WISCONSIN DEPARTMENT OF TRANSPORTATION  
TRAFFIC MANAGEMENT CENTER (TMC)  
DATA CENTER ELECTRICAL AND HVAC SYSTEM IMPROVEMENTS  
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Milwaukee, WI  53203-3007

ELECTRICAL SPECIFICATIONS  
LPA #8415

TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>SECTION</th>
<th>TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DIVISION 23 – MECHANICAL</td>
</tr>
<tr>
<td>23 05 00</td>
<td>COMMON WORK RESULTS FOR HVAC</td>
</tr>
<tr>
<td>23 05 29</td>
<td>HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT</td>
</tr>
<tr>
<td>23 05 48</td>
<td>VIBRATION AND SEISMIC CONTROLS FOR HVAC</td>
</tr>
<tr>
<td>23 05 53</td>
<td>IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT</td>
</tr>
<tr>
<td>23 05 93</td>
<td>TESTING ADJUSTING AND BALANCING FOR HVAC</td>
</tr>
<tr>
<td>23 07 19</td>
<td>PIPE INSULATION</td>
</tr>
<tr>
<td>23 08 00</td>
<td>COMMISSIONING FOR HVAC</td>
</tr>
<tr>
<td>23 09 16</td>
<td>CONTROL WIRING</td>
</tr>
<tr>
<td>23 23 00</td>
<td>REFRIGERANT PIPING</td>
</tr>
<tr>
<td>23 33 00</td>
<td>AIR DUCT ACCESSORIES</td>
</tr>
<tr>
<td>23 37 00</td>
<td>AIR OUTLET AND INLETS</td>
</tr>
<tr>
<td>23 81 23</td>
<td>COMPUTER ROOM AIR CONDITIONERS</td>
</tr>
<tr>
<td>23 81 26</td>
<td>SPLIT SYSTEM AIR CONDITIONERS</td>
</tr>
</tbody>
</table>

|         | DIVISION 26 – ELECTRICAL |
| 26 05 00 | COMMON WORK RESULTS FOR ELECTRICAL |
| 26 05 19 | LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES |
| 26 05 26 | GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS |
| 26 05 29 | HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS |
| 26 05 33 | RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS |
| 26 05 53 | IDENTIFICATION FOR ELECTRICAL SYSTEMS |
| 26 24 16 | PANELBOARDS |
| 26 26 53 | UNINTERRUPTIBLE POWER SUPPLY POWER DISTRIBUTION UNIT |
| 26 33 63 | UNINTERRUPTIBLE POWER SUPPLY |
| 26 36 23 | AUTOMATIC TRANSFER SWITCHES |
| 26 36 33 | STATIC TRANSFER SWITCH |
| 26 43 00 | SURGE PROTECTIVE DEVICE |
SECTION 23 05 00

COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SPECIAL NOTES

A. The TMC is a controlled access facility operational 24/7 – 365 days a year. All work activities shall be closely coordinated with WisDOT facility staff. While no major shutdowns are required for the HVAC scope, work will take place within the occupied work area.

B. Modifications to the controls of AC-3 shall be pre-planned and coordinated to minimize the amount of time the unit will need to be off. AC-3 serves the Control Room.

1.2 PERMITS AND REGULATIONS

A. Include payment of all Permit and inspection fees applicable to the work in this Division. Furnish for the Owner certificates of approval from the governing inspection agencies, as a condition for final payment.

B. Work must conform to applicable local, state and federal laws, ordinances and regulations. Where drawings or specifications exceed code requirements, the drawings and specifications shall govern. Install no work contrary to minimum legal standards.

1.3 INSPECTION OF SITE

A. Each bidder shall inspect the project site premises of the existing building. Conditions shall be compared with information shown on the drawings. Report immediately to the Architect any significant discrepancies which may be discovered. After the contract is signed, no allowance will be made for failure to have made a thorough inspection.

1.4 DRAWINGS AND SPECIFICATIONS

A. The drawings indicate the general arrangement of the work and are to be followed insofar as possible. The word "provide," as used, shall mean "furnish and install." If significant deviations from the layout are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to the Architect for approval before proceeding with the work.

B. Make all necessary field measurements to insure correct fitting. Coordinate work with all other trades in such a manner as to cause a minimum of conflict or delay.

C. The drawings and specifications shall be carefully studied during the course of bidding and construction. Any errors, omissions or discrepancies encountered shall be referred immediately to the Architect for interpretation or correction, so that misunderstandings at a later date may be avoided. The contract drawings are not intended to show every vertical or horizontal offset which may be necessary to complete the systems. Having ductwork, pipe and fittings fabricated and delivered in advance of making actual measurements shall not be sufficient cause to avoid making offsets and minor changes as may be necessary to install ductwork, piping and equipment.

D. The Architect shall reserve the right to make minor adjustment in locations of system runs and components where he considers such adjustments desirable in the interest of concealing work or presenting a better appearance where exposed. Any such changes shall be anticipated and requested sufficiently in advance as to not cause extra work, or unduly delay the work. Coordinate work in advance with all other trades and report immediately any difficulties which can be anticipated.
E. Equipment, ductwork or piping shall not be installed or run above electrical switchgear or panelboards, nor in or above the access space in the immediate vicinity of the electrical switchgear/panelboards, in accordance with NEC Article 384. Where any system runs and components are so placed as to cause or contribute to a conflict, it shall be readjusted at the expense of the contractor causing such conflict. The Architect’s decision shall be final in regard to the arrangement of ductwork, piping, etc., where conflict arises.

F. Provide offsets in system runs, additional fittings, necessary drains and minor valves, traps, dampers and devices required to complete the installation, or for the proper operation of the system. Each Contractor shall exercise due and particular caution to determine that all parts of the work are made quickly and easily accessible.

G. Should overlap of work among the trades become evident, this shall be called to the attention of the Architect. In such event, none of the trades or their suppliers shall assume that he is relieved of the work which is specified under his branch until instructions in writing are received from the Architect.

H. Any reference in any contract document to “Architect or Engineer” shall be interpreted to mean the Engineer of record for this project, who is:

Jason Beren
Pearson Engineering
14 Ellis Potter Court
Madison, WI 53711
Telephone (608) 274-3339
jason@pearsonengineering.com

1.5 ASBESTOS MATERIALS

A. Abatement, removal or encapsulation of existing materials containing asbestos is not included in the Contract.

B. If, in the performance of the mechanical work, materials are observed which are suspected to contain asbestos, the Contractor shall immediately inform the Architect who in turn will notify the Owner. Work that would expose workers to the inhalation of asbestos particles shall be terminated. Work may be resumed only after a determination has been made and unsafe materials have been removed or encapsulated and the area declared safe.

1.6 INSPECTION

A. All work shall be subject to inspection of Federal, State and local agencies as may be appropriate, and of the Architect, Engineer, and Owner.

B. Final inspection certificates shall be obtained by the Contractor and given to the Owner.

1.7 RECORD DRAWINGS

A. Each Contractor shall maintain a separate set of prints of the contract documents and shall show all changes or variations, in a manner to be clearly discernible, which are made during construction. Upon completion of the work, these drawings shall be turned over to the Architect.

1.8 OPERATING AND MAINTENANCE MANUALS
A. Three (3) paper copies and three (3) electronic copies of each operating and maintenance manuals shall be assembled for the HVAC work. Electronic copies shall be in PDF format and written to separate CDs.

B. All shop drawings and installation, maintenance and operating instruction pamphlets or brochures, wiring diagrams, parts list and other information, along with warranties, shall be obtained from each manufacturer of the principal items of equipment. (Air and water balance reports shall also be included.) In addition, the Contractor shall complete an Owner-provided equipment form for each item of equipment provided under his contract. These forms facilitate entry of equipment into a Work Order Management System, and may contain detailed information about the equipment as well as lubricating media or replacement material required for maintenance. Forms for each project shall be obtained from the Owner prior to assembly of the O&M Manual. Sample forms may be found at the end of this section.

C. These shall be assembled into three-ring loose leaf binders or other appropriate binding. An index and tabbed sheets to separate the sections shall be included. A CD containing PDF files of the above materials shall also be provided. These shall be submitted to the Architect for review. Files shall be organized into a logical folder system with descriptive file names. Upon approval, manuals shall be turned over to the Owner.

1.9 FINAL INSPECTION AND PUNCH LIST

A. As the time of work completion approaches, the Contractor shall survey and inspect his work and develop his own punch list to confirm that it is complete and finished. He shall then notify the Architect and request that a final inspection be made. It shall not be considered the Architect's or Engineer's obligation to perform a final inspection until the Contractor has inspected the work and so states at the time of the request for the final inspection.

B. Requests to the Architect, Engineer or Owner for final inspection may be accompanied by a limited list of known deficiencies in completion, with appropriate explanation and schedule for completing these; this is in the interest of expediting acceptance for beneficial occupancy.

C. The Architect and Engineer will inspect the work and prepare a punch list of items requiring correction, completion or verification. Corrective action shall be taken by the Contractor to the satisfaction of the Architect and Engineer within 30 days of receipt of the Architect/Engineer’s punch list.

1.10 WARRANTY

A. This Contractor shall warrant all workmanship, equipment and material entering into this contract for a period of one year from date of final acceptance or date of beneficial use, as agreed to between Contractor and Architect. Any materials or equipment proving to be defective during this warranty period shall be made good by this Contractor without expense to the Owner.

B. This provision is intended specifically to cover deficiencies in contract completion or performance which are discovered after systems are placed in operation. Also included shall be supplementary assistance in balancing, adjusting or providing operating instructions as the need develops, and replacing overload heater elements in starters where necessary to keep systems in operation. Heater element sizes shall not exceed the motor manufacturer's recommendations.

C. This provision shall not be construed to include maintenance items such as replacing filters, retightening or repacking glands, greasing, oiling, belt tightening and cleaning strainers after these have been done for final close-out.
D. Provision of this warranty shall be considered supplementary to warranty provisions under General Conditions.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials and equipment furnished under this contract shall be in strict accordance with the specifications and drawings and shall be new and of best grade and quality. When two or more articles of the same material or equipment are required, they shall be of the same manufacturer.

2.2 REFERENCE STANDARDS

A. Where standards (NFPA, NEC, ASTM, UL, etc.) are referenced in the specifications or on the drawings, the latest edition is to be used except, however, where the authority having jurisdiction has not yet adopted the latest edition, the edition so recognized shall be used.

2.3 EQUIPMENT SELECTION

A. The selection of materials and equipment to be furnished under this contract shall be governed by the following:
   1. Where trade names, brands, or manufacturers of equipment or materials are listed in the specification, the exact equipment listed shall be furnished. Where more than one name is used, the Contractor shall have the option of selecting between any one of the several specified. All products shall be first quality line of manufacturers listed.
   2. Where the words “or approved equal” appear after a manufacturer’s name, specific approval must be obtained from the Architect during the bidding period in sufficient time to be included in an addendum. The same shall apply for equipment and materials not named in the specifications, where approval is sought.
   3. Where the words “equal to” appear, followed by a manufacturer’s name and sometimes a model or series designation, such designation is intended to establish quality level and standard features. Equal equipment by other manufacturers will be acceptable, subject to the Architect’s approval, which must be obtained during the bidding period.

B. Substitute equipment of equal quality and capacity will be considered when the listing of such is included as a separate item of the bid. State the deduction or addition in cost to that of the specified product.

C. Before bidding equipment, and again in the preparation of shop drawings, the Contractor and his supplier shall verify that adequate space is available for entry and installation of the item of equipment, including associated piping and accessories. Also verify that adequate space is available for servicing the equipment.

D. If extensive changes in pipe, duct or equipment layout or electrical wiring and equipment are brought about by the use of equipment which is not compatible with the layout shown on the drawings, necessary changes shall be deemed to be included in the contract.

E. Submittals: Product Data. Six sets of shop drawings and descriptive information shall be assembled by the Contractor of equipment and materials furnished in his contract. Shop drawings shall be labeled and identified in the same manner as on the Contract Documents. Failure to do so may be cause for rejection of shop drawings.

F. Shop drawings of the following HVAC equipment and materials shall be submitted:
   1. Pipe, hangers, and saddles
   2. Pipe insulation
3. Split AC systems
4. Computer Room Cooling Units and Controls
5. Roof supports and pipe penetrations
6. Air outlets and inlets.

PART 3 - EXECUTION

3.1 GENERAL PIPING INSTALLATIONS

A. Install piping free of sags and bends.
B. Install fittings for changes in direction and branch connections.
C. Exterior Wall, Pipe Penetrations: Mechanical sleeve seals installed in steel or cast-iron pipes for wall sleeves.
D. Comply with requirements for sealing pipe penetrations in fire-rated construction.
E. Install unions at final connection to each piece of equipment.
F. Install dielectric unions and flanges to connect piping materials of dissimilar metals in gas piping.
G. Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals in water piping.

3.2 PIPE TESTING

A. All piping provided in this work shall be pressure tested, as specified below.
B. Pipe testing for HVAC piping shall be:
   1. Refrigerant piping - refer to appropriate Refrigeration Sections.
C. Testing shall be performed prior to application of insulation. Insure that air is vented from piping when piping is hydrostatically tested.
D. Tests shall be witnessed by the Facilities Engineering Manager and shall be monitored by a recorder. Furnish a written record of each piping system test indicating date, system, pressure, duration and results of tests. Copies of test reports shall be included in the O&M manuals.
E. Leaks discovered during testing shall not be patched. Replace defective pipe and fittings with new material. Threaded connections shall be either tightened or replaced. Small leaks in welded pipe may be chipped and re-welded. Caulking, plugging, or rusting is not permitted.
F. Where a new pipe connects to an existing pipe, provide the following to facilitate testing, cleaning, draining and eventual shutoff service:
   1. A shutoff valve in the new pipe near the point of connection.
   2. A ¾” valved stub and hose bib beyond the valve for testing of the new pipe extension.

3.3 GENERAL EQUIPMENT INSTALLATIONS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
B. Install equipment level and plumb, parallel and perpendicular to other building systems and components, unless otherwise indicated.

C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations.

D. Install equipment to allow right of way for piping installed at required slope.

3.4 OPERATION AND ADJUSTMENT OF EQUIPMENT

A. As each piping system and air distribution system is put into operation, all items of equipment included therein shall be adjusted to proper working order. This shall include balancing air and water in systems, adjusting fan speeds, belts, pulleys, tightening packing glands, and adjusting all operating equipment.

B. Caution: Verify that all bearings are lubricated, all motors are operating in the right direction, and correct overload heater elements are provided on all motors. Do not depend wholly on the electrician’s judgment in these matters. Follow specific instructions in regard to lubrication. Do not oil or grease pre-sealed ball bearings unless upon manufacturer’s specific instructions.

C. Test relief valves, air vents and regulating valves to insure proper operation.

3.5 OPERATING DEMONSTRATION AND INSTRUCTIONS

A. The Contractor shall set the various systems into operation and demonstrate to the Owner that the systems function properly and that the requirements of the Contract are fulfilled.

B. The Contractor shall provide the Owner’s representatives with detailed explanations of operation and maintenance of equipment and systems. A thorough review of the operating and maintenance manuals shall be included in these instructional meetings.

C. O&M manuals shall be submitted, reviewed and approved prior to scheduling of demonstrations.

END OF SECTION
SECTION 23 05 29
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

A. All interior and exterior piping shall be supported from the building structure.

B. Equipment shall be supported on concrete bases, roof curbs and structural steel supports as shown on drawings or as specified. All bases and supports shall be included in the Mechanical contracts except as otherwise noted.

PART 2 - PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Hangers and supports for horizontal piping shall be equal to:
   1. General service – clevis type – Grinnell Fig. 260.
   2. Uninsulated copper tubing – copper plated clevis type – Grinnell Fig. CT-65 (or plastic-coated clevis).

B. Hanger rods shall be solid steel, threaded-end or all-thread rod, of diameter listed below, with double nut attachment to the hanger and at the hanger attachment.

<table>
<thead>
<tr>
<th>Pipe Sizes</th>
<th>Min. Rod Diameter</th>
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<tbody>
<tr>
<td>1” and smaller</td>
<td>1/4”</td>
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<tr>
<td>1 1/4” to 3”</td>
<td>3/8”</td>
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<tr>
<td>4” to 6”</td>
<td>1/2”</td>
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<td>8”</td>
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<td>10”</td>
<td>3/4”</td>
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<tr>
<td>12” to 16”</td>
<td>1”</td>
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<tr>
<td>18” and larger</td>
<td>1-1/4”</td>
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C. Where the length of the hanger rod between the top of the hanger and the attachment device is 3” or less, clevis type hangers with rollers, Fig. 181, shall be used to allow for expansion travel.

D. Hangers on insulated horizontal piping shall be oversized to surround the pipe insulation. To protect the insulation from damage or inordinate compression due to concentrated weight, the following shall be provided at each hanger:
   1. Pipe 2” and smaller - Fig. 168 18 ga. sheet metal rib-lock shield with belled ends, 12” long.
   2. Pipe 2 1/2” and larger - factory or shop fabricated assembly Pipe Shields, Inc. A1000 or Grinnell No. 168 sheet metal shield with half-round high density hard insulation. Sheet metal shield 12” long.

E. Insulation saddles shall be compatible with pipe insulation materials and thickness. Vapor barrier shall be continuous.

F. The first two hangers on piping connecting to motor driven equipment shall be fitted with a steel spring and neoprene vibration isolation section similar to Mason Industries No. 30N.

G. Pipe riser supports shall be as follows:
   1. Riser clamps on cold service piping (cold water, chilled water, refrigerant suction, etc.) 2” and larger - insulated pipe riser clamp assembly, Pipe Shields, Inc. E1000, with high density calcium silicate insulation, galvanized steel jacket, steel top thrust plates and steel riser clamps.
   2. Riser clamps on cold service piping 1 1/2” and smaller - similar to Pipe Shields, Inc. E1000.
3. Riser clamps on piping other than cold service - Grinnell Fig. 261 except, on copper tubing, CT-121 (copper plated) or CT-121C (plastic coated).

H. Trapeze hangers for numerous pipes run in parallel may be utilized. Horizontal support members shall be unistrut type section with pipe rollers (to allow for expansion travel) and spring and nut connectors, suspended with hanger rods and attachments similar to individual pipe hanger suspension.

I. The piping contractor and the insulator shall coordinate during the bidding period and determine, consistent with industry practice, the selection, furnishing and installation of the needed components.

PART 3 - EXECUTION

3.1 PIPE HANGERS INSTALLATION

A. Spacing of hangers shall be as follows:
   1. Steel pipe (vertical) – at the base and 15 ft. maximum spacing unless otherwise shown.
   2. Steel pipe (horizontal) – 8 ft. intervals for piping 2” size and smaller, 10 ft. intervals for 2½” through 6”, 12 ft. intervals for larger pipe.
   3. Copper tubing (vertical) – at the base and 10 ft. maximum spacing unless otherwise shown.
   4. Copper tubing (horizontal) – 6 ft. intervals for tubing 1¼” size and smaller, 8 ft. intervals for 1½” and 2” sizes, 10 ft. intervals for tubing 2½” size and larger.

B. Attachment of pipe hangers to the structure shall be with:
   1. Pre-set concrete inserts in concrete construction of 4” minimum depth.
   2. After set concrete inserts, in 4” minimum depth concrete, shall be steel expansion type set in drilled holes. Powder actuated driven fasteners are not permitted.
   3. Beam clamps in steel construction shall be equal to Fig. 95 (‘C’ clamp with locknut), or Fig. 14 (adjustable beam clamp). Provide anchoring where clamps are attached to sloping surfaces of beam flanges and where otherwise required to insure permanent attachment.
   4. Unistrut channels with spring and nut rod connections may be utilized where a number of pipes run parallel. Channel shall be pre-set or attached to the structure with inserts or clamps.
   5. Attachment to steel deck is prohibited. Span from steel structural members with supplementary steel shapes where direct attachment to structural members is not practical. This does not apply to steel deck with concrete slab poured on the deck. Refer to 1) and 2) above.

C. Pipe hangers shall be adjusted to proper elevation and all hanger rods set in a vertical position before pipe insulation is installed.

D. Extended legs of pipe riser clamps shall be shortened as needed to maintain concealment of the clamps within the pipe chase. Insure that adequate support is still maintained.

E. Hanger and support assemblies which will remain exposed on completion of the project shall be painted before installation.

F. This contractor shall repair any fireproofing damaged, as part of their work on this project.

3.2 BASES, SUPPORTS, AND ANCHORAGES

A. Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
2. Install #5 rebar rods on 18-inch (450-mm) centers around the full perimeter of the base to connect concrete base to concrete floor.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer’s setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

END OF SECTION
SECTION 23 05 48
VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Vibration isolators shall be provided at equipment as shown on the drawings and as herein specified.

B. The supplier of isolation equipment shall study the application, the equipment to be isolated and the structure. The supplier shall assume responsibility to determine optimum deflection characteristics accounting for dynamic and static forces.

PART 2 - PRODUCTS

2.1 Following is a description of the various types of isolators required. Catalog designations are those of Mason Industries.

A. Type A1 (1” to 6” deflection) – Open spring mounting with base and mounting plates, bolts for attachment, adjustment and leveling and ribbed neoprene pad. Series “SLFH”.

B. Type A2 (1” deflection) - Housed spring mounting with base and mounting plates, cast steel housing, bolts for attachment, adjustment and leveling and ribbed neoprene pad. Series “C”.

C. Type B1 (½” deflection) - Rubber or neoprene in-shear mounting. Series “ND”

D. Type C1 (0.1” deflection) - Ribbed neoprene pad. Series “NR”. Cork and rubber neoprene sandwich pad. Series “NK”.

E. Type D1 - Concrete inertia base with structural steel frame, reinforcing steel, anchor bolts with sleeves and templates and steel spring isolation mountings. Series “K” or “BKM”. Concrete shall be provided by the HVAC Contractor.

F. Type E1 - Structural steel mounting frame with adjustable motor slide rails (if applicable) and steel spring isolation mountings. Series “WF”.

G. Type E2 - Structural steel mounting frame with adjustable motor slide rails (if applicable) and rubber or neoprene-in-shear isolation mountings. Series “WF”.

H. Type F1 - Thrust restraint assembly (set of two) - steel spring and neoprene with attachment angles and connecting rod, for installation at the inlet or discharge side of the fan housing. Series “WBI” (for inlet side) and “WBD” (for discharge side).

I. Type G1 - Hanger rod isolation unit with combination steel spring and neoprene-in-shear isolators. Series “30N”.

J. Type G2 - Hanger rod isolation unit with neoprene-in-shear isolator. Series “HD”.

K. Isolators shall be as manufactured by Mason Industries, Amber Booth, Vibration Mountings, Kinetics Noise control, Korfund or Vibration Eliminator. All isolators shall be of one manufacturer.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Isolators installed outside shall be furnished weather-protected with springs PVC coated and other ferrous parts hot dip galvanized or cadmium plated. Isolators for chillers, cooling towers, boilers and other equipment with significant water capacity shall be equipped with vertical limit stops.

B. Follow manufacturer’s instructions carefully in setting and adjusting vibration isolators. Insure that no direct hard surface-to-surface contact exists. Fasten to floor as recommended by the isolation supplier.

C. Where electrical connections are made to equipment mounted on isolators, caution the Electrical Contractor to connect through flexible conduits.

D. Refer to Section 230529 – ‘Hangers and Supports for HVAC Piping and Equipment’ for spring isolator sections in pipe hanger rods.

3.2 APPLICATIONS

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Type</th>
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<tbody>
<tr>
<td>Suspended Fan Coils</td>
<td>G2</td>
</tr>
<tr>
<td>Rooftop Units</td>
<td>C1</td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 23 05 53
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 Identification of mechanical equipment shall consist of equipment labeling, pipe and duct marking and valve tagging as specified hereinafter.

1.2 Each item of major equipment shall be labeled. This shall include pumps, air handling units, fans, heat exchangers, and other similar equipment.

1.3 Pipe markings shall be applied to all piping.

1.4 Duct markings shall be applied to all ductwork.

1.5 Each shutoff valve, other than at equipment, shall be identified with a stamped tag. Valves and tagging shall be scheduled typewritten on 8½” x 11” paper, tabulating valve number, piping system, system abbreviation, location of valve (room or area) and service (e.g. - South wing reheat boxes).

1.6 Labels, tags and markers shall comply with ANSI A13.1 for lettering size, colors and length of color field.

1.7 Equipment and device identification specified in other sections shall be provided as a part of those requirements.

PART 2 - PRODUCTS

2.1 Equipment labeling shall be permanently attached engraved brass or plastic laminated signs with 1” high lettering. Signs on exterior equipment shall be brass.

2.2 Pipe markings shall be:

   A. Plastic semi-rigid snap-on type, manufacturer’s standard pre-printed color coded pipe markers extending fully around the pipe and insulation or pressure-sensitive vinyl pipe markers similar to the above.

   B. On piping and insulation 6” and greater diameter, full band as specified above or strip-type markers fastened to the pipe or insulation with laminated or bonded application or by color-coded plastic tape not less than 1½” wide, full circle at both ends of the marker.

   C. Arrows for direction of flow provided integral with the pipe marker or separate at each marker.

2.3 Duct markings shall be laminated plastic color-coded pressure sensitive vinyl tape, 2½” width, 3 mils minimum thickness. Identification shall include service (supply, return, exhaust, outside air) and direction of flow.

2.4 Valve tags shall be polished brass or plastic laminate with solid brass S hook. Tags shall be engraved with “P”, “F” or “H” (for plumbing, fire suppression or HVAC) and the designated number.

2.5 Labels, markings and tags shall be manufactured by W.H. Brady, Seton, Allen or Industrial Safety Supply.
PART 3 - EXECUTION

3.1 Identification labeling, marking and tagging shall be applied after insulation and painting has been completed. Spray painting is not allowed.

3.2 Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified or scheduled on drawings.

3.3 The Plumbing, Fire Suppression and HVAC Contractors shall coordinate labeling, marking and tagging to attain coordinated and consistent systems of identification.

3.4 Equipment labeling shall consist of unit designation as shown on the drawings. Exhaust fan labeling shall also indicate service or room of area of service.

3.5 Pipe markers shall be placed on piping at 20 ft. centers, each change of piping direction 10 feet or longer, or one per room, whichever is greater. Where piping passes through a wall, provide identification on each side of wall. All identification shall be located on the piping for ease of reading from a standing position on the floor.

3.6 Refer to appropriate sections of this specification for installation of underground line marker tape.

3.7 Valve tags shall be placed on each valve except those intended for isolation of individual items of equipment. Valve tags schedules shall be prepared as specified above, and included in the Operating and Maintenance Manuals.

END OF SECTION
SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES:
   A. Testing, adjustment, and balancing of air systems.
   B. Testing, adjustment and balancing of hydronic systems.
   C. Measurement of final operating condition of HVAC systems.

1.2 SECTION REQUIREMENTS
   A. References:
      1. AABC MN-1 - AABC National Standards for Total System Balance; Associated Air
      2. ASHRAE Std 111 - Practices for Measurement, Testing, Adjusting and Balancing of
         Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems; American
      3. NEBB (TAB) - Procedural Standards for Testing Adjusting Balancing of Environmental
   B. Submittals:
      1. See section 230500 for submittal procedures.
      2. Qualifications: Submit name of adjust and balancing agency and TAB supervisor for
         approval within 30 days after award of Contract.
      3. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing approach
         for each system and component. Include at least the following in the plan:
         a. List of all air flow, water flow, sound level, system capacity and efficiency
            measurements to be performed and a description of specific test procedures,
            parameters, formulas to be used.
         b. Copy of field checkout sheets and logs to be used, listing each piece of equipment
            to be tested, adjusted and balanced with the data cells to be gathered for each.
         c. Discussion of what notations and markings will be made on the duct and piping
            drawings during the process.
         d. Final test report forms to be used.
         e. Procedures for formal deficiency reports, including scope, frequency and
            distribution.
      4. Final Report: Indicate deficiencies in systems that would prevent proper testing,
         adjusting, and balancing of systems and equipment to achieve specified performance.
         a. Revise TAB plan to reflect actual procedures and submit as part of final report.
         b. Submit draft copies of report for review prior to final acceptance of Project.
            Provide final copies for the Engineer and for inclusion in operating and
            maintenance manuals.
         c. Include actual instrument list, with manufacturer name, serial number, and date of
            calibration.
d. Test Reports: Indicate data on AABC MN-1 forms, forms prepared following ASHRAE Std 111, or NEBB forms. Submit data in IP units.

