, indicate installed conditions for:
   1. Major raceway systems, size and location, for both exterior and interior and locations of handholes and conduit stub-up locations.
   2. Panelboard circuit directories reflecting all field changes.
   3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
   4. Results of all testing performed as specified in the specification.
   5. Certification of inspection from Authorities Having Jurisdiction.

D. Record the locations and invert elevations of underground installations.

1.6 OPERATING AND MAINTENANCE MANUALS

A. Refer to Division 1 for additional requirements.

B. Submission:
   1. Submit an electronic copy of Operating and Maintenance Manuals prior to scheduling systems demonstration for the Owner.

C. Requirement Contents:
   1. Manuals shall have either a combined file with bookmarks for each section or individual file for each section. If individual files, each digital file shall include section number and title in the file name.
   2. Submittal for each section shall identify all equipment and materials installed on the project.
   3. Manual to include contact information for a local supplier that can provide the specific piece of equipment.
   4. Provide certificates for such items of equipment which have warranties in excess of one year.
   5. Provide test results for each specification section identified herein.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

B. Protection of Equipment:
   1. All electrical equipment to be used in the construction shall be properly stored and protected against the elements. All equipment shall be stored under cover, and shall not be stored at the construction site on the ground, in mud, water, rain, sleet, or dust. Large diameter cables may be stored on reels outside; however, all cable ends shall be waterproofed and the reels covered with weatherproof materials. Such weatherproof materials shall be heavy-duty, securely fastened, and made impervious to the elements.
   2. Conventional electrical construction materials such as building wire, outlet and junction boxes, wiring devices, conduit, lighting fixtures, fittings, etc., shall be stored in construction buildings, covered trailers, or portable covered warehouses. Any equipment subject to damage or corrosion from excessive moisture shall be stored in dry, heated areas. Any equipment containing plastic or material subject to damage caused by excessive heat or sunlight shall be stored to prevent such damage. This includes plastic ducts and lenses.
   3. Equipment damaged as a result of the above conditions shall be properly repaired at the contractor's expense or shall be replaced at the contractor's expense, if in the opinion of the Engineer, the equipment has been damaged to such an extent that it cannot operate properly after repairs are made.
   4. All electrical enclosures exposed to construction damaged such as paint spots, spackling or plaster spatter, grout splashes, waterproofing compound, tar spots or runs, and pipe covering compound splashes, shall be completely covered and protected against damage.
   5. In the event leakage into the building of any foreign material or fluid occurs or may occur, the contractor shall take all steps as described above to protect any and all equipment.
   6. After connections to electrical equipment are complete and the equipment is ready for operation, all construction debris shall be removed from all enclosures. Such debris includes dust, dirt, wire clippings, tape, and insulation removed in order to make the connection.

1.8 SAFETY AND INDEMNITY

A. The Contractor shall be solely and completely responsible for conditions of the job site, including safety of all persons and property during performance of the work. This requirement will apply continuously and not be limited to normal working hours. See also General Conditions.

B. No act, service, drawings review or construction review by the Architect or Engineer, is intended to include review of the adequacy of the Contractor's safety measures in, on, or near the construction site.

1.9 WARRANTIES

A. The warranty period is generally one year after Date of Acceptance.
   1. During this period, provide labor and materials as required to repair or replace defects in the electrical systems at no cost to the Owner. Provide certificate with O & M manual submittal which guarantees same day service response to the Owner's call for such warranty service.
   2. Provide certificates for such items of equipment which have warranties in excess of one year. Insert copies of O & M manual. Such equipment shall include:
      a. New electrical panelboards
   3. Provide extended manufacturers warranties to cover one full year from Date of Acceptance if standard manufacturers' warranty ends any time prior to that date.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIALS

A. All equipment and materials installed shall be new, unless otherwise specified.

B. All major equipment components shall have manufacturers' name, address, model number and serial number permanently attached in a conspicuous location.

C. All equipment shall be UL listed and bear the UL label.

D. All areas directly exposed to outside air shall be considered exterior. Contractor's electrical installation, means and methods and materials used shall be appropriate for outdoor installations in these areas.

2.2 GENERAL SUBMITTAL REQUIREMENTS

A. Coordination and Sequencing:
   1. After receipt of notice to proceed, the Contractor shall submit to the Architect a typed list of submittals and the scheduled date of submission. List shall include submittal number, section number and scheduled date of submission. Submittals shall be grouped and submitted in no more than ten complete packages.
   2. The contractor shall not submit any shop drawings or product data that does not comply with the contract documents. Prior to submitting shop drawings, review submittal for compliance with Contract Documents and place a stamp or other confirmation thereon which states that submittals have been reviewed. Submittals without such verification will be returned disapproved without review.
   3. Submittal is for information and record, unless otherwise indicated, and is not a change order request.

B. Preparation of Submittals:
   1. Refer to Division 1 requirements.

2. The Contractor shall submit for approval by the Architect data of materials and equipment to be incorporated in the work. Submittals shall be supported by descriptive material, catalogs, cuts, diagrams, performance curves, and charts published by the manufacturer to show conformance to specification and drawing requirements; model numbers alone will not be acceptable. Provide complete electrical characteristics for all equipment. Submit product submittals on items as outlined in sections hereinafter.
3. Product submittals shall be made by specification section. All items of a section, requiring submission, shall be submitted together in one individual electronic file.
4. If two or more sections require inter-coordination (e.g., emergency generator and transfer switch; short circuit study, coordination study, electrical room layouts and electrical switchboards, fire alarm and fire command center layout), they shall be submitted at the same time. If electrical gear is submitted without electrical room layouts, short circuit study, coordination study, the submittal will be returned without review.
5. Each section shall be submitted as an individual file with section number and section name in the file name of the submittal.
6. Submittals of an entire product catalog will be rejected without review. Products to be used on the project must be indicated on cut sheets.
7. Provide cover letter in electronic file identifying project name, Contractor, Subcontractor, submittal name, date of submission, specification section, and information to distinguish it from other submittals.
8. Submittals not presented in individual electronic files or neat and legible fashion will returned "Without Action."
9. Submittals shall show Contractor's executed review and approval marking. Submittals which are received from sources other than through Contractor's office will be returned "Without Action."
10. Provide space for Architect's "Action" marking.

C. Substitutions
1. Refer to the General Conditions, which govern "Substitution" of specified equipment or materials.
2. Indicate any portions of work which deviate from the Contract Documents.
   a. Explain the reasons for the deviations.
   b. Show how such deviations coordinate with interfacing portions of other work.
3. Where substitution of materials alters space requirements indicated on the drawings, submit shop drawings indicating proposed layout of space, all equipment to be installed therein and clearances between equipment (i.e., electrical rooms). All clearances required by the National Electrical Code and applicable state and local regulations must be maintained.

D. Review Process
1. The Architect reserves the right to require a sample of any equipment to be submitted for approval and to retain its possession.
2. Refer to the individual sections for identified equipment and material for which submittals are required. In addition, provide shop drawings and product data on the following equipment:
   Electrical Power Conductors and Cables
   Grounding and Bonding
   Hangers and Supports
   Raceway and Boxes
   Identification
   Panelboards
   Fuses
   Surge Protection Device
   Enclosed Switches and Circuit Breakers
   Power Distribution Units (PDU)
   Static Uninterruptable Power Supply (UPS)

Do not submit on equipment or materials not requested in the specifications.

3. Review of shop drawings and product data by the Architect/Engineer, including any review annotations or stamp notations, does not relieve the contractor from the required compliance with the contract documents.
4. The shop drawing and product data review stamp notation requirements are defined as follows:
   a. "NO EXCEPTION TAKEN:" The reviewer did not observe any items which were not in compliance with the contract documents. All dimensions, details, and coordination with other trades are the responsibility of the contractor.
   b. "MAKE CORRECTIONS NOTED:" The reviewer indicated items observed that were not in compliance with the contract documents. The contractor shall not resubmit, but shall make corrections and provide corrected documents with the "Record Drawings."
   c. "REJECTED, REVISE AND RESUBMIT:" The reviewer indicated items observed which were not in compliance with the contract documents. The contractor shall resubmit showing corrections of all noted items. Delays for resubmittal do not relieve the contractor from meeting project schedules.
   d. "REJECTED:" The submission does not comply with the contract requirements. The entire submittal must be corrected and submitted for review. Delays for resubmittal do not relieve the contractor from meeting project schedules.
5. If shop drawings are submitted and returned as "NO EXCEPTION TAKEN" or "MAKE CORRECTIONS NOTED" and meet contract requirements, the contractor shall not resubmit any other shop drawings for these items.
6. If resubmittals are necessary, they shall be made as specified above for submittals. Resubmittals shall highlight all revisions made and cover shall include the phrase "RESUBMITTAL NO. _____."
7. Resubmittal requirements do not entitle the Contractor to additional time and are not a cause for delay of the project.

PART 3 - EXECUTION

3.1 CONDITIONS AT SITE

A. Visit to site is required of all bidders prior to submission of bid. All bidders will be held to have familiarized themselves with all discernible conditions, and no extra payment will be allowed for work required because of these conditions, whether specifically mentioned or not.

B. Lines of other services and/or equipment that are damaged as a result of this work shall promptly be repaired at no expense to the Owner.

3.2 LICENSES, FEES AND PERMITS

A. Arrange for required inspections and pay all license, permit and inspection fees. Furnish a certificate of final inspections and approvals from local authority having jurisdiction over electrical installation.

3.3 WORKMANSHIP AND CONTRACTOR'S QUALIFICATIONS

A. Only professional quality workmanship will be accepted. Haphazard or poor installation practice will be cause for rejection of work.

B. Provide foreman in charge of this work at all times. Foremen for this work shall have had experience in installing not less than 5 such electrical systems of equal or greater complexity.

C. Where specifications call for an installation to be made in accordance with manufacturers' recommendations, a copy of such recommendations shall at all times be kept in job superintendent's office.

3.4 RELATION WITH OTHER TRADES

A. Contractor shall coordinate work of this Division with other trades to avoid conflict and to provide rough-ins and other connections for equipment furnished under other divisions that require electrical connections. Inform other trades of required clearances of accesses for or around electrical equipment to maintain serviceability and code compliance.

B. Verify equipment dimensions and rough-in requirements for Divisions 2 through 28 with provisions specified under this Section of work, and report discrepancies to the Architect in ample time to prevent delays or unwarranted changes of work.

3.5 TESTING

A. Provide all labor, materials, and equipment necessary to make required tests. Tests shall be complete and results approved before final inspection is begun.

3.6 PROGRESS OF WORK

A. Order progress of electrical work so as to conform to progress of work of other trades, and complete entire installation as soon as condition of building will permit. Assume any cost resulting from defective or ill-timed work performed under this Division.

3.7 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Division 1 Section "Cutting and Patching." In addition to the requirement specified in Division 1, the following requirements apply:
   1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
      a. Uncover work to provide for installation of ill-timed work.
      b. Remove and replace defective work.
      c. Remove and replace work not conforming to requirements of the Contract documents.
      d. Remove samples of installed work as specified for testing.
      e. Install equipment and materials in newly installed structures.
      f. Upon written instructions from the architect, uncover and restore work to provide for Architect observation of concealed work.

3.8 SLEEVES

A. Place sleeve in forms of walls, floor slabs and partitions for passage of all conduits, pipes, and ducts installed under Divisions 26, 27 and 28. Sleeves shall be set in place a sufficient time ahead of concrete work so as not to delay that work. Install sleeves and raceways through exterior walls so as to provide a waterproof installation. All floor penetrations shall be made watertight. Conduits passing through walls shall be installed to preserve integrity of the wall rating (i.e., fire rating, sound rating, air, etc.). All penetration made through existing concrete slabs or walls shall be x-rayed and approved by Structural Engineer prior to cutting.

3.9 CLEANUP

A. Remove all materials, scrap, etc., relative to electrical installations and leave premises in a clean, orderly condition. Any costs to the Owner for cleanup of site will be charged to the

Contractor. At completion, all equipment, raceways, etc., shall be thoroughly cleaned and all residue removed from the inside and outside surfaces. Defaced finish shall be refinished.

3.10 TEMPORARY POWER

A. Provide temporary power as requested by the general contractor and in accordance with OSHA and local code requirements. Lighting and power outlets shall be provided throughout the project. Check with construction manager or general contractor prior to bid for special lighting and power outlets and provide as needed.

3.11 MINOR CHANGES

A. The Owner reserves the right to make minor changes in the locations of outlets and equipment up to the time of electrical rough-in without any cost to the Owner.

3.12 ELECTRICAL SYSTEMS OPERATIONAL TESTS, CERTIFICATION, AND DESIGN AUTHORITY ASSISTANCE

A. Testing
   1. Refer to the individual specification sections for test requirements.
   2. Prior to the final inspection, the systems or equipment shall be tested and reported as herein specified. One electronic copy of the tests shall be submitted to the Architect/Engineer for approval.
   3. All electrical systems shall be tested for compliance with the specifications.

B. Design Authority Assistance
   1. The Contractor shall provide personnel to assist the Architect/Engineer or his representative during all construction review visits. The Contractor shall provide all necessary tools and equipment to demonstrate the system operation and provide access to equipment, including screwdrivers, wrenches, ladders, flashlights, circuit testing devices, meters, keys, etc.
   2. Remove equipment covers (i.e., switchgears, switchboards, panelboard trims, panelboards, motor controls, device plates, and junction box covers) as directed for inspection of internal wiring. Accessible ceiling shall be removed as directed for inspection of equipment installed above ceilings. Reinstall all covers or ceilings after inspection.
   3. Energize and de-energize circuits and equipment as directed. Demonstrate operation of equipment as directed by Architect/Engineer.
   4. The Contractor shall provide authorized representatives of the manufacturers to demonstrate to the Architect/Engineer compliance with the specifications of their respective system during or prior to the final inspection at a time designated by the Architect. Refer to the appropriate specification section for additional testing requirements. Representatives of the emergency generator/automatic transfer switch and fire alarm systems are required for demonstrations.

END OF SECTION

SECTION 26 05 03 - TESTING

PART 1 - GENERAL

1.1 RELATED WORK SPECIFIED ELSEWHERE

A. Acceptance and startup testing requirements for electrical power distribution equipment and systems. Contractor shall retain and pay for the services of a recognized independent testing firm for purpose of performing inspections and tests as herein specified.
   1. The testing firm shall provide all material, equipment, labor, and technical supervision to perform such tests and inspections.
   2. It is the purpose of these tests to assure that all tested electrical equipment is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications.
   3. The tests and inspections shall determine suitability for startup and energization.
   4. The following equipment shall be tested and calibrated:
      Electrical Power Conductors and Cables – Section 26 05 19
      Grounding and Bonding – Section 26 05 26
      Panelboards – Section 26 24 16

1.2 SUBMITTALS

A. Provide submittal per Contract General Conditions, Division 1, and Section 26 05 02.

B. Qualification of testing firm.

C. Submit one electronic copy of certified test reports to Engineer for approval.

D. One electronic copy of blank forms for checklists, test reports, and other related forms for Engineer's review and approval.

1.3 GENERAL REQUIREMENTS

A. The Contractor shall perform routine insulation resistance, continuity, and rotation tests for all distribution and utilization equipment prior to and in addition to any acceptance testing.

