

SECTION 09 51 00 - ACOUSTICAL CEILINGS Addendum 1 (Revision 2)

PART 1 - GENERAL

1.1 SCOPE:

The work covered by this section consists of furnishing all labor and materials for the complete installation of acoustical tile ceilings.

1.2 QUALITY ASSURANCE:

- A. In addition to complying with all pertinent codes and regulations, comply with all pertinent recommendations published by the Ceilings and Interior Systems Contracting Association and the requirements of ASTM C636 (latest edition).
- B. Seismic Loads: Design and size components to withstand seismic loads in accordance with the local governing building code, for the seismic design category as indicated on the structural drawings.

1.3 SUBMITTALS:

- A. Prior to installation, submit the following to the Architect for review:
 - 1. Submit manufacturer's project specifications and installation instructions for each type of acoustical panel and suspension system required, including certified laboratory test reports and other data necessary to show compliance with these specifications.
 - 2. Include manufacturer's recommendations for cleaning and refinishing acoustical panels, including precautions against materials and methods which may be detrimental to finishes and acoustical performances.
 - 3. Shop drawings, showing layout of each type of ceiling system in relation to surrounding structure, mechanical work (which shall include, but not be limited to, duct work and piping), lighting and electrical work, and any other pertinent fixtures and equipment. Drawings shall also show location of accessible panels. The reproduction of Architect's Drawings as the basis of these shop drawings will not be acceptable.
 - 4. Physical Samples: Furnish one sample of each type of ceiling board or tile and exposed grid in finish and pattern specified.

1.4 JOB CONDITIONS:

- A. Do not install interior acoustical panel ceilings until space enclosed and weatherproof, and until work above ceilings completed, and unit ambient conditions of temperature and humidity will be continuously maintained at values near those indicated for final occupancy.

1.5 EXTRA MATERIALS

- A. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Ceiling Panels: 2 unopened boxes for each type indicated.

- B. This material shall not be available to the contractor for replacement goods within the building warranty period.

PART 2 - PRODUCTS

2.1 ACOUSTICAL CEILING:

A. Ceiling panel:

1. ACT-1: (TYPE 1# Ceiling Types per Reflected Ceiling Plan Legend.)
Basis of design: Beveled Tegular edge lay-in 24" x 24" x 5/8" with a 9/16" ceiling grid suspension system.
 - a. Armstrong; Dune Beveled Tegular edge lay-in, No. 1775 (White), 24" x 24" x 5/8" Beveled tegular lay-in, (White), 24" x 24" x 5/8" with 9/16" Superfine Exposed Grid.
 - b. CertainTeed; SMH-190 Sand Micro Narrow Beveled Tegular edge lay-in, (White), 24" x 24" x 5/8" New Line.
 - c. USG; Olympia Micro. #4231, FLB (Fineline Beveled Edge), (White), 24" x 24" x 5/8" with 9/16" USG Centricitee™ DXT™, White
2. ACT-2: (TYPE 2# Ceiling Types per Reflected Ceiling Plan Legend.)
Basis of design: Vinyl faced Square edge lay-in 24" x 24" x 5/8" with a 15/16" ceiling grid aluminum suspension system.
 - a. Armstrong Clean Room V L, Unperforated No. 868, Square edge lay-in (White), 24" x 24" x 5/8"
 - b. USG "Clean Room" with Clima Plus No. 56099, Square edge lay-in (White), 24" x 24" x 5/8" New Line
 - c. CertainTeed "Vinyl Shield A" No. 1102-CRF-1, (White), 24" x 24" x 5/8"
3. ACT-3: (Type 3# Ceiling Types per Reflected Ceiling Plan Legend)
Basis of design: 2'x2' acoustical ceiling in back of house areas with square edge and 15/16" white grid.
 - a. Armstrong; Cortega, 15/16" square lay-in. No. 770, (White). 24" x 24" x 5/8"
 - b. USG Radar: No. 2110 (White). 24" x 24" x 5/8.
 - c. CertainTeed; Baroque, No BET – 157, (White). 24" x 24" x 5/8.

B. Suspension System:

1. Exposed grid suspension system designed to accommodate ceiling board.
2. Suspension system shall conform to ASTM C635-78 and installation shall be in accordance with ASTM C636-76.
3. The suspension system shall support the ceiling panels with a maximum deflection of 1/360 of span. Exposed finish shall be white unless otherwise noted. The system shall include, but not be limited to, the following:
 - a. Material:
 - 1) Components shall be formed from commercial quality cold-rolled steel electrogalvanized.
 - 2) High Use Kitchen/Decontamination room applications ACT-2 (Vinyl Faced Tiles): Components shall be formed from commercial quality aluminum construction for maximum corrosion resistance and non-magnetic environments. (Specify for use in commercial kitchens and decontamination rooms only)
 - b. Main Tee: Double web design; with cross tee holes at 6" O.C.; with hanger wire

holes at 2" O.C.; with an integral reversible splice.