C. Quality Assurance:
   1. Perform total system balance in accordance with AABC MN-1, ASHRAE Std 111, or NEBB Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.
   2. TAB Agency Qualifications: Company specializing in the testing, adjusting, and balancing of systems specified in this Section with minimum three years documented experience certified by AABC.
   3. Perform Work under supervision of AABC Certified Test and Balance Engineer or NEBB Certified Testing, Balancing and Adjusting Supervisor experienced in performance of this Work and licensed at the job site.

D. Pre-Balance Meeting: Convene a meeting one week prior to commencing work of this Section.

E. Perform TAB after leakage and pressure tests on air distribution systems have been satisfactorily completed. 
   Sequence work to commence after completion of systems and schedule completion of work before Substantial Completion of Project.

F. Warranty: Furnish AABC National Performance Guaranty for this project.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING, ADJUSTING, AND BALANCING AGENCIES
   1. T & B Services, LTD.
   2. Professional Systems Analysis, Inc.
   3. Prior Approval alternate

3.2 EXAMINATION
   A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
      1. Systems are started and operating in a safe and normal condition.
      2. Temperature control systems are installed complete and operable.
      3. Final filters are clean and in place. If required, install temporary media in addition to final filters.
      4. Duct systems are clean of debris.
      5. Fans are rotating correctly.
      6. Fire and volume dampers are in place and open.
      7. Air coil fins are cleaned and combed.
      8. Access doors are closed and duct end caps are in place.
      9. Air outlets are installed and connected.
     10. Duct system leakage is minimized.
     11. Hydronic systems are flushed, filled, and vented.
     12. Pumps are rotating correctly.
     13. Proper strainer baskets are clean and in place.
     14. Service and balance valves are open.
B. Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance.

C. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to the Engineer to facilitate spot checks during testing.

B. Provide additional balancing devices as required.

3.4 INSTALLATION TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.

B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

C. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.5 RECORDING AND ADJUSTING

A. Ensure recorded data represents actual measured or observed conditions.

B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

E. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

3.6 AIR SYSTEM PROCEDURE

A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.

B. Balance grilles in all rooms served by all systems shown on drawings, including existing terminal devices receiving new controls.

C. Make air quantity measurements in ducts by pitot tube traverse of entire cross sectional area of duct.

D. Measure air quantities at air inlets and outlets.

E. Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.
F. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

G. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

H. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

I. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

J. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.

K. On fan powered VAV boxes, adjust air flow switches for proper operation.

L. Balancing contractor shall install properly sized plugs for all test holes to provide an air tight seal. Holes shall all be drilled in a straight line. Holes drilled in HVAC equipment shall be at the same elevation. Repair damaged insulation to its original state.

3.7 SCOPE

A. Test, adjust, and balance the following:
1. Control and Projection room floor supply air outlet
2. AC-3

END OF SECTION
SECTION 23 07 19
PIPE INSULATION

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Quality Assurance: Labeled with maximum flame-spread index of 25 and maximum smoke-developed index of 50 according to ASTM E 84.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Insulation shall be manufactured by Schuller-Manville, Owens-Corning, Certainteed, Knauf, or Pittsburgh Corning.

B. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

C. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

D. Mineral-Fiber, Preformed Pipe Insulation: Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ.

E. Mineral-Fiber, Pipe and Tank Insulation: Complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB; and having factory-applied ASJ jacket. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less.

F. Extruded Polystyrene Insulation: Rigid closed cell, minimum nominal density of 1.6 lbs. per cu. ft., thermal conductivity of not more than 0.285 at 75 degrees F, minimum compressive strength of 20 psi, maximum water vapor permeability of 1.5 perm inch, maximum water absorption of .5 % by volume, rated for service range of -290 degrees F to 165 degrees F.


H. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

I. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

J. Factory-Applied Jackets: When factory-applied jackets are indicated, comply with the following:
   1. ASJ: White, Kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

K. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

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

PART 3 - EXECUTION

3.1 INSULATION INSTALLATION

A. Insulation shall be applied after the hydrostatic testing has been approved by the Facility Engineering Manager.

B. Pipe, fittings, unions, flanges, mechanical joint couplings, valves, devices, specialties and related items in the piping systems shall be insulated unless otherwise excepted.

C. Installation shall be performed by tradesman specializing in insulation work in strict accordance with manufacturer’s recommendations.

D. Insulation on cold service piping shall be run through floor and wall sleeves to maintain vapor barrier continuity. Insulation on other services may likewise be run continuous when sleeve size permits.

E. Insulation Installation at Fire-Rated Wall, Partition, and Floor Penetrations: Install insulation continuously through penetrations. Seal penetrations. Comply with requirements in Division 07 Section “Penetration Firestopping.”

F. Refer to Section 23 05 29 - Pipe Hangers for non-compressible insulation or blocking material and sheet metal saddles required at pipe hangers. Coordinate with the pipe contractor on the furnishing, installation and detailed requirements of these. Provide insulation and vapor barrier on and around supports for pipe risers of services which require vapor seal so as to prevent sweating.

G. Fittings, valves, flanges and other devices, both exposed and concealed, requiring insulation shall be covered same thickness as pipe insulation with:
   1. Factory molded fitting insulation cover with PVC one-piece fittings cover;
   2. Miter-cut segments of pipe insulation, held in place with adhesive and/or wire, filled with insulating cement smoothed to shape and covered with PVC one-piece fittings cover;
   3. Fiberglass blanket insulation, held in place and covered with PVC one-piece fitting cover;
   or
   4. Oversized pipe insulation, where applicable, finished same as straight run pipe insulation.

H. Flexible Elastomeric Insulation Installation:
   1. Seal longitudinal seams and end joints with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
   2. Insulation Installation on Pipe Fittings and Elbows: Install mitered sections of pipe insulation. Secure insulation materials and seal seams with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

I. Mineral-Fiber Insulation Installation:
   1. Pipe insulation shall be factory molded tubular fiberglass with “all service” jacket having an integral vapor barrier. Longitudinal joints of the jacket shall be overlapping with factory applied adhesive. In lieu of the factory adhesive, staples on 6” centers may be used with vapor barrier mastic applied to seal both the joint and staple holes. Butt joints shall be sealed with 3” wide ASJ pressure sensitive tape.

J. Extruded Polystyrene
   1. Fittings, valves, unions, flanges, couplings and specialties shall be insulated with factory molded insulation of the same thickness as adjoining insulation. Secure insulation
sections with two wraps of nylon filament tape 9”-12” on center. On single insulation layer systems and on the outer layer of double insulation layer systems, apply a thin coat of elastomeric joint sealant rated for system operating temperatures to all longitudinal and butt insulation joints covering entire face of joint. Allow sealant to fully cure before applying protective covering. For piping service below 0°F, use two layers of insulation with inner and outer butt and longitudinal joints staggered and offset 90 degrees. Where two layers of insulation are used, do not use sealant on the inner layer or adhere the inner layer to the outer layer. Apply vapor stop bead of joint sealant between pipe and insulation on both sides of valves, expansion/contraction joints, flanges, thermometers/gauges, attached vent and drain lines. Insulate attached non-circulated lines, control lines, vents, etc. for a minimum distance of 6” from pipe. Cover insulation with a protective jacket as specified below. Do not penetrate protective covering or insulation with mechanical fasteners.

K. Protective jacketing shall be applied over insulation on piping, fittings, valves and devices as specified above. All joints and seams of the jacket located outside shall be sealed watertight.

L. PFJ shall be provided for the following insulated piping:
1. Exposed piping in finished locations

M. Re-insulate piping where existing insulation has been damaged or removed in the performance of work in this project.

3.2 HVAC PIPING INSULATION SCHEDULE

A. Chilled Water and combination hot-chilled water: Insulation shall be the following:
1. 1” and larger: Mineral-Fiber, Preformed Pipe, Type I, 1½” thick.
2. ¾” and smaller: Mineral-Fiber, Preformed Pipe, Type I, 1” thick.

B. Hot water, 200°F and below: Insulation shall be the following:
1. All sizes: Mineral-Fiber, Preformed Pipe, Type I, 1½” thick.

C. Refrigerant Suction and Hot-Gas Piping: Insulation shall be one of the following:
1. Flexible Elastomeric: 1 inch thick.
2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
3. Polyolefin: 1 inch thick.

D. Refrigerant Suction and Hot-Gas Flexible Tubing: Insulation shall be one of the following:
1. Flexible Elastomeric: 1 inch thick.
2. Polyolefin: 1 inch thick.

E. Domestic cold water for system make-up: Insulation shall be the following:
1. 2½” and larger: Mineral Fiber, Preformed Pipe, Type I, 1½” thick.
2. 2” and smaller: Mineral Fiber, Preformed Pipe, Type I, 1” thick.

F. Condensate drainage piping: Insulation shall be the following:
1. All sizes: Mineral-Fiber, Preformed Pipe, Type I, 1” thick.

G. Insulation on HVAC systems is to be omitted on:
1. Hot water valves, devices, specialties and related items, 2” size and smaller, that are in the space served by the piping.
2. Hot water piping in cabinetry of convectors, unit heaters and through-wall A.C. units.

END OF SECTION
SECTION 23 08 00
COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of General and Supplementary Conditions and other Division Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
B. The commissioning process does not take away from or reduce the responsibility of the Contractor to provide a finished and fully functioning project. Commissioning is essentially a quality management process of observing and documenting that the equipment and systems operate and perform as intended.
C. Commissioning is a quality based process developed for the contractors use as a means of managing the quality of the installation, startup, and operations of the building equipment and systems to ensure they perform according to the design intent and the Owner’s operational needs. The commissioning process shall encompass and coordinate the separate functions of system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training. Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:
1. Verify that applicable equipment and systems are installed according to the manufacturer’s recommendations, the Owner’s needs, and to industry accepted minimum standards and that they received adequate operational checkout by installing Contractors.

D. The Engineer will act as the CxA.

1.3 DEFINITIONS
A. Commissioning Plan: An overall project specific plan, developed by the CxA, that outlines the organization, schedule, allocation of resources, and documentation of the commissioning process.
B. CxA: Commissioning Authority. The person who directs and coordinates the commissioning activities.
C. CxR: Commissioning Representatives. Members of the Construction Manager’s (CM) staff, contractor’s, sub-contractors’, manufacturers’ and suppliers’ staff, Owner’s staff, Architect/Engineer’s staff, or Owner’s independent contractor assigned to participate in the commissioning process.
D. OPR: Owner’s Project Requirements. A document that details the functional requirements of a project and the expectations of how it will be used and operated. These include Project goals, measureable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.
E. Equipment Startup: Static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension, oil levels OK, gauges in place, sensors calibrated, labels
affixed, etc.). Some startup items may entail simple testing of the components function, a piece of equipment or system (e.g., measuring voltage imbalance across three-phase motors). The CxA require that the procedures be documented in writing, and does not witness much of the equipment startup.

F. Functional Performance Testing (FPT): Tests of individual components of a system to make sure that the wiring, setpoints, and locations are acceptable. Tests of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring (BAS) methods. Performance testing is the dynamic testing of systems under a full range of operation. Systems are tested under various modes. The systems are run through all the control system's sequences of operation and components are verified to be responding as the sequences state. The CxA shall use sampling techniques to verify the quality of the Contractors testing by retesting randomly selected pieces of equipment.

G. HVAC&R: Heating, Ventilation, Air Conditioning and Refrigeration.

H. TAB: Testing, Adjusting and Balancing.

I. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean “as-built” systems, subsystems, equipment, and components.

1.4 COMMISSIONING SCHEDULE

A. The Contactors shall complete manufactures instillation and start-up checklists and provide for to the CxA for review prior to FTP.

B. The commissioning FPT are executed at the end of the project after the Contactors are completed with their installation and start-up work. It is possible to execute some tests on completed systems prior to final project completion. In general, the commissioning performance tests are scheduled for AFTER the TAB is complete and the controls contractor has completed the graphics in the BAS system. The commissioning tests typically occur after the Contactors request the substantial completion milestone.

C. The FPT are typically executed during a day. A deficiency list is prepared and given to the Contactors for remediation. Follow-up FPT will be scheduled after the Contactors report that the deficiencies are completed.

D. The Contactors are required to operate and maintain systems and equipment until final acceptance by the Owner. All guarantees and warranties shall not begin until after final acceptance of the systems and equipment by the Owner. Acceptance requires, at a minimum, complete systems commissioning.

E. Retainage will not be released until the commissioning is successfully completed.

F. The commissioning efforts offer documented benefits to the contractors because call-backs due to real or perceived equipment/system malfunctions will be substantially reduced.

1.5 RESPONSIBILITIES

A. The responsibilities of various parties in the commissioning process are provided in this section. Additional responsibilities of the mechanical Contractor, TAB and BAS Contactors are included in Division 23; those of the plumbing Contractor are included in Division 22; and those of the electrical Contractor are included in Division 26. Their responsibilities are listed here to clarify the commissioning process.
B. Architect and Engineer (A/E)
1. Attend the FTP
2. Perform normal submittal review, construction observation, as-built drawing preparation, O&M manual preparation, etc., as contracted.
3. Coordinate resolution of system deficiencies identified during commissioning, according to the Contract Documents.

C. Commissioning Authority (CxA)
1. Provide FTP plan.
2. Plan and conduct the functional test meeting.
3. Verify testing, adjusting, and balancing of Work are complete.

D. Mechanical Contractor
1. Submit completed equipment installation and start-up checklist sheets and data on systems to be commissioned to the CxA for review; these will include, but not be limited to, the following:
   a. New Liebert Unit
   b. AC Split System
   c. New remote thermostat on AC-3
2. Include scope to complete commissioning requirements for systems in the contract price.
3. Ensure cooperation and participation of specialty sub-Contractors.
4. Ensure participation of major equipment manufacturers in appropriate training and testing activities. Length of training shall be as required by other Division 23 Sections.
5. Prepare schedule for system commissioning related activities. Include time in the project schedule for equipment startup and functional performance tests. Include time for resolution of deficiencies found during tests.
6. Provide and operate tools necessary to start, checkout, and test equipment and systems. Instruments for testing and balancing shall have been calibrated within one month prior to testing and balancing.

1.6 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:
1. Process and schedule for completing manufacturer’s prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
2. Certificate of readiness, signed by the Contractor, certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
3. Certificate of completion, signed by the Contractor, certifying that installation, prestart checks, and startup procedures have been completed.
4. Test and inspection reports and certificates.
5. Corrective action documents.
6. Testing, adjusting, and balancing reports.
7. Completion report of pipe testing.

B. The CxA shall provide and include the following documentation:
1. Functional performance testing plan with procedures and checklists for each series of tests.

1.7 SYSTEMS TO BE COMMISSIONED

A. HVAC&R systems and associated control systems:
1. New Liebert Unit
2. AC Split System
3. New remote thermostat on AC-3
PART 2 - PRODUCTS (not used)

PART 3 - EXECUTION

3.1 FUNCTIONAL PERFORMANCE TESTING REQUIREMENTS (FPT)

A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Prior to the functional performance testing of each piece of equipment, verify that equipment has been correctly brought online and a TAB report has been accepted.

C. Certify that TAB discrepancies have been corrected and corrective work has been approved.

D. All members of the Cx team shall provide technicians, instrumentation, and tools as required in the respective FPT test format to perform commissioning test at the direction of the CxA.

E. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

F. Tests will be performed using design conditions whenever possible.

G. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

H. The CxA may direct that set points be altered when simulating conditions is not practical.

I. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

J. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

K. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

L. The following is a summary of the systems that are intended to be Functional Performance Tested as part of this project. The table offers a descriptive listing of equipment and components which will be tested for each of the typical systems. An opinion of probable time required for FPT is provided for typical systems for Contractor pricing. Deficiency correction time and follow-up tests will be required when deficiencies are discovered.
### HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

**A. Refrigeration System Testing:** Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

**B. HVAC&R Instrumentation and Control System Testing:** Field testing requirements are specified in Division 23 Sections “Instrumentation and Control for HVAC” and “Sequence of Operations for HVAC Controls.” Provide technicians, instrumentation, tools, and equipment to test performance.

**C. Non-Conformance**
1. The CxA will record the results of the FPT. All deficiencies, non-conformance issues, or test failures shall be noted and reported to the Contractors in a deficiency list or in a punchlist format.
2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA. In such cases the deficiency and resolution will be documented on the procedure form.
3. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures; however, the CxA will not be pressure into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so at the request of the Owner.

#### System or Equipment Tested

<table>
<thead>
<tr>
<th>Equipment Tested</th>
<th>General Description of Modes and Functions to Test</th>
<th>Test Strategy</th>
<th>Testing Time Estimate</th>
<th>Seasonal Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Split Systems</td>
<td>AC unit, controls. All sequences in all modes, backup cooling. Low ambient settings.</td>
<td>Test all.</td>
<td>2 hours per unit.</td>
<td>Anytime.</td>
</tr>
<tr>
<td>Computer Room AC Units – Controls Modifications</td>
<td>AC unit, controls. All sequences in all modes</td>
<td>Test all.</td>
<td>2 hours per unit.</td>
<td>Anytime.</td>
</tr>
<tr>
<td>Computer Room AC Units</td>
<td>AC unit, controls. All sequences in all modes, backup cooling.</td>
<td>Test all.</td>
<td>2 hours per unit.</td>
<td>Anytime.</td>
</tr>
</tbody>
</table>
4. **Re-testing:**
   a. If a FPT fails, corrections shall be made to the deficient equipment or systems by the Contractors. The systems will be re-tested until they pass the Tests.
   b. The time/cost for the CxA to perform and re-testing required because a specific item was overlooked in the equipment start-up procedures, reported to have been successfully completed, but determined during FPT to be faulty, will be charged to the CM, who may choose to recover costs from the party responsible for executing the faulty test.
   c. Any required re-testing by any Contractor shall not be considered a justified reason for a claim of delay or for a time extension by the Prime Contractor. The Contractors will be provided with the commissioning test forms in advance of the test to prepare the systems for the tests.

D. **Deficiencies and Re-testing**
   1. The CxA documents the results of each test (Corrections of minor installation or sequence of operation deficiencies are made during tests at the discretion of the CxA).
   2. Deficiencies/non-conformance issues not corrected during testing are reported to the Contractors for corrective action. Upon completion, a request is made by the Contractors to CxA for re-testing.

E. **Deferred Testing**
   1. Unforeseen Deferred Tests: If a Test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of Testing may be delayed upon approval of the Owner. These tests will be conducted in the same manner as the seasonal tests as soon as possible. Services of necessary parties due to unforeseen deferred testing will be negotiated.
   2. Seasonal Testing: During the warranty period, seasonal testing shall be completed as part of this contract at no additional cost. The Contractors shall coordinate this activity. Tests will be executed, documented and deficiencies corrected by the Contractor, with facilities staff and the CxA witnessing.

3.3 **FINAL ACCEPTANCE**

A. Final acceptance will be contingent upon satisfactory completion of all commissioning tasks and submittals, with final review and recommendation of acceptance to the Owner by the CxA.

END OF SECTION
SECTION 23 09 16
CONTROL WIRING

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. All electrical wiring, both line voltage and low voltage, which is required to perform the automatic control functions described, shall be included in this contract. The Electrical Contractor will provide a power source to motors through his starters only. Where power sources are required beyond these starters, or beyond sources explicitly shown on the electrical drawings, these shall be provided by the BAS Contractor. Where auxiliary contacts are required on starters to perform the required functions these, too, shall be provided by the BAS Contractor where not provided under Electrical Contract. Auxiliary external relays may be provided in lieu of auxiliary contacts.

B. Wiring, both line and low voltage, shall comply with NEC and shall be subject to approval of the local code enforcing authorities.

PART 2 - PRODUCTS

2.1 All analog input, analog output, binary input, binary output, 24 VAC, and general purpose cabling shall:

A. Consist of copper conductors not less than No. 18 AWG-stranded.

B. Be 2 or 3 conductor twisted cable with a drain wire.

C. Have 100% overall shielded.

D. Be plenum-rated.

E. Meet or exceed NEC voltage rating of 300V.

F. Meet or exceed UL temperature rating of +60 degrees C.

G. Be labeled at a minimum of every 24" with the BAS system manufacturer's name.

H. Be color coded for easy identification and troubleshooting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Electrical work shall conform to applicable sections of the Electrical Specifications except wiring smaller than No. 12 may be used.

B. Minimum rigid conduit size shall be ¾". Minimum flexible conduit shall be ½”.

C. All control conduit and junction box covers shall be the color blue.

D. All line voltage wiring and low voltage wiring (except as stated below) shall be run in conduit. Low voltage wiring concealed above accessible ceilings and in hollow walls for drops to thermostats may be run without conduit. Open wiring shall be bundled and supported at 3 ft. maximum intervals with a system of J-hooks, bridal rings, or equivalent...
supporting means. Open wiring in air plenums shall be rated for such use and so labeled.

E. Circuits serving control panels and transformers for low voltage service shall be independent and used for no other purpose. These shall originate from the nearest appropriate electrical panel. Circuit wiring from the electrical panel shall be included in this contract. These circuits shall be clearly identified at the panels.

F. Wiring shall be:

1. Directly from the controller to the device. Splicing is not acceptable.
2. Neatly organized within the controller or cabinet.
3. Be labeled with the exact given software name at each end (controller and device).
4. Wiring shall never be laid directly on the ceiling grid or attached in any manner to the ceiling grid wires.
5. Wiring shall not be attached to existing cabling, existing tubing, plumbing or steam piping, ductwork, ceiling supports or electrical or communications conduit.

G. Wall penetrations shall be sleeved.

3.2 WIRE INSTALLATION SCHEDULE

A. The following conduit schedule shall apply to wire in conduit where conduit is specified. Conduit referenced below shall meet specifications in Section 26 and as defined below.

B. Exposed Outdoor Locations: Rigid steel conduit.

C. Concealed in Concrete and Block Walls: Rigid steel conduit. Electrical Nonmetallic Tubing (ENT).


END OF SECTION
SECTION 23 23 00

REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS


B. Refrigerant piping shall conform to ANSI B31.5 and ASTM B280.

C. A pressure piping permit is required for all field installed refrigerant piping of systems greater than 5-ton capacity.

D. Pipe sizing and piping arrangement shown on the drawings shall be reviewed by the equipment supplier and Contractor to verify compatibility with the equipment provided, and revised as needed.

E. The equipment supplier shall provide piping installation instructions to the Contractor and supervision as needed to ensure that the piping system is installed in accordance with the equipment manufacturer’s recommendations.

PART 2 - PRODUCTS

2.1 TUBES AND FITTINGS

A. Copper Tube: Refrigerant tubing shall be Type “ACR” hard seamless copper thoroughly cleaned and dehydrated for use with the refrigerant used. Tubing which has not been so prepared and sealed or which has been open to the atmosphere for any length of time shall not be used.

B. Wrought-Copper Fittings: ASME B16.22. All changes in direction of piping shall be made with wrought copper fittings and silver brazed joints.

2.2 VALVES AND REFRIGERANT PIPING SPECIALTIES

A. Refrigerant devices and specialties shall be specifically designed for refrigerant applications and of construction pressure class consistent with the duty imposed.

B. Manual shutoff valves shall be brass construction with sweat ends. Valves shall be ball type, or may be packed type with back seating construction, or packless type.

C. Service valves shall be shutoff type with charging and test ports.

D. Solenoid valves shall have brass body, sweat ends, normally closed with manual lift stem and holding coil in a NEMA 1 enclosure, voltage to match controls.

E. Thermal expansion valves shall be thermostatically operated diaphragm type with brass body, external equalizer and external superheat adjustment. Expansion valves shall be manufactured by Alco or Sporlan.

F. Hot gas bypass valves shall be pilot operated modulating regulators with integral solenoid and pilot assembly and external equalizer tubing and connections, Alco FA8 or equal assembly by Sporlan.
G. Flexible pipe connectors shall be corrugated copper bellows type with woven bronze wire protective jacket suitable for 400 psi refrigerant use.

H. Filter-driers shall be sealed type or replaceable core type equal to Sporlan "Catch-All”.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All joints shall be brazed using silver solder while flowing an inert gas such as dry nitrogen through the piping.

B. Piping shall be hung from the building structure with clevis hangers and rods Section 230529 – Hangers and Supports for HVAC Piping and Equipment. Hangers for insulated pipe shall be oversized and a sheet metal saddle with belled ends incorporated to protect the insulation.

C. Service valves shall be provided on the condensing unit liquid and suction connections/compressor suction and hot gas connections/condenser hot gas and liquid connections if not furnished on the unit.

D. A solenoid valve, a sight glass-moisture indicator and a thermostatic expansion valve shall be provided for each evaporator coil circuit. A filter-drier shall be provided in each liquid line near the condensing unit or the evaporator coil. A shutoff valve shall be provided on both the inlet and outlet of a replaceable core filter-drier.

E. Flexible pipe connectors shall be provided where recommended by the equipment manufacturer.

F. Solenoid valves shall be mounted within the enclosure of outdoor equipment or otherwise protected from weather.

END OF SECTION
SECTION 23 33 00
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 Ductwork accessories specified herein shall include manual balancing dampers, backdraft dampers, fire dampers, smoke dampers, filter pressure differential gauges. Refer to the drawings for scope and application.

1.2 Manual balancing dampers, in addition to those shown, which will be required to affect a positive balancing of air in the system shall be provided in the ductwork. The company or agent who is to balance the air systems shall call the Sheet Metal Contractor’s attention to requirements for additional balancing dampers which are deemed necessary.

1.3 Fire dampers and smoke dampers shall be provided where shown on the drawings and where otherwise required to conform to the NFPA 90A and Building Code requirements.

1.4 A pressure differential gauge shall be provided at air filters in each air handling unit for pressure drop indication. Where pre-filter panels and higher efficiency filters are back-to-back, two gauge shall be provided.

1.5 Air blenders / Air blender boxes shall be provided in conjunction with air handling units as shown on the drawings.

1.6 Provide automatic control dampers in duct where shown. Coordinate with BAS contractor for control linkages, shaft extension locations and access to actuators.

PART 2 - PRODUCTS

2.1 Dampers and accessory items shall be constructed of galvanized steel, except those in ducts of stainless steel, aluminum, PVC coated or other such materials shall be stainless steel to maintain the intended corrosion resistance of the system.

2.2 Balancing dampers shall be equal to Titus AG-85.

2.3 Backdraft dampers shall be adjustable counterbalanced type with extruded aluminum frame and blades and extruded vinyl edge seals. Dampers shall be equal to Ruskin CBD6.

2.4 Fire dampers shall be as follows:
   A. Dampers shall be constructed and tested to conform with UL 555 and shall be UL labeled.
   B. Dampers shall be folded blade curtain type equal to Ruskin IBD2 (except as otherwise described) with blades folded in the head of the damper housing, and shall be equipped with a 165 degree (unless otherwise noted) fusible link. Dampers installed to a horizontal air stream shall be gravity drop type. Dampers in a vertical air stream shall be spring loaded type.
   C. The following is a description of fire damper types as indicated on the plans:
      1. TYPE “B”
         Low velocity with blades stored out of air stream.
      2. TYPE “C”
         High velocity with blades stored out of the air stream and rectangular, round or oval duct collar each side.
2.5 Pressure differential gauges for air filter application shall be Dwyer “Magnehelic” Series 2000 dial type gauges. Range shall be appropriate for the application. Each gauge shall be furnished with vent valves, aluminum or plastic tubing, static pressure tips and mounting bracket or flange.

2.6 Duct Access Doors

A. Access doors shall be Kees Model HD or equal by Elgen Manufacturing, 1” insulated access door with continuous hinge, double wall Lexan view ports, and neoprene gasket between door and frame. Access doors shall be 18” x 16” minimum except smaller where duct size will not permit such size.

B. Access doors and panels shall be designed to provide tight seal commensurate with the duct pressure. Apply duct sealer or rubber gasket between frame and duct and on ducts of 3” S.P. and higher construction class, mechanical fastening of the frame and rubber gasket shall be provided.

C. Where sufficient clearance is not available to allow the door to swing open 90°, an access panel with neoprene gasket, frame and cam lock latches on all four sides shall be provided in lieu of the hinged door.