B. The Contractor shall test all lighting, low-voltage relays and circuits to ensure proper operating conditions prior to acceptance testing.

C. The Contractor shall perform visual and mechanical inspections, verifying that the equipment nameplate information meets the intent of the drawings and specifications.

D. The Contractor shall be responsible for all final settings and adjustments on protective devices and tap changes, submitting settings to the Architect/Engineer for review.

E. Provide a complete short-circuit study, equipment interrupting/withstand evaluation, and a protective device coordination study for the electrical distribution system described herein. This study shall be submitted with electrical equipment submission and electrical room layouts.

F. The Contractor shall engage the services of a recognized corporate and financially independent testing firm for the purpose of performing inspections and tests as herein specified.

G. The firm shall provide all material, equipment, labor, and technical supervision to perform such tests and inspections.

H. It is the purpose of these tests to assure that all tested electrical equipment is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications.

I. The tests and inspections shall determine suitability for energization. Equipment shall not be energized until accepted by the testing firm.

1.4 QUALIFICATIONS OF TESTING FIRM

A. The testing firm shall be a recognized corporate and financially independent testing organization which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems evaluated by the testing firm.

B. The testing firm shall be regularly engaged in the testing of electrical equipment devices, installations, and systems.

C. The testing firm shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, or be a Full Member company of the InterNational Electrical Testing Association (NETA).

D. The lead, on-site, technical person shall be currently certified by the InterNational Electrical Testing Association (NETA) or National Institute for Certification in Engineering Technologies (NICET) in electrical power distribution system testing.

E. The testing firm shall utilize engineers and technicians who are regularly employed by the firm for testing and engineering services. All studies, tests, and reports shall be sealed by a registered electrical professional engineer with a current **[Spec Writer: Add State]** stamp.

F. The testing firm shall submit proof of the above qualifications with bid documents, when requested.

G. The terms used herewith, such as test agency, test contractor, testing laboratory, or contractor test company, shall be construed to mean the testing firm.

1.5 APPLICABLE CODES, STANDARDS, AND REFERENCES

A. All inspections and tests shall be in accordance with the following codes and standards except as provided otherwise herein:
   1. National Electrical Manufacturer's Association - NEMA
   2. American Society for Testing and Materials - ASTM
   3. Institute of Electrical and Electronic Engineers - IEEE
   4. InterNational Electrical Testing Association - NETA Acceptance Testing Specifications - ATS-2009
   5. American National Standards Institute - ANSI C2: National Electrical Safety Code
   6. State and City of Lee's Summit, Missouri Codes and Ordinances
   7. Insulated Cable Engineers Association - ICEA
   8. Association of Edison Illuminating Companies - AEIC
   9. Occupational Safety and Health Administration - OSHA
   10. National Fire Protection Association - NFPA
      a. ANSI/NFPA 70: National Electrical Code
      b. ANSI/NFPA 70B: Electrical Equipment Maintenance
      c. NFPA 70E: Electrical Safety Requirements for Employee Workplaces
      d. ANSI/NFPA 780: Lightning Protection Code
      e. ANSI/NFPA 101: Life Safety Code

B. All inspections and tests shall utilize the following references:
   1. Project design specifications.
   2. Project design drawings.
   3. Short-circuit and coordination study.
   4. Manufacturer's instruction manuals applicable to each particular apparatus.
   5. Project list of equipment to be inspected and tested as stated above.

PART 2 - SHORT-CIRCUIT, COORDINATION, AND ARC FLASH STUDIES

2.1 SHORT-CIRCUIT STUDY

The electrical equipment manufacturer shall perform a short-circuit analysis of the specified electrical power distribution system. This analysis shall include:

A. Calculation of the maximum RMS symmetrical three-phase short-circuit current available at significant locations in the electrical system. The results shall represent the highest short-circuit currents to which the equipment might be subjected under the reported system conditions. The short-circuit currents shall be calculated with the aid of a digital computer. Appropriate motor short-circuit contribution shall be included in the calculation.

B. The study shall include all portions of the electrical distribution system from the normal and alternate sources of power throughout the low-voltage distribution system. Normal system operating method, alternate operation, and operations which could result in maximum fault conditions shall be thoroughly covered in the study.

C. **[Spec Writer: Edit accordingly]** The study shall be calculated from the utility meter to the unit substation to the lowest overcurrent device or equipment on the electrical distribution system. The utility conductors shall not be used for calculations.

D. An evaluation of the adequacy of the short-circuit ratings of the electrical equipment supplied by that manufacturer.

E. Provide one electronic copy of the short-circuit analysis for the engineer's approval.

F. A computer printout of input data, a computer printout of calculated results and an explanation of how to interpret the printouts.

G. A one-line diagram identifying all bus locations and the maximum available short-circuit current at each bus.

H. A bus-to-bus listing of the maximum available short-circuit current expressed in RMS symmetrical amperes and the X/R ratio of the fault current.

I. A table of equipment short-circuit ratings versus calculated short-circuit current values.

J. An analysis of the results in which any inadequacies shall be called to the attention of the Engineer and recommendations made for improvements. These recommendations shall be incorporated by the electrical equipment manufacturer to the electrical equipment at no cost to the Owner, where approved by the Engineer.

2.2 PROTECTIVE DEVICE COORDINATION STUDY

The electrical equipment manufacturer shall perform a protective device time-current coordination analysis of the entire electrical power distribution system. This analysis shall include:

A. A determination of settings or ratings for the over-current protective devices supplied. Where necessary, an appropriate compromise shall be made between system protection and service continuity with system protection and service continuity considered to be of equal importance. The time-current coordination analysis shall be performed with the aid of a digital computer.

B. An evaluation to the degree of system protection and service continuity possible with overcurrent devices supplied.

C. Provide one electronic copy of the protective device time-current coordination analysis for the Engineer's approval.

D. Log-Log plots of time-current characteristic curves.

E. A tabulation of the suggested settings of the adjustable overcurrent protective devices supplied.

F. The key or limiting overcurrent device characteristics, load characteristics, and protection requirements affecting the setting or ratings of the overcurrent protective devices supplied.

G. The degree of service continuity and system protection achieved with the overcurrent protective devices supplied.

H. An analysis of the results in which any inadequacies shall be called to the attention of the Engineer and recommendations made for improvements. These recommendations shall be incorporated by the electrical equipment manufacturer to the electrical equipment at no cost to the Owner, where approved by the Engineer.

2.3 ARC FLASH HAZARD ANALYSIS

A. Provide with the coordination and short circuit studies an Arc Flash study and device by device listing of PPE requirements and ratings as required by the NEC and NFPA 70E. All equipment shall have appropriate labeling installed in the field by the electrical contractor as determined by the study.

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchgear, switchboards, panelboards, busway, etc.) where work could be performed on energized parts.

PART 3 - INSPECTION AND TEST PROCEDURES

3.1 PROCEDURE

A. Testing firm to provide and comply with the following:
1. Acceptance test procedures for each individual equipment listed in Part 1 of this section for Engineer review and approval prior to any test and after thorough evaluation of the system. Testing shall conform to the latest version of InterNational Electrical Testing Association (NETA) specifications and standards for electrical power distribution equipment and systems and manufacturer's instructions.
2. Refer to each individual specification section for testing requirements and comply.
3. Inspect installed equipment, record results and report any discrepancy and deficiency with contract documents and governing codes prior to testing. All results shall be submitted to the Engineer for approval.

3.2 SYSTEM FUNCTION TESTS

A. General:
1. Perform system function tests upon completion of equipment component tests as define in this specification. It is the purpose of system function tests to prove the proper interaction of all sensing, processing, and action devices.
2. Implementation:
   a. Develop test parameters for the purpose of evaluating performance of all integral components and their functioning as a complete unit within design requirements.
   b. Test all interlock devices, and trip settings on breakers.
   c. Record the operation of alarms and indicating devices.

3.3 DEFICIENCIES

A. All deficiencies reported by testing firm to be corrected by Contractor and Acceptance Test to be re-done accordingly.

END OF SECTION

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SECTION 26 05 04 - ELECTRICAL DEMOLITION AND RELOCATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. This Section supplements Division 1, General Requirements. Where contradictions occur between this Section and Division 1, the more stringent of the two shall apply. The Architect shall decide which is more stringent.

B. Requirements of the following Divisions and Sections apply to this Section:
   1. Division 26 Section 26 05 02 "Electrical Requirements."
   2. Division 9 Section "Painting" for related requirements.

C. Refer to other Division 26 Sections for additional specific electrical demolition or relocation associated with specific items.

1.2 SUMMARY

A. This Section includes basic requirements for demolition and relocation of electrical materials, equipment, and installations. The Contractor shall be responsible for visiting the site prior to bid to determine the actual conditions, which might affect the bid or contract price. No allowance will be made subsequently resulting from the neglect to visit the site and make such determinations.

B. Generally, electrical items that are to be replaced with other equipment in the same location are work covered by this section. Also covered by this section are electrical items that are to be removed in their entirety or that are to be relocated to another place.

1.3 UTILITY SERVICES

A. Maintain existing utility services. Where necessary to cut existing conduits, wires, cables, etc. of utility services or fire protection systems, they shall be cut and capped at suitable places or where directed by the Owner's representative.

B. Electrical service in demolition area shall be reduced to a minimum and identified to eliminate uncertainty about which circuits are energized.

C. The Contractor shall notify the Owner's representative in writing of any planned utility interruptions including interruptions of power to communications and fire protection systems at least 48 hours in advance or as otherwise specified. The request shall state the reason, date, beginning time, and expected duration of such interruptions. No interruptions shall be made without the Owner's written concurrence and such interruptions shall be coordinated with the Owner to cause the least inconvenience to the Owner's operations. Service interruptions which cannot wait for written approval may be granted with verbal approval from the Owner's representative. After verbal approval is granted, written confirmation shall be issued by the Contractor as soon as practical.

1.4 PROTECTIVE MEASURES

A. Provide the following protective measures:
   1. Wherever existing roofing surfaces are penetrated by electrical conduit, they shall be protected against water infiltration. Water leaks shall be repaired immediately upon discovery when they occur.
   2. Temporary protection against damage for all portions of existing structures and grounds where work is to be done, materials handled, and equipment moved or relocated.

3. Contractor shall patch and fill openings in floors, walls and ceilings for removed equipment or piping with the same material, fire and structural integrity that would have existed prior to the penetration including concrete, block, gyp wallboard, exterior walls, roof membranes, etc. except for steel and wood beams which shall have the openings capped with similar material.

B. The Contractor shall be responsible for contacting utilities or locating services and obtaining locations of all underground services in the general area of demolition work.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIALS

A. The Contractor shall provide all equipment and materials necessary for the removal or relocation of electrical equipment.

B. Materials used in restoration or repairing work related to demolition and relocation shall conform in type, quality, and function to that of the original existing construction or as otherwise indicated.

2.2 DISPOSAL AND RETENTION

A. Materials and equipment resulting from work and removed from the building or structures, or parts thereof, shall become the property of the Contractor and shall be removed from the site by the Contractor except as follow:
1. Light fixtures, lamps, and ballasts.
2. Fire, heat, and smoke detection devices.
3. Telephones and telephone equipment other than outlet devices.
4. Fire alarm notification devices and pull stations.
5. Paging speakers, clocks, and intercom call stations.

B. Items removed or noted to be retained by the Owner but which are declined to be retained by the Owner shall be removed from the site by the Contractor.

C. Combustible waste material and rubbish shall not be stored or allowed to accumulate within a building or its vicinity, but shall be kept in a suitable trash container for subsequent removal or shall be removed from the premises as rapidly as practical.

D. All hazard waste shall be properly disposed of by a licensed hazard waste disposal facility. Items shall include but not limited to fluorescent lamps, diesel fuel, radiator coolant, etc.

PART 3 - EXECUTION

A. Remove or relocate all items indicated on the drawings or as otherwise indicated.

B. Where the drawings indicate that equipment is to be replaced or where other equipment requires the relocation of existing equipment, the existing equipment shall be removed or relocated as though it was specifically noted to be removed or relocated.

C. Wherever electrical materials have been removed from surfaces of the building or structure, those surfaces shall be patched and repaired.

D. Remove, cut, alter, replace, patch, and repair existing work as necessary to install new work. Unless otherwise indicated or specified, do not cut, alter, or remove any structural members, ducts, piping, or service lines without approval of the Owner's representative.

E. Existing work or equipment to be altered or extended and found to be defective shall be reported to the Owner's representative before it is disturbed or any further work is performed on it.

F. Where electrical equipment is indicated to be removed or relocated, the work shall include the complete disconnection from its source, dismantling as necessary, and removal or installation of all conduit, wires, cables, etc. Unless noted otherwise, wires shall be removed from conduits back to the last utilization device or to the panelboard. No wiring shall be removed that prevents operation of other equipment not scheduled or indicated to be removed.

G. Perform and schedule all demolition work with other trades and work of the contract as necessary for the efficient progress and flow of the work.

END OF SECTION

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SECTION 26 05 05 - MANUFACTURERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The following lists of manufacturers are for the specifications as identified.

B. All submittals and documentation shall be in accordance with the project General Requirements, Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work are listed herein. All manufacturers not listed shall be pre-approved prior to bid in order to be considered. Refer to Division 1 for pre-approval format.

TITLE	SPECIFICATION SECTION	MANUFACTURER
Electrical Power Conductors and Cables	26 05 19	Aetna Insulated Wire Cerro Wire CME Wire and Cable Encore Wire Southwire Co. Draka Lifeline (Rated Cable) Radix Duralife (Rated Fire Alarm)

TITLE	SPECIFICATION SECTION	MANUFACTURER
Grounding and Bonding	26 05 26	Erico (Cadweld) Ideal Industries Okonite Hubbell (Burndy) VFC

TITLE	SPECIFICATION SECTION	MANUFACTURER
Hangers and Supports		
- Slotted Metal Angle and U-channel Systems	26 05 29	Eaton (B-Line Systems) Unistrut Diversified Products
- Conduit Sealing Bushings	26 05 29	Emerson (OZ/Gedney) Hubbell (RACO) Spring City Electrical Mfg. Thomas and Betts Corp.
Raceways - Conduit and Tubing	26 05 33	Allied Tube & Conduit Carlon, Inc. PW Pipe Wheatland
- Conduit Bodies	26 05 33	Emerson (Appleton Electric) Eaton (Crouse-Hinds) Hubbell (Killark Electric) Thomas & Belts (Steel City)
Wireway and Enclosures	26 05 33	Eaton (Cooper B-Line) Hoffman Engineering Co. Hammond Mfg.
Surface Raceways	26 05 33	Hubbell Legrand (Wiremold)

TITLE	SPECIFICATION SECTION	MANUFACTURER
Electrical Boxes and Fittings		
Raintight outlet boxes	26 05 33	Emerson (Appleton Electric) Eaton (Crouse – Hinds) Hubbell (RACO) Thomas & Betts (Steel City)
Bushings, knockout closures and locknuts	26 05 33	Emerson (Appleton Electric) Eaton (Crouse – Hinds) Hubbell (RACO) Midwest Electric Thomas & Betts (Steel City)
Identification	26 05 53	Ideal Industries, Inc. Panduit Corp. Seton Identification Product. Brady, Co.
Panelboards	26 24 16	Eaton (Cooper Industries) General Electric Company Siemens Schneider Electric (Square D)
Enclosed Switches and Circuit Breakers - Circuit and Motor Disconnects	26 28 16	Eaton (Cooper Industries) General Electric Company Siemens Schneider Electric (Square D)
Connections	26 28 16	Emerson (Appleton Electric) Burndy Corp. Ideal Industries, Inc. Thomas and Betts Corp.
Fuses (See Note)	26 28 16	Eaton (Bussman) Mersen (Ferraz Shawmut) Littelfuse
Surge Protection Device	26 43 13	Refer to Section
NOTE: Contractor shall submit fuse coordination for the entire electrical distribution if alternate manufacturer is used.		