- 1) 9/16" exposed face for non-rated assemblies.
 - 2) 15/16" exposed face for non-rated assemblies.
 - 3) 15/16" exposed face Fire Guard for rated assemblies.
- c. Cross Tee: Double web design; with web extended to form a positive interlock between cross tee webs through intersecting tee web holes; with the lower flange extended and offset to provide a flush level intersection.
 - d. Wall molding of a channel or angle shape with an exposed face.

2.2 OTHER MATERIALS:

- A. All other materials, not specifically described but required for a complete and proper installation of the suspended acoustical ceiling, shall be as selected by the Contractor subject to the approval of the Architect.

PART 3 - EXECUTION

3.1 SURFACE CONDITIONS:

- A. Prior to all work of this Section, carefully inspect the installed work of all other Trades and verify that all such work is complete to the point where this installation may properly commence.
- B. Verify that suspended acoustical ceiling may be installed in accordance with the original design, all codes and regulations, the manufacturer's current recommendations and the approved submittals.
- C. In the event of discrepancy, immediately notify the Architect.
- D. Do not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.

3.2 COORDINATION WITH MECHANICAL AND ELECTRICAL:

- A. Coordinate with the requirements of other Trades. Use all means necessary to interface with adjacent materials.
- B. Where recessed lighting fixtures are installed in suspension system, consult with the fixture manufacturer prior to preparation of shop drawings so that the work of this Section shall be installed ready to receive the lighting fixtures. Modify the suspension system members adjacent to fixture locations as approved by the Architect and to the extent necessary to accommodate the fixtures.
- C. In the event lighting fixtures or air distribution or return air equipment other than those specified should be substituted under their respective Sections and/or Drawings and should the substituted fixtures require more extensive modifications, the Contractor shall make such required additional modifications and any additional cost shall be paid by the Contractor.
- D. Where wide or deep air conditioning ducts above suspended acoustical ceilings interfere with suspension hangers, provide independent framing below the duct work to support the ceiling as an obligation under this Section. Framing shall meet the approval of the Architect. Framing shall be supported from floor or roof structure above and shall in no case be attached to the duct work, piping or conduit.

3.3 SUSPENDED CEILING INSTALLATION:

- A. Comply with ASTM C 636 as applicable to acoustical panel ceilings, except to extent more stringent requirements indicated or required for compliance with governing regulations or fire resistance ratings.
- B. Suspend ceiling hangers from building structural members only, and only as indicated.
 - 1. Secure to structure, including intermediate framing members, by attaching to metal clips designed for type of member involved, or where possible, by looping and wire-tying directly to members.
- C. Space hangers not more than 4'-0" o.c. along each member supported directly from hangers, unless otherwise shown, and provide hanger not more than 6" from ends of each member.
- D. For the support of light fixtures, the fixture load shall be supported by supplemental hangers within 6" of each corner, or the fixture shall be supported separately.

3.4 MOLDINGS:

- A. Cope exposed flanges of intersecting members so that flange faces will be flush.
- B. Install edge moldings of type indicated at edges of each acoustical panel ceiling area, and at locations where edge of panel would otherwise be exposed after completion of work.
- C. Secure moldings to building construction by fastening through holes drilled in vertical leg. Space holes not more than 3" from each end and not more than 16" o.c. Draw-up fasteners for tight set against vertical surfaces.
- D. Miter corners of moldings accurately to provide hairline joints.
- E. Level moldings with ceiling suspension system, to level tolerance of 1/8" in 12'-0".

3.5 ACOUSTICAL PANEL INSTALLATION:

- A. Plan each layout to balance border widths at opposite edges of each ceiling area. Avoid use of less-than-half width units wherever possible. Comply with Architect's reflected ceiling plans to greatest extent possible.
- B. Install acoustical panels in coordination with suspension system, with edges concealed by support of suspension members.
- C. Scribe and cut panels for accurate fit at borders and at interruptions and penetrations by other work through ceilings.