2.7 Plenum Access Doors

A. Plenum access doors shall be factory fabricated and as described for duct access doors except that doors shall be 18” x 48” (unless otherwise noted) with overlapping frame, continuous piano hinge and heavy duty latches (with lever on both outside and inside) equal to Ventfabrics “Ventlok No. 31. Two latches shall be provided except on doors 50” and higher three shall be provided. Frame shall be mechanically fastened to the plenum wall.

2.8 Flexible Duct Supports

A. Flexible duct supports shall have a fully adjustable radius and be capable of being applied to flexible duct up to 16” in diameter.

B. Manufacturer shall be Flexmaster FlexRight or approved equal.

PART 3 - EXECUTION

3.1 Fire and smoke dampers shall be installed in conformance with manufacturer’s instructions and SMACNA recommendations. Dampers shall be installed in sheet metal wall or floor sleeve along with retaining angles and duct access doors or panels. Sleeve and duct connections shall be breakaway type or rigid type with corresponding gauge requirements in accordance with SMACNA recommendations.

3.2 Smoke detectors and wiring associated with smoke dampers are provided by the Electrical Contractor.

3.3 Fire damper and access door shall be so arranged and located such that the spring catch and fusible link are accessible when the damper is closed.

3.4 Accessibility of each fire damper shall be demonstrated by the Contractor to the Owner by disconnecting the link, closing the damper, reopening and reattachment of the fusible link.
3.5 Install air filter pressure differential gauges in a readable location on or near the air handling unit, filter housing or as otherwise indicated on the drawings.

3.6 Where flexible duct has $90^\circ$ elbows, duct shall be supported by flexible duct support. Flexible duct support shall be fastened to duct using cable ties and suspended from structure.

END OF SECTION
SECTION 23 37 00
AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Air outlet and inlet devices include grilles, registers, diffusers, louvers, and specialty air diffusion devices associated with ceiling and lighting systems.

PART 2 - PRODUCTS

2.1 DIFFUSERS, REGISTERS AND GRILLES

A. Refer to the schedule on the drawings for description, catalog numbers, materials, finishes, accessories, mounting and other details of the devices required.

B. Air distribution devices other than louvers and specialty products shall be as listed:
   1. Supply Diffusers – Donco Pro-2 24x24 Plaque Diffusers, powder coat white finish.
   2. Ceiling Return or Exhaust – Donco LFRD 24x24 louvered register, powder coat white finish, plenum box painted flat inside (Aluminum for wet applications).
   3. Ceiling Transfer Grilles – Same as Ceiling Return.

C. Air outlet and inlet devices shall be equal to those specified by catalog number and description in the schedule on the drawings. Damper operators shall be concealed screw type. An auxiliary mounting frame shall be furnished with each grille and register except those mounted on exposed ducts or in lay-in application.

D. Linear “T” bar air supply diffusers shall be slotted diffusers with fixed air pattern control complete with a galvanized sheet metal supply plenum having a round or oval duct connection and ½” neoprene coated fiberglass insulation on the interior. The unit shall be designed to mount on or alongside the ceiling “T” bar and shall include flanges on both sides of the diffuser to support the ceiling tiles. Additional “T” bars matching those of the ceiling system shall be provided by the HVAC Contractor if the diffuser does not have these flanges. Units shall have a center notch where required to accommodate intervening “T” bars. Linear diffuser manufacturer shall be same as the other air devices or the terminal unit manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The Contractor shall be responsible for compatibility of ceiling mounted devices with the ceilings and suspension systems (lay-in, concealed spline, plaster, drywall, etc.). Verify with the architectural drawings.

B. Carefully align square and rectangular devices with the vertical and horizontal building lines. Diffusers shall be attached rigidly to the ductwork. Where connected by flexible ducts, special supports shall be provided as required, either from the ceiling suspension system or by independent suspension wires or rods from the building structure.

C. Inside of ducts behind grilles, registers and diffusers shall be painted flat black, as needed, to eliminate the sight of shiny surfaces.
D. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

E. Where flexible duct has 90° elbows, duct shall be supported by flexible duct supports suspended from building structure.

END OF SECTION
SECTION 23 81 23

COMPUTER ROOM AIR CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents:
   1. Drawings and general provisions of the Subcontract apply to this Section.
   2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:
   1. Packaged air conditioning unit.
   2. Charge of refrigerant and oil.
   3. Controls and control panel.
   4. Air filters.

1.2 REFERENCES

A. General:
   1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
   2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
   3. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.
   4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.

B. National Fire Protection Association:
   1. NFPA 90A Installation of Air Conditioning and Ventilating Systems.

1.3 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC, Review of Materials and Division 01 Section "General Requirements."

B. On equipment shop drawings, show piping, connections, valves, strainers, and thermostatic devices required for complete system.

C. Submit manufacturer’s installation instructions.

D. Submit manufacturer’s descriptive literature, operating instructions, and maintenance and repair data.

1.4 QUALITY ASSURANCE

A. Provide factory-assembled, package-type, computer room air conditioning unit(s); product of manufacturer regularly engaged in production of size and type of unit specified and issuing complete catalog data on such products.

B. Manufacturer shall be responsible for selection and operation of components supplied. Provide written certification that related components not supplied by the manufacturer have been selected in accordance with manufacturer’s instructions.
C. Products shall be UL listed and shall conform to requirements of applicable codes.

D. ASHRAE Compliance:
   1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."


PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS
   A. Liebert, or approved equal.

2.2 TYPE
   A. Provide packaged, [water] [air]-cooled, factory-assembled, prewired unit, consisting of cabinet, evaporator fans and motors, compressors, cooling and heating coils, filters, humidifier, and controls.

2.3 CABINET (FLOOR-MOUNTED UNITS, CEILING-MOUNTED UNITS)
   A. Fabricate structural-steel base frame of 18-gage (1.21 mm) steel, suitably cross-braced for rigidity, to support compressors and other mechanical equipment and fittings. Removable enclosing panels and doors.
   B. Fabricate doors and access panels of 18-gage (1.21 mm) steel, installed to close against pressure-tight gaskets. Provide concealed hinges and fastening devices.
   C. Thermally and acoustically line cabinet interior with fireproof material meeting requirements of NFPA 90A.
   D. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
   E. Finish exterior surfaces of doors, panels, and frame in textured vinyl enamel to match computer equipment.

2.4 CABINET (CONSOLE UNITS)
   A. Evaporator Cabinet: Furniture-grade steel with baked-enamel finish; with front access and containing direct-drive centrifugal fans and two-speed motor.
   B. Other requirements as in Section 2.4.

2.5 REFRIGERATION SYSTEM
   A. Refrigerant: R-407C or R-410A.
   B. Provide at least two refrigeration circuits, each complete with thermal expansion valve, filter drier, moisture indicator, sight glass, shut-off valves, and charging valves.
   C. Refrigerant Evaporator Coil: Alternate-row or split-face-circuit, direct-expansion coil of seamless copper tubes expanded into aluminum fins.
1. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1-2004 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.

2.6 EVAPORATOR FANS AND MOTORS

A. Provide direct-drive, double-inlet, forward-curved centrifugal fans, statically and dynamically balanced, with permanently lubricated ball bearings.

B. Each fan shall be independently driven by heavy-duty, drip-proof, permanently lubricated ball-bearing motor with built-in current and overload protection.

2.7 COMPRESSORS

A. Provide hermetic or semi-hermetic type compressors, internally protected, resiliently mounted, with positive lubrication.

B. Compressors shall be serviceable without dismantling other components.

2.8 FILTERS

A. Provide removable, disposable filters; MERV-7 rating.

2.9 CONDENSERS

A. Provide water-cooled units with shell-and-tube or tube-in-tube condensers, each complete with liquid-line stop valve and water-regulating valve. Stub-off piping inside cabinet for easy external connections.

B. Provide air-cooled units with matched air-cooled condenser consisting of corrosion-resistant cabinet, incorporating copper-tube, aluminum-fin, condenser coils arranged for at least two circuits, and multiple direct-drive condenser fans with inherently protected motors. Operating controls shall permit fan cycling for head-pressure control.

2.10 CONTROL PANEL AND CONTROLS

A. Provide prewired control panel within unit casing. Incorporate contactors and switching devices; including switches to permit manual operation of the various circuits. Code wire terminal points for identification.

B. Incorporate devices with wide, gradual throttling range that causes system to pass from cooling to heating mode only when temperature fluctuation from normal has persisted for a given time span. Hunting and stop-start procedures for compressors and heaters is not permitted.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install unit(s) in accordance with manufacturer’s instructions.

END OF SECTION
SECTION 23 81 26
SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. The units shall be built in compliance with the National Electric Code and UL Standards and bear a UL label.

B. EER: Equal to or greater than that prescribed by ASHRAE/IESNA 90.1,

C. Comply with NFPA 70.

D. Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace refrigeration components that fail in materials or workmanship within five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SPLIT-SYSTEM AIR CONDITIONERS

A. Work includes packaged split system air conditioners with remote air cooled condensing units, in place, with controls. Refer to drawings for selection data and electrical characteristics.

B. Indoor cooling unit shall include a DX cooling coil, tangential centrifugal fan, disposable filter, supply air grille with adjustable deflection, condensate pump and control panel.

C. The unit control panel shall be remotely controlled by a wired unit control, which includes the following functions:
   1. Fan speed – high, medium, low, auto
   2. Temperature set point

D. Integral condensate pump shall be capable of lifting condensate a minimum of 8 feet.

E. Remote air cooled condensing unit shall include compressor, condenser coil, and condenser fan, in a weather proof cabinet, with all appropriate operating and safety controls. Unit shall be capable of low-ambient operation, to operate the condensing unit, and provide indoor cooling down to outdoor temperatures as low as -20°F.

F. Manufacturer: Carrier

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install indoor and outdoor units, and provide power to each, in accordance with the manufacturer’s instructions.

B. Connect indoor and outdoor units with suction and liquid refrigeration piping in accordance with the manufacturer’s instructions, and related portions of this specification. Do not exceed line lengths or elevation differences established by the manufacturer. Insulate to suction line to prevent sweating. Refer to related portions of this specification.

END OF SECTION
SECTION 26 05 00
COMMON WORK RESULTS FOR ELECTRICAL

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 and the other sections of Division 26.

B. The Electrical Drawings and Specifications are complementary and what is called for by one shall be as binding as if called for by both. Items shown on the Drawings are not necessarily included in the Specifications. All directives and instructions to furnish, install, complete, test and methods described in these Specifications and Drawings shall be interpreted as directives to the Electrical Contractor unless clearly specified otherwise. It is the intent of these specifications and the accompanying drawings to describe complete and functional electrical systems. If errors or discrepancies are discovered, notify the Architect/Engineer immediately.

C. The contractor will be held responsible for the complete and satisfactory accomplishment of all work under this section, along with the procedures and formalities outlined in the instructions to bidders, general conditions, special conditions and addenda.

D. Reference Standards:
1. Agencies or publications referenced herein refer to the following:

   ADA             Americans with Disabilities Act
   ANSI            American National Standards Institute
   ICEA            Insulated Cable Engineers Association
   IEEE            Institute of Electrical & Electronics Engineers
   NEC             National Electrical Code
   NECA            National Electrical Contractors Association
   NEMA            National Electrical Manufacturers Association
   NFPA            National Fire Protection Association
   NIST            National Institute of Standards & Technology
   UL              Underwriters Laboratories

1.2 SUMMARY

A. Work Included:
1. Provide electrical system as shown in Electrical Drawings.

2. Electrical system work includes, but is not necessarily limited to, the following:
   a. Visit site and verify existing conditions.
   b. Replace existing three phase uninterruptable power supply (UPS) with two new three phase UPS’s and power distribution unit (PDU) to create new dual bus distribution to server loads.
   c. Provide static transfer switch ahead of PDU-2 to provide UPS power from both A and B bus to single corded loads in the control room.
d. Provide transient voltage surge protection device in panel EMDP to protect downstream UPS’s.

e. Extend emergency power off control system for shutdown of new UPS and HVAC systems.

f. Extend power to new HVAC system equipment.

g. U.L. rated firestopping materials at cable or wire penetrations of rated wall or floor systems.

h. All permits, testing and inspection fees.

i. One year guarantee on labor and materials.

j. Removal of existing electrical equipment released from service. See demolition specifications.

3. Coordinate with Owner regarding outages and scheduling of work.

B. This Section includes general administrative and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:

1. Submittals.
2. Site visitation.
3. Work sequence.
4. Cooperation with Owner.
5. Electrical drawings.
6. Record documents.
7. Maintenance manuals.
8. Delivery, storage and handling.
9. Materials and equipment.
10. Warranty.
11. Approvals and substitutions.
12. Rough-in.
13. Electrical installations.
15. Floor, wall, roof and ceiling openings.
16. Cutting and patching.
17. Protection.
18. Equipment connections.
19. Housekeeping and cleanup.
20. Cleaning.

C. Related Sections: The following sections contain requirements that relate to this section:

1. Division 23 Section "ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT", for factory-installed motors, controllers, accessories, and connections.

1.3 SUBMITTALS

A. General: Follow the procedures specified in Division 1 Section “SUBMITTALS”.

B. Bill of Material: Within 30 days after date of contract, submit one (1) hardcopy and one (1) electronic copy of Bill of Materials listing subcontractors and specific manufacturer/vendor’s
product intended to be provided. Items requiring Bill of Material Submittal are identified under the Submittals section of each specification section. Submittal shall be indexed using CSI section numbers as utilized in this specification. Equipment and/or material orders shall be placed only after approval by the A/E. The Electrical Contractor assumes the risk of subsequent rejection for placing orders on equipment other than as named in the contract documents and without prior approval of the A/E. Any and all costs or damages arising therefrom shall be borne by the Electrical Contractor.

C. **Shop Drawings:**
   1. After approval of Bill of Material List, submit for approval one (1) hardcopy and one (1) electronic set of shop drawings for required equipment.

   2. Shop drawings shall bear the Electrical Contractor’s name, date, and approval stamp. Approval shall state, in effect, that the documents offered for consideration conform to the contract documents and applicable codes and/or requirements and to supplementary corrections, have been examined by the Electrical Contractor, and depicts equipment compatible with construction. Shop drawings will not be reviewed by the A/E if this requirement is not met.

   3. Shop drawings depicting common equipment shall be assembled and submitted in a bound brochure with an index sheet. Include wiring diagrams where called for.

   4. Each drawing shall be indexed to conform to indexing scheme on electrical drawings.

   5. Review and recommendations by the Architect or Engineer are not to be construed as change authorizations. If discrepancies between the shop drawings submitted and the Contract Documents are discovered either prior to or after the data is processed, the Contract Documents will govern.

D. Additional copies may be required by individual sections of these Specifications.

E. **Governmental Agency Requirements:**
   1. EC shall familiarize himself with all such requirements and shall process all materials.

   2. **Permits, Licenses and Inspection Fees:** Prepare and submit applications and submittals required, obtain necessary permits and certificates of compliance and approvals required and shall deliver these to the A/E paying all necessary fees.

   3. **Standards and Code:** All work shall be performed in strict conformity with all applicable laws, ordinances and codes including State Electrical Code, National Electrical Code and OSHA. The EC will be held to complete work necessary and to provide all equipment required to comply with the foregoing without extra compensation.

### 1.4 SITE VISITATION

A. Visit the site prior to bidding to familiarize self with existing conditions and all other factors which may affect the execution of the work.

### 1.5 WORK SEQUENCE

A. Review the work sequence and determine if any dates of completion cannot be met for the work. Any conflicts with completion dates shall be brought to the Engineer/Owner’s attention prior to submitting a bid. No time extensions will be granted after contracts are let unless permitted in other parts of these specifications.

### 1.6 COOPERATION WITH OWNER
A. Cooperate with the Owner to the maximum extent possible to insure that the project is completed in a quality manner and on a timely basis. Any expenses incurred on the part of the Owner which were caused by non-cooperation of the Contractor shall be borne by the Contractor.

1. Contact Owner’s representative one week prior to any demolition or construction work adjacent to occupied areas so work can be scheduled with least disruption to Owner’s personnel in area.

2. Shields with drop cloths are required to contain dust and debris within demolition area.

3. Clean up and maintain areas adjacent to demolition work at the close of each work day.

1.7 ELECTRICAL DRAWINGS

A. The Electrical Drawings accompanying these Specifications are design drawings and generally are diagrammatic indicating approximate locations of outlets and wiring. They do not show every offset, bend, junction box, etc., which may be required for installation to complete the system. Minor deviations in methods, circuiting and branch circuit distribution or arrangements to suit construction conditions are permissible.

B. The intent of the branch circuiting and control shown shall not be changed nor homeruns combined without the approval of the Architect/Engineer. Feeder runs shall not be combined or changed.

C. Except as otherwise defined in greater detail, the terms “provide”, furnish” and “install” as used in Division 26 contract documents shall have the following meanings:

   1. “Provide” or “provided” shall mean “furnish and install”.

   2. “Furnish” or “furnished” does not include installation.

   3. “Install” or “installed” does not include furnishing.

1.8 RECORD DOCUMENTS

A. Maintain one set of reproducible drawings marked up (red lined) on a daily basis as the work progresses, showing all changes, deviations, change orders, omissions, or other variations from the contract drawings.

B. 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; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.

   2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.

   3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

C. On acceptance of the contractor record drawings by the Engineer, the contractor will transfer record drawings to AutoCAD electronic format following CUNA Mutual Group CAD standards. Provide electronic drawings in PDF and DWG format on CD along with three (3) reproducible full size printed copies for Owner’s file. Copies of the base project construction document files will be made available to the contractor at no charge.
D. Deliver record drawings files on disk to the Engineer promptly upon completion of the project. Record information added to the AutoCAD drawing files is to have compatible format, line work and lettering as the original files. All new work done by the contractor on the original drawing files is to be on a single layer noted in the revised drawing file as Record.

1.10 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1. In addition to the requirements specified in Division 1, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.

3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

4. Servicing instructions and lubrication charts and schedules.

5. Include name, address and telephone number of local supplier or agent and nearest service depot.

1.11 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.

1.12 MATERIALS AND EQUIPMENT

A. All materials and equipment furnished by this contractor under this agreement shall:

1. Bear the UL label and such other labels attesting to compliance with applicable Codes and requirements.

2. Be responsive to requirements of these specifications, the contract documents and shall be acceptable to the A/E.

3. Be new, unused and suitable for environment, conditions and duties imposed upon same in service.

4. Be the most recent production run product of the manufacturer.

5. Be installed, connected, cleaned and conditioned in accord with manufacturer's requirements and recommendations.

1.13 WARRANTY

A. Warrant and maintain, remedy and/or replace any work, materials, equipment or components thereof which develops defects within one year from the date of the A/E final certificate providing such defects are not clearly due to “Acts of God”, fire, violence, abuse, negligence
or accidents of other contractors or agents of the Facility Owner, who reserves the right to make temporary repairs as necessary to keep equipment in operating condition without voiding the PEC’s Warranty nor relieving him from his responsibilities during the warranty period.

PART 2 - PRODUCTS

2.1 APPROVALS AND SUBSTITUTIONS

A. The use of manufacturer’s names, models and numbers in this Specification is intended to establish style, quality, appearance and usefulness. Items noted “or equal” require prior approval.

B. Submit for the Architect/Engineer’s approval, manufacturer’s detailed specifications and data sheets for all proposed substitutions. Submittals shall consist of a single sheet, or sheets, if required, for each piece of equipment and shall give the specific data needed for consideration of approval. All pertinent data listed in the Specifications and in Schedules shall be furnished, including all special features. See that all submittals are in proper order, and that all equipment will fit in the space provided.

C. The Architect/Engineer reserves the right to require the submission of an actual sample before the acceptance of any product as an equal to that specified.

D. Application for prior approval will NOT be permitted via FAX.

PART 3 - EXECUTION

3.1 ROUGH-IN

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

3.2 ELECTRICAL INSTALLATIONS

A. Provide a complete properly operating system for each item of equipment called for under this work. Installations shall be in accord with the equipment manufacturer’s instructions, the best industry practices and the contract documents. Where a conflict in these guides appears, the Architect/Engineer shall be requested to provide proper clarification before work is roughed in and his decision will be final. Work installed without such clarification shall be removed and corrected by the Contractor at no cost to the Owner.

B. Make installation in a neat, finished and safe manner, according to the latest published NECA Standard of Installation under competent supervision.

C. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment, and materials installation with other building components.

2. Verify all dimensions by field measurements.
3. Provide all chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.

4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.

7. Coordinate connection of electrical systems with exterior underground utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Engineer.

9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

10. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

11. Install access panel or doors where units are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "ACCESS DOORS".

12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

13. Coordinate rough-in and wiring requirements for all mechanical equipment with mechanical contractor and equipment supplier. Make installation in accordance with rough-in and wiring diagrams provided by equipment supplier for Contractor's use. Report immediately to Engineer any deviation between contract documents and actual equipment requirements.

14. All equipment and material shall be installed in such a manner as to permit easy maintenance and/or removal of parts of this work or other Contractors’ work. Arrange all equipment and material to clear openings such as doors and access panels. Any work installed in such a manner as to interfere with access to or maintenance of any equipment shall be relocated by the contractor at no additional cost to the Owner.

D. Equipment Access:

1. Install all raceways, equipment, junction and pull boxes, and accessories to permit access to equipment for maintenance. Any relocation of raceways, equipment, or accessories required to provide maintenance access shall be accomplished by the contractor at no additional cost.

2. Install equipment with ample space allowed for removal, repair or changes to the equipment. Provide ready accessibility to equipment and wiring without moving other equipment which is to be installed or which is already in place.
3. Provide access doors where any equipment requiring access for servicing, repairs or maintenance is located in walls, chases or above inaccessible ceilings, unless noted otherwise. Access frames and doors shall be as manufactured by Milcor, Inc. or similar, of a style applicable to the surface. Access doors used in fire-rated construction must have UL label. Access doors shall be steel, prime coated, except use stainless steel doors in ceramic tile walls, toilet rooms, locker rooms, and in areas subject to excessive moisture. Access doors shall be of sufficient size to allow for total maintenance. The location of access doors shall be coordinated with the General Contractor and the location of equipment shall be roughed in accordingly.

E. Equipment Supports:
1. Provide all supporting steel not indicated on the Drawings as required for installation of equipment and materials including angles, channels, beams, hangers, etc.
2. Concrete anchors, used for attachment to concrete, shall be steel shell with plug type. Plastic anchors shall not be used on drywall or plaster surfaces. Rawhide or anchors utilizing lead are not allowed.
3. Do not support equipment or fixtures from metal roof decking.

F. Support Protection:
1. In occupied areas, mechanical rooms and any areas requiring normal maintenance access, certain equipment must be guarded to protect personnel from injury due to walking into surfaces likely to cause lacerations.
2. Provide minimum 1/2-inch thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of all equipment, including bus duct, cable tray, pull boxes and electrical supporting devices suspended less than 7 feet above floors, platforms or catwalks in these areas.
3. Threaded rod or bolts shall not extend beyond the supporting element and shall be protected as described above.

3.3 DEMOLITION

A. Note that the existing building will remain in service during construction. Areas of the building will be vacated as required to facilitate construction. Proceed with the completion of the work in such a manner as to cause the least possible interference with the Owner’s operation. All work required in the existing building shall be done in a manner and time acceptable to the Owner. Outages and other work rendering existing equipment inoperative shall be held to a minimum; prior arrangement for each shall be made with the Owner and shall be acceptable as to time and duration.

B. Perform the necessary demolition work in the areas affected, including the removal of lighting fixtures, lamps, wiring devices, raceway, and electrical equipment. In addition, and preceding demolition work, de-energize all circuits in the affected areas and where wiring is routed through these areas serving areas of the building remaining in service, provide temporary and/or permanent wiring as required. Also, where necessary and required, provide sources of power and temporary wiring.

C. Electrical equipment in conflict with construction shall be removed and/or relocated as indicated on the drawings, as directed or required. Remove all electrical equipment released from service as a result of construction, and equipment removed shall not be reused, except as specifically directed on the drawings or elsewhere herein. Review equipment being removed with Owner. Unless otherwise indicated, all electrical equipment removed shall
become the property of the EC and shall be removed from the site by the EC. Equipment indicated to be retained by Owner shall be stored on site at location designated by Owner.

D. The EC shall be responsible for the work normally done by other trades as may be necessary to facilitate the installation of electrical work in the existing building. Such work that is normally done by other trades and is not covered as a part of other divisions of the work shall be done under the direction and at the expense of the EC.

E. Any existing circuits or equipment not shown on the drawings and which are logically expected to be continued in service and which may be interrupted or disturbed during construction shall be reconnected in an approved manner. In addition, any existing circuit or equipment which may require relocation or rerouting as a result of construction shall be considered a part of the work of this branch and shall be done by the EC with no additional compensation.

F. Caulk and seal any holes created by removal of existing conduit.

G. Remove all wiring to existing equipment and receptacles being discontinued or removed due to construction.

H. The Contractor shall be responsible for notifying the Architect/Engineer of any code violation in the portions of the electrical system which are being modified or reused. If the correction of the violation changes the scope of the work contracted to perform, the Contractor shall inform the Architect/Engineer in writing of the change in the scope and include a cost estimate to include the work within the new scope. After a change order is issued, the violations shall be corrected.

3.4 FLOOR, WALL, ROOF AND CEILING OPENINGS

A. Coordinate the location of openings, chases, furred spaces, etc. with the appropriate contractors. Provide during the progress of construction all sleeves, hangers and inserts that are to be built into the structure.

B. Temporary sleeves, if used to form openings, shall be removed prior to the installation of the permanent materials. Permanent sleeves shall be 24 gauge galvanized sheet metal unless noted otherwise.

C. Steel sleeves, when required, shall be Schedule 40 pipe with integral water stop.

D. Submit product data and installation details for all penetrations of building structure. Submittal shall include schedule indicating penetrating materials, (steel conduit, PVC conduit, cables, cable tray, etc.), sizes of each, opening sizes and sealant products intended for use.

E. Where penetrations of fire-rated assemblies are involved, submit manufacturer’s UL classified firestopping system and application details demonstrating compliance with ASTM E-814.

F. Openings for penetrations shall be minimum 1/2-inch larger on all sides than the outside dimensions of the raceways or cables. However, where fire resistant penetrations are required, size openings in accordance with recommendations of the sealant manufacturer.

G. Seal non-fire-rated floor penetrations with non-shrink grout equal to Embeco, by Master Builders, or urethane caulk, as appropriate.

H. Seal non-rated wall openings with urethane caulk.
I. Seal penetrations of fire rated structure with firestopping systems which are UL classified for the application, tested in accordance with ASTM E-814, approved for intended use by authority having jurisdiction, as manufactured by Chase Technology, 3M, Nelson Firestop Products, Specified Technologies, Inc., The Rectorseal Corporation, Thomas and Betts, or Tremco. Install all materials in accordance with manufacturer’s recommendations.

J. Multiple penetrations of a common fire barrier opening shall be avoided. When at all possible, each penetration shall be individually finished in accordance with the project details. When multiple penetrations are unavoidable, seal openings with UL classified fire resistant sealant systems by the above manufacturers.

K. Provide chrome or nickel plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Escutcheons shall be sized to fit raceways and shall give a finished appearance. Finished areas shall not include mechanical rooms, janitor closets, storage rooms, etc., unless suspended ceilings are specified.

3.5 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with the following requirements:

   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. Upon written instructions from the Architect/Engineer, uncover and restore Work to provide for Architect/Engineer observation of concealed Work.

   2. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

   3. Do not pierce beams or columns without permission of the Architect/Engineer and then only as directed. If any openings are required through walls or floors where no sleeve has been provided, drill the hole to avoid all unnecessary damage and structural weakening.

3.6 PROTECTION

A. Protect all conduit, wireway and equipment against entrance of liquids and foreign matter by means of plugs or caps. Cover fixtures, detectors and devices furnished and/or installed under this Section during the construction period.

B. Protect equipment against entry of foreign matter and vacuum, both inside and outside before testing, operating and painting.

C. Protect materials and equipment from damage. Devices damaged prior to final acceptance of the work shall be restored to their original condition or replaced.

D. Equipment shall be inherently safe and moving parts shall be covered with guards.

E. In sprinkled rooms where electrical equipment is installed, provide either galvanized metal hoods or galvanized metal shields to deflect all water spray away from such equipment.
F. Electrical panels and any electrical apparatus shall not be installed below water pipes. Coordinate location of such items with the mechanical trades prior to roughing in.