PART 3 - EXECUTION - NOT USED.

END OF SECTION

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SECTION 26 05 06 - BASIC MATERIAL AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. This Section supplements Division 1, General Requirements.

1.2 DESCRIPTION OF WORK

A. Work included in this section consists of conduits, wires and other miscellaneous materials not specifically mentioned in other sections of Division 26, 27 and 28 but necessary or required for equipment or system operation or function, and the labor to install them.

1.3 SUBMITTALS

A. Materials list with manufacturer, style, series or model identified.

B. Manufacturer's descriptive literature and/or sample if requested by the Architect/Engineer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Refer to Section 26 05 05.

2.2 CONDUIT RACEWAYS

A. Refer to Section 26 05 33.

2.3 ELECTRICAL POWER CONDUCTORS AND CABLES

A. Refer to Section 26 05 19.

2.4 OUTLET BOXES, JUNCTION AND PULL BOXES

A. Refer to Section 26 05 33 for additional requirements.

2.5 WIRE CONNECTORS

A. For wires that are #8 AWG and smaller: Insulated pressure type with live spring, rated 105°C, 600-Volt, for building wiring and 1000-Volt in signs or fixtures.

B. For wires that are #6 AWG and larger: Compression type with 3M #33 or equal tape insulation.

2.6 CONDUIT HANGERS

A. Refer to Section 26 05 29 for additional requirements.

2.7 FUSES

A. Refer to Section 26 28 16.

2.8 ACCESS PANELS

A. Electrical Contractor to provide access panels for electrical equipment which are required for accessibility by code.

2.9 CONDUIT SLEEVES

A. Sleeves for Conduit Penetration: Hilti, Inc., model CP 6820-P; or 3M Corp. MCID or PCID. Refer to Division 7 "Firestopping" for additional requirements.

B. Exterior Wall Penetration Seals: Provide seals at all foundation of exterior wall locations. Link Seal or approved manufacturer.

2.10 EQUIPMENT MOUNTING AND SUPPORT HARDWARE

A. Steel channels, bolts and washers, used for mounting or support of electrical equipment shall be galvanized typed. Where installed in corrosive atmosphere, stainless-steel type hardware shall be used.

B. Refer to Section 26 05 29 for additional requirements.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide complete raceway systems for all conductors including control wiring and low-voltage wiring unless otherwise noted.

B. Electrical system layouts indicated on drawings are generally diagrammatic, but shall be followed as closely as actual construction and work of other trades will permit. Govern exact routing of raceways and locations of outlets by structure and equipment served. Take all dimensions from architectural drawings.

C. All home runs to panelboards are indicated as starting from the outlet nearest to the panel and continuing in the general direction of that panel. Continue such circuits to panel as though routes were completely indicated.

D. Avoid cutting and boring holes through structure or structural members wherever possible. Obtain prior approval of the Architect, and conform to all structural requirements when cutting or boring structure.

E. Furnish and install all necessary hardware, hangers, blocking, brackets, bracing, runners, etc., required for equipment specified under this Section.

F. Furnish and install all raceways from elevator machine room to fire command center for elevator status.

3.2 RACEWAYS

A. Refer to Section 26 05 33.

3.3 JUNCTION PULL BOXES

A. Construct junction or pull boxes not over 150 cubic inches in size shall be standard outlet boxes, and those over 150 cubic inches shall be constructed the same as "Cabinets," with screw covers of same gauge metal. Removal covers must be accessible at all times.

B. Provide a standard access panel having a hinged metal door neatly fitted into a flush metal trim, where a junction box or equipment is located above non-accessible ceilings or behind finished walls. Coordinate location and type with the Architect.

END OF SECTION

SECTION 26 05 19 - ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Requirement of the following Division 26 Sections apply to this section:
   1. Electrical Requirements

1.2 SUMMARY

A. This Section includes wires, cables, and connectors for power, lighting, signal, control and related systems rated 600-Volts and less.

B. Related Sections: The following Sections contain requirements that relate to this section:
   1. Division 2 Section "Earthwork" for trenching and backfilling.
   2. Division 26 Section "Electrical Boxes and Fittings" for connectors for terminating cables in boxes and other electrical enclosures.
   3. Division 26 Section "Raceways and Boxes" for MC cable, raceway and boxes.

1.3 SUBMITTALS

A. Product Data for electrical wires, cables and connectors.

B. Submit pulling tension calculations for all underground feeders.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with provisions of the following code:

B. NFPA 70 "National Electrical Code."
   1. Conform to applicable codes and regulations regarding toxicity of combustion products of insulating materials.

C. UL Compliance: Provide components, which are listed and labeled by UL under the following standards.
   1. UL Standard 44 — Rubber Insulated Wires and Cables
   2. UL Standard 83 — Thermoplastic-Insulated Wires and Cables
   3. UL Standard 486A — Wire Connectors and Soldering Lugs for Use with Copper Conductors
   4. UL Standard 854 — Service Entrance Cable
   5. UL Standard 2196 — Testing for Fire Resistive Cables
   6. UL Standard 1424 — Cables for Power-Limited Fire-Alarm Circuits

D. NEMA/ICEA Compliance: Provide components which comply with the following standards:
   1. WC-5: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
   2. WC-7: Cross Linked Thermosetting Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

E. IEEE Compliance: Provide components, which comply with the following standard.
   1. Standard 82: Test procedures for Impulse Voltage Tests on Insulated Conductors.

PART 2 - PRODUCTS

2.1 WIRES AND CABLES (600-VOLT COPPER CONDUCTORS – BASE DESIGN)

A. General: Provide suitable wire and cable for the temperature, conditions and location where installed. All wires and cables shall be new and delivered to the site in unbroken packages and reels.

B. All wires and cables shall be of the same manufacturer throughout the entire project.

C. Conductors: Provide solid conductors for power and lighting circuits #10 AWG and smaller. Provide stranded conductors for #8 AWG and larger.

D. Conductor Material: All wires and cables shall be copper, single conductor rated at 600-Volts, which conform to or exceed ICEA specifications and the following:
   1. In sizes 1/0 AWG to 4/0: Cross-linked polyethylene insulation type XHHW-2 (90°C) or THWN-2.
   2. In sizes 250 KCMIL and larger: Type XHHW-2 (90°C) or THWN.
   3. In sizes 1 AWG and smaller: All conductors shall have heat/moisture resistant thermoplastic insulation type THWN-2 (90°C) except as follows:
      a. Where conduit temperature will exceed 100°F, use type THHN (90°C).
      b. In 120-Volt incandescent fixtures, type SF-2 or SFF-2 (150 - 200°C).
      c. In wireway of fluorescent lighting fixtures type THHN (90°C).

E. Rated Conductor Material: Where required by these specifications and code, provide 2-hour rated cable conforming to the following requirements:
   1. Cabling must meet current UL requirements for fire alarm resistance.
   2. Cabling must meet current NEC 517, 700 and 760 requirements.

F. Grounding conductors: Shall be of the same type as its associated phase conductors.

G. All conductors shall be label with wire size, insulation rating, etc. using an engraved process, computer scan on labels are not permitted.

H. Color Coding for phase identification in accordance with Table 1 in Part 3 herein.

I. Connectors for Conductors:
   1. Provide UL-listed factory-fabricated, solderless metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Use connectors with temperature ratings equal to or greater than those of the wires upon which used.
   2. For wires that are #8 AWG and smaller: Insulated pressure type with live spring, rated 105°C, 600-Volt, for building wiring and 1000-Volt in signs or fixtures.
   3. For wires that are #6 AWG and larger: Compression type with 3M #33 or equal tape insulation.

J. Splices and Taps:
   1. No. 10 AWG and smaller - Connectors for solid conductors shall be solderless, screw-on, spring pressure cable type, 600-Volt, 105°C with integral insulation and UL approved for aluminum and copper conductors. Connectors for stranded conductors shall be crimp-on type with integral insulating cover.
   2. No. 8 AWG and larger - Hydraulically applied crimping sleeve or tap connector sized for the conductors. Insulate the hydraulically applied connector with 90-degree, 600-Volt insulating cover provided by the connector manufacturer. Insulator materials and installation shall be approved for the specific application, location, voltage, and temperature and shall not have an insulation value less than the conductors being joined.

2.2 ALUMINUM WIRES AND CABLES (ALTERNATE DESIGN)

A. Where indicated on drawings as AL: aluminum alloy, compact stranded, Type XHHW-2 or THHN/THWN, 90°C meeting requirements of UL#44 and Federal Spec A-A-59544 with XLPE insulation and AA-8000 series alloy only may be used in lieu of copper conductors.

B. Terminations shall be compression bolted lug with appropriate joint compounds and Belleville spring washers.

C. Installation and terminations shall be in strict accordance with manufacturer's recommendations and as identified in specifications.

D. Uses not allowed:
   1. As final branch feeders to motors, mechanical equipment, heaters, etc.
   2. For any applications under 100Amps.
   3. Where terminations that are unable to utilize compression, bolted lug fittings.
   4. For use as emergency and standby system feeders.

E. All grounding conductors shall be copper.

F. Refer to feeder table on drawings for conductor and conduit sizes to correspond with over current protection device size.

2.3 TWO-HOUR RATED CABLE ASSEMBLY

A. Two Hour Rated Cable Assemblies: Complete cable system shall have a two-hour fire rating as Listed and Classified by Underwriters Laboratories, Inc. or ETL.
   1. Two-hour rated cable assemblies or two-hour rated cable systems that are approved by the authority having jurisdiction shall be used in lieu of two (2) inch concrete encasement or routing in two (2) hour fire rated enclosure for the following applications:
      a. Trunk cabling for fire alarm detection and annunciation.
      b. Feeders for fire pumps.
      c. Emergency feeders.
      d. Life Safety feeders.
      e. Cabling for Area of Rescue Assistance System.
   2. Conduit sizes shall be adjusted to accommodate the larger diameter conductors per the national electrical code.

PART 3 - EXECUTION

3.1 WIRING METHOD

A. Use the following wiring methods as indicated:
   1. Install all wire in raceway. Power and control wiring shall be installed in separate raceways.

3.2 INSTALLATION OF WIRES AND CABLES

A. General: Install electrical cables, wires, and connectors in compliance with NEC.

B. Coordinate cable and wire installation with other Work.

C. Do not install more conductors in a raceway than indicated on the drawings. A maximum of three ungrounded conductors are to be installed in any one conduit on a 3-phase, 4-wire system, unless specifically noted otherwise on the drawings. When more than three ungrounded conductors are installed in a raceway, the conductor size shall be increase per code for derating. No two ungrounded conductors of the same phase are to be installed in the same conduit, unless specifically noted otherwise on the drawings.

1. Where multi-wire circuits are permitted by these specifications, all grounded and ungrounded conductors shall be grouped by wire markers, cable ties or similar means with the panelboard or wireway at least one location.

D. Provide dedicated neutral conductor for all single phase circuits. Shared neutral conductor is not acceptable on single phase circuits.

E. Minimum wire size shall be a No.12 AWG except for control or signal circuits, which may be No. 14 AWG.

F. Unless otherwise indicated on drawings, all wiring for branch circuits shall be a minimum No. 12 AWG in ¾" conduit, protected by 20 amperes circuit breakers. If distance from panel to first outlet is 75 feet or greater for 120-Volt circuits, and 125 feet or greater for 277-Volt circuits, No. 10 AWG shall be installed throughout the circuit, unless noted otherwise on the drawings.

G. Size of current carrying conductors, unless noted otherwise on drawings, shall be determined from Table 310.15(B)(16) of the latest National Electric Code for the load served.

H. Pull conductors simultaneously where more than one is being installed in same raceway. Use UL listed pulling compound or lubricant, where necessary.

I. Use pulling means including: fish tape, cable, rope, and basket weave wire/cable grips which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable.

J. Size of conduits, unless specifically shown, shall be determined from Appendix C of the latest National Electrical Code.

K. Keep conductor splices to a minimum. All splices shall be made within junction boxes, wiring troughs and other enclosures as permitted by the National Electrical Code.
1. Splices shall not be permitted within 25 feet of any panel or electrical room.
2. Do not splice conductors in panelboards, safety switches, switchboards, motor control centers or motor control enclosures.
3. Splices in conductors installed below grade will not be permitted, unless approved in writing by the Architect and Engineer.

L. Install splice and tap connectors, which possess equivalent or better mechanical strength and insulation rather than conductors being spliced.

M. Use splice and tap connectors which are compatible with conductor material.

N. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than No. 10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal.

O. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturers' published torque tightening values. Where manufacturers' torque requirements are not indicated, tighten connectors and terminals to comply with tightening torque values specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Prior to energizing, check installed wires and cables with megohm meter to determine insulation resistance levels to assure requirements are fulfilled.

B. Prior to energizing, test wires and cables for electrical continuity and for short circuits.

C. Subsequent to wire and cable hook-ups, energize circuits and demonstrate proper functioning. Correct malfunctioning units, and retest to demonstrate compliance.

D. Prior to completion of project, an infrared scan of switchgear and panelboard feeder equipment connection shall be performed when all loads are energized.

E. TABLE I: Color Coding for Phase Identification:
1. Color code secondary service, feeder, and branch circuit conductors with factory applied color as follows:

208V/120-Volts	Phase	480V/277-Volts
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray
Green	Ground	Green

3.4 FEEDER TESTING

A. Products
1. Material: Contractor shall provide all necessary testing equipment and devices required to perform the test described in this section.

B. Execution
1. Visual and Mechanical Inspection
   a. Inspect cables for physical damage and proper connection in accordance with one-line diagrams.
   b. Test cable mechanical connections to manufacturer's recommended values using a calibrated torque wrench.
   c. Check cable color coding with specification section 26 05 53 and National Electrical Code standards.
2. Electrical Tests
   a. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 1000-Volts D.C. for 1 minute.
   b. Perform continuity test to insure proper cable connection.
3. Test Values
   a. Evaluate results by comparison with cables of same length and type. Investigate any insulation-resistance values less than 50 megohms.
   b. Submit results to Engineer for approval in accordance with Section 26 05 03.

END OF SECTION

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SECTION 26 05 26 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.

B. Division 26 Basic Materials and Methods sections apply to work of this section.

C. Requirements of this section apply to electrical grounding and bonding work specified elsewhere in these specifications.

1.2 SUMMARY

A. Extent of electrical grounding and bonding work is indicated by drawings and schedules and as specified herein. Grounding and bonding work is defined to encompass systems, circuits, and equipment.