3.6 CLEANING AND PROTECTION:

- A. Clean exposed surfaces of acoustical panels and of trim, edge moldings, and suspension members; comply with manufacturer's instructions for cleaning and touch-up of minor finish damage. Remove and replace work which cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.
- B. Institute required protection for acoustical panel ceilings, including temperature and humidity

limitations and dust control, so that work will be without damage and deterioration at time of substantial completion.

END OF SECTION 09 51 00

SECTION 10 14 00 – SIGNAGE Addendum 1 (Revision 2)

PART 1 - GENERAL

1.01 SUMMARY:

- A. This section includes the following types of signs:
 - 1. Interior Plastic Plaques.
 - 2. Exterior Plastic Plaques
 - 3. Cast Aluminum Letter Signage
 - 4. Applied Vinyl Signs
 - 5. Metal Informational Signs
 - 6. Metal County Seals
 - 7. Bronze Dedication Plaque
 - 8. Rated Wall Marking
- B. Related Sections: The following sections contain requirements that relate to this section:
 - 1. Division 22 sections for labels, tags, and nameplates for plumbing equipment.
 - 2. Division 23 sections for labels, tags, and nameplates for mechanical equipment.
 - 3. Division 26 sections for labels, tags, and nameplates for electrical equipment.
 - 4. Civil drawings for Accessible Parking Signage and Painted Directional Arrows.
 - 5. Section 01 58 00 – Project Identification for the Project Sign

1.02 SUBMITTALS:

- A. General:
 - 1. Submit the following according to the Conditions of the Contract and Division 01 Specification Sections.
- B. Product Data:
 - 1. Product data for each type of sign specified, including details of construction relative to materials, dimensions of individual components, profiles, and finishes.
- C. Samples: Provide the following samples of each sign component for initial selection of color, pattern and surface texture as required and for verification of compliance with requirements indicated.
- D. Color Charts: Manufacturer's color charts consisting of actual sections of material including the full range of colors available for each material required.
- E. Samples of Interior Plaques: Two actual-sized samples of interior plaques showing compliance with requirements.

1.03 QUALITY ASSURANCE:

- A. Sign Fabricator Qualifications: Firm experienced in producing signs similar to those indicated for this Project, with a record of successful in-service performance, and sufficient production capacity to produce sign units required without causing delay in the Work.
- B. Single-Source Responsibility: For each separate sign type required, obtain signs from one source of a single manufacturer.

- C. Design Concept: The drawings indicate sizes, profiles, and dimensional requirements of signs and are based on the specific types and models indicated. Sign units by other manufacturers may be considered provided deviations in dimensions and profiles do not change the design concept as judged by the Architect. The burden of proof of equality is on the proposer.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Subject to compliance with requirements, provide products by one of the following:
1. Manufacturers of Cast Letters:
 - a. Andco Industries Corp.
 - b. ASI Sign Systems, Inc.
 - c. Gemini, Inc.
 - d. Leeds Architectural Letters, Inc.
 - e. Spanjer Brothers, Inc.
 - f. Vomar Products, Inc.
 - g. Signage Industries, Inc.
 - h. 2/90 Signage Systems
 - i. Mohawk Sign Systems
 - j. Signcraft USA
 2. Manufacturers of Interior and Exterior Plastic Plaques:
 - a. Andco Industries Corp.
 - b. ASI Sign Systems, Inc.
 - c. Leeds Architectural Letters, Inc.
 - d. Signage Industries, Inc.
 - e. 2/90 Signage Systems
 - f. Mohawk Sign Systems
 - g. Rite Lite Signs, Inc.
 - h. Signcraft USA

2.02 MATERIALS:

- A. Cast Acrylic Sheet: Provide cast (not extruded or continuous cast) methyl methacrylate monomer plastic sheet, in sizes and thick nesses indicated, with a minimal flexural strength of 16,000psi when tested according to ASTM D 790, with a minimum allowable continuous service temperature of 176 deg F.
- B. Aluminum Sheet: Provide aluminum sheet of alloy and temper recommended by the sign manufacturer for the type of use and finish indicated, and with not less than the strength and durability properties specified in ASTM B 209 for 5005-H15.
- C. Fasteners: Use concealed fasteners fabricated from metals that are not corrosive to the sign material and mounting surface.
- D. Anchors and Inserts: Use nonferrous metal or hot-dipped galvanized anchors and inserts for exterior installations and elsewhere as required for corrosion resistance. Use toothed steel or lead expansion bolt devices for drilled-in-place anchors. Furnish inserts, as required, to be set into masonry work.
- E. Colored Coatings for Acrylic Plastic Sheet: Use colored coatings, including inks and paints for copy and background colors, that are recommended by acrylic manufacturers for optimum adherence to acrylic surface and are nonfading for the application intended.