G. Provide covers or hoods for devices, boxes, fixtures, etc. recessed in fire rated ceilings as required to maintain the ceiling fire rating integrity. Coordinate work with architectural drawings.

3.7 EQUIPMENT CONNECTIONS

A. Provide complete electrical connections for all items of equipment requiring such connections, including incidental wiring, materials, devices and labor necessary for a finished working installation.

B. Verify the location and method for connecting to each item of equipment prior to roughing-in. Check the voltage and phase of each item of equipment before connection.

C. Furnish all code required disconnects under this work, whether specifically shown or not.

3.8 HOUSEKEEPING AND CLEANUP

A. Periodically as work progresses, remove waste materials from the building and leave area of work broom clean. Upon completion of work, remove all tools, scaffolding, broken and waste materials, etc., from the site.

3.9 CLEANING

A. After installation has been completed, contractor shall clean all systems.

B. Clean debris from all panelboards, switchboards, motor starter and disconnect switch enclosures, junction boxes and pull boxes and arrange wire neatly with surplus length cut off prior to installation of covers.

C. Wash and wipe clean all lighting fixtures, lens, louvers and lamps.

D. Thoroughly clean equipment of all stains, paint spots, dirt and dust. Remove all temporary labels not used for instruction or operation.

3.10 FINAL ACCEPTANCE

A. See Division 1 of Project Requirements. In addition to these requirements specified in Division 1, include the following:

1. Conduct tests and demonstrations to confirm suitability of installation and performance of equipment and systems.

2. Submit test data prepared by manufacturer, suppliers, installers, private testing agencies, etc. and submit a certificate of inspection prepared by the inspection authority.

B. Electrical Tests:

1. General:
   a. Prior to energization of electrical equipment, conduct operating checks and proof tests to establish that equipment is complete, properly installed, wired and connected and ready for energization.
b. Equipment subject to field adjustment and calibration shall be calibrated and adjusted by the EC or under the direction of the EC employing instrumentation, methods, and personnel acceptable to the EC.

c. Equipment tests shall be conducted by the EC and/or manufacturer/supplier in accordance with other sections of this specification.

C. Demonstration:
1. Each electrical system, special apparatus and equipment furnished with operation instruction or description shall be demonstrated to the Owner or Owner’s personnel at a time convenient to the Owner.

2. Demonstrations shall be by the EC and supplier or supplier’s representative.

3. Demonstration shall include a functional description of the system (or equipment), major features and operating characteristics and necessary settings of equipment or apparatus.

4. Confirm dates of demonstration in advance with Owner and Construction Manager.

D. Final Submittals:
1. Upon substantial completion of the work and prior to final acceptance review submit to the Owner:

   a. Certificates of final inspection and approval of the installation as issued by local inspection authorities or affidavit attesting that electrical work is in compliance with codes and applicable ordinances.

   b. All electrical equipment test data required under “Electrical Tests” of these specifications.

   c. Record Drawings.

   d. Provide two Project Manuals which shall consist of the following data prepared in a neatly indexed vinyl covered three-ring, loose-leaf binder with index tabs.

      1) Maintenance Manuals.

      2) All warranties on equipment.

      3) One set of final approved shop drawings.

      4) One set of final wiring and control diagrams associated with Generator Control System.

      5) One set of all test data, inspection certificates, etc.

      6) Any and all other data and/or drawings required during construction as may be directed.

   e. Major pieces of equipment may be furnished in a separate manual properly identified and conforming to the Project Manual requirements.

E. Final Acceptance Review:
1. Operation of electrical systems and equipment does not constitute acceptance of the work. Final acceptance of the electrical work shall not occur until final submittals are
processed and after the EC has demonstrated that the electrical installation fulfills all requirements of the contract documents.

2. Final acceptance review shall be conducted upon notification by the EC that electrical work is complete on date mutually agreed to between Owner, Construction Manager, Architect/Engineer and Electrical Contractor. On this date, the EC shall demonstrate that all work, electrical systems, equipment and facilities is complete, free from physical and/or electrical defects and/or deficiencies and is judged to be in satisfactory operating condition.

F. Defective Work:
1. Defective work, materials, equipment or components thereof shall be determined by judgment of the Architect/Engineer. Where judged to be defective prior to or during the warranty period, such work or materials shall be corrected or made good in manner and time acceptable to the Architect/Engineer by the EC at the EC’s expense. Such corrections shall include costs associated with damages to furnishing, building proper, work or construction disturbed by changes necessitated in consequence of said defects and direct and incidental damages resulting from or associated with such defects.

2. All material and/or equipment provided by the EC to replace same judged to be defective shall be warranted by the EC the same as for original item replaced except that such warranty shall commence from the date of acceptance of the replacement.

3. It is hereby understood that the basis upon which materials and equipment may be judged defective by the Architect/Engineer shall include but not be limited to:
   a. Failure to comply with the contract documents with respect or regard to quality, amount or value of materials, appliances, or labor employed in the work.
   b. Failure to comply with functional requirements, purposes or intent due to inherent defects, imperfections or inadequacies.
   c. Failure in service.

END OF SECTION
SECTION 26 05 19
LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes building wires and cables and associated splices, connectors, and terminations for wiring systems rated 600 volts and less.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Section 26 05 29 "Hangers and Supports for Electrical Systems" for supports and anchors for fastening cable directly to building finishes.

2. Section 26 05 53 "Identification for Electrical Systems" for insulation color coding and wire and cable markers.

1.3 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70 "National Electrical Code" for components and installation.

B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms "Listed and Labeled": As defined in the "National Electrical Code", Article 100.

C. Conductors for special systems shall be as recommended by the equipment manufacturer except as noted.

1.5 SEQUENCING AND SCHEDULING

A. Coordination: Coordinate layout and installation of cable with other installations.

1. Revise locations and elevations from those indicated as required to suit field conditions and as approved by the Architect.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver wire and cable according to NEMA WC-26. Deliver conductors to the job site in cartons, protective covers or on reels.
PART 2 - PRODUCTS

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

1. Wires and Cables:
   b. Cerro Wire.
   c. Colonial Wire.
   d. Encore Wire Ltd.
   e. Southwire Co.

2. Connectors for Wires and Cables:
   a. AFC, Monogram Co.
   b. AMP, Inc.
   c. Anderson, Square D Co.
   d. Electrical Products Division, 3M Co.
   e. O-Z/Gedney Unit, General Signal.

2.2 BUILDING WIRES AND CABLES
A. UL-listed building wires and cables with conductor material, insulation type, cable construction, and rating as specified in Part 3 "Applications" Article.
B. Rubber Insulation: Conform to NEMA WC 70.
C. Thermoplastic Insulation: Conform to NEMA WC 70.
D. Cross-Linked Polyethylene Insulation: Conform to NEMA WC 70.
E. Ethylene Propylene Rubber Insulation: Conform to NEMA WC 70.
F. Solid conductor for 10 AWG and smaller; stranded conductor for larger than 10 AWG.

2.3 CONNECTORS AND SPLICES
A. UL-listed factory-fabricated wiring connectors of size, ampacity rating, material, and type and class for application and for service indicated. Select to comply with Project's installation requirements and as specified in Part 3 "Applications" Article.
B. Joints, taps and splices sizes No. 10 and smaller: Ideal-Nut Connectors or Scotchlok Spring connectors.
C. Joints, taps and splices sizes No. 8 and larger: Aluminum/copper compression connectors that have been installed with a hydraulic compression tool.
D. Plastic snap-on splice insulators are not permitted.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine raceways and building finishes to receive wires and cables for compliance with installation tolerances and other conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.
3.2 APPLICATIONS

A. Branch Circuits: Type THHN/THWN, copper conductor, in raceway, recommended color circuits.

B. Conductor Sizes: Conductor shall be furnished and applied in accordance with the following AWG size requirements considered minimum.

   1. No. 12 wire for branch circuit of any kind.
   2. No. 10 wire for exit, emergency, security and exterior lighting circuits.

C. Conductor shall be sized in accordance with the foregoing, the National Electric Code, and shall be increased one wire size larger for home runs exceeding the following circuit lengths. Increase two wire sizes for circuits exceeding 750 feet.

   1. For circuits less than 200 volts - 50'-0".
   2. For circuits above 200 volts - 100'-0".
   3. Maximum 3% voltage drop is permitted for branch circuits and a total of 5% for feeders and branch circuits combined. Conductor sizes indicated on drawings are not necessarily compensated for voltage drop and must be increased in size to meet code recommendations.

D. Conductor and conduit sizes in these contract documents are based on copper wire.

E. Wire and cable boxes and reels shall bear the date of manufacture. The date of manufacture shall not precede contract date by more than one year.

3.3 INSTALLATION

A. Install wires and cables as indicated, according to manufacturer's written instructions and the NECA "Standard of Installation".

B. Pull conductors into raceway simultaneously where more than one is being installed in same raceway.

   1. Use pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not install wiring in raceways containing water or debris.
   2. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway. If cable is damaged in the opinion of the A/E, the contractor shall replace it at his own cost.
   3. Total number of current carrying conductors in a single raceway shall not exceed nine (9). Install no more than six (6) ungrounded conductors. Conductor ampacity is to be derated as required by NEC.
   4. Grouped 20A. branch circuit “families” sharing a common neutral conductor shall utilize a #10 AWG neutral conductor.

C. Install exposed cable, parallel and perpendicular to surfaces or exposed structural members, and follow surface contours where possible.
D. **Conductor Splices:** Keep to minimum.
   1. Install splices and tapes that possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.
   2. Use splice and tap connectors that are compatible with conductor material.

E. Connect outlets and components to wiring and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A.

F. Branch circuit wires in panels shall be neatly arranged with all surplus wire cut off and all wires tied with non-metallic ties. Metallic ties not permitted.

END OF SECTION
SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

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 Section 26 05 00 "Common Work Results for Electrical" apply to this Section.

1.2 SUMMARY
A. This Section includes solid grounding of electrical systems and equipment. It includes basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this Section may be supplemented in other sections of these Specifications.
B. Related Sections: The following sections contain requirements that relate to this Section:
   1. Section 26 05 19 "Low Voltage Electrical Power Conductors and Cables".

1.3 SUBMITTALS
A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
B. Submit Bill of Material List, as outlined in Section 26 05 00, Article 1.3, Submittals, identifying subcontractors (if any) and specific manufacturer/vendor’s product intended to be provided for the following items in this Section:
   1. Connectors.
   2. Grounding Fittings.

1.4 QUALITY ASSURANCE
A. Listing and Labeling: Provide products specified in this Section that are listed and labeled. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.
B. Electrical Component Standard: Components and installation shall comply with NFPA 70, "National Electrical Code" (NEC).
C. UL Standard: Comply with UL 467, "Grounding and Bonding Equipment".

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. A.B. Chance Co.
2. Burndy.
3. Erico Products, Inc.
4. Ideal Industries, Inc.
5. ILSCO.
6. O-Z/Gedney Co.
7. Raco, Inc.
8. Thomas & Betts Corp.

2.2 GROUNDING AND BONDING PRODUCTS

A. **Products**: Of types indicated and of sizes and ratings to comply with NEC. Where types, sizes, ratings, and quantities indicated are in excess of NEC requirements, the more stringent requirements and the greater size, rating, and quantity indications govern.

B. **Conductor Materials**: Copper.

2.3 WIRE AND CABLE CONDUCTORS

A. **General**: Comply with Section 26 05 19 "Low Voltage Electrical Power Conductors and Cables". Conform to NEC, Chapter 9, Table 8, except as otherwise indicated, for conductor properties, including stranding.

B. **Equipment Grounding Conductor**: Green insulated.

C. **Grounding Electrode Conductor**: Stranded cable.

D. **Bare Copper Conductors**: Conform to the following:
   1. **Solid Conductors**: ASTM B-3.
   2. **Assembly of Stranded Conductors**: ASTM B-8.
   3. **Tinned Conductors**: ASTM

2.4 MISCELLANEOUS CONDUCTORS

A. **Ground Bus**: Bare annealed copper bars of rectangular cross section.

2.5 CONNECTOR PRODUCTS

A. **General**: Listed and labeled as grounding connectors for the materials used.

B. **Pressure Connectors**: High-conductivity-plated units.

C. **Bolted Clamps**: Heavy-duty units listed for the application.

D. **Exothermic Welded Connections**: Provided in kit form and selected for the specific types, sizes, and combinations of conductors and other items to be connected.

PART 3 - EXECUTION

3.1 APPLICATION

A. **Equipment Grounding Conductor Application**: Comply with NEC Article 250 for sizes and quantities of equipment grounding conductors, except where larger sizes or more conductors are indicated.
1. Multiple conductors in a single lug are not permitted. Each grounding conductor shall terminate in its own terminal lug.

2. A green grounding conductor shall be provided with phase conductors in every conduit. This green wire ground conductor shall be used to provide ground continuity between equipment or device and the conduit-raceway system.

3. All grounding conductors shall be installed in conduit.

3.2 INSTALLATION

A. General: Ground electrical systems and equipment in accordance with NEC requirements except where the Drawings or Specifications exceed NEC requirements.

3.3 CONNECTIONS

A. General: Make connections in such a manner as to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to assure high conductivity and make contact points closer in order of galvanic series.

2. Make connections with clean bare metal at points of contact.

3. Coat and seal connections involving dissimilar metals with inert material such as red lead paint to prevent future penetration of moisture to contact surfaces.

B. Terminate insulated equipment grounding conductors for feeders and branch circuits with pressure-type grounding lugs. Where metallic raceways terminate at metallic housings without mechanical and electrical connection to the housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to the ground bus in the housing. Bond electrically noncontinuous conduits at both entrances and exits with grounding bushings and bare grounding conductors.

C. 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 torque tightening values specified in UL 486A and UL 486B.

D. Compression-Type Connections: Use hydraulic compression tools to provide the correct circumferential pressure for compression connectors. Use tools and dies recommended by the manufacturer of the connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on the ground conductor.

END OF SECTION
SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

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 Section 26 05 00 “Common Work Results for Electrical” apply to this section.

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 relate to this Section:
   1. Refer to other Division 26 sections for additional specific support requirements that may be applicable to specific items.

1.3 SUBMITTALS
A. None required.

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Slotted Metal Angle and U-Channel Systems:
      a. Allied Tube & Conduit.
      c. B-Line Systems, Inc.
      d. Unistrut Diversified Products.

   2. Conduit Sealing Bushings:
      a. Cooper Industries, Inc.
      c. O-Z/Gedney.
      d. Raco.
      e. Thomas & Betts Corp.

2.2 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.

2.3 **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.

3. **Powder-Driven Threaded Studs:** Heat-treated steel, designed specifically for the intended service.

C. **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.

D. **U-Channel Systems:** 16-gage 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.

2.4 **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.

C. **Pipe Sleeves:** Provide pipe sleeves of one of the following:

1. **Sheet Metal:** Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from the following gage metal for sleeve diameter noted:

   a. 3-inch and smaller: 20-gage.
   b. 4-inch to 6-inch: 16-gage.
   c. over 6-inch: 14-gage.

2. **Steel Pipe:** Fabricate from Schedule 40 galvanized steel pipe.

3. **Plastic Pipe:** Fabricate from Schedule 80 PVC plastic pipe.

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 1/4-inch-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.

6. Perforated hanger iron and tie wire are not acceptable.

7. Space supports for raceways in accordance with Table I of this section. Space supports for raceway types not covered by the above in accordance with NEC.

8. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support 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 or threadless box connectors.

9. 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. **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.

E. 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 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.

F. **Sleeves:** Install in concrete slabs and walls and all other fire-rated floors and walls 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 Resistant Joint Sealers" requirement of Division 7 Section "Joint Sealers".

G. **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, busways, 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 solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.

2. 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.

### 3.2 TABLE I: SPACING FOR RACEWAY SUPPORTS

<table>
<thead>
<tr>
<th>Raceway Size (Inches)</th>
<th>No. of Conductors in Run</th>
<th>Location</th>
<th>RMC &amp; IMC (1)</th>
<th>EMT (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2, 3/4</td>
<td>1 or 2</td>
<td>Flat ceiling or wall.</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>1/2, 3/4</td>
<td>1 or 2</td>
<td>Where it is difficult to provide supports except at intervals fixed by the building construction.</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>1/2, 3/4</td>
<td>3 or more</td>
<td>Any location.</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>1/2-1</td>
<td>3 or more</td>
<td>Any location.</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>1 &amp; larger</td>
<td>1 or 2</td>
<td>Flat ceiling or wall.</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>1 &amp; larger</td>
<td>1 or 2</td>
<td>Where it is difficult to provide supports except at intervals fixed by the building construction.</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>1 &amp; larger</td>
<td>3 or more</td>
<td>Any location.</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Any</td>
<td>....</td>
<td>Concealed.</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Raceway Size (Inches)</td>
<td>No. of Conductors in Run</td>
<td>Location</td>
<td>RMC &amp; IMC (1, 2)</td>
<td>EMT (1)</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------------------------</td>
<td>------------------</td>
<td>------------------</td>
<td>---------</td>
</tr>
<tr>
<td>1/2, 3/4</td>
<td>....</td>
<td>Exposed.</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>1, 1-1/4</td>
<td>....</td>
<td>Exposed.</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>1-1/2 &amp; larger</td>
<td>....</td>
<td>Exposed.</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Up to 2</td>
<td>....</td>
<td>Shaftway.</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>2-1/2</td>
<td>....</td>
<td>Shaftway.</td>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td>3 &amp; larger</td>
<td>....</td>
<td>Shaftway.</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Any</td>
<td>....</td>
<td>Concealed.</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

**NOTES:**

(1) Maximum spacing of supports (feet).

(2) Maximum spacings for IMC above apply to straight runs only. Otherwise the maximums for EMT apply.

**ABBREVIATIONS:**

- EMT  Electrical metallic tubing.
- IMC  Intermediate metallic conduit.
- RMC  Rigid metallic conduit.

**END OF SECTION**
SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Work Included:
1. Provide separate raceways and conduits of specified types for all electrical systems wiring, except where clearly shown or specified otherwise. All fittings, boxes, hangers and appurtenances shall be included.

2. Separate raceway system shall be dedicated to a specific system. Systems include, but are not limited to 480/277V. power, 208/120V. power, emergency power, controls, fire alarm, sound, automation and security. Any portions of this system damaged during construction shall be replaced by the Contractor at the expense of the Contractor responsible for the damage.

3. Size raceways and conduits as indicated on the Drawings. Where no size is indicated, conduit may be the minimum code permitted size for the quantity of type THW conductors installed but no less than 3/4".

B. Raceways Include the Following:
1. Electrical metallic tubing (EMT).
2. Flexible metal conduit.

C. Boxes, Enclosures, and Cabinets Include the Following:
1. Device boxes.
2. Outlet boxes.
3. Pull and junction boxes.
4. Cabinets and hinged cover enclosures.

D. Related Sections: The following Sections contain requirements that relate to this Section:
1. Division 07 Section "Firestopping".
2. Division 26 Section "Hangers and Supports for Electrical Systems" for raceway and box supports.

1.3 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.

B. Submit Bill of Material List per Section 01330 and as outlined in Section 26 05 00, identifying subcontractors (if any) and specific manufacturer/vendor's product intended to be provided for the following items in this Section:
1. Raceways.
2. Boxes.
1.4 QUALITY ASSURANCE

A. Comply with NFPA 70 "National Electrical Code" for components and installation.

B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
   
   1. The Terms "Listed and Labeled": As defined in the "National Electrical Code", Article 100.

C. Comply with NECA "Standard of Installation".

D. Coordinate layout and installation of raceway and boxes with other construction elements to ensure adequate headroom, working clearance, and access.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide Products by one of the following:

   1. Metal Conduit and Tubing:
      a. Allied Tube and Conduit, Grinnell Co.
      b. Anixter Brothers, Inc.
      c. Carol Cable Co., Inc.
      d. Triangle PWC, Inc.
      e. Wheatland Tube Co.

   2. Conduit Bodies and Fittings:
      a. Carlon.
      c. Scott Fetzer Company, Adalet-PLM.
      d. General Signal, O-Z/Gedney Unit.

   3. Boxes, Enclosures, and Cabinets:
      b. Cooper Industries, Midwest Electric.
      c. Erickson Electrical Equipment Co.
      d. Scott Fetzer Company, Adalet-PLM.
      e. General Signal, O-Z/Gedney.
      g. Hubbell Inc., Killark Electric Manufacturing Co.
      h. Raco, Inc., Hubbell Inc.
      i. Robroy Industries, Inc., Electrical Division.
      j. Square D Co.
      k. Thomas & Betts Corp.

2.2 METAL CONDUIT AND TUBING

A. Electrical Metallic Tubing and Fittings: ANSI C80.3 with compression-type fittings.

B. Flexible Metal Conduit: Zinc-coated steel.
C. Fittings: NEMA FB 1, compatible with conduit/tubing materials.

2.3 OUTLET AND DEVICE BOXES

A. Sheet Metal Boxes: NEMA OS 1.

B. Outlet boxes shall be of code required size to accommodate all wires, fittings and devices. Provide multi-gang boxes as required to accept devices installed with no more than one device per gang. Equip all metallic boxes with grounding provisions.

C. Flush wall switch and receptacle outlets used with conduit systems shall be 4 inches square, 1-1/2 inches or more deep, with one or two-gang plaster ring mounted vertically. Where three or more devices are at one location, use one piece multiple gang tile box or gang box with suitable device ring.

D. Wall bracket and ceiling surface mounted lighting fixture outlets shall be 4-inch octagon, 1-1/2 inches deep with 3/8-inch fixture stud where required. Wall bracket outlets to have single gang opening where required to accommodate fixture canopy. Provide larger boxes or extension rings where quantity of wires installed requires more cubic capacity.

E. Boxes for the special systems shall be suitable for the equipment installed. Coordinate size and type with the system supplier.

F. Boxes shall be flush with finished surfaces or not more than 1/8-inch below surface and be level and plumb. Long screws with spacers or shims for mounting devices will not be acceptable. No combustible material shall be exposed to wiring at outlets.

G. Conduit and boxes attached to building surfaces which may be damp shall be spaced out to avoid rust and/or corrosion using fittings approved for the use.

2.4 PULL AND JUNCTION BOXES

A. Small Sheet Metal Boxes: NEMA OS 1.

B. Provide pull boxes where shown or where required to limit the number of bends in any conduit to not more than three 90 degree bends or equivalent. Use galvanized boxes of code required size with removable covers installed so that covers will be accessible after work is completed.

C. Code gauge steel with galvanized or sheradized finish with covers secured by galvanized machine screws. Boxes shall be large enough so that code required minimum cable bending radii can be rolled and constructed. Knock out punches shall be used for required holes.

2.5 FITTINGS

A. EMT Conduit: Provide galvanized all steel (not cast) conduit fittings for metallic conduit. Provide 2-inch and smaller, rain and concrete-tight compression gland type fittings and insulated throat.

B. Set Screw Fittings: Indentation type, set-screw type and push-on type fittings are NOT acceptable.

C. Die-Cast Fittings: Fittings with die-cast bodies, wholly or partially, are NOT acceptable.

D. Flexible Metal Conduit: Connectors for use with flexible metal conduit shall be all steel, threaded type.
E. Expansion Fittings: O.Z./Gedney Type DX conduit expansion deflection fittings are required in all conduit runs where movement perpendicular to the axis of the conduit may be encountered. Provide O.Z./Gedney Types TX or AX conduit expansion fittings complete with bonding jumpers in all conduit runs at the following locations.

1. Conduit runs which cross an expansion joint in the structure.
2. Conduit runs mechanically attached to two separate structures.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of the raceway system. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Indoors: Use the following wiring methods:

1. **Exposed**: Electrical metallic tubing in trade sizes up through 4”.
2. **Concealed**: Electrical metallic tubing in trade sizes up through 4 Electrical metallic tubing for all branch circuits containing an isolated grounding conductor.
3. **Boxes and Enclosures**: NEMA Type 1, except in damp or wet locations use NEMA Type 4, stainless steel.

3.2 INSTALLATION

A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions.

B. Conceal conduit and EMT, unless otherwise indicated, within finished walls, ceilings, and floors.

C. Run conduits concealed to avoid adverse conditions such as heat and moisture, to permit drainage, and to avoid all materials and equipment of other trades.

D. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot water pipes. Install horizontal raceway runs above water and steam piping.

E. Install raceways level and square and at proper elevations. Provide adequate headroom. Run raceways parallel or perpendicular to construction, not at diagonals across it.

F. Do not route exposed conduits over boilers or other high temperature machinery nor in contact with such equipment. Exposed conduits to be offset at boxes.

G. Complete raceway installation before starting conductor installation.

H. Support raceway as specified in Division 26 Section "Hangers and Supports for Electrical Systems".

I. Suspended ceiling systems shall not be considered as structural parts of the construction for conduit support. Conduit, conduit systems or boxes shall not be supported or secured by
wire, but shall be supported by devices manufactured specifically for this purpose. Plastic tie-wrap is not permitted.

J. Conduits supported on channel systems shall be secured on each channel with appropriate clamps.

K. Use temporary closures to prevent foreign matter from entering raceway.

L. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends is not visible above the finished slab.

M. Make bends and offsets so the inside diameter is not 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 compatible with raceway and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, except as otherwise indicated.

O. Provide conduit expansion and deflection fittings in all conduit runs imbedded in or penetrating concrete where movement perpendicular to the axis of the conduit may be encountered. Provide conduit expansion fittings complete with bonding jumpers in all such rigid steel heavy wall conduit runs which cross an expansion joint in the structure and conduit runs mechanically attached to two separate structures. An alternate flexible connection made up of a full size 24-inch length of flexible metal conduit and couplings may be used where EMT runs across expansion joints in ceiling spaces. On work exposed to the weather or in damp locations, fittings shall be made weatherproof.

P. 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.

Q. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much as practical.
1. Run parallel or banked raceways together, on common supports where practical.
2. Make bends in parallel or banked runs from same center line to make bends parallel. Use factory elbows only where they can be installed parallel; otherwise, provide field bends for parallel raceways.

R. Join raceways with fittings designed and approved for the purpose and make joints tight.
1. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
2. Use insulating bushings to protect conductors.
3. Die cast fittings are not permissible.
4. Set-screw, indentation, or push-on type fittings are not permissible.
5. All conduit joints shall be cut square, reamed smooth with all fittings drawn up tight.

S. 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 the box.
T. 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.

U. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb (90 kg) tensile strength. Leave not less than 12 inches (300 mm) of slack at each end of the pull wire.

V. Install raceway sealing fittings according to 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 enter or leave hazardous locations.
   2. Where conduits pass from warm locations to cold locations, such as the boundaries of refrigerated spaces and air-conditioned spaces.
   3. Where otherwise required by the NEC.

W. Flexible Connections: Use maximum of 6 feet (1830 mm) of flexible conduit for recessed and semirecessed lighting fixtures. Use maximum of 4 feet of liquidtight flexible metal conduit for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquidtight flexible conduit in wet or damp locations. Install separate ground conductor across all flexible connections.

X. Install hinged cover enclosures and cabinets plumb. Support at each corner.

Y. Provide grounding connections for raceway, boxes, and components as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A.

Z. No box shall be installed where it is not easily accessible or where its usefulness will be impaired by other equipment. Easily accessible means covers can be seen and removed with a standard 8" screwdriver, the box interior can be viewed from a normal standing position on the floor, a ladder or a lift, and all contents can be easily reached with both hands simultaneously.

**3.3 PROTECTION**

A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, to ensure that coatings, finishes, and cabinets are without damage or deterioration at Substantial Completion.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to paint finishes with matching touch-up coating recommended by the manufacturer.
3.4 CLEANING
A. Upon completion of installation of system, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

END OF SECTION
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 Section 26 05 00 “Common Work Results for Electrical” apply to this section.

1.2 SUMMARY

A. Clearly and properly identify the complete electrical system to indicate the loads served or the function of each item of equipment connected under this work.

B. 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. Identification labeling for raceways, cables, and conductors.
2. Operational instruction signs.
3. Warning and caution signs.
4. Equipment labels and signs.
5. Identification of main and feeder protective devices in switchgear.

C. Related Sections: The following Sections contain requirements that relate to this Section:

1. Section 26 05 19 "Low Voltage Electrical Power Conductors and Cables" for requirements for color coding of conductors for phase identification.