B. Type of electrical grounding and bonding work specified in this section includes the following:
   1. Solidly grounded.

C. Applications of electrical grounding and bonding work in this section includes the following:
   1. Electrical power systems.
   2. Raceways.
   3. Enclosures.
   4. Equipment.

D. Refer to other Division 26 sections for wires/cables, electrical raceways, boxes and fittings, and wiring devices which are required in conjunction with electrical grounding and bonding work; not work of this section.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's data on grounding and bonding products and associated accessories.

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of grounding and bonding products, of types, and ratings required, and ancillary grounding materials, including stranded cable, copper braid and bus, grounding electrodes and plate electrodes, and bonding jumpers whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: Firms with at least 5 years of successful installation experience on projects with electrical grounding work similar to that required for project.

C. Codes and Standards:
   1. Electrical Code Compliance: Comply with applicable local electrical code requirements of the authority having jurisdiction, and NEC as applicable to electrical grounding and bonding, pertaining to systems, circuits and equipment.
   2. UL Compliance: Comply with applicable requirements of UL Standards No.'s 467, Electrical Grounding and Bonding Equipment", and 869 "Electrical Service Equipment", pertaining to grounding and bonding of systems, circuits and equipment. In addition,

comply with UL Standard 486A, "Wire Connectors and soldering Lugs for Use with Copper Conductors." Provide grounding and bonding products which are UL-listed and labeled for their intended usage.

3. IEEE Compliance: Comply with applicable requirements and recommended installation practices of IEEE Standards 80, 81, 141 and 142 pertaining to grounding and bonding of systems, circuits and equipment.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials and Components:
   1. Provide electrical grounding and bonding system; with assembly of materials, including, but not limited to, cables/wires, connectors, solderless lug terminals, grounding electrodes and plate electrodes, bonding jumper braid, surge arresters, and additional accessories needed for a complete installation. Where more than one type component product meets indicated requirements, selection is installer's option. Where materials or components are not indicated provide products which comply with NEC, UL, and IEEE requirements and with established industry standards for those applications indicated.

2.2 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
   1. Solid Conductors: ASTM B3.
   2. Stranded Conductors: ASTM B8.
   3. Tinned Conductors: ASTM B33.
   4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductors, 1/4 inch (6 mm) in diameter.
   5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductors.
   6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
   7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

C. Bare Grounding Conductor and Conductor Protector for Wood Poles:
   1. No. 4 AWG minimum, soft-drawn copper.
   2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.

2.3 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
   1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by Cadweld (or approved equal) manufacturer for materials being joined and installation conditions. Exothermically welded connections are required on all grounding electrode conductors, all connections to building steel (connections to structural member), all grounding conductors run under the earth,

connection to ground rods and in any case where grounding conductors are subject to a hostile environment.

1. The exothermic welding system furnished under these specifications shall meet the applicable requirements of IEEE-80, Chapter 9, Section of conductors and joints.
2. Molds shall be made from graphite or other material that is so designed to provide an average life of not less than 50 exothermic welds under normal conditions. Molds shall bear permanent marking, indicating the name of the manufacturer, the mold model, the type and size of welding mixture compatible with the welding process, and the size of the conductor. Instructions detailing general safety information, and welding procedures shall be provided with each mold.
3. Starting material, if used, shall consist of aluminum and copper/copper oxide and iron oxides. It shall not contain phosphorous or any caustic, toxic or explosive substance. Weld metal used for grounding connections shall contain copper oxide, aluminum. Where welding is done in enclosed structures, the Erico Exolon smokeless system shall be used.

D. Exothermic connections are to be performed by manufacturer's trained personnel with a qualification and/or training certificate on file with the contractor.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No.10 AWG and smaller, and stranded conductors for No.8 AWG and larger, unless otherwise indicated.

B. Conductor Terminations and Connections:
1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits. The conduit shall not be acceptable as an equipment ground.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
1. Feeders and branch circuits.
2. Single-phase motor and appliance branch circuits.
3. Three-phase motor and appliance branch circuits.
4. Flexible raceway runs.
5. Armored and metal-clad cable runs.

C. Protection:
1. All grounding electrode conductors smaller than #6 AWG shall be routed in conduit – EMT or Rigid/IMC if exposed to damage or weather.
2. All grounding electrode conductors #6 AWG and larger shall be routed in conduit – EMT or Rigid/IMC if exposed to weather.

D. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

E. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

3.3 EXAMINATION

A. Examine areas and conditions under which electrical grounding and bonding connections are to be made and notify Engineer in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.4 INSTALLATION OF ELECTRICAL GROUNDING AND BONDING SYSTEMS

A. General: Install electrical grounding and bonding systems in accordance with manufacturer's instructions and applicable portions of NEC, NECA's "Standard of Installation", and in accordance with recognized industry practices to ensure that products comply with requirements.

B. Coordinate with other electrical work as necessary to interface installation of electrical grounding and bonding system work with other work.

C. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment
   3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

E. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

F. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.

G. Apply corrosion-resistant finish to field-connections, buried metallic grounding and bonding products, and places where factory applied protective coatings have been destroyed, which are subjected to corrosive action.

H. Install all connectors on clean metal contact surfaces, to ensure electrical conductivity and circuit integrity.

3.5 FIELD QUALITY CONTROL

A. Upon completion of installation of electrical grounding and bonding systems, test ground resistance with ground resistance tester. Where tests show resistance to ground is over 5 ohms, take appropriate action to reduce resistance to 5 ohms, or less, by driving additional ground rods; then retest to demonstrate compliance.

END OF SECTION

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SECTION 26 05 29 - HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Requirements of the following Division 26 Sections apply to this section:
   1. "Electrical Requirements."

1.2 SUMMARY

A. This Section includes secure support from the building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.

B. Related Sections: The following Sections contain requirements that related to this Section:
   1. Division 3 Section "Mild Steel Concrete Reinforcement" for inserts, anchors, and sleeves to be installed in concrete for use with supporting devices.
   2. Division 5 Section "Metal Fabrications" for requirements for miscellaneous metal items involved in supports and fastenings.
   3. Division 7 Section "Firestopping" for requirements for firestopping at sleeves through walls and floors that are fire barriers.
   4. Refer to Division 26 Sections for additional specific support requirements that may be applicable to specific items.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for each type of product specified.
   1. Hanger and support schedule showing manufacturer's figure number, size, spacing, features, and application for each required type of hanger, support, sleeve, seal, and fastener to be used.

C. Shop drawings indicating details of fabricated products and materials.

D. Engineered Design consisting of details and engineering analysis for supports for the following items:
   1. Conduit (racked)
   2. Ceiling-mounted boxes.
   3. Conduit - Ceiling mounted, concrete encased.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

B. Electrical components shall be listed and labeled by UL, ETL, CSA, or other approved, nationally recognized testing and listing agency that provides third-party certification follow-up services.

C. Installation shall comply with local authorities seismic requirements.

PART 2 - PRODUCTS

2.1 COATINGS

A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized and where installed in corrosive atmosphere, stainless-steel type hardware shall be used.

2.2 MANUFACTURED SUPPORTING DEVICES

A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.

B. Fasteners: Types, materials, and construction features as follows:
   1. Expansion Anchors: Carbon steel wedge or sleeve type.
   2. Toggle Bolts: All steel springhead type.

C. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.

D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.

E. U-Channel Systems: 16-gauge steel channels, with 9/16-inch-diameter holes, at a minimum of 8 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacture.

2.3 FABRICATED SUPPORTING DEVICES

A. General: Shop- or field-fabricated supports or manufactured supports assembled from U-channel components.

B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.

B. Coordinate with the building structural system and with other electrical installation.

C. Raceway Supports: Comply with the NEC and the following requirements:
   1. Conform to manufacturer's recommendations for selection and installation of supports.
   2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs., provide additional strength until there is a minimum of 200 lbs safety allowance in the strength of each support.
   3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.

4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1 1/2 inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use ¼-inch diameter or larger threaded steel. Use spring fasteners that are specifically designed for supporting single conduits or tubing.
6. Space supports for raceway in accordance with NEC.
7. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, supports at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples of threadless box connectors.
8. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.

D. Vertical Conductor Supports: Install simultaneously with installation of conductors (i.e., strain reliefs).
   1. Support shall be at each individual conductor.

E. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

F. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to the raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches from the box.

G. Sleeves: Install in concrete slabs and walls and all other fire-rated floors and wall for raceways and cable installations. For sleeves through fire-rated wall or floor construction, apply UL-listed firestopping sealant in gaps between sleeves and enclosed conduits and cables in accordance with "Fire Stopping" requirement of Division 7.

H. Conduit Seals: Install seals for conduit penetrations of slabs on grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.

I. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with the following:
   1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions or light steel construction, use sheet metal screws.
   2. Holes cut to depth of more than 1 1/2 inches in reinforced concrete beams or to depth of more than ¾ inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.
   3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock-resistant fasteners for attachments to concrete slabs.

J. TESTS: Test pull-out resistance of one of each type, size, and anchorage material for the following fastener types:
   1. Expansion anchors.
   2. Toggle bolts.

K. Provide all jacks, jigs, fixtures, and calibrated indicating scales required for reliable testing. Obtain the structural Engineer's approval before transmitting loads to the structure. Test to 90 percent of rated proof load for fastener. If fastening fails test, revise all similar fastener installations and retest until satisfactory results are achieved.

END OF SECTION

SECTION 26 05 33 - RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this section.

B. Requirements of the following Division 26 Sections apply to this Section:
   1. "Electrical Requirements."
   2. "Basic Material and Methods"

1.2 SUMMARY

A. Drawings are diagrammatic. All bends, boxes, fittings, couplings are not necessarily shown. Supply as necessary to comply with the National Electric Code.

B. Provide complete raceway systems for all conductors including control wiring and low-voltage wiring unless otherwise noted.

C. This Section includes raceways for electrical wiring. Types of raceways, boxes and fittings in this section include the following:
   1. Electrical metallic tubing (EMT).
   2. Flexible metal conduit.
   3. Intermediate metal conduit (IMC).
   4. Liquid-tight flexible conduit.
   5. Rigid metallic conduit (RMC).
   6. Metal clad cable (MC).
   7. Surface raceways.
   8. Rigid non-metallic conduit.
   9. Electrical non-metallic tubing (ENT)
   10. Wireway.
   11. Outlet boxes.
   12. Junction boxes.
   13. Pull boxes.
   14. Bushings.
   15. Locknuts.
   16. Knockout closures.

D. Related Sections: The following section contains requirements that relate to this section:
   1. Division 26 Section "Raceway and Boxes" for conduit connectors, fittings, and couplings.
   2. Division 7 Section "Firestopping" for conduit penetrations through rated walls and slabs.

E. Section only applies for electrical systems to be installed within raceways. This excludes beverage piping and pneumatic systems pulled within raceways.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of contract and Division 1 Specification Section.

B. Product Data for the following products:
   1. Raceways and fittings.
   2. Wireways and fittings.

3. Boxes and fittings.

C. Installation Instructions: Manufacturer's written installation instructions for wireway, surface raceway, and nonmetallic raceway products.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

B. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to raceways.

C. UL Compliance and Labeling: Comply with applicable requirements of UL standards pertaining to electrical raceway systems. Provide raceway products and components listed and labeled by UL.

D. Manufacturers: Firms regularly engaged in manufacture of electrical boxes and fittings, of types, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than five years.

E. Installer's Qualifications: Firms with at least five years of successful installation experience on projects utilizing electrical boxes and fittings similar to those required for this project.

F. NEC Compliance: Comply with NEC as applicable to construction and installation of electrical wiring boxes and fittings.

G. UL Compliance: Comply with applicable requirements of UL 50, UL 514-Series, and UL 886 pertaining to electrical boxes and fittings. Provide electrical boxes and fittings which are UL-listed and labeled.

H. NEMA Compliance: Comply with applicable requirements of NEMA Standards/Pub No.'s OS1, OS2 and PUB 250 pertaining to outlet and device boxes, covers and box supports.

I. Federal Specification Compliance: Comply with applicable requirements of FS W-C 586, "Electrical Cast Metal Conduit Outlet Boxes, Bodies, and Entrance Caps."

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Rigid Steel Conduit: ANSI C80.1

B. Intermediate Steel Conduit: UL 1242.

C. Electrical Metallic Tubing and Fittings: ANSI C80.3.

D. Flexible Metal Conduit: UL 1, zinc-coated steel.

E. Liquid-tight Flexible Metal Conduit and Fittings: UL 360.

2.2 METAL CLAD CABLE, TYPE MC

A. The multi-conductor metal clad cable shall comply with UL 1569 "Metal Clad, Type MC," UL 83 "Thermoplastic Insulated Wires and Cables" Federal Specification J-C-30B "Wire and Cable," Local and National Electrical Codes.

B. The metal clad cable shall be THHN insulation, copper conductors in sizes #12 through #8 AWG only for continuous operation at a maximum conductor temperature of 90 degree C dry.

C. These cables shall bear appropriate Underwriters Laboratories labels for metal clad cable and be suitable for use as branch circuits in both exposed and concealed work in accordance with applicable sections of the National Electrical Code.

D. An insulated grounding conductor sized in accordance with Table 5.3 Underwriter's Standard UL 1569 shall be cabled with the circuit conductors and shall be identified in compliance with Section 29 of UL 1569. The grounding conductor shall not be smaller than size indicated in NEC Article Table 250.122.

E. A galvanized steel or aluminum armor shall be applied over the inner cable assembly with a positive interlock in compliance with Section 10 of UL 1569. A PVC jacket shall completely cover the steel or aluminum armor when installed in the slab.

2.3 NONMETALLIC CONDUIT AND DUCTS

A. Rigid Nonmetallic Conduit (RNC): NEMA TC 2 and UL 651, Schedule 40 or 80 PVC.

B. PVC Conduit and Tubing Fittings: NEMA TC 3; match to conduit or conduit/tubing type and material.

C. Conduit, Tubing and Duct Accessories: Types, sizes and materials complying with manufacturer's published product information. Mate and match accessories with raceway.

D. Electrical non-metallic tubing (ENT): NEMA TC13 and UL1653.

2.4 CONDUIT BODIES AND FITTINGS

A. General: Types, shapes, and sizes as required to suit individual applications and NEC requirements. Provide matching gasketed covers secured with corrosion-resistant screws.

B. Metallic Conduit and Tubing: Use metallic conduit bodies. Use bodies with threaded hubs for threaded raceways.

C. EMT Conduit Bodies 1 Inch and Smaller: Use bodies with steel set screw connectors and couplings for interior applications and steel compression gland connectors and couplings for exterior applications.

D. EMT Conduit Bodies 1 Inch and Larger: Use bodies with steel set screw connectors and couplings for interior applications and steel compression gland connectors and couplings for exterior applications.

E. Nonmetallic Conduit and Tubing: Use nonmetallic conduit bodies conforming to UL514B.

F. Liquid-Tight Flexible Conduit Fittings: With threaded grounding cone, steel, nylon or equal plastic compression ring, and a gland for tightening. Either steel or malleable iron only with insulated throats and male thread and locknut or male bushing with or without O-ring seal. Each connector shall provide a low resistance ground connection between the flexible conduit and the outlet box, conduit or other equipment to which it is connected.