2.03 FINISHES:

- A. Baked-Enamel Finish: AA-M4xC12C42R1x (Mechanical Finish: Manufacturer's standard, other non-directional textured; Chemical Finish: Chemical conversion coating, acid chromate-fluoride-phosphate pretreatment; Organic Coating: as specified below). Apply baked enamel in compliance with paint manufacturer's specifications for cleaning, conversion coating, and painting.
 - 1. Organic Coating: Thermosetting-modified acrylic enamel primer/topcoat system complying with AAMA 603.8 except with a minimum dry film thickness of 1.5 mils, medium gloss.
 - a. Color: Selected from manufacturer's standard colors
- 2.05 INTERIOR PLASTIC PLAQUES: Sign Types 1 through 8, 15, 16, 17, and 27
 - A. Plaques: Plaque signs shall be a modular type signage system. Signs shall be fabricated of acrylic.
 - 1. Material: Factory-painted matte finish acrylic plastic laminated to acrylic back, thickness and size as shown; 1/2" radius corners.
 - B. Window Signs: Window signs shall consist of acrylic back laminated to matte finish acrylic plastic face with message slots as detailed for insertion of changeable message strips. Thickness and size of signs shall be as shown. Corners of signs shall be 1/2" radius.
 - C. Mounting: 1/16-inch-thick double-sided vinyl foam tape.
 - D. Tactile Graphics: Signage shall be tactile (Perceptible to touch); comply with ANSI A117.1, paragraph 4.28. Letters, numbers, and pictograms on tactile signs shall be raised 1/32 inch minimum. Tactile letters and numbers shall be Helvetica Regular and 5/8 inch high. Raised characters and symbols shall be accompanied by Grade 11 Braille. The Contractor shall be responsible for the translations into Braille. Letters shall contract with their background.
 - 1. Graphics Application: Signage graphics shall be relieved 1/32 inch minimum from plaque first surface by photomechanical stratification process. Cut and adhered graphics will not be acceptable.
 - E. Messages: See signage locations and details on sheets A711 and A712.
- 2.06 EXTERIOR PLASTIC PLAQUES: Sign Types 9, 13, 14, and 15
 - A. Provide materials to match the interior signs as indicated above, except modified as recommended by the manufacturer to withstand exterior local weather conditions for not fewer than 10 years without discoloration, delamination, or detachment from its substrate mounting.
- 2.07 CAST ALUMINUM LETTER SIGNAGE: Sign Type 25 and used on Type 22 and 23
 - A. Cast Characters with uniform faces, sharp corners, and precisely formed lines and profiles, and as follows:
 - 1. Character Material: Cast Aluminum.
 - 2. Character Height: As indicated on Drawings.
 - 3. Finishes: Baked-Enamel or Powder-Coat Finish: Manufacturer's standard, in color selected by the Architect from the RAL K5 Classic 2018 color palette.
 - 4. Overcoat: Manufacturer's standard baked-on clear coating.
 - 5. Mounting: Concealed studs
- 2.08 APPLIED VINYL SIGNS: Sign Types 10, 11, 12, and 18
 - A. UV-resistant vinyl film with pressure-sensitive, permanent adhesive; die cut to form characters or images as indicated on Drawings.
- 2.09 METAL INFORMATIONAL SIGNS: Sign Types 24.
 - A. Base materials:

1. Painted aluminum with pressure-applied letters and graphics. The paint shall be flat, opaque acrylic polyurethane as recommended by manufacturer of substrate and graphic media.
2. Graphics and Copy: Pressure applied non-reflective letters/symbols.
3. Letters shall be digitally produced, and cut by computer-driven processes from 3M Scotchcal Electrocut 7725 film.
4. The inside corners of the letters shall be rounded using the largest radius consistent with acceptable appearance. Minimum radius shall be 1/8 inch on a 3 inch letter. Use pre-spacing tape as recommended by manufacturer of sheeting as a carrier for letters, numerals and symbols.

2.10 METAL COUNTY SEALS: Sign Type 19

- A. Provide wall mounted signage to match the Sampson County Seal. Sign shall be installed as recommended by manufacturer for exterior installation.
- B. Mounting: Concealed studs for substrates encountered.
- C. Finishes: Baked-Enamel or Powder-Coat Finish: Manufacturer's standard, in two colors selected by the Architect from the RAL K5 Classic 2018 color palette.
- D. County Seals shall be 7'-0" in diameter and manufactured of not less than 1/4" thick front plate aluminum with lettering and other graphics cut out of the front plate to expose a back plate of not less than 1/4" plate aluminum. The perimeter edge of the front plate shall be turned back 2".
- E. The seals shall be made with uniform faces, sharp corners, and precisely formed lines and profiles.
- F. Submit draft of proposed sign for review prior to fabrication to allow Owner to make any revisions.
- G. The seals and their support systems shall be designed to withstand wind and seismic loads indicated in the Structural Drawings. The seals shall be constructed to allow no visible deformation under applicable wind loads. The structural design shall be provided by a Professional Engineer registered in the State of North Carolina.