D. Refer to other Division 26 sections for additional specific electrical identification associated with specific items.

1.3 QUALITY ASSURANCE

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

B. Submit identification to the Architect/Engineer for approval. The Architect/Engineer reserves the right to modify identifications prior to shop drawing approval.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. American Labelmark Co.
2. Calpico, Inc.
3. Cole-Flex Corp.
4. Emed Co., Inc.
5. George-Ingraham Corp.
6. Ideal Industries, Inc.
8. LEM Products, Inc.
9. Markal Corp.
11. Panduit Corp.
12. Radar Engineers Div., EPIC Corp.
13. Seton Name Plate Co.
15. W. H. Brady Co.

2.2 ELECTRICAL IDENTIFICATION PRODUCTS

A. Engraved, Plastic-Laminated Labels, Signs, and Instruction Plates: Engraving stock melamine plastic laminate, 1/16-inch minimum thick for signs up to 20 square inches, or 8 inches in length; 1/8-inch thick for larger sizes. Engraved legend in white letters on black face and punched for mechanical fasteners.

B. 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.

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.

D. Identify Junction, Pull, and Connection Boxes as Follows:

1. Junction boxes 6" x 6" and smaller shall be identified by permanent marking on the cover plate indicating originating panelboard and circuit.

2. Identification of junction boxes and conductors shall include panelboard, switchboard or motor control center circuit number, phase, control circuit number or other appropriate number or letter that will expedite future tracing and trouble shooting.

3. After painting is completed, identify all equipment as hereinafter indicated. Locate identification as conspicuously as possible except where such would distract from the finished area.
E. **Conductor Color Coding:** Provide color coding for secondary service, feeder, and branch circuit conductors throughout the project secondary electrical system as follows:

<table>
<thead>
<tr>
<th>Volts</th>
<th>Phase</th>
<th>Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>208/120</td>
<td>A</td>
<td>480/277</td>
</tr>
<tr>
<td>Black</td>
<td>Brown</td>
<td>Black</td>
</tr>
<tr>
<td>Red</td>
<td>Orange</td>
<td>Red</td>
</tr>
<tr>
<td>Blue</td>
<td>Yellow</td>
<td>Blue</td>
</tr>
<tr>
<td>White</td>
<td>Neutral</td>
<td>White</td>
</tr>
<tr>
<td>Green</td>
<td>Ground</td>
<td>Green</td>
</tr>
<tr>
<td>Green with Yellow Stripes</td>
<td>Isolated Ground</td>
<td>Green with Yellow Stripes</td>
</tr>
</tbody>
</table>

F. 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 tape 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. Circuit switch legs shall remain the same color as the circuit phase and be identified with such adhesive markers.

G. **Tag or Label Conductors as Follows:**

1. **Future Connections:** Conductors indicated to be for future connection or connection under another contract with identification indicating source and circuit numbers.

2. **Multiple Circuits:** Where multiple branch circuits or control wiring or communications/signal conductors are present in the same box or enclosure (except for three-circuit, four-wire home runs), label each conductor or cable. Provide legend 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.

3. Match identification markings with designations used in panelboards shop drawings, Contract Documents, and similar previously established identification schemes for the facility's electrical installations.

4. Identify each conductor of all systems at each panel, termination or splice in junction, or pull box and at each outlet with permanently attached sleeve type; Brady Pro-Line; wrap around adhesive markers as manufactured by Brady Company, or Panduit.

5. Wire colors and ID number shall remain continuous through their entire length. Dissimilar wire colors or number shall not be spliced.

6. All branch circuit identification shall correspond to the number of the branch circuit breaker serving it. At no time shall the branch circuit number differ from the circuit breaker number and at no time shall the phase color differ.
H. **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.

I. For panelboards, new and existing, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker. All twin panelboards shall have circuits numbered consecutively, not duplicated.

J. Identify receptacle coverplates (on front side) with adhesive label, such as Brady Pro-Line, addressing circuit number and panel.

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

L. 4-inch round, 4-inch square and 4-11/16-inch junction boxes concealed above ceilings may be identified with neat lettering on the cover with a permanent type black marking pen.

### 3.2 EXISTING EQUIPMENT

A. Provide new labels or nameplates for existing switchgear and panels in accordance with panel descriptions shown on the Drawings and where non-existent, incorrect or confusing.

B. Equip existing branch circuit panelboards scheduled to remain with new, accurate circuit directories in existing panels where circuiting changes are made.

END OF SECTION
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 this Section.
B. Requirements of Section 26 05 00 “Common Work Results for Electrical” apply to this Section.

1.2 SUMMARY
A. This Section includes lighting and power panelboards and associated auxiliary equipment rated 600 V. or less.

1.3 DEFINITIONS
A. Overcurrent Protective Device (OCPD): A device operative on excessive current that causes and maintains the interruption of power in the circuit it protects.

1.4 SUBMITTALS
A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
B. Submit Bill of Material List per Section 01330 and as outlined in Section 26 05 00 Submittals, identifying subcontractors (if any) and specific manufacturer/vendor’s product intended to be provided for the following items in this Section:
   1. Panelboards.
C. Shop drawings from manufacturers of panelboards including dimensioned plans, sections, and elevations. Show tabulations of installed devices, major features, and voltage rating. Include the following:
   1. Enclosure type with details for types other than NEMA Type 1.
   2. Bus configuration and current ratings.
   4. Features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components.
D. Maintenance data for panelboard components, for inclusion in Operating and Maintenance Manual specified in Division 1 and in Section 26 05 00 "Common Work Results for Electrical”. Include instructions for testing circuit breakers.

1.5 QUALITY ASSURANCE
A. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
1. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.

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

C. **NEMA Standard:** Comply with NEMA PB1, "Panelboards".

D. **UL Standards:** Comply with UL 61, "Panelboards", and UL 50, "Cabinets and Boxes".

1.6 **EXTRA MATERIALS**

A. **Keys:** Furnish six spares of each type for panelboard cabinet locks.

B. **Remote Controlled Breakers:** Provide 20% spare.

## PART 2 - PRODUCTS

2.1 **MANUFACTURERS**

A. **Manufacturers:** Subject to compliance with requirements, provide products by the following:

   (Square D used for sizing.) All panelboards shall be by one manufacturer.

   1. ABB Power Distribution Inc.
   5. Square D Co.

2.2 **PANELBOARDS, GENERAL REQUIREMENTS**

A. **Overcurrent Protective Devices (OCPDs):** Provide type, rating, and features as indicated. Comply with Division 26 Section "Enclosed Switches and Circuit Breakers", with OCPDs adapted to panelboard installation. Tandem circuit breakers shall not be used. Multipole breakers shall have common trip.

B. **Enclosures:** Cabinets, flush or surface mounted as indicated. NEMA Type 1 enclosure, except where the following enclosure requirements are indicated.

   1. NEMA 3R: Raintight.

C. **Front:** Hinged trimmed, secured to box with concealed trim clamps except as indicated. Front for surface-mounted panels shall be same dimensions as box. Fronts for flush panels shall overlap box except as otherwise specified. Fronts shall have padlock hasps installed.

D. **Directory Frame:** A typewritten circuit schedule shall be installed in a metal frame covered with plastic inside the panel cover door.

E. **Bus:** Hard drawn copper of 98 percent conductivity.

F. **Main and Neutral Lugs:** Mechanical type.

G. **Equipment Ground Bus:** Adequate for feeder and branch-circuit equipment ground conductors. Bonded to box.
H. **Provision for Future Devices:** Equip with mounting brackets, bus connections, and necessary appurtenances, for the OCPD ampere ratings indicated for future installation of devices.

I. **Special Features:** Provide the following features for panelboards as indicated.

   1. **Isolated Equipment Ground Bus:** Adequate for branch-circuit equipment ground conductors; insulated from box.

   2. **Extra Gutter Space:** Dimensions and arrangement as indicated.

   3. **Gutter Barrier:** Arranged to isolate section of gutter as indicated.

   4. **Auxiliary Gutter:** Conform to UL 870, "Wireways, Auxiliary Gutters and Associated Fittings".

   5. **Subfeed:** OCPD or lug provision as indicated.

J. **Feed-Through Lugs:** Sized to accommodate feeders indicated.

K. **Width:** Panels to be minimum of 20" wide.

### 2.3 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. **Branch OCPDs:** Bolt-on circuit breakers, replaceable without disturbing adjacent units.

B. **Double-Width Panels:** Where more than 42 poles are indicated or where otherwise indicated, provide two panelboards with separate trims. Flush cabinets adjacent to one another shall be identical in size. Dual panels shall include subfeed lugs and neutral bus in each panel section.

C. **Doors:** In panel front, with concealed hinges. Secure with flush catch and tumbler lock, all keyed alike.

### 2.4 DISTRIBUTION PANELBOARDS

A. **Doors:** In panel front, omit single panelboard door in cabinet front for fusible switch panelboards except as indicated. Secure with vault-type with tumbler lock, all keyed alike.

B. **Branch-Circuit Breakers:** Where OCPDs are indicated to be circuit breakers, use bolt-on breakers except circuit breakers 225-ampere frame size and greater may be plug-in type where individual positive locking device requires mechanical release for removal.

C. Circuit breakers shall be equipped with individually insulated, braced and protected connectors. The front faces of all circuit breakers shall be flush with each other. Large, permanent, individual circuit numbers shall be affixed to each breaker in a uniform position. Tripped indication shall be clearly shown by the breaker handle taking a position between "ON" and "OFF". Provisions for additional breakers shall be such that no additional connectors will be required to add breakers.

D. Each panelboard as a complete unit shall have a short circuit current rating equal to or greater than the integrated equipment rating shown on the panelboard schedule or on the plans. Panelboards shall be marked with their maximum short circuit current rating at the supply voltage and shall be UL listed.

E. Panelboard interior assembly shall be dead front with panelboard front removed. Main lugs or main breakers shall have barriers on five sides. Barrier in front of main lugs shall be
hinged to a fixed part of the interior. The end of bus structure opposite mains shall have barriers.

2.5 IDENTIFICATION

A. **General:** Refer to Division 26 Section "Identification for Electrical Systems" for labeling materials.

B. **Panelboard Nameplates:** Engraved laminated plastic or metal nameplate for each panelboard mounted with self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers. Nameplates shall identify panel name, voltage and source of power.

PART 3 - EXECUTION

3.1 INSTALLATION

A. **General:** Install panelboards and accessory items in accordance with NEMA PB 1.1, "General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less" and manufacturers' written installation instructions.

B. When installing bolt-in circuit breakers, care must be exercised to avoid cross-threading.
   1. Do not use power screwdrivers.
   2. Start all bolts on multi-pole circuit breakers before tightening.
   3. Tighten bolt with torque wrench to manufacturer’s recommended torque.
   4. If cross-threading occurs, replace bus finger; do not retap.

C. Install panelboards so that no cracks or gaps exist between breakers, breaker cover, panelboard cover and wall (where flush).

D. All wires shall be neatly installed inside the panelboard box.

E. Provide space for minimum 25% future capacity in all panels.

F. Circuits in twin panelboards shall be numbered consecutively, not duplicated.

G. **Ground Fault Protection:** Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289, "Application Guide for Ground Fault Circuit Interrupters".

H. **Mounting Heights:** Top of trim 6'-2" above finished floor, except as indicated.

I. **Mounting:** Plumb and rigid without distortion of box. Mount flush panels uniformly flush with wall finish.

J. **Circuit Directory:** Typed and reflective of final circuit changes required to balance panel loads. Obtain approval before installing.

K. Install filler plates in unused spaces.
L. **Provision for Future Circuits at Flush Panelboards:** Stub four 1-inch empty conduits from panel into accessible ceiling space or space designated to be ceiling space in future. Stub four 1-inch empty conduits into raised floor space or below slab other than slabs on grade.

M. **Auxiliary Gutter:** Install where a panel is tapped to a riser at an intermediate location.

N. **Wiring in Panel Gutters:** Train conductors neatly in groups, bundle, and wrap with wire ties after completion of load balancing.

### 3.2 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs in accordance with Division 26 Section "Identification for Electrical Systems".

### 3.3 GROUNDING

A. **Connections:** Make equipment grounding connections for panelboards as indicated.

B. Provide ground continuity to main electrical ground bus indicated.

### 3.4 CONNECTIONS

A. Tighten electrical connectors and terminals, including grounding connections, in accordance with manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. **Visual and Mechanical Inspection:** Include the following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.

2. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.

3. Check panelboard mounting, area clearances, and alignment and fit of components.

4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.

5. Perform visual and mechanical inspection and related work for overcurrent protective devices as specified in Division 26 Sections "Fuses" and "Enclosed Switches and Circuit Breakers".

C. **Electrical Tests:** Include the following items performed in accordance with manufacturer's instruction:

1. Insulation resistance test of buses and portions of control wiring that disconnected from solid-state devices. Insulation resistance less than 100 megohms is not acceptable.

2. Ground resistance test on system and equipment ground connections.

3. Test main and subfeed overcurrent protective devices in accordance with Section "Enclosed Switches and Circuit Breakers".

D. **Retest:** Correct deficiencies identified by tests and observations and provide retesting of panelboards by testing organization. Verify by the system tests that the total assembly meets specified requirements.
3.5 CLEANING

A. Upon completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

3.6 COMMISSIONING

A. Balancing Loads: After Substantial Completion, but not more than two months after Final Acceptance, conduct load-balancing measurements and circuit changes as follows:

1. Perform measurements during period of normal working load as advised by the Owner.

2. Perform load-balancing circuit changes outside the normal occupancy/working schedule of the facility. Make special arrangements with Owner to avoid disrupting critical 24-hour services such as FAX machines and on-line data processing, computing, transmitting, and receiving equipment.

3. Recheck loads after circuit changes during normal load period. Record all load readings before and after changes and submit test records.

4. Tolerance: Difference between phase loads exceeding 20 percent at any one panelboard is not acceptable. Rebalance and recheck as required to meet this minimum requirement.

END OF SECTION
SECTION 26 26 53

UNINTERRUPTABLE POWER SUPPLY POWER DISTRIBUTION UNIT

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 section 26 05 00 “Common Work results for Electrical” apply to this section.

1.2 SUMMARY

A. These specifications describe requirements for a complete power conditioning and distribution system, supplying computer-grade power to sensitive loads. The specified system shall provide isolation*, distribution, control and monitoring of AC power. It shall include all equipment to properly interface the AC power source to the intended load.

1.3 STANDARDS

A. The specified system shall be designed, manufactured, tested and installed in compliance with:
   • American National Standards Institute (ANSI)
   • Canadian Standards Association (CSA)
   • Department of Energy (DOE)
   • Federal Information Processing Standards Publication 94 (FIPS Pub 94)
   • Institute of Electrical and Electronics Engineers (IEEE)
   • ISO 9001
   • National Electrical Code (NEC - NFPA 70)
   • National Electrical Manufacturers Association (NEMA)
   • National Fire Protection Association (NFPA 75)
   • Underwriters Laboratories (UL)

B. The system shall be UL listed as a complete system under UL 60950 Standard for Information Technology Equipment (UL listing applies to 60 Hz units only). 50 Hz units shall comply with EN and the European Low Voltage Directive and be CE marked.

C. The specified system shall comply with latest FCC Part 15 EMI emission limits for Class A computing devices and the emission and immunity limits of EN50081-2/EN550022 Class A and EN50082-2.

D. The system shall safely withstand without misoperation or damage:
   • Transient voltage surges on the AC power input as defined by ANSI/IEEE C62.41 for Category B3 locations (high surge exposure industrial and commercial facilities),
   • Electrostatic discharges (ESD) up to 10 kV at any point on the exterior of the unit and
   • Electromagnetic fields from portable transmitters within 3 ft. (1m) of the unit.

1.4 SYSTEM DESCRIPTION      MODEL NO. PPA075C231A

A. Electrical Requirements
   a. Output capacity shall be 75 kVA.
   b. Input voltage shall be 480 volts AC, 60 Hz, three-phase, three wire-plus-ground.
   c. Output voltage shall be 120/208 volts AC, three-phase, four-wire-plus-ground, wye configuration.
B. Environmental Requirements
   a. Storage temperature range: -67 to +185°F (-55 to +85°C).
   b. Operating temperature range: +32 to 104°F (0 to 40°C).
   c. Relative humidity: 0% to 95% without condensing.
   d. Operating altitude: Up to 6,600 ft. (2,000m) above Mean Sea Level. Derated for higher altitude applications.
   e. Storage/transport: Up to 40,000 ft. (12,200m) above Mean Sea Level.
   f. Audible noise level: Under normal operation noise level shall not exceed the NEMA ST-20 standard for transformers.

1.5 DOCUMENTATION
   A. Equipment Manual
      a. The manufacturer shall furnish an installation manual with installation, startup, operation and maintenance instructions for the specified system.
   B. Drawings
      a. Wiring diagrams and drawings of major components shall be furnished.
   C. Spare Parts
      a. A list of recommended spare parts shall be supplied at the customer’s request.
   D. User’s List
      a. An in-service user’s list shall be furnished upon request.

1.6 WARRANTY
   A. The manufacturer shall provide a one-year warranty against defects in material and workmanship for 12 months after initial startup or 18 months after ship date, whichever occurs first. Refer to the Warranty Statement for details.

1.7 QUALITY ASSURANCE
   A. The specified system shall be factory-tested before shipment. Testing shall include, but shall not be limited to: Quality Control Checks, “Hi-Pot” Test (two times rated voltage plus 1000 volts, per UL requirements) and Metering Calibration Tests. The system shall be designed and manufactured according to world class quality standards. The manufacturer shall be ISO 9001 certified.

PART 2 - PRODUCT

2.1 COMPONENTS
   A. Frame Construction and Enclosure
      a. The frame shall be constructed of welded steel to provide a strong substructure. The enclosure shall be mounted on four (4) heavy-duty swivel casters for portability and ease of installation and shall be provided with four permanent leveling jacks for final installation. (The top entry/exit unit shall have a solid top and side vents with provisions for entrance and exit of all input and output cabling through the top of the unit.) (The bottom entry/exit unit shall have a screen top with provisions for entrance and exit of all input and output cabling through the bottom of the unit.) The unit shall have easily removable and interchangeable output cable trays for each panelboard to allow matching of the size and number of cable/conduit openings to the site requirements. A minimum of 72 cable/conduit openings shall be provided for each output panelboard. All service shall be capable of being performed with access to the front plus a choice of any one side or rear for installation flexibility. Retrofitting additional power distribution cables shall require access to the front of the unit only. A tool shall be required to remove the exterior panels,
which access the hazardous voltage area of the unit. To ensure grounding integrity and for static protection and EMI/RFI shielding, the removable exterior panels shall be grounded to the frame by way of stranded copper wire. Hinged double front doors shall provide access to the main input circuit breaker and to all output circuit breakers. The color of the exterior panels shall be manufacturer’s standard color, black gray matte. Optional custom-painting to match or accent the Data Processing equipment shall be available.

b. The unit shall be naturally convection-cooled. No fans for forced-air cooling system shall be used. The convection cooling method shall allow continuous full-load operation without activation of over-temperature circuits. Heat rejection shall be through a screened protective (top on bottom entry/exit) (bottom and top vents on the rear and each side panel on top entry/exit) units, which prohibits entry of foreign material.

c. The frame shall be configured to accept future field installation of additional bolt-on distribution sections containing additional panelboard and cable tray capacity.

d. The complete system dimensions shall be a maximum of 32in. wide by 77in. high by 32in. deep. The distributed floor weight shall be less than 250 lb./ft² (1225kg/sq²).

B. Main Input Circuit Breaker

a. The specified unit shall be equipped with a main input circuit breaker to provide overcurrent protection and a means for disconnecting all power to the unit. The main input circuit breaker shall be a three-pole molded case circuit breaker sized for 125% of the specified full load input current and rated for 600 VAC. The minimum UL-listed interrupting rating for the main input circuit breaker shall be 35,000 75 kVA RMS symmetrical amperes at 480 volts AC. The main input circuit breaker shall include a 24 VDC shunt trip mechanism to interface with unit controls, EPO buttons and other remote controls as required by the NEC and local codes.

C. Isolation Transformer

a. The unit shall contain an electrostatically shielded TP-1 listed isolation transformer with a rating as described in Section 1.3. The transformer shall be a dry-type, double-shielded, three-phase, common-core, convection air-cooled transformer. The transformer shall conform to UL1561, with 302°F (150°C) maximum temperature rise. All transformer windings shall be copper. The transformer shall be energy efficient and shall meet DOE standard TP-1 2016. The transformer shall exhibit the following characteristics: percent impedance, 3.3 to 5.3%; common mode noise attenuation, 120 dB; harmonic voltage distortion, 0.5% maximum additive; full-load efficiency, 96.4 (15kva) to 98.15% (225kva).

b. The isolation transformer shall be provided with six full-capacity compensation taps at 2-1/2% increments to accommodate field adjustment to match the source voltage. These compensation taps shall be easily accessible by removal of one exterior panel. Tap changes include: two above nominal voltage (upper range limit of +5%), nominal voltage and four below nominal voltage (lower range limit of -10%).

c. The unit shall be provided with additional thermal overload protection for the transformer. An alarm shall notify personnel if the transformer temperature reaches 356°F (180°C). The unit shall automatically shut down if the transformer temperature reaches 392°F (200°C). Temperature sensors shall be located in each coil of the three-phase windings.

D. Manual Restart

a. The specified unit shall be equipped with a manual restart feature to allow for an orderly supervised startup after power failure. The control circuit shall automatically energize the shunt trip mechanism of the main input breaker upon sensing output voltage failure. A field-selectable auto-restart mode shall be provided to deactivate the manual restart if desired.

E. Emergency Power Off (EPO)

a. The local EPO shall include a covered “Emergency Power Off” push button. Pressing the EPO switch shall immediately shut down the unit by activating the shunt trip of the main
input circuit breaker. As part of the EPO circuit, an interface shall also be provided for connecting one or more normally open or normally closed remote EPO switches to the EPO circuit. For flexibility in meeting shutdown control schemes, the local EPO (unit shutdown) circuit shall be isolated from the remote EPO (room shutdown) circuit. The remote EPO circuit shall be designed to allow direct connection of multiple units with single and multiple shutdown control contacts.

F. Computer Grade Ground
   a. The specified system shall include a computer-grade, single-point ground in accordance with computer manufacturers’ recommendations, IEEE Std. 1100 and the requirements of the NEC. The transformer output neutral shall be solidly grounded in accordance with NEC Article 250-26. Grounding conductors shall be sized in accordance with IEC 364-HD-384 and applicable national and local codes.

G. Output Distribution Panelboards
   a. The specified system shall contain one vertically mounted output Square D bolt/plug-in panelboard for distribution to the intended loads. Each output distribution panelboard shall be individually protected by a main panelboard circuit breaker. Each panelboard shall be totally enclosed with a hinged accent panel that provides access to that panelboard. The panelboard shall have a rating of 400 amperes Square D, with an interrupting rating of 22kA RMS at 240/120 VAC. Each panelboard shall provide a total of 72 Square D single-pole branch circuit breaker positions. Each panelboard shall include separate isolated neutral and safety-ground busbars for the neutral and safety-ground connections to match the number of output circuits. The neutral busbar and wiring shall be sized for at least 1.73 times the panelboard’s full load rating.

2.2 POWER MONITORING SYSTEM

The specified PPC™ shall be equipped with a microprocessor-based power monitor panel. The monitor panel shall gather and process information from electrical and environmental sensors, relays and switches both internal and external to the unit. The monitored parameters and alarms shall be displayed on the unit monitor panel and shall also be available for communication to a Liebert® centralized monitoring system using a two-wire, twisted-pair, low-voltage signal circuit for reliable communication up to 3,280 ft. (1000m). Additionally, the monitor panel shall be equipped with a DB-9 setup port for adjusting parameters and performing diagnostics. Three Liebert IntelliSlot® ports shall be provided to allow communication to remote monitoring systems using Liebert IntelliSlot cards.

A. Monitored Parameters
   a. The monitoring system shall monitor and display all of the following parameters:
      o Input Voltage, Line-to-Line for all three phases
      o Output Voltages, Line-to-Line for all three phases
      o Output Voltages, Line-to-Neutral for all three phases
      o Output Voltage Total Harmonic Distortion (THD) for all three phases
      o Output Current for all three phases
      o Output Current Total Harmonic Distortion (THD) all three phases
      o Output Current Crest Factor (Peak/RMS) for all three phases
      o Output Current Harmonic K-Factor for all three phases
      o Output Neutral Current
      o System Ground Current
      o Output Frequency
      o Output kVA
      o Output kW
      o Output Power Factor
      o Output kW-Hours
      o Percent Load
b. All three phases of the three-phase parameters shall be displayed simultaneously. All voltage and current parameters shall be monitored using true RMS measurements for accurate representation of non-sinusoidal waveforms typical of computers and other sensitive loads.

B. Alarm Annunciation

a. The monitoring system shall detect and annunciate by audible alarm and alarm message the following conditions:
   - Output Overvoltage
   - Output Undervoltage
   - Output Overcurrent
   - Neutral Overcurrent
   - Ground Overcurrent
   - Output Voltage Distortion
   - Frequency Deviation
   - Phase Sequence Error
   - Phase Loss
   - Transformer Overtemp

b. All alarm thresholds for monitored parameters shall be adjustable by way of the DB-9 setup port to match site requirements. The factory setpoints for the alarms shall be:
   - Output Overvoltage - voltage exceeds +6% of nominal
   - Output Undervoltage - voltage falls below -13% of nominal
   - Output Overcurrent - current exceeds 95% of full load amps
   - Neutral Overcurrent - current exceeds 95% of full load amps
   - Ground Overcurrent - current exceeds 5 amps (15-125kVA), 10 amps (150-225kVA)
   - Output Voltage Distortion - output voltage THD exceeds 10%
   - Frequency Deviation - output frequency exceeds ±0.5Hz of nominal

c. To facilitate troubleshooting, all alarms shall be stored in battery-backed (non-volatile) memory until reset to protect against erasure by a power outage. Alarms shall be able to be manually reset after the alarm condition has been corrected either at the unit or with the central monitoring system.

C. Custom Alarm Annunciation

The monitoring system shall be capable of providing alarm annunciation for up to five contact closures (four N.O. and one N.C.). A custom alarm message up to 20 characters shall be provided for each contact. Alarm messages shall be programmable by way of the DB-9 setup port to match site requirements.

D. Summary Alarm Contact

A Form C (one N.O. and one N.C.) Summary Alarm Contact shall be provided for remote alarm status. The contacts shall change state upon occurrence of any alarm and shall rest upon alarm silence.

E. Display

All monitored parameters and alarm messages shall be displayed on a monochrome Liquid Crystal Display (LCD) with oval bezel that includes a covered Emergency Power Off (EPO) switch, power and alarm LED’s, an audible alarm and an alarm silence/reset push button. The display shall be mounted on the front door, the display and switches shall be accessible without opening the door.

The Alarm Silence switch shall be used to silence the audible alarm and reset inactive alarms.
2.3 ACCESSORIES PROVIDED

A. Liebert IntelliSlot IS-UNITY-DP Card
   The Liebert PPC shall be supplied with an IS-UNITY-DP Card for remote communication using two of the following protocols: HTTP/HTTPS, Emerson Protocol, Email, SMS, SNMP v1/v2c/v3, BACnet IP/MSTP and Modbus TCP/RTU output. A serial RS-485 two wire connector shall be supplied. Note: Two of the 3rd party protocols (SNMP, Modbus or BACnet) may be configured and used simultaneously. Modbus RTU and BACnet MSTP cannot both be enabled simultaneously.

PART 3 - EXECUTION

Factory startup, preventive maintenance and full service for the specified system shall be available and included upon request. The manufacturer shall directly employ a nationwide service organization of factory-trained field service personnel dedicated to the startup, maintenance and repair of the manufacturer’s power equipment. The manufacturer shall maintain a national dispatch center 24 hours per day, 365 days per year to minimize service response time and to maximize availability of qualified service personnel.

END OF SECTION
SECTION 26 33 63
UNINTERRUPTABLE POWER SUPPLY

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 section 26 05 00 “Common Work Results for Electrical” apply to this section.