G. Bushings: Insulated type, designed to prevent abrasion of wires without impairing the continuity of the conduit grounding system, for rigid steel conduit, IMC and EMT, larger than ¾" size.

H. Expansion Fittings: Each conduit that is buried in or secured to the buildings construction on opposite sides of a building expansion joint and each long run of exposed conduit that may be subject to excessive stresses shall be provided with an expansion fitting. Expansion fittings for rigid steel conduit shall be hot-dipped galvanized malleable iron with factory installed packing and a grounding ring. Expansion fittings for rigid non-metallic conduit shall be of the short type in runs 25' or less, and the long type in runs 26' to 80'. The long type shall be a two piece barrel and piston joint, providing 6" of the total movement range in ¾" through 6" conduit sizes. The short type shall be a one piece, coupling with O-ring, providing 2" of total movement range in ¾" to 2" conduit sizes.

I. Seal Off Fittings: Refer to section 26 05 06 for additional requirements.

J. Sleeves for Conduit Penetration: Refer to section 26 05 06 for additional requirements.

2.5 WIREWAYS

A. General: Electrical wireways shall be of types, sizes, and number of channels as indicated. Fittings and accessories including but not limited to couplings, offsets, elbows, expansion joints, adapters, hold-down straps, and end caps shall match and mate with wireway as required for complete system. Where features are not indicated, select to fulfill wiring requirements and comply with applicable provisions of NEC.

B. Wireway covers shall be hinged type.

2.6 SURFACE RACEWAYS

A. General: Sizes and channels as indicated on drawings. Provide fittings that match and mate with raceway. Provide internal barriers for areas with power and communications sections.

B. Surface Metal Raceway: Construct of two piece galvanized steel with snap-on covers, with 9/32-inch mounting screw knockouts in base approximately 8 inches o.c. Finish with manufacturer's standard prime coating suitable for painting. Provide raceways of types suitable for each application required. Sizes 1-3/4" H x 4-3/4" W.

C. Accessories:
1. Couplings for joining raceway sections.
2. Wire clips for conductors.
3. Blank end fittings.
4. Circuit breaker housings for single pole breakers.
5. Device brackets for single or two gang devices.
6. Combination receptacle and tele/data outlet covers.
7. Outlet boxes with hubs for conduit connectors.

2.7 FABRICATED MATERIALS - BOXES

A. Outlet Boxes: Provide galvanized flat rolled sheet-steel outlet wiring boxes, of shapes, cubic inch capacities, and sizes (minimum 4-inch square, 1 ½-inch deep), including box depths as required, suitable for installation at respective locations. Construct outlet boxes with mounting holes, and with cable and conduit-size knockout openings in bottom and sides. Provide boxes with threaded screw holes, with corrosion-resistant cover and grounding screws for fastening surface and device type box covers, and for equipment type grounding.
1. Outlet Box Accessories: Provide outlet box accessories as required for each installation, including box supports, mounting ears and brackets, wallboard hangers, box extension rings, fixture studs, cable clamps and metal straps for supporting outlet boxes, which are compatible with outlet boxes being used to fulfill installation requirements for individual wiring situations. Choice of accessories is Installer's code-compliance option.

B. Device Boxes: Provide galvanized coated flat rolled sheet-steel non-gangable device boxes, of shapes, cubic inch capacities, and sizes (minimum 4-inch square, 1 ½-inches deep), including box depths as indicated, suitable for installation at respective locations. Construct device boxes for flush mounting with mounting holes, and with conduit-size knockout openings in bottom and ends, and with threaded screw holes in end plates for fastening devices. Provide conduit connectors and corrosion-resistant screws for equipment type grounding.
1. Device Box Accessories: Provide device box accessories as required for each installation, including mounting brackets, device box extensions, switch box supports, plaster ears, and plaster ears, and plasterboard expandable grip fasteners, which are

compatible with device boxes being utilized to fulfill installation requirements for individual wiring situations. Choice of accessories is Installer's code-compliance option.

C. Raintight Outlet Boxes: Provide corrosion-resistant cast-metal raintight outlet wiring boxes, of types, shapes and sizes, including depth of boxes, with threaded conduit holes for fastening electrical conduit, cast-metal face plates with spring-hinged watertight caps suitably configured for each application, including face plate gaskets and corrosion-resistant plugs and fasteners.

D. Junction and Pull Boxes: Provide code-gauge sheet steel junction and pull boxes, with screw-on covers; of types, shapes and sizes, to suit each respective location and installation; with welded seams and equipped with stainless-steel nuts, bolts, screws, and washers. Pull boxes installed in finished spaces must be flush-mounted cabinets provided with trim, hinged door and flush latch and lock to match flush-mounted panelboard trim. Provide galvanized code-gauge steel where required for outdoor exposure.

E. Exterior junction or pull boxes, flush with grade:
1. All exterior pull box locations shall be submitted and approved by landscape architect prior to installation.
2. Junction or pull box to be mounted flush with grade shall be polymer composite raintight with screw cover lids. Box dimensions shall be 30"W x 48"L x 36"D. Covers shall be polymer composite suitable for pedestrian traffic secured to box with stainless-steel screws. Box to be furnished with continuous neoprene gasket to seal cover. Conduit entry shall be on side of box with bell ends.

F. Bushings, Knockout Closures and Locknuts: Provide corrosion-resistant box knockout closures, conduit locknuts and malleable iron conduit bushings, offset connectors, of types and sizes, to suit respective installation requirements and applications.

PART 3 - EXECUTION

3.1 WIRING METHOD

A. Outdoors: Use the following wiring methods:
1. Exposed: Intermediate metal conduit, rigid steel conduit, raintight box.
2. Concealed: Intermediate metal conduit, rigid steel conduit.
3. Underground, Single Run: Rigid non-metallic conduit. PVC coated GRC 90° elbows.
4. Underground, Grouped: Rigid non-metallic conduit. PVC coated GRC 90° elbows.
5. Connection to Vibrating Equipment including transformers, pneumatic or electrical solenoid, and motor-operated equipment: Liquid-tight flexible metal conduit.

B. Indoors: Use the following wiring methods:
1. Exposed (below 10 ft. to floor): Intermediate metal conduit, rigid steel conduit.
2. Exposed (above 10ft. or in electrical room): Electrical metallic tubing.
3. Concealed: Electrical metallic tubing.
4. Concealed: Metal clad cable will be allowed as final branch wiring of receptacles (maximum total length of 25' from homerun J-box or hard piped J-box to first outlet on circuit). MC is not allowed for homeruns to panels, connections to mechanical equipment. Maximum conductor size is in MC cable #8 AWG. MC is acceptable for final light fixture connection, maximum 6' length.
5. Connection to Vibrating Equipment including transformers, pneumatic or electrical solenoid, and motor-operated equipment: Flexible metal conduit.
6. Connection to Vibrating Equipment in Moist/Humid or Corrosive Atmosphere including pneumatic or electric solenoid, and motor-operated equipment: Liquid-tight flexible metal conduit.
7. Within concrete slabs: Rigid non-metallic conduit. PVC coated MC cable and ENT is not allowed. Homeruns shall be in conduit. Maximum sizes and locations as approved by the Structural Engineer.

8. Raceway mounted to underside of metal-corrugated sheet roof decking shall be Rigid Metal Conduit or intermediate Metal Conduit.
9. Exposed Wet Locations: Intermediate metal conduit, rigid steel conduit, raintight box.
   a. Provide conduit bodies or exterior boxes with a minimum of 1/8" drain. Drain shall be located to allow exterior raceway system to drain.

3.2 INSTALLATION OF RACEWAYS

A. General: Install electrical raceways in accordance with manufacturers' written installation instructions, applicable requirements of NEC, and as follows.

B. Electrical system layouts indicated on drawings are generally diagrammatic, but shall be followed as closely as actual construction and work of other trades will permit. Govern exact routing of raceways and locations of outlets by structure and equipment served. Take all dimensions from architectural drawings.

C. All home runs to panelboards are indicated as starting from the outlet nearest to the panel and continuing in the general direction of that panel. Continue such circuits to panel as though routes were completely indicated.

D. Avoid cutting and boring holes through structure or structural members wherever possible. Obtain prior approval of the Architect, and conform to all structural requirements when cutting or boring structure.

E. Furnish and install all necessary hardware, hangers, blocking, brackets, bracing, runners, etc., required for equipment specified under this Section.

F. Minimum size conduit shall be ¾" for power circuits and 1" for telecommunications devices.

G. Conceal conduit and EMT, unless indicated otherwise, within finished wall, ceilings, and floors. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot water pipes. Install raceways level and square and at proper elevations.

H. Elevation of Raceway: Where possible, install horizontal raceway runs above water and steam piping.

I. Complete installation of electrical raceways before starting installation of conductors within raceways.

J. Provide supports for raceways as specified elsewhere in Division 26 and in accordance with NEC and local authorities' seismic requirements.

K. Prevent foreign matter from entering raceways by using temporary closure protection.

L. Protect stub-ups from damage where conduits rise from floor slabs. Arrange so curved portion of bends is not visible above the finished slab. All elbow penetration through the slab shall be PVC coated rigid metallic conduit Ells. Where elbows end below the slab, extend PVC coated rigid conduit a minimum of 6 inches above the finished slab.

M. Make bends and offsets so the inside diameter is not effectively reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel.

N. Use raceway fittings that are of types compatible with the associated raceway and suitable for the use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings except as otherwise indicated.

O. Run concealed raceways with a minimum of bends in the shortest practical distance considering the type of building construction and obstructions except as otherwise indicated.

P. Install exposed raceways parallel and perpendicular to nearby surfaces or structural members and follow the surface contours as much as practical. All exposed conduit runs shall be approved by the Architect prior to installing.

Q. All exposed conduits in public areas shall be painted to match surrounding walls. Verify exact color with the Architect. Coordinate painting of all exposed conduits with Construction Manager / General Contractor.

R. Run exposed, parallel, or banked raceways together. Make bends in parallel or banked runs from the same center line so that the bends are parallel. Factory elbows may be used in banked runs only where they can be installed parallel. This requires that there be a change in the plane of the run such as from wall to ceiling and that the raceways are of the same size. In other cases, provide field bends for parallel raceways. All exposed conduit routing shall be approved by the Architect prior to installing.

S. Join raceways with fittings designed and approved for the purpose and make joints tight. Where joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system. Make raceway terminations tight. Where terminations are subject to vibration, use bonding bushings or wedges to assure electrical continuity. Where subject to vibration or dampness, use insulating bushings to protect conductors. Use expansion fittings at building expansion joints.

T. Tighten set screws of threadless fittings with suitable tool.

U. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts with dished part against the box. Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside of the box. All conduit connections to junction boxes shall have insulated bushings.

V. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.

W. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb tensile strength. Leave no less than 12 inches of slack at each end of the pull wire.

X. Install raceway sealing fittings in accordance with the manufacturer's written instructions. Locate fittings at suitable, approved, accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points and elsewhere as indicated:
   1. Where conduits pass from warm locations to cold locations, such as the boundaries of refrigerated spaces, air-conditioned spaces and walk-in coolers.
   2. Where required by the NEC.

Y. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment with an adjustable top or coupling threaded inside for plugs and set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; flexible metal conduit may be used 6 inches above the floor. Where equipment connections are not made under this contract, install screwdriver-operated threaded flush plugs flush with floor.

Z. Flexible connection: Use length (maximum of 6 ft.) of flexible conduit for recessed and semi-recessed lighting fixtures, for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquid-tight flexible conduit in wet locations. Install separate equipment grounding conductor across flexible connections.

AA. Install nonferrous conduit or tubing for circuits operating above 60 Hz.

BB. PVC externally coated rigid steel conduit: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduit.

CC. All underground conduits shall be installed a minimum of 48 inches below finish grade for medium-voltage feeders and 30 inches for 480-Volt feeders. All other conduits shall be installed in accordance with the NEC and coordinated depth with other trades.

DD. All medium-voltage ductbanks shall be encased in concrete.

EE. Grounding: Install a separate green equipment grounding conductor in all raceways from the panelboard/junction box supplying the raceway to the receptacle or equipment ground terminals. Conduits will not be permitted as a ground conductor.

FF. Emergency feeder raceways that are not concealed in the electrical room or in sprinkled spaces shall be wrapped in a 2-hour protected fire wrap (MFR: 3M interam wrap or approved equal) or wiring shall be 2-hour protected and UL listed for that purpose.

GG. Furnish and install all raceways from elevator machine room to fire command center for elevator status.

HH. Clearances: All electrical raceways shall be routed to maintain appropriate clearances from low-voltage raceways per NEC, ANSI/EIA/TIA, and BICSI requirements. Provided below are minimum requirements of key components that shall be maintained. For any instances where field conditions do not allow for the minimum clearances, the Contractor shall notify the Architect and Engineer so that an acceptable solution can be coordinated.
1. 120V Power Conduits: 6 inches (150mm)
2. 208V and Higher Power: 24 inches (600mm)
3. Lighting System: 12 inches (300mm)
4. Transformers: 48 inches (1200mm)
5. Motors and Fans: 48 inches (1200mm)
6. Other Interfering Sources to be field verified and coordinated by Contractor with Architect and Engineer.

II. Support: All electrical raceways shall be independently supported. Support from suspended ceiling elements is not permitted.

3.3 INSTALLATION OF ELECTRICAL BOXES AND FITTINGS

A. General: Install electrical boxes and fittings in accordance with manufacturer's written instructions, applicable requirements of NEC and NECA's "Standard of Installation," and in accordance with recognized industry practices to fulfill project requirements.

B. Dimensions unless shown on drawings are given below and are from finished floor to center line of outlets unless noted otherwise. Adjust heights of outlets in masonry walls to correspond with consistent brick or block course. Outlets in block walls shall be installed in core of block.

Wall Switches	4' - 0" (to top of box)
Convenience outlets	1' - 4" (to bottom of box) – gyp or 8" block 1' – 6" (to bottom of box) – 6" block
Hallways	1' - 6" (to bottom of box)
Above counter wall outlet	0' - 8" (above counter to top of box, maximum 44" AFF, field verify height of backsplash)
Panelboards wall mounted	6' - 6" (to top of back box)
Wall phone outlet	4' - 0" (to top of box)
Tele/Data outlets	1' - 6" (to bottom of outlet)
Fire alarm horns, speakers	ceiling or wall
Fire alarm pull stations	4' - 0" (to top of device)
Fire alarm strobes	6' - 8" or 6" below ceiling (whichever is lower)
Television outlets	Refer to A/V or architectural drawing.

Confirm final location and heights of all outlets, wall switches, and television outlets with architectural drawings and furniture plans prior to installation.

C. Exact location of outlets and equipment shall be governed by structural conditions and obstructions or other equipment items. When necessary, relocate outlets so that when fixtures or equipment are installed, they will be symmetrically located according to room layout and will

not interfere with other work or equipment. Verify final location of all outlets, panels, equipment, etc., with the Architect/Engineer.

D. Coordinate installation of electrical boxes and fittings with wire/cable, wiring devices, and raceway installation work.