1.2 SUMMARY
A. These specifications describe requirements for an Uninterruptible Power System (UPS) optimized for maximum efficiency. The UPS shall automatically maintain AC power to the critical load within specified tolerances and without interruption during failure or deterioration of the normal power source.
B. The manufacturer shall design and furnish all materials and equipment to be fully compatible with electrical, environmental and space conditions at the site. The UPS shall include all equipment to properly interface the AC power source to the intended load and shall be designed for unattended operation.

1.3 STANDARDS
A. The UPS and all associated equipment and components shall be manufactured in accordance with the following applicable standards:
   a) The UPS shall be UL listed per UL Standard 1778, Fourth edition, Uninterruptible Power Supplies, and shall be CSA Certified.
   b) The UPS shall be provided with a Short Circuit Withstand Rating (SCWR) label denoting the maximum source fault short circuit current that is applicable to the unit. The withstand rating shall be independently verified by a nationally recognized, third-party lab.
   c) The UPS shall withstand input surges to both the rectifier and bypass when configured as a dual-input unit without damage as per the criteria in EN62040-2 (4kV). The manufacturer shall provide evidence of compliance upon request.
   d) The UPS shall comply with FCC Rules and Regulations, Part 15, Subclass B, Class A. This compliance is legally required to prevent interference with adjacent equipment. The UPS shall have a label stating FCC compliance. The manufacturer shall provide evidence and test data of compliance upon request.
   e) The UPS shall be compatible with the wiring practices, materials and coding in accordance with the requirements of the National Electrical Code, OSHA and applicable local codes and standards. Provisions shall be made in the cabinets to permit installation of input, output and external control cabling using raceway or conduit for top and bottom access to input, output, bypass and DC connections. Connection cabinets shall provide for wiring gutter and wire bend radius as defined by the NEC and UL.

1.4 SYSTEM DESCRIPTION
A. Design Requirements Model No. 51SA100BAAO Liebert EXM
   a) The UPS shall be sized to provide a minimum of ___50___kW output Initially (unity load power factor rating)
   b) The UPS output capacity shall have the option to enable scalability at the time of ordering and shall be upgradeable by Vertiv Services.
   c) 100kVA frame – Scalable from 50kVA to 100kVA (50kVA hardware increments)
d) The UPS shall be able to supply all required power to full rated output kVA loads with power factor from 0.5 lagging to unity. The UPS shall also work from unity power factor to 0.5 leading power factors subject to derating.

e) Load voltage and bypass line voltage shall be 480VAC, three-phase, three-wire plus ground. Input voltage shall be 480VAC, three-phase, three-wire plus ground. The AC input source and bypass input source shall each be a solidly grounded wye service.

f) The battery shall support the UPS at 100% rated kW load for at least _18_ minutes at 77°F (25°C) at startup.

g) The UPS shall have an active power factor-corrected IGBT converter/rectifier, capable of maintaining input power factor and input current total harmonic distortion (THDi) within specifications without an additional input filter.

h) The UPS shall be of transformer-free design, requiring no internal transformer in the main power path for the basic operation of the module. Optional transformers in cabinets or otherwise external to the basic UPS module shall be permissible to provide isolation and/or voltage transformation.

B. Modes of Operation

a) The UPS shall operate as an on-line reverse transfer system in the following modes:

1. Normal: The critical AC load shall be continuously powered by the UPS inverter. The rectifier/charger shall derive power from the utility AC source and supply DC power to the DC-DC converter, which in turn shall supply the inverter while simultaneously float charging the battery.

2. ECO Mode: The critical AC load shall be continuously powered by the bypass with the inverter available to power the load if the bypass source voltage or frequency exceeds adjustable parameters of power quality.

3. Battery: Upon failure of utility AC power, the critical load shall be powered by the inverter, which, without any switching, shall obtain its power from the battery plant via the DC-DC converter. There shall be no interruption in power to the critical load upon failure or restoration of the utility AC source.

4. Recharge: Upon restoration of the utility AC source, the rectifier shall supply power to the output inverter and to the DC-DC converter, which shall simultaneously recharge the batteries. This shall be an automatic function and shall cause no interruption to the critical load.

5. Bypass: If the UPS must be taken out of service, the static transfer switch shall transfer the load to the bypass source. The transfer process shall cause no interruption in power to the critical load. An optional external wrap-around maintenance bypass shall be used to ensure full isolation of the unit for the service of internal components while providing safety from arc flash and in compliance with OSHA requirements.

6. Off-Battery: If the battery only is taken out of service, it shall be disconnected from the DC-DC converter by means of an external disconnect circuit breaker (in the case of external batteries). The UPS shall continue to function and meet all of the specified steady-state performance criteria, except for the power outage backup time capability. If multiple battery strings are used, each string shall be capable of being electrically isolated for safety during maintenance.

C. Performance Requirements

a) The solid-state power components, magnetics, electronic devices and overcurrent protection devices shall operate within the manufacturer’s recommended temperature when the UPS is
operating at 100% critical load and maintain battery charging under either of the following conditions:

1. Any altitude within the specified operating range up to 3300 ft. (1000m) elevation
2. Any ambient temperature within the specified operating range of 32°F to 104°F (0°C to 40°C).

D. Input

a) **Voltage:** Input/output voltage specifications of the UPS shall be
   1. Rectifier AC Input: 480V, three-phase, three -wire-plus-ground
   2. Bypass AC Input: 480V, three-phase, three -wire-plus-ground
   3. AC Output: 480V, three-phase, three -wire-plus-ground
b) **Voltage Range:** +20%, -15% at full load; -40% at half load
c) **Frequency Range:** 40 - 70Hz
d) **Maximum Inrush Current:** UPS inrush current not to exceed 1.5 times rated input current
e) **Power Factor:** Minimum 0.99 at full load with nominal input voltage
f) **Current Distortion:** Less than 3% THD at full load linear input current and less than 5% at full load non-linear input current in double-conversion mode
g) **Surge Protection:** Withstands input surges of 4kV (Line to ground) without damage as per criteria listed in EN 61000-4-5: 1995
h) **Short Circuit Current Rating:** Units shall carry as standard 65kA Short Circuit Withstand Rating. All ratings shall be certified and a label shall be applied to the unit clearly identifying this rating as required by the National Electrical Code.

E. AC Output

a) **Load Rating:** 100% of load rating at 104°F (40°C) for any load from 0.5 lagging to 0.9 leading
b) **Voltage Regulation:**
   1. ±1% RMS average for a balanced, three-phase load
   2. ±2% for 100% unbalanced load for line-to-line imbalances
c) **Voltage Adjustment Range:** ±5% for line drop compensation adjustable by factory service personnel
d) **Frequency Regulation:**
   1. Synchronized to bypass: ±2.0Hz default setting, (adjustable by factory service personnel)
e) **Phase Imbalance:**
   1. Balanced loads 120° ±0.5°
   2. 100% unbalanced loads 120° ±1.5°
f) **Voltage Transients (average of all three phases):**
   1. 0-100% or 100-0%
   Response: Meets ITIC and CBEMA Curve Requirements
   Complies with IEC/EN 62040-3: 2010 Figure 2 Curve 1, Class 1
   Transient Voltage Deviation, RMS: 5%
   Recovers within 60ms
g) **Overload at Full Output Voltage with ±1% voltage regulation:**
   1. 100% continuously
   2. 105% - 110% of full load for 60 minutes at 104°F (40°C) ambient
   3. 110% - 125% of full load for 10 minutes at 104°F (40°C) ambient
4. 125% - 150% of full load for 60 seconds at 104°F (40°C) ambient
5. >150% of full load for a minimum of 200 milliseconds at 104°F (40°C) ambient

F. Grounding
   a) The UPS chassis shall have an equipment ground terminal.

1.5 ENVIRONMENTAL CONDITIONS

The UPS shall be able to withstand the following environmental conditions without damage or degradation of operating characteristics:

A. Operating Ambient Temperature
   a) UPS: 32°F to 104°F (0°C to 40°C) without derating
   b) Battery: 77°F (25°C), ±5°F (±3°C)

B. Storage/Transport Ambient Temperature
   a) -4°F to 158°F (-20°C to 70°C)

C. Relative Humidity
   a) 0 to 95%, non-condensing

D. Altitude
   a) Operating: To 3300 ft. (1000m) above Mean Sea Level without derating (compliant with IEC/EN 62040-3 at altitudes exceeding 1000m)
      Consult factory for derating above 3300 ft. (1000m) elevation.
   b) Storage/Transport: To 50,000 ft. (15,000m) above Mean Sea Level

E. Audible Noise Level

<table>
<thead>
<tr>
<th>Unit Size</th>
<th>Noise/Load, dB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100% Load</td>
</tr>
<tr>
<td>50kVA</td>
<td>63.2</td>
</tr>
<tr>
<td>100kVA</td>
<td>66.1</td>
</tr>
<tr>
<td>150kVA</td>
<td>67.1</td>
</tr>
<tr>
<td>200kVA</td>
<td>68.5</td>
</tr>
<tr>
<td>250kVA</td>
<td>68.7</td>
</tr>
</tbody>
</table>

Measured 4.6 ft. (1.4m) from the surface of the unit.

1.6 SUBMITTALS

A. Proposal Submittals
   a) Submittals with the proposal shall include:
   b) Descriptions of equipment to be furnished, including deviations from these specifications.
   c) Document stating compliance with FCC requirements.
   d) Document stating listing to UL, including edition used for listing.
   e) Document showing compliance with required SCCR and labeling.
   f) System configuration with single-line diagrams.
   g) Detailed layouts of customer power and control connections.
   h) Functional relationship of equipment, including weights, dimensions and heat dissipation.
   i) Information to allow distribution system coordination.
   j) Size and weight of shipping units to be handled by contractor.
B. Order Submittals
Submittals supplied at time of order shall include:
   a) All of the documentation presented with the proposal, per Section 1.5.1.
   b) Detailed installation drawings including all terminal locations.
   c) Interconnect wiring diagrams showing conduit wiring with terminal numbers for each wire.

C. UPS Delivery Submittals
Submittals upon UPS delivery shall include:
   a) A complete set of submittal drawings.
   b) Two (2) sets of instruction manuals. Manuals shall include a functional description of the
equipment, safety precautions, instructions, step-by-step operating procedures and routine
maintenance guidelines, including illustrations.

1.7 WARRANTY
A. UPS Warranty
   a) The UPS manufacturer shall warrant the unit against defects in workmanship and materials for 12
   months after initial startup or 18 months after the shipping date, whichever comes first.

B. Warranty – End User
   a) Warranties associated with items not manufactured by the UPS supplier but included as part of
   the system shall be passed through to the end user.

1.8 QUALITY ASSURANCE
A. Manufacturer’s Qualifications
   a) A minimum of 20 years’ experience in the design, manufacture and testing of solid-state UPS
   systems shall be required.
   b) The quality system for the engineering and manufacturing facility shall be certified to conform to
   Quality System Standard ISO 9001 for the design and manufacture of power protection systems
   for computers and other sensitive electronics.

B. Factory Testing
   a) Before shipment, the manufacturer shall fully and completely test the UPS unit to ensure
   compliance with the specification.
   b) The UPS unit shall be tested at the system-specified capacity. Testing shall be done using load
   banks at part-load and the full kW rating of the unit. Operational discharge and recharge tests to
   ensure guaranteed rated performance. System operations such as startup, shutdown and
   transfers shall be demonstrated.
   c) A certified copy of the test results shall be available for each system as indicated on the order.

PART 2 - PRODUCT
2.1 FABRICATION
A. Materials
   a) All materials of the UPS shall be new, of current manufacture, high grade and shall not have been
   in prior service except as required during factory testing. All active electronic devices shall be
   solid-state. All power semiconductors shall be sealed. Control logic and fuses shall be physically
   isolated from power train components to ensure operator safety and protection from heat.
B. UPS Internal Wiring
   a) Wiring practices, materials and coding shall be in accordance with the requirements of the National Electrical Code, OSHA and applicable local codes and standards. All bolted connections of busbars, lugs and cables shall be in accordance with requirements of the National Electrical Code and other applicable standards. All electrical power connections shall be torqued to the required value and marked with a visual indicator.

C. Field Wiring
   a) All field wiring power connections shall be to tin-plated copper busbars for connection integrity. Busbars shall have adequate space to allow two-hole, long-barrel, compression type lugs forming a permanent connection between field wiring and field-installed lugs.
   b) Provisions shall be made in the cabinets to permit installation of input, output and external control cabling using raceway or conduit. Provision shall be made for top and bottom access to input, output, bypass and DC connections. In conformance with the NEC, connection cabinets shall provide for adequate wire bend radius.

D. Construction and Mounting
   a) The UPS shall be in NEMA Type 1 enclosures, designed for floor mounting. The UPS shall be structurally adequate and have provisions for hoisting, jacking and forklift handling. Maximum cabinet height shall be 78.7 in. (2000mm).
   b) The UPS shall be NEMA Type 1-compliant, with front doors open to enable safe change of air filters without the need for shutdown.

E. Cooling
   a) Adequate ventilation shall be provided to ensure that all components are operated well within temperature ratings.
   b) Temperature sensors shall be provided to monitor the UPS’s internal temperature. Upon detection of temperatures in excess of the manufacturer’s recommendations, the sensors shall cause audible alarms to be sounded and visual alarms to be displayed on the UPS control panel. Air filters shall be located at the point of air inlet and shall be changeable. No service clearance or ventilation shall be required in the rear of the system.

2.2 EQUIPMENT

A. UPS System Model No. 51SA100BAAO
   a) The UPS system shall consist of an IGBT power factor-corrected rectifier, DC-DC converter and three-phase, transformer-free inverter, bypass static transfer switch, bypass synchronizing circuitry, protective devices and accessories as specified. The specified system shall also include a battery disconnect breaker and battery system.

B. Output Protection
   a) The UPS shall be protected against sudden changes in output load and short circuits at the output terminals. The UPS shall have built-in protection against permanent damage to itself and the connected load for all predictable types of malfunctions. Fast-acting, current-limiting devices shall be used to protect against cascading failure of solid-state devices. Internal UPS malfunctions shall cause the module to trip off-line with minimum damage to the module and provide maximum information to maintenance personnel regarding the reason for tripping off-line. The load shall be automatically transferred to the bypass line uninterrupted for an internal UPS malfunction. The status of protective devices shall be indicated on a graphic display screen on the front of the unit.
2.3 COMPONENTS

A. Rectifier

a) The term rectifier shall denote the solid-state equipment and controls necessary to convert alternating current to regulated direct current to supply the inverter and charge the battery. The DC output of the rectifier shall meet the input requirements of the inverter without the battery being connected.

1. Input Current Harmonic Distortion
   The rectifier shall actively control and reduce input current distortion over the full operating range of the UPS without the need for an additional passive input filter. Input current THD shall be less than 5% at rated load and nominal voltage in double-conversion mode.

2. Dynamic Current Input Limit Reduction
   The rectifier, in conjunction with the other UPS controls and circuitry, shall adjust the current demanded for battery charging as a function of UPS wattage load and input voltage level.

B. DC-DC Converter

The term DC-DC converter shall denote the equipment and controls to regulate the output of the rectifier to the levels appropriate for charging the battery and to boost the battery voltage to the level required to operate the inverter. The DC-DC converter shall be solid-state, capable of providing rated output power and, for increased performance, shall be a pulse width-modulated design and shall utilize insulated gate bipolar transistors (IGBTs). The DC-DC converter shall control charging of the battery. The AC ripple voltage of the charger DC shall not exceed 1% RMS of the float voltage.

a) Battery Equalize Charge
   1. A manually initiated equalize charge feature shall be provided to apply an equalize voltage to the battery. The duration of equalize charge time shall be adjustable from 8 to 30 hours. A method shall be available to deactivate this feature for valve regulated battery systems.

b) Stop Battery Charging Function
   1. Battery charging may be stopped by a shunt trip of the battery cabinet breaker when overtemperature is sensed in the battery cabinet, on generator or when environmental contact is closed.

c) Overvoltage Protection
   1. There shall be DC overvoltage protection so that if the DC voltage rises to the pre-set limit, the UPS shall shut down automatically and initiate an uninterrupted load transfer to bypass or shall disconnect the battery via the DC breaker(s) in the battery string.

d) Temperature-Compensated Charging
   1. The UPS shall adjust the battery charging voltage based on the battery temperature reported from external battery temperature sensors. When multiple sensors are used, the voltage shall be based on the average temperature measured. Excessive difference in the temperature measurements shall be reported and the charging voltage adjusted to protect the batteries from excessive current.

e) Battery Load Testing
   1. The UPS shall be capable of performing battery load testing under operator supervision. To accomplish this, the rectifier shall reduce charging voltage to force the batteries to carry the load for a short time. If the curve of battery voltage drop indicates diminished
battery capacity, the UPS shall display an alarm message. If the voltage drop indicates battery failure, the UPS shall terminate the test immediately and annunciate the appropriate alarms.

C. Inverter

The term *inverter* shall denote the equipment and controls to convert direct current from the rectifier or battery via the DC-DC converter to precise alternating current to power the load. The inverter shall be solid-state, capable of providing rated output power and, for increased performance, the inverter shall be a pulse-width-modulated design and shall utilize insulated gate bipolar transistors (IGBTs). To further enhance reliable performance and efficiency, the inverter shall not require an inverter output series static switch/isolator for the purposes of overload or fault isolation or transfers to bypass.

   a) Overload Capability

      1. The inverter shall be able to withstand an overload across its output terminals while supplying full rated voltage of up to 150% for 60 seconds. The inverter shall be capable of at least 170% current for short-circuit conditions including phase-to-phase, phase-to-ground and three-phase faults. After the fault is removed, the UPS shall return to normal operation without damage. If the short circuit is sustained, the load shall be transferred to the bypass source and the inverter shall disconnect automatically from the critical load bus.

   b) Output Frequency

      1. The inverter shall track the bypass continuously, providing the bypass source maintains a frequency of 60Hz ±1% (0.6 Hz).

   c) Phase-to-Phase Balance

      1. The inverter shall provide a phase-to-phase voltage displacement of no worse than ±3% with a 100% unbalanced load.

   d) Inverter Fault Sensing and Isolation

      1. The UPS shall be provided with a means to detect a malfunctioning inverter and isolate it from the critical load bus to prevent disturbance of the critical load voltage beyond the specified limits.

   e) Battery Protection

      1. The inverter shall be provided with monitoring and control circuits to protect the battery system from damage due to excessive discharge. Inverter shutdown shall be initiated when the battery voltage has reached the end of discharge voltage. The battery end-of-discharge voltage shall be calculated and automatically adjusted for partial load conditions to allow extended operation without damaging the battery. Automatic shutdown based on discharge time shall not be acceptable.

D. Inverter Bypass Operation

When maintenance is required or when the inverter cannot maintain voltage to the load due to sustained overload or malfunction, a bypass circuit shall be provided to isolate the inverter output from the load and provide a path for power directly from an alternate AC (bypass) source. The UPS control system shall constantly monitor the availability of the inverter bypass circuit to perform a transfer. The inverter bypass circuit shall consist of a continuous duty bypass static switch and an overcurrent protection device to isolate the static bypass switch from the bypass utility source. The bypass static switch shall denote the solid-state device incorporating SCRs (silicon controlled rectifiers) that can automatically and instantaneously connect the alternate AC source to the load.

   a) Static Bypass Switch Rating
1. The static bypass switch shall be rated for continuous duty operation at full rated load for highest reliability without the use of mechanical devices, such as those used with a momentary rated device.

b) Manual Load Transfers

1. A manual load transfer between the inverter output and the alternate AC source shall be initiated from the control panel. Manually initiated transfers shall be make-before-break, utilizing the inverter and the bypass static switch.

c) Automatic Load Transfers

1. An automatic load transfer between the inverter output and the alternate AC source shall be initiated if an overload condition is sustained for a period in excess of the inverter output capability or due to a malfunction that would affect the output voltage. Transfers caused by overloads shall initiate an automatic retransfer of the load to the inverter only after the load has returned to a level within the rating of the inverter source and the alarm has been acknowledged.

d) Momentary Overloads

1. In the event of a load current inrush or branch load circuit fault in excess of the inverter rating, the bypass static switch shall connect the alternate AC source to the load for at least 600 milliseconds, allowing up to 1000% of the normal rated output current to flow. Output voltage shall be sustained to the extent the alternate AC source capacity permits. If the overload condition is removed before the end of the 600-millisecond period, the bypass static switch shall turn Off and the load shall remain on inverter power. If the overload remains, then a transfer to the alternate AC source is to be completed.

e) Back-Feed Protection

1. As required by UL1778 and CSA, the static transfer switch shall not back-feed UPS power to the bypass distribution system while the UPS is operating on battery during a bypass power outage. The purpose of this requirement is to prevent the risk of electrical shock on the distribution system when the normal source of power is disconnected or has failed. If a shorted SCR is detected, the static transfer switch shall be isolated by automatically tripping the upstream bypass circuit breaker and an alarm message shall be annunciated at the UPS control panel. The load shall remain on conditioned and protected power after detection of a shorted SCR and isolation of the bypass static switch.

f) Active ECO-Mode

1. When selected, this mode of operation shall transfer the load to the bypass source and maintain it there as long as the bypass source frequency, slew rate and voltage are within the adjusted operating parameters. While in this mode, the inverter shall remain operating to be able to instantaneously assume the load without interrupting the output voltage. Should the bypass source go outside the adjusted limits, the bypass static switch shall turn Off, isolating the load from the bypass while the inverter assumes the full critical load. The load shall be transferred from the bypass source to the inverter while maintaining the output voltage within the ITIC and CBEMA curves.

E. Display and Controls

a) UPS Control Panel

1. The UPS shall be provided with a microprocessor-based control panel for operator interface (may also be referred to as User Interface, or UI) to configure and monitor the UPS. The control panel shall be located on the front of the unit where it can be operated without opening the hinged front door. A backlit, menu-driven, full-graphics, color touchscreen liquid crystal display shall be used to display system information, metering information, a one-line diagram of the UPS and battery, active events and event history.
2. No mechanical push buttons shall be used.

b) Logic

1. UPS system logic and control programming shall reside in a microprocessor-based control system with nonvolatile flash memory. Rectifier, inverter and system control logic shall utilize high-speed digital signal processors (DSPs). CANbus shall be used to communicate between the logic and the User Interface as well as the options. Switches, contacts and relays shall be used only to signal the logic system as to the status of mechanical devices or to signal user control inputs. Customer external signals shall be isolated from the UPS logic by relays or optical isolation.

c) Metered Values

1. A microprocessor shall control the display and memory functions of the monitoring system. All three phases of three-phase parameters shall be displayed simultaneously. All voltage and current parameters shall be monitored using true RMS measurements for accuracy to ±3% of voltage, ±5% AC current. The following parameters shall be displayed:
   I. Input voltage, line-to-line
   II. Input current per phase
   III. Input frequency
   IV. Input apparent power (kVA)
   V. Battery voltage
   VI. Battery charging/discharging current
   VII. Output voltage, line-to-line
   VIII. Output frequency
   IX. Bypass input voltage, line-to-line
   X. Bypass input frequency
   XI. Load current
   XII. Load real power (kW), total and percentage
   XIII. Load apparent power (kVA), total and percentage
   XIV. Battery temperature

d) Power Flow Indications

1. A power flow diagram shall graphically depict whether the load is being supplied from the inverter, bypass or battery and shall provide, on the same screen, the status of the following components:

2. AC Input Circuit Breaker (optional)

3. Battery Circuit Breaker, each breaker connection of complete battery complement, complete disconnection and partial connection (one or more, but not all breakers open.)

4. Maintenance Bypass Status

e) Main Display Screen

The following UPS status messages shall be displayed:

1. Rectifier (Off / Soft Start / Main Input On / Battery Input On)
2. Input Supply (Normal Mode / Battery Mode / All Off)
3. Battery Self Test (True / False)
4. Input Disconnect (Open / Closed)
5. EPO (True / False)
6. Charger (On / Off)
7. Output Disconnect (Open / Closed)
8. Maint. Disconnect (Open / Closed)  
9. Bypass Disconnect (Open / Closed)  
10. Inverter (Off / Soft Start / On)  
11. Bypass (Normal / Unable To Trace / Abnormal)  
12. Output Supply (All Off / Bypass Mode / Inverter Mode / Output Disable)  
13. Inverter On (Enable / Disable)  

f) HMI Control Buttons  
1. Buttons shall be provided to start and stop the inverter.  
2. Other buttons shall be provided to reset faults and silence the alarm buzzer.  

g) Event Log  
1. This menu item shall display the list of events that have occurred recently while the UPS was in operation. The Event Log shall store up to 2048 events, with the oldest events being overwritten first if the log’s capacity is reached.  

h) Battery Status Indicator  
1. A battery status indicator shall display DC alarm conditions, temperature, battery state of charge, the present battery voltage and battery time remaining during discharge.  
2. The UPS shall provide the operator with controls to perform the following functions:  
3. Configure and manage manual battery test  
4. Start battery test  
5. Monitor test status and progression  
6. Stop battery test  
7. Battery test status  

i) Alarms  
The following alarm messages shall be displayed:  

1. Mains Voltage Abnormal  
2. Mains Undervoltage  
3. Mains Freq. Abnormal  
4. Charger Fault  
5. Battery Reversed  
6. No Battery  
7. Parallel Comm. Fail  
8. Bypass Unable To Track  
9. Bypass Abnormal  
10. Inverter Asynchronous  
11. Fan Fault  
12. Control Power Fail  
13. Output Overload  
14. Bypass Phase Reversed  
15. Transfer Time-Out  
16. Load Sharing Fault  
17. Bypass Over Current.  

j) Controls  
System-level control functions shall be:
1. Start Inverter (and transfer to inverter)
2. Stop Inverter (after transferring to bypass)
3. Startup Screen
4. Configure Manual Battery Test
5. Initiate Manual Battery Test
6. System Settings (Time, Date, Language, Password
7. Alarm Silence Command
8. Fault Reset Command
9. ECO mode

k) Manual Procedures
1. Load Transfers: HMI buttons (START INVERTER, STOP INVERTER) shall provide the means for the user to transfer the load to bypass and back on UPS.

F. Self-Diagnostics
a) Event Log File - The control system shall maintain a log of the event conditions that have occurred during system operation. Each log shall contain the event name, event time/date stamp and a set/clear indicator.

G. Remote Monitoring and Integration Capabilities
a) LIFE™ Services: The UPS manufacturer shall provide as an option LIFE services, which provides 24x7 continuous monitoring of events and parametric data, event and data analysis reports and dispatch of factory-trained field service personnel. The UPS shall be able to initiate periodic and critical event-driven communication with a remote service center to transfer event and parametric data for analysis and action. The remote service center shall be staffed with factory-trained service personnel who are capable of receiving, analyzing and interpreting the communicated events and data. The remote service center personnel shall also be capable of dispatching factory-trained field service personnel to the location of the UPS.

b) Communication Cards: The UPS shall be equipped with up to three optional communication card(s) including:
   1. Provide Liebert IntelliSlot™ Unity™ card providing Web-based UPS monitoring and management capabilities, LIFE Services delivery and two of the following third-party open protocols:
   2. SNMP protocols (v1, v2, v3)
   3. Modbus RTU or Modbus TCP
   4. BACnet MSTP or BACnet IP
   
   Note: Modbus RTU and BACnet MSTP cannot both be enabled simultaneously.

c) Output Alarm Contacts: Dry contact outputs shall be provided for Summary Alarm, Bypass Active, Low Battery and AC Input Failure.

H. Battery Disconnect Breaker (Present in Battery Cabinet)
a) The battery cabinet shall have a properly rated circuit breaker (600VDC) to isolate it from the Liebert EXM UPS. This breaker shall be in a separate NEMA-1 enclosure or in a matching battery cabinet. When this breaker is open, there shall be no battery voltage in the UPS enclosure. The UPS shall be automatically disconnected from the battery by a shunt trip of the battery cabinet breaker when signaled by other control functions.

I. Optional Accessories and Features
a) Wiring Cabinet
   1. Provide 300MM 480V wiring cabinet to allow for top cable entry.
b) Communication Card
   1. Provide per section 2.3.7.B above

c) Relay Contact Card
   1. A relay contact card shall provide output dry contact signals communicating the following UPS states: Summary Alarm, Bypass Active (On Bypass), Low Battery, AC Input Failure (UPS Fault) and On UPS.

d) Integral Alber Battery Monitoring
   1. Detailed in Battery cabinet section 3.0

e) Maintenance Bypass Panelboard with Load Breakers.
   1. Detailed in Maintenance Bypass Panelboard Section 4.0

PART 3 - BATTERY CABINET

3.1 BATTERY PLANT

The battery plant shall comply with the specifications of:

1. Matching Battery Power Pack

A. Matching Battery Power Pack (VRLA Battery) *Model No 51BEEPXB1L1*

   a) The battery power pack shall consist of sealed, valve-regulated batteries and a properly rated circuit breaker (432VDC nominal for isolating the battery pack from the UPS. The battery cells and disconnect breaker (400 Amp) shall be installed and housed in a NEMA-1 cabinet, matching the UPS style and design. Cabinet shall include interconnecting cabling and draw out tray for servicing.

   b) The battery system shall be sized to support a 50kW load for 18 minutes. The battery system shall provide 100% initial capacity upon delivery.

   c) The battery shall be lead-calcium, sealed, valve-regulated type with a 3-year full warranty and a 7-year pro rata warranty under full float operation. The battery design shall utilize absorbent glass mat (AGM) technology to immobilize the electrolyte.

B. Cabinet shall be equipped with integral Alber battery monitoring Hardware and software as described below:

   a) Monitoring System Description

   This specification defines the minimum requirements for a predictive on-line Universal Battery Diagnostic System with test, analysis, and remote monitoring control capabilities. The system shall be capable of automatically monitoring, displaying, and recording all battery parameters described in this specification. Communications shall be capable of supporting multiple protocols by optional plug in modules. Communication protocols, such as MODBUS, SNMP, SMTP, SMS, HTTP and others will be required. Shall be equipped with USB interfaces for PC use and USB memory sticks for performing data archiving and field firmware upgrades.

   b) System Specifications

   **String Capacity**
   Supports strings with 40-50 12V monoblocs per string. There should not be any limitation to the amount of strings to be monitored.

   **Input Power**
   115VAC ±10%, 1 Phase 50 to 60Hz, 3.6 Amps
   230VAC ±10%, 1 Phase 50 to 60Hz, 1.8 Amps

   **Operating Temperature Range**
   5°C to 40°C
41°F to 104°F

Altitude 0 to 2000 meters above sea level

Humidity 0% to 80% RH (non condensing) at 5°C to 31°C
0% to 50% RH (non condensing) at 32°C to 40°C

Environment Indoor use only

Category Installation Category II

Jar voltage:
12V range 0 to 18V, 0.1% ±12mV
16V range 0 to 24V, 0.1% ±16mV

Jar resistance: 0 to 32,000µΩ, ±5% of reading ±2µΩ

String voltage: 0 to 700.0V, ±0.2% of reading ±0.5V

Intertier resistance: 0 to 5mΩ, ±5% of reading ±5µΩ.

Temperature: 0°C to 80°C (32°F to 176°F), ±1°C.

Discharge current: ±4000A ±1% full scale

Float current: 0 to 5000mA ±50mA.

Current Sensors - One per battery string. Optional current transducer required.

Temperature Sensors (optional) - Two ambient sensors per string can be defined.

3.2 MEASUREMENT CAPABILITY

A. Individual jar voltage
B. Individual jar DC resistance accomplished by applying a momentary load at user defined intervals.
C. Individual intertier and disconnect switch resistance measurements performed at user defined intervals. The measurements should not be combined with the internal resistance of the adjacent jars.
D. Total overall battery voltage per string (Calculated).
E. Two temperatures per string for temperature trending.
F. Real time system discharge logging of the overall voltage, individual jar voltage, discharge current, and temperatures.
G. Float current per string (optional).
H. Ripple current per string.
I. Thermal runaway detection (optional).
PART 4 – SYSTEM HARDWARE AND SOFTWARE REQUIREMENTS

A. LED’s indicating alarms, communications, and processor status
B. Four communication ports: A USB port for either a local PC connected at all times or for temporary viewing with a notebook computer. A Ethernet port configurable for use on a network using TCP/IP/Modbus, SNMP, SMTP, SMS or HTTP. An RS-485 port for Modbus interface. Viewing of data is to be performed from any one of these ports.
C. Nonvolatile memory for storage of embedded database for entire history of battery data.
D. Prefabricated and labeled wiring harnesses with a fast on connection for easy field installation.
E. Individual resistor terminated leads must have a $10\,\text{K}\Omega 1\,\text{W}$ flame proof resistor to limit current for the safety of the technician.
F. Two voltage-free, form C, alarm contacts for annunciating a common alarm to the alarm reporting system. Each contact can be programmed for either a critical or maintenance event.
G. Windows® 2000, XP, Windows 7 (32 or 64 bit) or higher compatible software for data analysis, display, archiving, and trending.
H. One form C contact per string to be triggered in the event of a thermal runaway condition.

PART 5 – SYSTEM PERFORMANCE

A. The battery monitoring system shall monitor, display, and record the battery bank voltage, battery discharge current, individual jar voltages, ambient temperature, individual jar resistance, intertier resistances, and thermal runaway conditions. All these parameters shall be continuously monitored in real time during normal operation and during all battery discharges, except for resistance test, which is a user programmable event.
B. The system shall automatically detect, display, record, and alert all alarm conditions, as they occur. This reporting shall include the following parameters.
   a) Individual jar voltage high and low alarm. Shall support an individual alarm threshold for each jar.
   b) Individual internal resistance high and low alarm. Shall support an individual alarm threshold for each jar.
   c) Interior resistance high alarm. Shall support an individual alarm threshold for each intertier.
   d) Overall voltage high and low alarm.
   e) Ambient temperature high and low.
   f) Individual jar voltage low alarm during discharge.
   g) Discharge string current high alarm.
   h) Maximum discharge time alarm.
   i) Float current high and low alarm.
   j) String current high alarm.
   k) Thermal Runaway
C. Each alarm record shall include defined limits, alarming parameter, show the time and date of the event, and the peak value reached during the violation.
D. Each alarm event shall permit acknowledging.
E. Each parameter alarm shall be configurable for a latching or nonlatching alarm contact function.
F. As user defined, the system shall automatically e-mail a report to responsible personnel when any alarm thresholds are exceeded.
G. The system shall provide and maintain a complete, real-time discharge event log and a dynamic on-line display of battery voltage, individual cell voltages, battery string current, and ambient temperature whenever the battery is in a discharge mode. In addition to the numerical display, the system shall provide a graphical display of the battery voltage and cell voltages versus time that allows playback of the discharge event.
H. Store historical record of the internal and intertier resistances, voltages of each jar, temperatures, overall voltages, string, float and ripple currents for trending analysis.

PART 6 - SOFTWARE
The software shall operate on the Windows 2000, XP, Windows 7 or 8 (32 or 64 bit) or higher operating systems. Software will allow service technicians to view real time analysis from any accessible network connection.

PART 7 - REPORTS
A. Alarm condition reporting – tabular, fax or email.
C. Individual jar voltages over time – graph or tabular.
D. Individual jar resistance values over time – graph or tabular.
E. Total battery voltage over time – graph or tabular.
F. Battery temperature / room temperature over time – graph or tabular.
G. Discharge report: total battery voltage decay vs. time – graph or tabular.
H. Discharge report: jar voltage decay vs. time – graph or tabular.
I. Discharge hit summary report – tabular.
J. Discharge hit interval summary report – tabular.
K. General summary report of battery and monitor status of all systems to the battery or string level based on user set thresholds.
L. Detail summary reports of battery and monitor status of all systems with a line graph trend of any parameter that violated a threshold.
M. Executive report showing over all system health.

PART 8 – COMMUNICATION I/O
A. Modbus and SNMP protocols for third party interface.
B. Local port, USB connector.
C. LAN port, RJ-45.
D. Fiber optic for system module interconnect communications. Wireless devices not accepted.

PART 9 - MAINTENANCE BYPASS PANELBOARD
A. Maintenance Bypass Panelboard with Distribution Breakers Model No MBPSITACQPFF2000002
   A 175 Amp make-before-break maintenance bypass panelboard with Solenoid Key Release Unit (SKRU) interlock shall be provided in a panelboard cabinet. Three Key interlocked Thermal-magnetic breakers shall be provided for bypass and maintenance isolation. Unit shall also include a 100 amp and 125 amp output load distribution breaker. Standard withstand rating shall be 35 KAIC.

PART 10 - EXECUTION
10.1 FIELD QUALITY CONTROL
   The following inspections and test procedures shall be performed by factory-trained field service personnel during the UPS startup.
A. Visual Inspection
   a) Inspect equipment for signs of damage.
   b) Verify installation per drawings supplied with installation manuals or submittal package.
   c) Inspect cabinets for foreign objects.
   d) Verify that neutral and ground conductors are properly sized and configured per Vertiv requirements as noted in Vertiv drawings supplied with installation manuals or submittal package.
   e) Inspect each battery jar for proper polarity.
   f) Verify that all printed circuit boards are configured properly.

B. Mechanical Inspection
   a) Check all control wiring connections for tightness.
   b) Check all power wiring connections for tightness.
   c) Check all terminal screws, nuts and/or spade lugs for tightness.

C. Electrical Inspection
   a) Check all fuses for continuity.
   b) Confirm input and bypass voltage and phase rotation are correct.
   c) Verify control transformer connections are correct for voltages being used.
   d) Ensure connection and voltage of the battery string(s).

10.2 UNIT STARTUP
1. Energize control power.
2. Perform control/logic checks and adjust to meet Vertiv specification.
3. Verify DC float and equalize voltage levels.
4. Verify DC voltage clamp and overvoltage shutdown levels.
5. Verify battery discharge, low battery warning and low battery shutdown levels.
6. Verify fuse monitor alarms and system shutdown.
7. Verify inverter voltages and regulation circuits.
8. Verify inverter/bypass sync circuits and set overlap time.
10. Simulate utility outage at no load.
11. Verify proper recharge.

10.3 MANUFACTURER’S FIELD SERVICE
A. Service Personnel
   a) The UPS manufacturer shall directly employ a nationwide service organization, consisting of factory-trained field service personnel dedicated to the startup and maintenance of UPS and power equipment.
   b) The manufacturer shall provide a national dispatch center to coordinate field service personnel schedules. One toll-free number shall reach a qualified support person 24 hours a day, 7 days a week and 365 days a year. If emergency service is required, on-site response time shall be 4 hours or less within 150 miles of a Vertiv Services center.
   c) Two local customer engineers shall be assigned to the site with a regional office as a backup. Escalation procedures shall be in place to notify Power Technical Support if a site is not functioning within 24 hours.

B. Automated Site Monitoring
   a) The UPS manufacturer shall provide as an option an automated site monitoring service. This service shall be staffed by a qualified support person 24 hours a day, 7 days a week and 365 days a year. At the detection of an alarm within the UPS, the controls shall
initiate communication with the monitoring service. The monitoring service shall be capable of interpreting the communicated alarms to allow dispatch of a service engineer.

C. Replacement Parts Stocking
   a) Parts shall be available through an extensive network to ensure round-the-clock parts availability throughout the country.
   b) Spare parts shall be stocked by local field service personnel with backup available from national parts centers and the manufacturing location. A Customer Support Parts Coordinator shall be on call 24 hours a day, 7 days a week, 365 days a year for immediate parts availability.

D. Maintenance Contracts
   a) A complete offering of preventive and full-service maintenance contracts for both the UPS system and battery system shall be available.

END OF SECTION
SECTION 26 36 23
TRANSFER SWITCHES

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. "Common Work Results for Electrical".

1.2 SUMMARY
A. This Section includes transfer switches rated 600 V and under. It includes the following items:
   1. Automatic transfer switch (ATS).

1.3 SUBMITTALS
A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
B. Product data for each transfer switch including dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and materials lists.
C. Wiring diagrams, elementary or schematic, differentiating between manufacturer-installed and field-installed wiring.
D. Operation and maintenance data for products, for inclusion in Operating and Maintenance Manual specified in Division 1 and in Division 26 Section "Common Work Results for Electrical". Operating and maintenance data shall cover each type of product, including all features and operating sequences, both automatic and manual. List all factory settings of relays and provide relay setting and calibration instructions. Provide spare parts data.
E. Manufacturer's certificate of compliance to the referenced standards and manufacturer's certification of tested short circuit closing and withstand ratings.

1.4 QUALITY ASSURANCE
C. NEMA Compliance: Comply with NEMA standards: ICS 1, "General Standards for Industrial Control"; ICS 2, "Industrial Control Devices, Controllers and Assemblies"; and ICS 6, "Enclosures for Industrial Controls and Systems".

12/12/19  26 36 23-1  8514
D. **UL Listing and Labeling**: Provided items specified in this section that are listed and labeled by UL for emergency service under UL 1008.

E. **UL Compliance**: Comply with UL Standard 1008, "Automatic Transfer Switches", except where requirements of these specifications are stricter.

**PART 2 - PRODUCTS**

### 2.1 MANUFACTURERS

A. **Manufacturers**: Subject to compliance with requirements, provide products by the following:

1. Cummins

### 2.2 TRANSFER SWITCH PRODUCTS, GENERAL

A. **General**: The following requirements apply to automatic transfer switch products:

B. **Ratings**: Provide number of poles and current and voltage ratings as indicated. Current ratings for units below 600 amperes shall be identical for all classes or mixtures of loads including 100 percent tungsten filament lamp load or 100 percent inductive. Current ratings for units 600 amperes and above shall be for mixtures of loads including up to 30 percent tungsten filament lamp load.

C. **Tested-Fault Current Rating**: Exceed the indicated available rms symmetrical fault current at the equipment terminals for closing and withstand ratings based on testing in accordance with UL 1008, conducted at full-rated system voltage and 20 percent power factor. Test each product for withstand duration time for rated short-circuit current correlated with the actual type of circuit protective device indicated for the transfer switch as follows:

1. **Molded-Case Circuit Breakers, Over 150 Amperes**: Three (3) closing and withstand duration cycles.

D. **Solid-State Controls**: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 deg C to 70 deg C. Components shall meet or exceed voltage surge withstand capability when tested in accordance with ANSI Standard C37.90.1, "IEEE Guide for Surge Withstand Capability (SWC) Tests".

E. **Four-Pole Switches**: Where four-pole switches are indicated, provide full-capacity neutral switching.

F. **Enclosures**: General-purpose NEMA 1 in accordance with UL 508, "Electric Industrial Control Equipment", except as otherwise indicated.

G. **Factory Wiring**: Train and bundle factory wiring and identify consistently with shop drawings, either by color code or by numbered or lettered wire and cable tape markers at all terminations. Provide designated terminal blocks for field wiring, and arrange power terminal and field wiring space to be suitable for top, side, or bottom entrance of feeder conductors as indicated. Provide pressure-type terminals suitable for copper or aluminum conductors of sizes indicated.

H. Electrical operation, where indicated, shall be accomplished by a nonfused momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions. Transfer switches using components of molded case circuit breakers or contactors not designed for continuous duty repetitive switching between active power sources are not acceptable.
I. Switch action for double-throw-type switches shall be mechanically held in both directions.

J. **Switch Contacts:** Silver composition for switching load current with separate arcing contacts where rated 400 amperes and above.

K. Overcurrent devices shall not be part of transfer switch products.

### 2.3 AUTOMATIC TRANSFER SWITCHES (ATSs)

A. Comply with requirements for Level 1 equipment per NFPA 110, “Standard for Emergency and Standby Power Systems”.

B. **Features and Characteristics:** Include the following:

1. Double throw type switching arrangement, incapable of pauses or intermediate position stops during normal functioning except as indicated.

2. **Manual Operator:** Capable of transferring the switch to either source position for maintenance purposes. Control circuit shall be disconnected from electrical operator during manual operation.

C. **ATS for Large Motor Loads/Computer Loads:** For ATSs indicated, provide switch operator with a programmed neutral position arranged to provide a midpoint between the two working switch positions with an intentional, controlled, timed pause during transfer at the midpoint. The midpoint pause shall be adjustable from 0.5 to 30 seconds, minimum, and factory set at 0.5 second, except as indicated. Time delay shall occur for both transfer directions but shall be automatically bypassed when a time delay has already been established by loss of power.

D. **Accessories:** Provide the following ATS accessories:

1. Close differential voltage sensing on each phase of normal source. Pick-up voltage shall be adjustable from 85 percent to 100 percent of nominal, and dropout shall be adjustable from 75 percent to 98 percent of the pick up value. Factory set for pick-up at 95 percent and dropout at 85 percent.

2. Time-delay override of normal source voltage sensing shall delay all transfer and engine start signals. Adjustable 0 to 6 seconds, and factory set at 1 second.

3. Voltage/frequency lockout relay and sensing of the emergency source shall be provided to prevent premature transfer. Voltage pick-up shall be adjustable from 85 to 100 percent of nominal. Factory set to pick-up at 90 percent of nominal. Pick-up frequency shall be adjustable from 90 percent to 100 percent of nominal. Factory set to pick-up at 95 percent.

4. System test switch, momentary type.

5. Retransfer time delay to normal or preferred power source: adjustable from 0 to 30 minutes and factory set at 30 minutes. Provide automatic defeat of the delay upon loss of voltage or sustained under voltage of the emergency source, provided the normal supply has been restored.

6. Pilot lights to indicate source to which the load is connected.

7. Engine starting contacts, one isolated normally closed and one isolated normally open. Contacts shall be gold flashed or plated and rated 10 amperes at 32 V d.c.
8. **Engine Shutdown Contacts:** Instantaneous, to initiate shutdown sequence at remote engine-generator controls after retransfer of the load to normal or preferred source.

9. **Unassigned Auxiliary Contacts:** Two (2) normally open SPDT contacts for each switch position.
   
a. **Rating:** 10 amperes at 240 V a.c.

10. **Source Available Indicating Lights:** A green indicating light to supervise the normal power source with a nameplate engraved "NORMAL SOURCE AVAILABLE", and a red indicating light to supervise the emergency power source with a nameplate engraved "EMERGENCY SOURCE AVAILABLE". Supervision of sources shall be via the transfer switch normal and emergency source sensing circuits, respectively.

11. **Transfer Override Switch:** To override automatic retransfer control so the ATS will remain connected to the emergency power source regardless of the condition of the normal source. Provide a pilot light to indicate the override status.

### 2.4 FINISHES

A. Clean ferrous surfaces to be painted free of oil, grease, welding slag, and spatter, mill scale, corrosion, and dirt.

B. Paint with rust-inhibiting primer and finish enamel. Apply primer to clean, dry surface immediately after cleaning. Use manufacturer's standard material and procedure except as required to produce a total dry film thickness not less than 2.5 mils. Use finish coat of manufacturer's approved standard color. Provide a finish free from runs, sags, peeling, and other defects.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

A. **Wall Mounting of Transfer Switches:** Level and anchor the unit to the wall.

B. Identify components in accordance with Division 26 Section "Identification for Electrical Systems".

#### 3.2 GROUNDING

A. Provide equipment grounding connections for transfer switch units as indicated and as required by NEC. Tighten connectors to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounding.

#### 3.3 FIELD QUALITY CONTROL

A. **Preliminary Tests:** Perform electrical tests as follows:

   1. Measure, with insulation resistance tester, phase-to-phase and phase-to-ground insulation resistance levels to assure requirements are fulfilled. Disconnect control circuits for this test to prevent damage.
   2. Check for electrical continuity of circuits and for short circuits.
B. Manufacturer’s Field Services: Provide services of a factory service representative to assist with demonstrations and field tests.

C. Field Tests: Energize transfer switches and demonstrate functioning of all devices, components, and sequences. Give seven calendar days’ advance notice of the tests, and perform tests in presence of Owner’s representative.

D. Tests shall be coordinated with tests of generator plant and run concurrently with them. Tests shall include the following:

E. Tests for ATSs: Include the following:

1. Simulate power failure of normal source.
2. Simulate power failure of emergency source with normal sources available.
3. Simulate low phase to ground voltage for each phase of normal source.

F. Checking, measuring, and optimizing all adjustable time delays.

G. Test Failures: Correct deficiencies identified by tests and make ready for retest. Verify equipment meets the specified requirements.

H. Reports: Maintain a written record of observations and tests. Report defective materials and workmanship and retest corrected defective items. Submit written test reports. Include a record of all adjustable relay settings and measured time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.4 DEMONSTRATION

A. Training: Furnish the services of a factory authorized service representative to instruct Owner’s personnel in the operation and maintenance of transfer switches and related equipment. Provide a minimum of two hours of instruction scheduled seven days in advance.

3.5 CLEANING

A. Upon completion of installation, inspect interiors and exteriors of accessible components. Remove dust, dirt, foreign matter, paint splatters and other spots, dirt, and construction debris. Vacuum interior. Touch up scratches and mars of finish to match original finish.

END OF SECTION
SECTION 26 36 33
STATIC TRANSFER SWITCH

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 section 26 05 00 “Common Work Results for Electrical” apply to this section.

1.2 SUMMARY

A. These specifications describe the requirements for an automatic static transfer switch. The Liebert STS2 is a solid-state, three-pole, dual-position transfer switch designed to switch automatically and manually between two synchronized three-phase AC power sources without an interruption of power to the load typically less than 1/4 cycle.

B. The input power shall be supplied from two different AC power sources, which are nominally of the same voltage level, phase rotation and frequency. The primary purpose of the Liebert STS2 is to allow virtually uninterrupted transfer from one source to the other in case of the failure of one source or by manual initiation for test or maintenance. The switching action shall not connect together the two sources of power that would allow backfeeding one source to the other. The Liebert STS2 shall allow for either source to be designated as the preferred source. The switch will automatically transfer to the preferred source and remain so until manually initiated to transfer or until the selected source fails. If the selected source fails, the Liebert STS2 shall transfer without interruption typically in less than 1/4 cycle to the other source, designated as the alternate source. The Liebert STS2 shall be furnished with key-interlocked static switch isolation and bypass Molded-case Switches (MCSs) to each source, which allow uninterrupted manual transfer to and from either source for maintenance.

C. For Optimized Transfer, the transfer will be within the ITIC/CBEMA voltage quality standard. This is an optional setting which minimizes the resulting downstream transformer saturation inrush current.

1.3 STANDARDS

A. The specified system shall be designed, manufactured, tested and installed in accordance with:

a) American National Standards Institute (ANSI)
b) Canadian Standards Association (CSA)
c) Institute of Electrical and Electronics Engineers (IEEE)
d) ISO 9001
e) National Electrical Code (NEC)
f) National Electrical Manufacturers Association (NEMA)
g) National Fire Protection Association (NFPA 70)
h) Underwriters Laboratories (UL)
i) EN 61000-6-4 & 6-2

B. The Liebert STS2 shall be UL and UL listed per UL Standard 1008 for Automatic Transfer Switches or 1008S for Solid State Transfer Switches

C. The Liebert STS2 shall comply with the latest FCC Part 15 EMI emission limits for Class A computing devices and the emission limits of EN/IEC61000-6-4 Class A.

D. The Liebert STS2 shall safely withstand without misoperation or damage:
a) Transient voltage surges on either AC power input as defined by ANSI/IEEE C62.41 for Category B3 locations (high surge exposure industrial and commercial facilities)
b) Electrostatic discharges (ESD) up to 10 kV at any point on the exterior of the unit
c) Electromagnetic fields from portable transmitters within 3 ft. (1m) of the unit

E The Liebert STS2 shall comply with the immunity requirements of EN/IEC61000-6-2 Class A.

1.4 DEFINITIONS
A. STS - Static Transfer Switch
B. SCR - Silicon Controlled Rectifier
C. MTBF - Mean Time Between Failure is the actual arithmetic average time between failures of the critical AC output bus.
D. Molded-case Switches (MCS) - A circuit breaker that has no automatic thermal overload trip element but does have a magnetic trip element for short-circuit/fault protection. Short-circuit and overload protection must be provided by an upstream overcurrent device.

1.5 SYSTEM DESCRIPTION Model No. STA0100A32A
A. Design Requirements
   a) Voltage. Input/output voltage specifications of the Liebert STS2 shall be 480 volts, three phase, 60 Hz, (3)-wire plus ground.
   b) Output Load Capacity. Specified output load capacity of the Liebert STS2 shall be 100 A. The Liebert STS2 shall be continuous rated to carry a full 100% load.

B. Modes of Operation
   a) The Static Transfer Switch shall be a three-pole, double-throw, solid-state, automatic transfer switch that is fed from two AC power sources. One source shall be designated as the preferred source, while the other is the alternate source. Selection of which input source is preferred shall be user selectable from the operator control panel. All transfers shall be a fast break-before-make with no overlap in conduction from one source to the other. All transfers, including sense and transfer times, shall have typically less than a 1/4 cycle interruption in power to the load.
   b) The Static Transfer Switch is fuseless and consists of six pairs of Silicon Controlled Rectifiers (SCRs) connected in an AC switch configuration. The SCRs are continuous rated to carry 100% of the Liebert STS2 rated load while operating within the Liebert STS2 specifications. The use of fuses for protection is not permitted due to possible fuse clearing in an out of phase transfer.
   c) The Static Transfer Switch logic power shall automatically power up when connected to the power source. The control panel shall be active as long as one input to the Liebert STS2 is energized. The Liebert STS2 shall be supplied with factory default settings; mechanical trim pots shall not be used for calibration or adjusting settings. All settings must be adjustable; the settings shall be adjusted/configured from the LCD display.

1. Normal Mode. The unit is fed by two sources with the output connected to the load. In normal operation, the load shall be connected to the preferred source as long as all phases of the preferred source are within the acceptable limits. The transfer voltage limits shall default to ±10% of the nominal input voltage for steady state conditions, with low voltage transfer limits having an inverse time relationship that is within the IEEE Std. 446 computer voltage tolerance envelope. Upon failure of the preferred source, the load shall be transferred to the alternate source. After the preferred source returns to within the acceptable voltage limits for at least the preset adjustable retransfer time delay (typically 3 seconds) and is in phase with the alternate source, the load shall be retransferred automatically to the preferred source. The automatic retransfer to the preferred source can be disabled if so selected by the user from the operator.
control panel. When the automatic retransfer is disabled, emergency transfers from the alternate source to the preferred source shall not be disabled upon alternate source failure.

2. Load Current Inhibit (also called Ipeak or Peak Current Overload). The Liebert STS2 shall sense the load current and, if the load current exceeds an adjustable preset level deemed to represent a load inrush or fault condition, the Liebert STS2 shall disable the automatic transfer even if the voltage on the selected source exceeds the transfer limits. The load current transfer inhibit shall be [(automatically) (manually)] reset after the current returns to normal to allow for continued protection against a source failure.

3. Manual Transfer. The Liebert STS2 shall allow manually initiated transfers between the two sources, providing the alternate source is within acceptable voltage limits and phase tolerances with the preferred source. Allowable phase differences between the sources for manually initiated transfers shall be adjustable from the operator control panel. The Liebert STS2 shall be capable of tolerating transfers up to 180 degrees out of phase for emergency conditions. The user-adjustable phase synchronization window shall be limited to ±30 degrees, without the Optimized Transfer option. With the Optimized Transfer option installed, the user-adjustable phase synchronization window will be ±180 degrees. If the transfer is manually initiated, the Liebert STS2 shall transfer between the two sources without interruption of power to the load greater than 1 millisecond provided that both sources are available and synchronized within the user-adjustable phase synchronization window. For sources where the two frequencies are not exactly the same (as would be the case between a utility and standby generator source), manually initiated transfers shall be delayed by the Liebert STS2 until the two sources are within the user-adjustable phase synchronization window.

4. Emergency Transfer. In an effort to maintain power to the load, upon loss of the source that the load is connected to, the Liebert STS2 shall automatically transfer to the other source in less than 1/4 cycle, overriding any retransfer time delays or other inhibits except load overcurrent providing that the other source is available. If one source is shorted upstream, causing an undervoltage condition on that source, the Liebert STS2 will sense the undervoltage and transfer to the alternate source.

5. SCR Failure. The Liebert STS2 shall continuously monitor the status of the SCR switching devices for proper operation. In the event of a shorted SCR on the source powering the load, the Liebert STS2 shall automatically alarm the condition and trip open the other source isolation MCS. In the event of a shorted SCR on the other source, the Liebert STS2 shall automatically alarm the condition and trip open the other source isolation MCS. In the event of an open SCR, the switch shall automatically alarm the condition and transfer to the other source. All open and shorted SCR alarm conditions shall be latched and require the system to be repaired and reset to restore normal operation.