E. Provide zinc-coated or cadmium-plated sheet steel outlet boxes not less than 4" octagonal or square, unless otherwise noted. Equip fixture outlet boxes with 3/8" no-bolt fixture studs. Where fixtures are mounted on or in an accessible type ceiling, provide a junction box and extend flexible conduit to each fixture. Outlet boxes in finished ceilings or walls shall be fitted with appropriate covers, set to come flush with the finished surface. Where more than one switch or device is located on one point, use gang boxes and covers unless otherwise indicated. Sectional switch boxes or utility boxes will not be permitted.

F. Provide tile box or a 4" square box with tile ring in masonry walls which will not be plastered or furred, or where "dry-wall" type materials are applied. Through the wall type boxes are not permitted. Install minimum 12" lateral separation for back to back boxes.

G. Provide outlets in rain tight box with metallic "in use" covers for interior and exterior locations exposed to weather or moisture.

H. Provide rain tight box for all interior, exterior and non-conditioned locations exposed to weather or moisture. This includes boxes located under overhangs not directly exposed to moisture.

I. Surface-mounted devices are to be mounted in cast type boxes with gasketed covers: (Crouse-Hinds condulets or equal).

J. Provide knockout closures to cap unused knockout holes where blanks have been removed.

K. Install electrical boxes in those locations which ensure ready accessibility to enclosed electrical wiring.

L. Electrical Contractor to provide access panels for electrical boxes which are code required to have accessibility.

M. Installing boxes back-to-back in walls shall not be permitted. Provide no less than 12 inches (150 mm) of separation.

N. Position recessed outlet boxes accurately to allow for surface finish thickness.

O. Avoid using round boxes where conduit must enter box through side of box, which would result in difficult and insecure connections when fastened with locknut or bushing on rounded surfaces.

P. Fasten electrical boxes firmly and rigidly to substrates, or structural surfaces to which attached, or solidly embedded electrical boxes in concrete or masonry.

Q. Provide electrical connections for installed boxes.

R. Exterior junction or pull boxes shall be mounted flush with grade, unless noted otherwise or indicated to be above ground on the drawings. Boxes shall be surrounded on all sides with 6 inches minimum of concrete. Top of concrete shall flush with grade. Seal all conduit entries into box with duct seal to prevent entrance of moisture, after conductors are installed.

S. Tap and splices, where permitted by these specifications within exterior junction boxes, shall be performed with an encapsulating watertight splice or tap kit which insulates and moisture seals the connection. Kit shall consist of the appropriate size and type mold, encapsulating resin and end sealing tape.

T. Subsequent to installation of boxes, protect boxes from construction debris and damage.

U. Provide a standard access panel having a hinged metal door neatly fitted into a flush metal trim, where a junction box or equipment is located above non-accessible ceilings or behind finished walls. Coordinate location and type with the Architect.

V. Outlets except over counters, benches, special equipment, baseboards, fin tube radiators, etc., or at wainscoting, shall be at a height to prevent interference to service equipment, or as noted on drawings.

3.4 GROUNDING

A. Upon completion of installation work, properly ground electrical boxes and demonstrate compliance with requirements.

3.5 ADJUSTING AND CLEANING

A. Upon completion of installation of raceways, inspect interiors of raceways; clear all blockages and remove burrs, dirt, and construction debris.

END OF SECTION

SECTION 26 05 53 - IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Requirements of the following Division 26 Sections apply to this Section:
   1. "Electrical Requirements."

1.2 SUMMARY

A. This Section includes identification of electrical materials, equipment, and installations. It includes requirements for electrical identification components including but not limited to the following:
   1. Buried electrical line warnings.
   2. Identification labeling for raceways, cables, and conductors.
   3. Operational instruction signs.
   4. Warning and caution signs.
   5. Equipment labels and signs.

B. Related Sections: The following Sections contain requirements that relate to this Section;
   1. Division 9 Section "Painting" for related identification requirements.
   2. Division 26 Section "Wires and Cables" for requirements for color coding of conductors for phase identification.

C. Refer to other Division 26 Sections for additional specific electrical identification associated with specific items.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product Data for each type of product specified.

C. Schedule of identification nomenclature to be used for identification signs and labels.

D. Samples of engraved, plastic laminate to be used on switchgear, switchboards, disconnect switches and panelboards.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

B. ANSI Compliance: Comply with requirements of ANSI Standard A13.1, "Scheme for the identification of Piping Systems," with regard to type and size of lettering for raceway and cable labels.

PART 2 - PRODUCTS

2.1 ELECTRICAL IDENTIFICATION PRODUCTS

A. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: Self-adhesive vinyl tape not less than 3 mil thick by 1 inch to 2 inches in width.

B. Underground Line Marking Tape: Permanent, bright-colored, continuous-printed, plastic tape with magnetic tracer strip not less than 6-inches wide by 4-mil thick. Printed legend indicative of general type of underground line below.

C. Wire/Cable Designation Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wrap around, cable/conductor markers with preprinted numbers and letters.

D. Engraved, Plastic-Laminated Labels, Signs, and Instruction Plates: Engraving stock melamine plastic laminate, 1/16-inch minimum thick for sign up to 20 square inches, or 8 inches in length; 1/8-inch thick for larger sizes. Engraved legend in black letters on white face for normal power and white letters on red face for emergency and standby power. Plastic laminate shall be punched for mechanical fasteners. Refer to details on drawings for exact information requirements.

E. Baked-Enamel Warning and Caution Signs for Interior Use: Preprinted aluminum signs, punched for fasteners, with colors, legend, and size appropriate to the location.

F. Exterior Metal-Backed Butyrate Warning and Caution Signs: Weather-resistant, non-fading, preprinted cellulose acetate butyrate signs with 20-gage, galvanized steel backing, with colors, legend, and size appropriate to the location. Provide ¼-inch grommets in corners for mounting.

G. Fasteners for Plastic-Laminated and Metal Signs: Self-tapping stainless-steel screws or number 10/32 stainless-steel machine screws with nuts and flat and lock washers.

H. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking nylon cable ties, 0.18-inch minimum width, 50-lb minimum tensile strength, and suitable for a temperature range from minus 50°F to 350°F. Provide ties in specified colors when used for color coding.

I. Electronic Labels: Self-adhesive, 3/16-inch-industrial label, black on clear for normal circuits and red on clear for emergency/standby circuits. Acceptable manufacturers include the following:
   1. Brother
   2. Kroy

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as approved in submittals and as required by code.

B. Install identification devices in accordance with manufacturer's written instructions and requirements of NEC.

C. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.

3.2 IDENTIFICATION

A. Identify Junction, Pull, and Connection Boxes: Code-required caution sign for boxes shall be pressure-sensitive, self-adhesive label indicating system voltage in black, preprinted on orange background. Install on outside of box cover. Also, label box covers with identity of contained

circuits. Use pressure-sensitive plastic labels at exposed locations and similar labels at concealed boxes.

B. Underground Electrical Line Identification: During trench backfilling, for underground power, signal, and communications lines, install continuous underground plastic line marker, located directly above line at 6 to 8 inches below finished grade. Where multiple lines installed in a common trench or concrete envelope do not exceed an overall width of 16 inches; install a single line marker.

C. Install line marker for underground wiring, both direct-buried and in raceway.

D. Identify Raceways of Certain Systems with Color Banding: Band exposed or accessible raceways of the following systems for identification. Bands shall be painted with colors indicated below. Make each color band 2 inches-wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side. Install bands at changes in direction, at penetrations of walls and floors, and at 40-foot maximum intervals in straight runs. Apply the following colors:
   1. Fire Alarm Systems: Red.
   2. Fire Suppression Supervisory and Control System: Red and Yellow.
   3. Mechanical and Electrical Supervisory System: Green and Blue.
   4. Telephone System: Green and Yellow.
   5. Tag or label conductors as follows:
      a. Future Connections: Conductors indicated to be for future connection or connection under another contract with identification indicating source and intent.
      b. Multiple Circuits: Where multiple branch circuits or control wiring or communications/signal conductors are present in the same box or enclosure label each conductor or cable. Provide label on each box indicating source, voltage, circuit number, and phase for branch circuit wiring. Phase and voltage of branch circuit wiring may be indicated by mean of coded color of conductor insulation. For control and communications/signal wiring, use color coding or wire/cable marking tape at terminations and at intermediate locations where conductors appear in wiring boxes, troughs, and control cabinets. Use consistent letter/number conductor designations throughout on wire/cable marking tapes.
      c. Match identification markings with designations used in panelboards shop drawings, Contract Documents, and similar previously established identification schemes for the facilities' electrical installations.

E. Install labels at locations indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

F. Conductor Color Coding: Provide color coding for secondary service, feeder, and branch circuit conductors throughout the project secondary electrical system as follows:

208/120-Volts	Phase	480/277-Volts
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray
Green	Ground	Green

G. Use conductors with color factory-applied the entire length of the conductors except as follows:
   1. The following field-applied color-coding methods may be used in lieu of factory-coded wire for sizes larger than No. 10 AWG:
      a. Apply colored, pressure-sensitive plastic tap in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply the last two laps of tape with no tension to prevent possible unwinding. Use 1-inch-wide tape in colors as specified. Do not obliterate cable identification markings by taping. Tape locations may be adjusted slightly to prevent such obliteration.

b. In lieu of pressure-sensitive tape, colored cable ties may be used for color identification. Apply three ties of specified color to each wire at each terminal or splice point starting 3 inches from the terminal and spaced 3 inches apart. Apply with a special tool or pliers, tighten for snug fit, and cut off excess length.

2. All grounded conductors No. 6 AWG and smaller shall be a factory applied color across the entire length of conductors.

H. Power Circuit Identification:
1. Securely fasten wrap-around marker bands to cables, feeders, and power circuits in pull boxes, junction boxes, and switchgear rooms.

I. Apply warning, caution, and instruction signs and stencils as follows:
1. Install warning, caution, or instruction signs where required by NEC where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.
2. Emergency Operating Signs: Install engraved laminate signs with white legend on red background with minimum 3/8-inch-high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.
3. Arc Flash Labels: All electrical equipment shall be marked with a label consisting of the following information:
   a. Nominal voltage.
   b. Available fault current at the equipment.
   c. Clearing time.
   d. Arc flash hazard boundary.
   e. Flash hazard at 18".
   f. PPE (Personnel protective equipment) level.
   g. Distance of limited approach.
   h. Distance of restricted approach.
   i. Distance of prohibited approach.
   j. Date label is applied or calculations were performed.

J. Install equipment/system circuit/device identification as follows:
1. Apply equipment identification labels of engraved plastic-laminate on each major unit for electrical equipment in the Fire Station including central or master unit of each electrical system. This includes communication/signal/alarm system, unless unit is specified with its own self-explanatory identification. Except as otherwise indicated, provide single line of text, with 3/8-inch-high lettering on 1-1/2-inch-high label (2-inch-high where two lines are required), black lettering in white field for normal power and red lettering on white field for emergency and standby power. Text shall match terminology and numbering of the Contract Documents and shop drawings. Apply labels for each unit of the following categories of electrical equipment:
   a. Panelboards, electrical cabinets, and enclosures.
      1) Labels shall include at a minimum: voltage, phase, ampacity, AIC rating, available fault current (and when it was calculated) and where the equipment is fed from. Refer to detail on drawings for additional information.
   b. Access doors and panels for concealed electrical items.
   c. Motor starters, motor control centers.
   d. Contactors.
   e. Remote-controlled switches.
   f. Control devices.
2. Apply electronic label on the inside of all receptacle and switch plates. The labels shall identify circuit and panelboard.
3. All emergency circuits shall be permanently marked as emergency as indicated below:
   a. Junction Boxes – with permanently fastened labels.

b. Raceways – with permanently fastened labels at intervals of not more than 25ft.

K. Apply circuit/control/item designation labels of engraved plastic laminate for disconnect switches, breakers, pushbuttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components, where labeling is specified elsewhere. For panelboards, provide framed, typed circuit schedules with explicit description and identification (including room numbers) of items controlled by each individual breaker.

L. Fire Pump Service Identification: A placard shall be externally installed on the Fire Pump primary disconnecting means stating, "Fire Pump Disconnecting Mean." The lettering shall be at least one inch in height. In addition, a placard shall be placed adjacent to the Fire Pump controller stating the location of this disconnecting means and the location of the key (if the disconnecting means is locked).

M. Electrical Service Room Distribution Placard: In each of the main electrical rooms, provide a single line riser diagram placard of the entire electrical distribution fed from that room. The placard shall also identify where other services are located per NEC 230.2(e). The riser diagram shall be framed under glass and mounted on the wall in the electrical room. The print shall be of diffusion transfer process to eliminate fading.

END OF SECTION

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SECTION 26 24 16 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.

B. Division 26 Basic Electrical Material and Methods sections apply to work specified in this section.

1.2 SUMMARY

A. Provide all panelboards and enclosure work, including cabinets and cutout boxes, as indicated by drawings and schedules, and a specified herein.

B. Types of panelboards, and enclosures required for the project include the following:
   1. Power-distribution panelboards.
   2. Lighting and appliance panelboards.

C. All switchboards, panelboards, switchgears, transformers, disconnect switches, starters, etc., shall be fabricated by same manufacturer throughout the entire project unless specifically noted otherwise.

D. Wires/cables, bus-way, electrical boxes and fittings, and raceways required in conjunction with the installation of panelboards, and enclosures are specified in other Division 26 sections.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's data on panelboards, and enclosures.

B. Wiring Diagrams: Submit wiring diagrams for panelboards showing connections to electrical power feeders and distribution branches.

C. Submit electrical room plan view drawings at ¼" scale showing all equipment, panelboards, disconnects and ratings, buss work, conduit areas, dimensions and mounting of equipment supplied.

D. Shop drawings showing dimensions, voltage, phasing, continuous current capacity, and short circuit rating.

E. The equipment product data, electrical room layouts and short-circuit study shall be submitted together in order to provide proper evaluation.

F. Submittals shall be in accordance with specification section 26 05 02.

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications: The manufacturer of this equipment shall be regularly engaged in manufacture of panelboards and enclosures, of types, sizes, and ratings required and have produced similar electrical equipment, for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. Codes and Standards

1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC Article 384 as applicable to installation, and construction of electrical panelboards and enclosures.
2. UL Compliance: Comply with applicable requirements of UL 67, "Electric Panelboards", and UL's 50, 869, 486A, 486B, 891, and 1053 pertaining to panelboards, accessories and enclosures. Provide panelboard units which are UL-listed and labeled.
3. Special-Use Markings: Provide panelboards, constructed for special-use, with appropriate UL markings which indicated that they are suitable for special type of use/application.
4. NEMA Compliance: Comply with NEMA Standards Pub/No. 250, "Enclosure for Electrical Equipment (1000-Volts Maximum)", Pub/No. PB 1, "Panelboards", and Pub/No. PB 1.1, "Instructions for Safe Installation, Operation, and Maintenance of Panelboards Rated 600-Volts or Less".

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store panelboards in clean dry space. Protect units from dirt, fumes, water, construction debris and traffic; where necessary to store outdoors, store electrical components above grade and enclose with watertight wrapping.

B. Handle panelboards carefully to prevent internal components damage, breakage, denting, and scoring enclosure finish. Do not install damaged components; replace and return damaged units to equipment manufacturer.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate installation of panelboards and enclosures with installation of wires/cables, electrical boxes and fittings, and raceway work.

PART 2 - PRODUCTS

2.1 PANELBOARDS (800 AMPS OR LESS)

A. General: Except as otherwise indicated, provide panelboards, enclosures and ancillary components, of types, sizes, and ratings indicated on drawings, which comply with manufacturer's standard materials; with the design and construction in accordance with published product information; equip with proper numbers of unit panelboard devices as required for complete installation.
   1. Prefabricated or pre-wired panelboards are not acceptable.

B. Power Distribution Panelboards: Provide dead-front safety type power distribution panelboards as indicated, with panelboards switching and protective devices in quantities, ratings, types, and with arrangement shown; with anti-turn solderless pressure type main lug connectors approved for use with copper conductors. Select unit with feeders connecting at top of panel. Equip with copper buss bars with not less than 98% conductivity, and with full-sized neutral buss; provide suitable lugs on neutral bus for outgoing feeders requiring neutral connection. Provide molded-case main and branch circuit-breaker types for each circuit, with toggle handles that indicated when tripped. Where multiple-pole breakers are indicated, provide with common trip so overload on one pole will trip all poles simultaneously. Where multiple single pole breakers share a common neutral conductor, provide breaker tie bars as required so overload on one pole will trip all poles simultaneously. Provide panelboards with bare un-insulated grounding bars suitable for bolting to enclosures. Select enclosures fabricated by same manufacturers as panelboards, which mate and match properly with panelboards. Employ bolt on breakers that are fully rated for the available short-circuit condition but of not less than 22,000 sym AIC.

C. Lighting and Appliance Panelboards: Provide dead-front safety type lighting and appliance panelboards as indicated, with switching and protective devices in quantities, ratings, types and arrangements shown. Equipped with anti-turn solderless pressure type lug connectors approved for use with copper conductors; construct unit for connecting feeders at top of panel; equip with copper buss bars, full-sized neutral bar, with bolt-in type heavy-duty, quick-make, quick-break, single-pole circuit breakers, with toggle handles that indicate when tripped. Provide suitable lugs on neutral buss for each outgoing feeder required; and provide bare uninsulated grounding bars suitable for bolting to enclosures. Select enclosures fabricated by same manufacturers as panelboards, which mate and match properly with panelboards.
   1. Employ breakers that are fully rated for the available short-circuit condition but not less than 10,000 sym AIC at 120/208-Volts.
   2. Where multiple single pole breakers share a common neutral conductor, provide breaker tie bars as required so overload on one pole will trip all poles simultaneously.
   3. All circuit breakers feeding food service loads or vending machines shall be GFCI type.

D. Panelboard Enclosures: Provide galvanized sheet steel cabinet type enclosures, in sizes and NEMA types as indicated, code-gage, minimum 16-gage thickness. Construct with multiple knockouts and wiring gutters. Provide fronts with adjustable trim clamps, and doors with flush locks and keys, all panelboard enclosures keyed alike, with concealed piano door hinges with door in door swings as indicated. Equip with interior circuit-directory frame, and card with clear plastic covering. Provide baked gray enamel finish over a rust inhibitor coating. Design enclosures for surface mounting. Provide enclosures which are fabricated by same manufacturer as panelboards, which mate and match properly with panelboards to be enclosed.

E. Molded-Case Circuit Breakers: Provide factory-assembled, molded-case circuit breakers of frame sizes, characteristics, and ratings including RMS symmetrical interrupting ratings indicated. Select breakers with permanent thermal and instantaneous magnetic trip, and ampere ratings as indicated on the drawings. Construct with overcenter, trip-free, toggle-type operating mechanisms with quick-make, quick-break action and positive handle trip indication. Construct breakers for mounting and operating in any physical position, and operating in ambient temperature of 40°C. Provide breakers with mechanical screw or compression type removable connector lugs, AL/CU rated.
   1. Breakers feeding the primary side of a transformer shall have provisions for locking the breaker on or off.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine area and conditions under which panelboards and enclosures are to be installed, and notify Engineer in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install panelboards and enclosures as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC standards and NECA's "Standards of Installation" and in compliance with recognized industry practices to ensure that products fulfill requirements.

B. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturers' published torque tightening values for equipment connectors. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with torque tightening requirements specified in UL Standards 486A and B.

C. Fasten enclosures firmly to walls and structural surfaces, ensuring that they are permanently and mechanically anchored.

D. Provide properly wired electrical connections for panelboards within the enclosures.
   1. Prefabricated or pre-wired panelboards are not acceptable.

E. Provide engraved, plastic laminate labels for all panelboards indicating name, voltage, phase, wire and short circuit rating. Refer to Section 26 05 53 for more information.

F. At all recessed panel locations, provide three ¾" spare conduits stubbed to the accessible ceiling space for future use.

G. Provide typed panelboards circuit directory card upon completion of installation work to match as-built conditions and nomenclature indicated on engineering drawings and submit directories to the Engineer for review prior to mounting in panelboard.

3.3 GROUNDING

A. Provide equipment grounding connections as indicated herein. Tighten connection to comply with torque tightening requirements specified in UL Standard 486A to assure permanent and effective grounds.

B. Refer to Section 26 05 26 for additional grounding requirements.

3.4 FIELD QUALITY CONTROL

Tests shall conform to International Electrical Testing Association (INETA) Standard ATS, "Acceptance Testing Specifications for Electrical Power Distribution Equipment".

A. Infrared Inspection (After Energized)
   1. The scan is to include all electrical panelboards or bussed distribution equipment.
   2. All equipment should be energized at normal load levels during an event for at least 1 to 2 hours prior to being scanned.
   3. Access covers are to be removed and reinstalled by the electrical Contractor for the Engineer to inspect and scan all electrical junctions, buss, and cable.
   4. The IR Scan will be made using a Flir Thermal Imaging Camera. The camera shall provide infrared photos clearly indicating problem areas.
   5. All problem areas will be noted as to location, description, and recommended solution by providing a typed report including infrared and digital pictures of all problem areas.

B. Panelboards:
   1. Visual and Mechanical Inspection:
      a. Inspect for physical damage and code violations.
      b. Inspect for proper alignment, anchorage and grounding.
      c. Inspect for proper identification of protective devices and switches.
      d. Check tightness of accessible bolted buss joints.
      e. Physically test all electrical or mechanical interlocks to assure proper function.
      f. Clean interior and insulator surfaces once a month prior to job completion.
      g. Inspect for proper operation of space heaters and thermostat settings (if they exist).
   2. Electrical Tests:
      a. Measure insulation resistance of each buss section phase-to-phase and phase-to-ground.
      b. Check panelboards for electrical continuity of circuits and for short circuits.

3.5 ADJUSTING AND CLEANING

A. Adjust operating mechanisms for free mechanical movement.

B. Touch-up scratched or marred surfaces to match original finishes.

3.6 DEMONSTRATION

A. Subsequent to wire and cable hook-ups, energize and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

END OF SECTION

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SECTION 26 28 16 - ENCLOSED SWITCHES, FUSES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.

B. Section 26 05 06, "Basic Material and Methods", applies to work of this section.

1.2 SUMMARY

A. Provide all circuit and motor disconnect switch work including fusing, electrical connections to motors, appliance and mechanical equipment as indicated on the drawings and schedules.

B. Types of circuit and motor disconnect switches in this section include the following:
1. Equipment disconnects.
2. Appliance disconnects.
3. Motor-circuit disconnects.

C. Applications of electrical power connections specified in this section include the following:
1. To resistive heaters.
2. From electrical source to motor starters.
3. From motor starters to motors.
4. To lighting fixtures.
5. To converters, rectifiers, transformers, inverters, rheostats, and similar current adjustment features of equipment.
6. To grounds including earthing connections.
7. To panelboards, contactors, time clocks and similar equipment.
8. Enclosed busway plug-in assemblies.

D. All switchboards, panelboards, transformers, disconnect switches, starters, etc., shall be fabricated by same manufacturer throughout the entire project.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's data on circuit and motor disconnect switches, and equipment connectors.

B. Fuse Product Data: For each type of fuse indicated. Include construction details, material, dimensions, and descriptions of individual components. Include the following for each fuse type indicated:
1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
   a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
   b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
5. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 QUALITY ASSURANCE

A. All equipment shall be in compliance with codes and standards referenced in Section 26 05 02 titled "Electrical Requirements".

B. UL Compliance: Comply with requirements of UL 98, "Enclosed and Dead-Front Switches." Provide circuit and motor disconnect switches which have been UL listed and labeled.

C. Comply with UL Standard 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors," including, but not limited to, tightening of electrical connectors to torque values indicated.

D. NEMA Compliance: Comply with applicable requirements for NEMA Standards Pub/No. KS 1, "Enclosed Switches," and No. 250, "Enclosures for Electrical Equipment (1000-Volts Maximum)."

E. ANSI Compliance: Comply with applicable requirements of ANSI C97.1, "Low-Voltage Cartridge Fuses 600-Volts or Less."

F. NEMA Compliance: Comply with NEMA FU1 for cartridge fuses.

1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings

PART 2 - PRODUCTS

2.1 CIRCUIT AND MOTOR DISCONNECT SWITCHES

A. Furnish and install safety switches as required for motor outlets or other equipment. Switches shall be of size, number of poles, and fused or non-fused, as required for job conditions and the National Electrical Code.

B. Switches shall be equipped with fuse contacts and jaws which ensure positive fuse and jaw contact by means of reinforcing spring clips of other approved means. All current carrying parts shall be silver-plated. Hinges shall be non-current carrying. Switches shall be so designed that they can be locked in either open or closed position.

C. All safety switches shall be NEMA 1 enclosed Type "HD" (heavy duty) quick-make, quick-break, and have interlocking cover with handle that may either be front or side operating with padlocking provisions. Provide NEMA 3R weatherproof enclosures where indicated on the drawings or exposed to exterior or damp locations. Incorporate rejection clips where used with Class "R" fuses.

D. Fusible Switches: Heavy duty switches, with fuses of classes and current ratings indicated on drawings. See Section "2.3" for Fuse specifications. Where current limiting fuses are indicated, provide switches with non-interchangeable feature suitable only for current limiting type fuses.

E. Non-fusible Disconnects: Heavy duty switches of classes and current ratings as indicated on drawings.

F. Double-Throw Switches: Heavy duty switches of classes and current rating as indicated on drawings.

G. Bolted Pressure Switches: Bolted pressure switches conforming to and listed under UL Standard 977; single or double-throw arrangement as indicated. For fusible units provide fuses as indicated on drawings.

H. Accessories:

1. Electrical Interlocks: Provide number and arrangement of interlock contacts in switches as indicated on drawings or specified elsewhere in specifications.
2. Special Enclosure Material: Provide special enclosure material as follows for switches indicated on drawings to be NEMA 4X:
   a. Stainless Steel Type 316.
   b. Heavy case aluminum.
3. Captive Fuse Pullers: Provide built-in pullers arranged to facilitate fuse removal.

2.2 CONNECTIONS FOR EQUIPMENT

A. General: For each electrical connection indicated provide complete assembly of materials, including but not necessarily limited to, pressure connectors, terminals (lugs), electrical insulating tape, electrical solder, electrical soldering flux, heat-shrinkable insulating tubing, cable ties and solderless wirenuts. All other items and accessories as needed to complete splices and terminations of types indicated.

B. Metal Conduit, Tubing and Fittings:
   1. General: Provide metal conduit, tubing and fitting of types, grades, sizes and weights (wall thicknesses) indicated for each type service. Where types and grades are not indicated, provide proper selection as determined by Installer to fulfill wiring requirements and comply with NEC requirements for raceways. Provide products complying with Section 26 05 06 titled "Basic Materials and Methods" and Section 26 05 33 titled "Raceways and Boxes" and in accordance with the following listing of metal conduit, tubing and fittings:
      a. Rigid steel conduit.
      b. Rigid metal conduit fittings.
      c. Electrical metallic tubing.
      d. EMT fittings.
      e. Flexible metal conduit.
      f. Flexible metal conduit fittings.
      g. Liquid-tight flexible metal conduit.
      h. Liquid tight flexible metal conduit fittings.

C. Wires, Cables, and Connectors:
   1. General: Provide wires, cables and connectors complying with Division 26 05 06 titled "Basic Materials and Methods" and "Section 26 05 19" titled "Electrical Power Conductors and Cables."
   2. Wires/Cables: Unless otherwise indicated, provide wires/cables (conductors) for electrical connections which match, including sizes and rating, of wires/cables which are supplying electrical power. Provide copper conductors with conductivity of not less than 98% at 20°C (68°F).
   3. Connectors and Terminals: Provide electrical connectors and terminals which mate and match, including sizes and ratings, with equipment terminals and are recommended for use by equipment manufacturer for intended applications.
   4. Electrical Connection Accessories: Provide electrical insulating tape, heat shrinkable insulating tubing and boots, electrical solder, electrical soldering flux, wirenuts and cable ties as recommended for use by accessories manufacturers for type services indicated.

2.3 FUSES

A. General: Except as otherwise indicated, provide fuses of types, sizes, ratings, and average time-current and peak let-through current characteristics, which comply with manufacturer's standard design, materials, and constructed in accordance with published product information, and with industry standards and configurations.

B. Class RK1 dual element time-delay fuses: Provide UL Class RK1 current limiting time-delay fuses rated 600-Volts, (250-Volts where specified), 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting circuit breakers, motors and panelboards.

C. Class RK5 dual element time-delay fuses: Provide UL Class RK5 current limiting time-delay fuses rated 600-Volts, (250-Volts where specified), 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting circuit breakers, motors, and transformers.

D. Class L time-delay fuses: Provide UL Class L time-delay fuses rated 600-Volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating.

E. Class J dual element time-delay fuses: Provide UL Class J time-delay fuses rated 600-Volts, 60 Hz, with 300,000 RMS symmetrical interrupting current rating.

PART 3 - EXECUTION

3.1 INSTALLATION OF CIRCUIT AND MOTOR DISCONNECT SWITCHES

A. Install circuit and motor disconnect switches as indicated, complying with manufacturer's written instructions, applicable requirements of NEC, NEMA, and NECA's "Standard of Installation," and in accordance with recognized industry practices.

B. Coordinate circuit and motor disconnect switch installation work with electrical raceway and cable work, as necessary for proper interface.

C. Install disconnect switches for use with motor-driven appliances, and motors and controllers within sight of controller position unless otherwise indicated. For all disconnecting means located remote from the motor controller (starter or variable frequency drive), contractor to provide disconnect with auxiliary contacts, contacts and control wiring back to motor controller.

D. Provide NEMA 3R disconnect switches for all exterior locations and any location subject to moisture.

3.2 INSTALLATION OF EQUIPMENT CONNECTIONS

A. Install electrical connections in accordance with equipment manufacturer's written instructions and with recognized industry practices, and complying with applicable requirements of UL, NEC and NECA's "Standard of installation" to ensure that products fulfill requirements.

B. Coordinate with other work, including wires/cables, raceway and equipment installation, as necessary to properly interface installation of electrical connections for equipment with other work.

C. Connect electrical power supply conductors to equipment conductors in accordance with equipment manufacturer's written instructions and wiring diagrams. Mate and match conductors of electrical connections for proper interface between electrical power supplies and installed equipment.