6. System Bypass. The Liebert STS2 shall be furnished with key-interlocked maintenance bypass MCSs that allow the Liebert STS2 power, controls and monitoring electronics to be bypassed to either input source for maintenance without interruption of power to the load. The packaging of the Liebert STS2 shall have all electronics isolated from the input, output and bypass connections to allow servicing of any components without access to hazardous voltages when the unit is in maintenance bypass.
C. Performance Requirements
   a) Nominal Input/Output Voltage: 480 volts three phase, 3-wire-plus-ground
   b) Default Voltage Range: +10%, -10% of nominal
   c) Nominal Frequency: 60 Hz
   d) Maximum Continuous Current: 100 amps
   e) Source Voltage Distortion: Up to 10% THD with notches and ringing transients
   f) Surge Protection: Sustains input surges without damage per criteria listed in ANSI C62.41
      Category B3
   g) Sensing and Transfer Time: typically less than ¼ cycle
   h) Overload Capability:  
      \[
      \begin{array}{ccc}
      125\% & \text{for 30 minutes (100-400A)} \\
      150\% & \text{for 2 minutes} \\
      500\% & \text{for 0.25 seconds} \\
      \end{array}
      \]
   i) Short Circuit Withstand Capability:
      \[
      \begin{array}{ccc}
      208-240V & 380-480V & 600V \\
      100-250A & 125kA & 100kA & 50kA \\
      \end{array}
      \]
D. Environmental Conditions
   a) Storage Temperature Range: -40° to +80°C (-40° to 176°F)
   b) Operating Temperature Range: 0° to 40°C (32° to 104°F)
   c) Relative Humidity: 0 to 95% without condensation
   d) Operating Altitude: Up to 4000 ft. (1200m) above sea level without derating. Above 4000 ft.
      (1200m), output current is derated by 6% per 1000 ft. (18% per 1000m).
   e) Storage/Transport Altitude: Up to 40,000 ft. (12,200m) above sea level
   f) Audible Noise: Less than 55 dBA at 5 ft. (1.5m) with audible alarm off
E. Reliability
   a) MTBF
      1. The Liebert STS2 shall be designed for high reliability and high availability with an MTBF
         exceeding 1,000,000 hours. To the fullest extent practical, redundant circuits and
         components shall be used to eliminate single points of failure.
   b) Power Supply
      1. Redundant power supplies shall be provided to prevent any single-point power supply
         failure mode. The Liebert STS2 shall have two completely separate power supplies
         mounted on separate boards so a power supply can be replaced while the load is on
         bypass. There shall be two separate DC buses, one from each power supply, to provide
         redundancy throughout the controls.
   c) Logic
      1. Control logic shall be triple-redundant. Each of the three logic modules shall have its own
         separate power connection to each power supply bus. Each logic module shall be fused
         to prevent it from shorting the power supplies if an internal failure occurs. Gating and
         control logic shall be partitioned so that the failure of one source's gating or sensing logic
         does not prevent the switch from transferring to the other source.
   d) Components
      1. All electrical components requiring normal maintenance or repair shall be replaceable
         without de-energizing the load, assuming that at least one source is available. Solid-state
         switching devices shall be packaged to allow safe repair of the switching devices without
         having to de-energize the load. All MCSs shall be of a plug-in or draw-out type to allow
replacement without de-energizing the load. All control and logic components shall be mounted separate from the power components.

e) Fuseless
   1. No fuses are used to protect the solid-state power switching devices.

f) Access
   1. The Liebert STS2 shall be designed for front access only. The Liebert STS2 shall be designed so all installation, repairs and maintenance can be done from the front or top of the unit. The Liebert STS2 shall be designed to minimize the exposure of hazardous voltages to allow safe servicing of the unit while the load is energized. Barriers shall be used on and around customer connections to protect personnel during maintenance.

1.6 DOCUMENTATION

A. Equipment Manual
   a) The manufacturer shall furnish an installation, operation and maintenance manual with installation, startup, operation and maintenance instructions for the specified system.

B. Proposal Submittals
   a) Submittals with the proposal shall include:
      1. A system one-line diagram.
      2. Outline drawing including weights, dimensions, heat dissipation and recommended service clearances.
      3. Location and detailed layouts of customer power and control connections.
      4. Description of equipment to be furnished, including deviations from these specifications.

C. Delivery Submittal
   a) Submittals upon STS delivery shall include a complete set of submittal drawings and one (1) installation, operation and maintenance manual that shall include a functional description of the equipment with block diagrams, safety precautions, instructions, step-by-step operating procedures and routine maintenance guidelines, including illustrations.

D. Spare Parts
   a) A list of recommended spare parts shall be furnished upon request.

1.7 WARRANTY

A. The manufacturer shall provide a warranty against defects in material and workmanship for 12 months after initial system startup or 18 months after ship date, whichever occurs first. (Refer to the Warranty Statement for details.)

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications
   a) A minimum of five years’ experience in the design, manufacture and testing of STS systems is required. The specified system shall be completely factory-tested before shipment. Testing shall include, but shall not be limited to: quality control checks, Hi-Pot test (two times rated voltage plus 1000 volts, per UL requirements), transfer tests and metering calibration tests. The system shall be designed, manufactured and tested according to world-class quality standards. The manufacturer shall be ISO 9001 certified.

B. Factory Testing
   a) Before shipment, the manufacturer shall fully and completely test the Liebert STS2 to assure compliance with the specifications.
PART 2 - PRODUCT

2.1 FABRICATION

A. Materials
   a) All materials of the Liebert STS2 shall be new, of current manufacture, high grade and free from all defects and shall not have been in prior service except as required during factory testing.
   b) The maximum working voltage, current and di/dt of all solid-state power components and electronic devices shall not exceed 75% of the ratings established by their manufacturer. The operating temperature of solid-state component subassembly shall not be greater than 75% of their ratings.

B. Wiring
   a) Wiring practices, materials and coding shall be in accordance with the requirements of the National Electrical Code (NFPA 70). All bolted connections of busbars, lugs and cables shall be in accordance with requirements of the National Electrical Code and other applicable standards. All electrical power connections are to be torqued to the required value and marked with a visual indicator.
   b) Provision shall be made for power and control cables to enter or leave from the top or bottom of the Liebert STS2 cabinet.

C. Frame and Enclosure
   a) The Liebert STS2 unit, comprised of solid-state, three-pole, dual-position transfer switch, key-interlocked static switch isolation and bypass MCSs, shall be housed in a single free-standing NEMA type 1 enclosure and meet IP20 requirements. The frame shall be constructed of galvanized steel and pop riveted to provide a strong substructure. The frame shall include four heavy-duty swivel castors for ease of installation and four permanent leveling feet for final installation. Doors and removable exterior panels shall be a minimum of 16GA steel and be powder-painted the manufacturer’s standard color textured enamel finish paint. A key-lock, hinged front door shall provide access to the MCSs. A tool shall be required to remove exterior panels that expose hazardous voltages. All removable panels shall be grounded to the frame for safety and EMI/RFI protection. The cabinet shall be structurally designed to handle forklifting from the base.
   b) Removable conduit/cable termination plates shall be provided in the top and bottom of the unit for termination of the two source input and/or output conduits, raceways or cables.
   c) The complete STS shall have maximum dimensions of 30 in. wide by 32.2 in. deep by 77 in. high.
   d) The Liebert STS2 can be tipped 15 degrees in any direction without falling over.

D. Cooling 100A
   a) The Liebert STS2 shall utilize convection air cooling for the enclosure with forced air cooling of the heat sinks. All fans shall be redundant so that a single fan failure will not cause temperature to increase beyond acceptable limits. Individual sensor(s) are located on heat sinks for alarm and shutdown. Heat rejection shall be through screened protective openings in the top of the unit. Air filters shall be located in the front door at the point of air inlet.

E. Grounding
   a) The Liebert STS2 shall operate from sources that are solidly grounded or impedance-grounded (for 480V and below). The unit shall not be used on corner-grounded delta systems.
   b) The AC output neutral shall be electrically isolated from the Liebert STS2 chassis. The Liebert STS2 chassis shall have an equipment ground terminal.

2.2 COMPONENTS

A. Molded-case Switches (MCS)
a) The Liebert STS2 shall be equipped with five MCSs. The MCSs shall be UL listed and IEC rated for use at the system voltage. The plug-in feature of the breaker shall include interlock, which prevents the breaker from being unplugged without being in the Off (open) position. Three of the MCSs shall provide for total isolation of the solid-state switching devices with an input MCS for each source and a load isolation MCS. Two of the MCSs shall provide for maintenance bypassing of the solid-state switching devices to either input source. Key interlocks shall be provided on the MCSs to prevent improper maintenance bypassing of the solid-state switch. A bypass MCS cannot be closed unless the solid-state switch is connected to the same input source, and only one bypass MCS can be closed at a time. All MCSs shall be equipped with N.O. and N.C. auxiliary switches for monitoring of the breaker positions. The two input MCSs for the solid-state switching devices also shall be equipped with 48 VDC shunt trips to allow for control by the Liebert STS2 logic.

B. Silicon Controlled Rectifiers (SCRs)

a) The Liebert STS2 consist of six pairs of SCRs connected in an AC switch configuration. The SCRs shall be brick-type and rated to carry the full 100% rated load. The SCRs shall be rated to prevent hazardous device failure in power systems with available fault currents listed under Section 0, Item i).

C. Control Panel

a) The Liebert STS2 shall be provided with a microprocessor-based Human-Machine Interface (HMI) to configure and monitor the Liebert STS2. The HMI shall be located on the front of the unit and can be operated without opening the hinged front door. The HMI shall not be mounted to the front door so the door can be easily removed for maintenance. A backlit, menu-driven, full graphics, color touch-screen Liquid Crystal Display (LCD) shall be used to display system information, status information, a one-line diagram of the Liebert STS2, active alarms, alarm history information, startup and bypass instructions. No mechanical pushbuttons shall be used.

b) The mimic screen shall indicate the power flow, the status of all MCSs, the preferred source and the Liebert STS2 position (connected to source 1 or 2) as well as active alarms.

c) Pop-up boxes selected from the menu bar shall be provided for operator interface to the HMI for menu selection, control of the preferred source, manual transfer initiation, auto/manual retransfer selection and other system setpoints. In addition, an operator can silence and reset the audible alarm by touching the screen. To facilitate STS operation, help text, step-by-step startup, transfer and maintenance bypass procedures shall be displayed on the LCD screen. For manual transfers, a syncscope shall display the leading or lagging real-time phase difference between the two input sources.

d) The HMI shall be equipped with an internal RS232 port and Flash memory to allow the Liebert STS2 software to be upgraded by a factory-trained customer engineer without shutting down the load.

e) To facilitate diagnostics, an event log of the last 512 alarm events shall be stored in non-volatile memory and displayed on the LCD. Two history logs, each having 64 frames of unit status frozen upon an alarm condition designated as a freeze fault, will be stored in non-volatile memory and displayable on the LCD. A frame shall be acquired every 4 milliseconds, with 40 frames before the fault and 23 frames after the fault. Each frame contains metering data, active alarms/faults and unit status. A system calendar and real-time clock shall be included to time-stamp all stored events. Monitored parameters shall be acquired two times per 4-millisecond frame.

f) CAN bus shall be used to communicate between the logic and the HMI as well as the options.

g) For remote monitoring, a serial RS-232 port shall provide present switch status information, alarm history information and the history of status screens that are triggered upon a major alarm event.

1. Metering

   The following metering parameters shall be displayed:

   i. Input AC voltage for both sources, line-to-line for each phase
ii. Input AC current for both sources for each phase
iii. Input frequency for both sources
iv. Output kVA
v. Output kW
vi. Percent load
vii. Number of switch transfers
viii. Synchronization phase angle

All voltages and currents shall be measured using true-RMS techniques for accurate representation of non-sinusoidal waveforms associated with computers and other electronic loads. The metering parameters shall have a full-scale accuracy of ±2%.

2. Alarm Messages

Active alarms shall be monitored and displayed simultaneously as part of the LCD event panel. The following alarm messages shall be displayed:

Source 1 Failure CB1 (Source 1) Open Power Supply S1 AC Failed
Source 2 Failure CB2 (Source 2) Open Power Supply S2 AC Failed
Sources Out of Sync CB3 (Output) Open Power Supply DC A Failed
Source 1 Overvoltage CB3A Open (If used) Power Supply DC B Failed
S1 Undervoltage (fast) CB4 (S1 Bypass) Closed Power Supply Logic Failed
S1 Undervoltage RMS (slow) CB5 (S2 Bypass) Closed S1 Voltage sense module failed
Source 2 Overvoltage CB1 Shunt trip fail S2 Voltage sense module failed
S2 Undervoltage (fast) CB2 Shunt trip fail S1 SCR sense module failed
S2 Undervoltage RMS (slow) S1 SCR Open S2 SCR sense module failed
Source 1 Overcurrent S2 SCR Open S1 Current sense module failed
Source 2 Overcurrent S1 SCR Shorted S2 Current sense module failed
Source 1 Over/Under Frequency S2 SCR Shorted S1 Gate drive module failed
Source 2 Over/Under Frequency Primary fan failure S2 Gate drive module failed
Source 1 Phase Rotation Error Control Module Fail Internal comm failed
Source 2 Phase Rotation Error S1 I-peak Option comm failed
Output undervoltage S2 I-peak Output voltage sense module failed
STS on alternate source Auto Retransfer Inhibit Heatsink Overtemp
Transfer Inhibit
An audible alarm shall be activated when any of the alarms occurs. All alarms shall be displayed in text form.

2.3 ACCESSORIES PROVIDED

A. Optimized Transfer

a) The Liebert STS2 shall be furnished with an optimized transfer control algorithm. This algorithm shall optimize the Liebert STS2 transfer timing such that the volt-seconds applied to a downstream transformer(s) primary is balanced, thus sufficiently minimizing peak saturation current drawn by the downstream transformer(s).

b) In addition to controlling the transformer primary current and flux, the optimized transfer control algorithm must maintain the load voltage within the CBME/ITIC Standards during the transfer. To maintain load voltage after the preferred source is turned off, the control algorithm must be able to pulse-fire the alternate source SCRs to minimize load discontinuity and voltage disruption.

c) The Liebert STS2 must maintain the above specification under the following conditions:

1. Loss of source
2. Loss of a single phase
3. Voltage droop
4. Phase-to-neutral short
5. Phase-to-phase short
6. Power factor load range of 0.75 to 1.0 leading or lagging
7. Out-of-phase conditions from +180° to -180°

B. Programmable Relay Board

a) A Programmable Relay Board with eight sets of isolated Form C contacts shall be provided to indicate a change of status of any alarm condition. Any alarm can be programmed onto any channel or channels. Up to two programmable relay boards can be installed in the Liebert STS2. Programming is performed through the touch screen display. Each contact shall be rated 1A @ 30 VDC or 250mA @ 125 VAC.

C. Communications Board

a) The Liebert STS2 shall be provided with a Communications Board that can communicate with a Liebert SiteScan® monitoring system.

b) The Liebert STS2 shall be equipped with an RS-422 communication port for communication to a Liebert SiteScan monitoring system using a 2-wire twisted pair for reliable communication up to 3281 ft. (1000m). Information available from the RS-422 port shall include the present switch status information, all monitoring parameters and all active alarms.

D. Liebert IntelliSlot® Web/485 Card with Adapter

a) The Liebert STS2 shall have a Liebert IntelliSlot network card that enables the Liebert STS2 to communicate with a network management system (NMS). The Liebert IntelliSlot Web/485 Card with Adapter (IS-WEB485ADPT) will include internal hardware and software to communicate (via SNMP and HTTP) to any IP-based Ethernet network through a RJ-45 connector. The Liebert IS-WEB485ADPT shall provide redundant paths for communication that make it possible to connect to a Building Management System (BMS) using 2-wire Modbus while simultaneously communicating with an NMS through SNMP and HTTP. A terminal block shall be provided to connect to Modbus.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL
The following inspections and test procedures shall be performed by factory-trained field service personnel during the Liebert STS2 startup.

A. Visual Inspection
   a) Inspect equipment for signs of damage.
   b) Verify installation per drawings.
   c) Inspect cabinets for foreign objects.
   d) Verify neutral (if used) and ground conductors are properly sized and configured.
   e) Verify all printed circuit boards are configured properly.

B. Mechanical Inspection
   a) Check all control wiring connections for tightness.
   b) Check all power wiring connections for tightness.
   c) Check all terminal screws, nuts and spade lugs for tightness.

C. Electrical Inspection
   a) Check all fuses for continuity.
   b) Confirm input voltage and phase rotation is correct.
   c) Verify control transformer connections are correct for voltages being used.

3.2 MANUFACTURER’S FIELD SERVICE

A. Service Personnel
   a) The Liebert STS2 manufacturer shall directly employ a nationwide service organization, consisting of factory-trained field service personnel dedicated to the startup, maintenance and repair of UPS and power equipment. The organization shall consist of regional and local offices.
   b) The manufacturer shall provide a fully automated national dispatch center to coordinate field service personnel schedules. One toll-free number shall reach a qualified support person 24 hours/day, 7 days/week, 365 days/year. If emergency service is required, response time shall be 20 minutes or less.
   c) An automated procedure shall be in place to ensure that the manufacturer is dedicating the appropriate technical support resources to match escalating customer needs.

B. Replacement Parts Stocking
   a) Parts shall be available through an extensive network to ensure round-the-clock parts availability throughout the country.
   b) Recommended spare parts shall be fully stocked by local field service personnel with backup available from the national parts center and the manufacturing location. The national parts center Customer Support Parts Coordinators shall be on call 24 hours/day, 7 days/week, 365 days/year for immediate parts availability. Parts from the national parts center shall be shipped within 4 hours on the next available flight out and delivered to the customer’s site within 24 hours.

C. STS Maintenance Training
   a) Maintenance training courses for customer employees shall be made available by the Liebert STS2 manufacturer. This training is in addition to the basic operator training conducted as a part of the system startup.
   b) The training course shall cover STS theory, location of subassemblies, safety and STS operational procedures. The course shall include control, metering and feedback circuits to the Printed Circuit Board (PCB) level. Troubleshooting and fault isolation using alarm information and internal self-diagnostics should be stressed.

D. Maintenance Contracts
a) A complete offering of preventive and full service maintenance contracts for the Liebert STS2 shall be available. An extended warranty and preventive maintenance package shall be available. Factory-trained service personnel shall perform warranty and preventive maintenance service.

END OF SECTION
SECTION 26 43 00
SURGE PROTECTIVE DEVICE

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 section 26 05 00 “Common Work Results for Electrical” apply to this section.

1.2 SUMMARY
A. These specifications describe the electrical and mechanical requirements for a modular, high-energy surge protective device (SPD). The specified system shall provide effective, high-energy surge current diversion and be suitable for use as Type 1, 20kA device per ANSI/UL 1449 Fourth Edition.

1.3 STANDARDS
A. The specified system shall be designed, manufactured, tested and installed in compliance with the following codes and standards:
B. Underwriters Laboratories; ANSI/UL 1449 4th Edition 2014 Revision
Underwriters Laboratories; UL 1283 6th Edition 2015 (complimentary listing for Type 2 locations)
Canadian Underwriters Laboratories (cUL)
American National Standards Institute and Institute of Electrical and Electronic Engineers (ANSI/IEEE C62.34, C62.41, C62.45)
Institute of Electrical and Electronic Engineers 1100 Emerald Book
Federal Information Processing Standards Publication 94 (FIPS PUB 94) National Fire Protection Association (NFPA 20, 70, 75 and 780)
International Standards Organization (ISO) Company certified ISO 9001 for manufacturing, design and service
Federal Communications Commission (FCC)
C. The system shall be UL listed and labeled under ANSI/UL 1449 Fourth Edition and the voltage protection ratings (VPRs) shall be permanently affixed to the SPD. Type 2 units of the product family shall be cUL listed and labeled to UL1283 Standard for Electromagnetic Interference Filters.

1.4 SYSTEM DESCRIPTION
A. The system shall be constructed using multiple surge current diversion modules utilizing metal oxide varistors (MOV) computer matched to a variance of ±1 volt and tested for manufacturing defects. The modules shall be designed and constructed in a manner that ensures surge current sharing. Use of gas tubes, silicon avalanche diodes or selenium cells are unacceptable unless documentation from a nationally recognized laboratory demonstrates current sharing of all dissimilar components at all surge current levels.

1.5 ELECTRICAL REQUIREMENTS
A. Nominal system operating voltage
277/480 VAC
WYE Configuration
3 Phase
4 Wires plus Ground
B. Maximum Continuous Operating Voltage (MCOV): The SPD and all components in the suppression path (including all current diversion components) maximum continuous operating voltage (MCOV) shall be greater than 115% of the nominal system operating voltage to ensure the ability of the system to withstand temporary RMS over-voltage (swell.
C. Operating Frequency: The operating frequency range of system shall be at least 47-63 Hz.

1.6 LIFE CYCLE TESTING

A. The SPD shall be duty life cycle tested to withstand 10kA (8x20 µs), 20kV (1.2x50µs), IEEE C62.41 Category C surge current with less than 5% degradation of clamping voltage. The minimum numbers of surges the unit shall be able to protect against are:

B. Number of Life Cycle Surges: (Selection Required)
   15,000 Life Cycle Surges per Mode
   30,000 Life Cycle Surges per Phase

1.7 OVER CURRENT PROTECTION

A. Fusing: All suppression components shall be individually fused and rated to allow maximum specified surge current capacity. For every 100k amps of surge current capacity, 120 amps RMS of internal, integral fusing shall be required. Devices that utilize a single fuse to protect two or more suppression paths are not excepted. Individual surge components shall be sand packed and shall be UL listed to be capable of interrupting up to 200 kA symmetrical fault current with 480 VAC applied. Replaceable fusing is unacceptable. Overcurrent protection that limits specified surge currents is not acceptable.

1.8 PERFORMANCE RATINGS

A. Surge Current Capacity:
   80 kA Surge Rating per Mode
   160 kA Surge Rating per Phase (L-N and L-G)

1.9 DESIGN REQUIREMENTS

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. Protection Modes: The SPD shall provide protection as follows: All modes, L-N or L-L, L-G and N-G (where applicable). Note: L = Line, G = Ground, N = Neutral

C. ANSI/UL 1449 Voltage Protection Ratings: The maximum UL 1449 listed surge ratings for each and/or all of the specified protection modes shall not exceed the following:

<table>
<thead>
<tr>
<th>System Voltage</th>
<th>ANSI/UL 1449 Fourth Edition VPR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L-N</td>
</tr>
<tr>
<td>120/208</td>
<td>700V</td>
</tr>
<tr>
<td>277/480</td>
<td>1000V</td>
</tr>
<tr>
<td>480</td>
<td></td>
</tr>
</tbody>
</table>

D. ANSI/UL 1449 Nominal Discharge Current: The ANSI/UL 1449 Nominal Discharge Current Rating shall be a minimum of 20kA.

1.10 SUBMITTALS
A. Documentation: These specifications are based on the ASCO Model 560. All other manufacturers shall submit for 10-day pre-approval, a detailed compliance or exception statements to all provisions of this specification to allow consideration. Additionally, manufacturers shall submit test data verifying the following: life cycle testing, overcurrent protection, UL1449 Fourth edition, noise attenuation and surge current capacity. Failure to do so will result in product disapproval. Any deviation from the published specification will result in an applicable deduct applied.

B. Equipment Manual: The manufacturer shall furnish an installation manual with installation, startup, and operating instructions for the specified system.

C. Drawings: Electrical and mechanical drawings shall be provided by the manufacturer that show unit dimensions, weights, component and connection locations, mounting provisions, connection details and wiring diagram.

1.11 QUALITY ASSURANCE

A. The manufacturer shall be ISO 9001:2000 certified. The specified interconnect assembly shall be designed and manufactured in the USA by a qualified manufacturer of SPD products and line conditioning equipment. The manufacturer shall have been engaged in the design and manufacturer of such products for a minimum of 20 years.

1.12 ENVIRONMENTAL REQUIREMENTS

Storage Temperature: -55 to +85°C (-67 to +185°F)
Operating Temperature: -40 to +60°C (-40 to +140°F)
Relative Humidity: 0% to 95% (non-condensing)
Audible Noise: less than 45dB at 5 feet (1.5m)
Operating Altitude: 0 to 18,000 feet (5,486m) above sea level

1.13 WARRANTY

A. The manufacturer shall provide a full ten-year parts and five-year labor warranty from date of shipment against any part failure when installed in compliance with manufacturer’s written instructions, UL Listing requirements and any applicable national, state or local electrical codes. Direct factory trained, ISO 9001:2000 certified employees must be available for 48-hour assessment. A 24-hour 800 number must be available to support warranty.

PART 2 - PRODUCTS

2.1 ENCLOSURE

A. The specified system shall be provided in a heavy duty NEMA 4 dust-proof, drip-proof enclosure with no ventilation openings. The cover of the enclosure shall be hinged on the left side and require a tool for access to internal components. All monitoring indication must be visible without opening the door. The enclosure maximum dimensions shall be 20 in. (508 mm) high x 20 in. (508 mm) wide x 10 in. (254 mm) deep.

2.2 CONNECTIONS

A. The terminals shall be provided to accommodate wire sizes up to #2/0 AWG.

2.3 INTERNAL CONNECTIONS AND SERVICABILITY

A. All surge current diversion module connections shall be by way of low-impedance copper plates. Surge current diversion modules shall use bolted connections to the plates for reliable, low-impedance connections. The system shall be designed for easy servicing by a qualified
field electrician, providing simple change out of any or all SPD modules. Designs that require factory service are not acceptable. Any unit using “plug-in” type modules are not acceptable. All connections, conductors and terminals must be appropriately sized for specified surge current capacity.

2.4 STANDARD FEATURES

A. Unit Testing Capability—The SPD monitoring circuitry must continually verify the protection status during operation and display this information on the front cover status panel. The SPD must also contain a built-in-test circuit that will verify the integrity of all fuse links and each associated MOV. The built-in-test circuit must cycle through all phase banks and the neutral-ground bank sending test signals to all modules. The integrity of all fuses in test must be indicated on the status panel. All testing must be able to be performed without disconnecting power to the SPD. Units that require external test sets or equipment are unacceptable.

B. Unit Status Indicators—SPD shall be equipped with red and green solid state indicators for each phase and N-G (where applicable). Indicators must be mounted within the enclosure and must be externally visible.

C. Dry Contacts for Remote Monitoring—SPD must have a minimum of 2 sets of electrically isolated Form C dry contacts, one normally open and one normally closed.

D. Undervoltage Detection—SPD shall be equipped with 70% undervoltage detection.

E. Phase Loss Monitoring—SPD shall be equipped with phase loss monitoring.

F. Power Loss Monitoring—SPD shall be equipped with power loss monitoring.

G. Audible alarm—The specified system shall be equipped with an audible alarm that is activated during a fault condition. In conjunction with alarm, an alarm on/off switch shall be provided to silence the alarm, and an alarm push-to-test switch shall be provided to test the alarm’s function. A visible LED will confirm whether alarm is on or disabled. Both switches shall be located on the unit’s hinged front cover.

2.5 OPTIONAL FEATURES

A. Transient Counters—Single or dual adjustable transient counters shall be available to tally Normal & Common mode transient voltage surges in both surge and swell conditions. The readout shall be at least a seven-digit LCD located on the unit’s hinged front cover. The counter reset switches may be inhibited and must be remotely located. Counter must utilize lithium batteries with a 10-year nominal life to maintain accurate counts in the event of total power loss.

2.6 TESTING

A. Component Testing and Monitoring: 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 [1.2x50µs], 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 [1.2x50µs], 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%.

Due to present industry test equipment single pulse surge current capacities over 200,000 amps are established via testing of individual modules in each mode.

PART 3 - EXECUTION

3.1 INSTALLATION

12/12/19 26 43 00 - 4 8514
A. The installing contractor shall install the parallel SPD with short and straight conductors as practically possible. The contractor shall twist the SPD input conductors together to reduce input conductor inductance. The contractor shall follow the SPD manufacturer’s recommended installation practices as found in the installation, operation and maintenance manual and comply with all applicable codes.

*These Guide Specifications comply with the outlines of the Construction Specification Institute per CSI MP-2-2-85 and MP-2-1-88*

END OF SECTION