D. Cover splices with electrical insulating material equivalent to, or of greater insulation resistivity rating, than electrical insulation rating of those conductors being spliced.

E. Prepare cables and wires, by cutting and stripping covering armor, jacket, and insulation properly to ensure uniform and neat appearance where cables and wires and terminated. Exercise care to avoid cutting through tapes which will remain on conductors. Also avoid "nicking" copper conductors while skinning wire.

F. Trim cables and wires as short as practicable and arrange routing to facilitate inspection, testing and maintenance.

G. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturers published torque tightening values for equipment connectors. Accomplish tightening by utilizing proper torque tools, including torque screwdriver, beam-type torque wrench, and ratchet wrench with adjustable torque settings. Where manufacturer's torque requirements are not available, tighten connectors and terminals to comply with torque values contained in UL 486A.

H. Provide PVC-coated conduit and fittings for highly-corrosive atmospheres.

I. Provide flexible conduit for motor connections, and other electrical equipment connections, where subject to movement and vibration.

J. Provide liquid-tight flexible conduit for connection of motors and other electrical equipment where subject to movement and vibration, and also where connections are subjected to one or more of the following conditions:
   1. Exterior location.
   2. Moist of humid atmosphere where condensation can be expected to accumulate.
   3. Corrosive atmosphere.
   4. Water spray.
   5. Dripping oil, grease, or water.

K. Fasten identification markers to each electrical power supply wire/cable conductor which indicates their voltage, phase and feeder number in accordance with Division 26 section titled "Electrical Identification." Affix markers on each terminal conductor, as close as possible to the point of connection.

L. Provide flexible metal conduit or Type "S" rubber cords, pigtails, caps, etc., as required to constitute an operating system. All flexible cords shall have grounding conductors. Ground all equipment. See Section 26 05 26 titled "Grounding and Bonding" for additional requirements.

M. Prior to roughing-in, refer to all equipment manufacturer's shop drawings for details of equipment connections. Provide receptacles as required to match the cord caps on the equipment furnished. Provide either direct wiring or receptacles for final connection to equipment as required for the particular equipment furnished regardless of the type of outlet shown on the plans.

3.3 INSTALLATION OF FUSES

A. Install fuses as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to ensure that protective devices comply with requirements. Comply with NEC and NEMA standards for installation of fuses.

B. Coordinate work including electrical wiring, as necessary, to interface installation of fuses with other trades.

C. Install fuses in fused switches.

D. Provide spare fuse of size and type for every five (5) fuses installed. A minimum of three (3) spare fuses shall be provided for each size installed.

3.4 GROUNDING

A. Provide equipment grounding connections, sufficiently tight to assure a permanent and effective ground for electrical disconnect switches.

3.5 FIELD QUALITY CONTROL

A. Testing: Subsequent to completion of installation of electrical disconnect switches, energize circuits and demonstrate capability and compliance with requirements. Except as otherwise

indicated, do not test switches by operating them under load. However, demonstrate switch operation through six opening/closing cycles with circuit unloaded. Open each switch enclosure for inspection of interior, mechanical and electrical connections, fuse installation, and for verification of type and rating of fuses installed. Correct deficiencies then retest to demonstrate compliance. Remove and replace defective units with new units and retest.

END OF SECTION

SECTION 26 43 14 - SURGE PROTECTIVE DEVICE (SPD)

PART 1 - GENERAL

1.1 SUMMARY

A. This specification includes requirements for a high energy, field-mounted, Surge Protective Device (SPD) Type 1 (formerly known as Secondary Surge Arrestor/TVSS) and SPD Type 2 (formerly known as Transient Voltage Surge Suppressor) electronic filtering system used to protect low-voltage AC electrical distribution from the effects of lightning, utility switching events, temporary over voltages (TOV), and impulses generated internally within a facility.

1.2 RELATED DOCUMENTS

A. The specified unit shall be designed, manufactured, tested and installed in compliance with the following standards:
   1. ANSI/IEEE C62.41.1-2002, C62.41.2-2002 and C62.45-2002
   2. Canadian Standards (CUL)
   3. Federal Information Processing Standards Publication 94 (FIPS PUB 94)
   4. National Fire Protection Association (NFPA 70 (NEC), 75 and 78)
   5. Underwriters Laboratories Listed (UL 96A, 198, 248-1, 489, 1283 and 1449-Third Edition)

1.3 SUBMITTALS

A. Product Data: Provide complete product data detailing manufacturer's model number, specifications, features and options.

B. Test Data: Manufacturers shall submit certified independent 3rd party test data verifying the following: life cycle testing, overcurrent protection, UL1449 Third edition as tested by Underwriters Laboratories (UL), noise attenuation and surge current capacity. Data shall include type classification (Type 1, Type 2), voltage protective rating (VPR), actual MCOV test value, nominal discharge current test (I_n) rating.

C. Shop Drawings: Provide electrical and mechanical drawings that include detail on unit dimensions, weights, field connections and mounting provisions.

D. Installation, Operation and Maintenance Manuals: Provide one copy of the installation, start-up, operation and maintenance data for each unit supplied.

1.4 ACCEPTABLE MANUFACTURER

A. These specifications detail performance requirements for a surge suppression system manufactured by Current Technology, Citel (Panelboards only), Emerson/Liebert, Square D/Schneider, Eaton/Bussmann, General Electric, Mersen, Siemens or Thor. Substitute, value-engineered or alternate products shall meet all performance and reliability aspects of this specification, including the substitute/alternate products submittal requirements.

1.5 SUBSTITUTION PRE-APPROVAL PROCEDURES

A. Manufacturers requesting approval of their products shall identify the full model number and submit product data and specifications.

1.6 WARRANTY

A. The manufacturer shall provide a ten (10) year limited warranty for service entrance and switchboard units, and a ten (10) year limited warranty for panelboard units from the date of shipment against failure when installed in compliance with applicable national/local electrical codes and the manufacturer's installation, operation and maintenance instructions.

1.7 LOCAL SERVICE SUPPORT

A. A dedicated support organization shall be located within 150 miles of the project location, and shall have experience supporting at least twenty other projects of similar complexity within the last three years.

PART 2 - PRODUCTS

2.1 HIGH PERFORMANCE SUPPRESSION SYSTEM

A. The suppression system shall incorporate metal oxide varistor (MOV) arrays and filtering capacitors. These components shall optimally share surge currents to ensure maximum performance and long-term reliability. The system shall not utilize gas tubes, spark gaps, silicon avalanche diodes, or other components that might short or crowbar the line, thus leading to power interruption.

2.2 UL 1449 THIRD EDITION UL TYPE 1 AND TYPE 2 DEVICE

A. The unit shall be certified as a Type 1 or Type 2 device suitable for use in these applications. The nominal discharge current shall be 20 KA, and the applied MCOV value shall be the actual MCOV of the unit's suppression components (i.e. between 115% and 130% of nominal installed voltage, according to Section 2.4).

2.3 UNIT OPERATING VOLTAGE

A. The operating voltage and configuration shall be 277/480-Volt or 120/208-Volt grounded wye as indicated on the drawings.

2.4 MAXIMUM CONTINUOUS OPERATING VOLTAGE (MCOV)

A. The MCOV shall be greater than 115 percent (%) of nominal voltage, but no greater than 130 percent (%).

2.5 PROTECTION MODES

A. All modes on all phases shall be protected (e.g., line-to-line, line-to-neutral, line-to-ground and neutral-to-ground).

2.6 RATED SINGLE PULSE SURGE CURRENT CAPACITY

A. The proposed product shall be single pulsed surge current tested in all modes at the rated surge currents by an industry recognized independent test laboratory. The test shall include a surge impulse (6kV (1.2x50 µs), 500 amp (8x20 µs) waveform) to benchmark the unit's suppression voltage. The applied impulse is followed by a single pulse surge of the maximum rated surge current magnitude, followed by a second 6kV (1.2x50 µs), 500 amp (8x20 µs) impulse as a means of measuring clamping deviation (component degradation). Compliance is achieved if the two measured suppression voltage do not vary by more than 5%.

Rated Single Pulse Surge Current Capacity				
Location	L-N	L-G	N-G	L-L
Service Entrance & Switchboards	120,000 A	120,000 A	120,000 A	120,000 A
Panelboards	50,000 A	50,000 A	50,000 A	50,000 A

2.7 MINIMUM REPETITIVE SURGE CURRENT CAPACITY

A. Per ANSI/IEEE C62.41 and ANSI/IEEE C62.45-2002, every mode of the suppression filter system shall be designed to survive multiple Category C 20 KV, 10 KA impulses. Test documentation shall detail the unit's ability to survive the following number of events (at one minute intervals) without any performance degradation.

Repetitive Surge Current Capacity - Number of Impulses				
Locations	L-L	L-N	L-G	N-G
Service Entrance & Switchboards	>12,000	>12,000	>12,000	>12,000
Panelboards	>4500	>4500	>4500	>4500

2.8 HIGH FREQUENCY EXTENDED RANGE FILTER

A. Noise Attenuation: The filter shall provide an attenuation of 63 db max from 10 kHz to 100MHz, per 50 Ohm Insertion Loss Methodology from MIL 220A. The system shall provide up to 120-dB insertion loss from 100 kHz to 100 MHz when used in a coordinated facility system

B. For installations that install multiple downstream filters, the filters shall be coordinated to provide minimum noise rejection/attenuation as follows:
   1. NOTE: Insertion loss data shall be based on a minimum of 100 feet of #4 AWG conductor between filters.

2.9 UL 1449 THIRD EDITION VOLTAGE PROTECTIVE RATING

A. The voltage protective rating (VPR) for grounded wye circuits at applicable voltage shall not exceed the following:

System Voltage	**Mode**	**UL 1449 Third Edition VPR**
120/208	Line to Line (L-L) Line to Neutral (L-N) Line to Ground (L-G) Neutral to Ground (N-G)	1200 700 700 700

System Voltage	Mode	UL 1449 Third Edition VPR
277/480	Line to Line (L-L) Line to Neutral (L-N) Line to Ground (L-G) Neutral to Ground (N-G)	2000 1200 1200 1200

2.10 REDUNDANT OVERCURRENT PROTECTION

A. Each suppression element shall utilize individual tested fuses to ensure that the failure of a single suppression component, or operation of any single fuse does not render the entire mode, phase or product deficient by more than twenty percent (20%). All fuses shall be capable of withstanding the rated single pulse surge current capacity of the individual components they protect without failure.

2.11 INTERNAL CONNECTIONS

A. Internal surge current paths shall utilize low-impedance copper bus bar. No plug-in modules or quick-disconnect terminals shall be used in the surge current-carrying paths.

2.12 ENCLOSURE

A. The service entrance unit shall utilize a NEMA 1 metallic enclosure for interior locations.

2.13 ADDITIONAL FEATURES/EQUIPMENT

A. Advanced Monitoring Feature. A battery-powered audible alarm with event counter display and two sets of form C dry contacts (N.O. or N.C.) shall be provided. The alarm shall indicate single or multiple phase failure of the filter.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The service entrance, switchboards, and panelboard filters shall be installed internal to the switchgear/panelboard as close as possible to the connection point following the manufacturer's recommendations for conductor size and minimal bends.

B. All insulation resistance tests shall be performed without being connected to the distribution equipment.

3.2 START UP SERVICES

A. Complete start up checks according to manufacturer's written instructions.

3.3 EQUIPMENT MANUAL

A. An equipment manual shall be provided that details installation, operation, and maintenance instructions for the filter. Information shall include unit dimensions, weights, mounting provisions, connection details and a layout diagram.

END OF SECTION

SECTION 26 90 00 - PROJECT CLOSEOUT

PART 1 - GENERAL

1.1 WORK INCLUDED

A. The contractor shall summarize and document adherence with the requirements of the specifications for project closeout including:
   1. Copies of all warranties
   2. Operation & Maintenance Manuals
   3. Required tests
   4. Certifications
   5. Record drawings
   6. Permit requirements

B. The contractor shall compile a closeout manual which shall include:
   1. A list of all required tests and a place for signoff of date completed.
   2. A list of all submittals with dates of acceptance by the engineer.
   3. A schedule indicating dates for beginning testing and startup of equipment and dates of tests to be witnessed by the engineer, or designated representative, as required by the specifications.
   4. Test procedures to be used for life safety systems.
   5. Project close out check list.

C. The final closeout manual shall include the following:
   1. Test reports as required by the specifications with signoff by the appropriate individual (engineer, architect, building official, etc.).
   2. Documentation indicating all equipment is operating properly and is fully accessible for maintenance.
   3. Copies of all warranties.

D. This section only includes the requirements for documentation of the contract documents, by the contractor, for project completion. This section does not in any way decrease the scope of any of the drawings or specifications.

1.2 SUBMITTALS

A. Within 90 days after notice to proceed submit a preliminary closeout manual with the following:
   1. A list of all required tests.
   2. Preliminary schedule showing major milestones for completion of the electrical and technology systems.

B. Within 30 days of the first major milestone submit the completed closeout manual as described in Part 1.

C. Within 2 weeks of substantial completion submit a completed "Project Closeout Check List", and the Final Closeout Manual.

D. Listed below is a checklist for use by the contractor. This list is not all inclusive for this project.

Project Close-Out Summary - Electrical

☐ The following tests have been completed. Submit test report for record.
   ☐ Feeder Testing and Reporting (Megger Result)
   ☐ Grounding System Testing and Reporting

- ☐ All main components of the electrical system cleaned and vacuumed. This includes unit substations, switchboards, distribution boards, panel boards, etc. Provide ME Engineers with schedule when this is going to occur and a letter stating it has been completed.
- ☐ The contractor shall schedule a walk through with the engineer to inspect all main feeder sizes. Covers for panel boards should be removed by the contractor for visual inspection of feeder sizes.
- ☐ Provide spare fuses per specifications.
- ☐ Panelboard directories completed.
- ☐ Record drawings submitted.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 EQUIPMENT STARTUP AND TESTING

A. Prior to completion and punchlist by the engineer, the contractor shall startup and test each piece of equipment as required by the specifications. The contractor shall provide documentation of all required tests with signoff of by the appropriate individual (engineer, architect, and building official).

3.2 LIFE SAFETY SYSTEMS

A. All life safety systems shall be fully and successfully tested by the contractor before being witnessed by the engineer or building official.

B. The contractor shall provide a detailed test procedure, with instrumentation to be used, for approval by the engineer and building official prior to any testing.

C. Once tested by the contractor and fully operation the systems shall be demonstrated to the engineer. Once accepted by the engineer the system shall be demonstrated to the building and fire officials.

3.3 COORDINATION WITH OTHERS

A. The Division 26 contractor shall coordinate his requirements with the general contractor to ensure the other building systems are completed to the point that they will not adversely affect the operation of the Division 26, 27 and 28 systems.

3.4 PUNCH LISTS

A. The contractor shall submit in writing that the project is ready for final review by the engineer.

B. Once the project is ready for final review the engineer will create a punch list of any corrections or deficiencies.

C. The contractor shall complete all punch list items and provide a letter to the architect after completion stating all items have been completed or reasons why they were not completed.

D. Upon receipt of this letter the engineer will verify that the punch list has been satisfactorily completed.

END OF SECTION

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