2.11 BRONZE DEDICATION PLAQUE: Sign Type 21

- A. Provide castings free from pits, scale, sand holes, and other defects. Comply with requirements specified for metal, border style, background texture, and finish and in required thickness, size, shape, and copy.
- B. Border Style: Raised flat band.
- C. Background Texture: Manufacturer's standard pebble texture.
- D. Mounting: Concealed studs for substrates encountered.
- E. See drawings for details regarding each type of cast sign.
- F. Submit draft of proposed sign for review prior to fabrication to allow Owner to make any revisions.

2.12 MARKING FIRE AND SMOKE ASSEMBLIES

- A. Sign applied directly on indicated substrate to identify fire and smoke assemblies, including preparatory treatment as required.
- B. Sign Material: Stenciled-on paint or preprinted, self-adhesive decals.
- C. Font: Minimum 3 inches high characters in a contrasting color, with minimum 0.375-inch wide strokes.
- D. Text: "FIRE AND/OR SMOKE BARRIER - PROTECT ALL OPENINGS, 1-HOUR FIRE BARRIER - PROTECT ALL OPENINGS, 2-HOUR FIRE BARRIER - PROTECT ALL OPENINGS, SMOKE BARRIER - PROTECT ALL OPENINGS" as applicable.
- E. Permanently identify both sides of each fire and smoke assembly indicated on Drawings. Place signs in accessible, concealed floor, floor-ceiling, or attic space at maximum 15

- feet from end of wall and at maximum intervals of 30 feet measured horizontally along the assembly. Locate signs for greatest visibility in the space.
- F. Stenciled signage;
1. Stencils must be die-cut.
 2. Must finish without under-spray or over-spray of the stencil.
 3. Must finish without drips.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. General: Locate signs where indicated, using mounting methods of the type described and in compliance with the manufacturer's instructions.
1. Install signs level, plumb, and at the height indicated, with sign surfaces free from distortion or other defects in appearance.
- B. Interior Plaques: Attach panel signs to wall surfaces using the methods indicated below:
1. Vinyl-Tape Mounting: Use double-sided foam tape to mount signs to smooth, nonporous surfaces.
 2. Concealed Mounting: Mount the plaques by inserting threaded studs into tapped lugs on the back of the plaque. Set in predrilled holes filled with quick-setting cement.
 3. Cement Mounting: Mount plaques using exposed fasteners with rosettes attached through the face of the plaque into the wall surface.

3.02 CLEANING AND PROTECTION:

- A. After installation, clean soiled sign surfaces according to the manufacturer's instructions. Protect units from damage until acceptance by the Owner.

END OF SECTION 10 14 00

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes clean-agent extinguishing systems and the following:
 - 1. Piping and piping specialties.
 - 2. Extinguishing-agent containers.
 - 3. Extinguishing agent.
 - 4. Detection and alarm devices.
 - 5. Control and alarm panels.
 - 6. Accessories.
 - 7. Connection devices for and wiring between system components.
 - 8. Connection devices for power and integration into building's fire alarm system.

1.3 DEFINITIONS

- A. ATS: Acceptance Testing Specifications.
- B. EPO: Emergency Power Off.

1.4 SYSTEM DESCRIPTION

- A. Clean-agent fire-extinguishing system shall be an engineered system for total flooding of the hazard area including the room cavity below the ceiling and below the raised floor.

1.5 PERFORMANCE REQUIREMENTS

- A. Design clean-agent extinguishing system and obtain approval from authorities having jurisdiction. Design system for Class A, B, or C fires as appropriate for areas being protected and include safety factor. Use clean agent indicated and in concentration suitable for normally occupied areas.
- B. Performance Requirements: Discharge HFC 227ea within 10 seconds and maintain 7.1 percent concentration by volume at 70 deg F for 10-minute holding time in hazard areas.
 - 1. HFC 227ea concentration in hazard areas greater than **9.0** percent immediately after discharge or less than 5.8 percent throughout holding time will not be accepted without written authorization from Owner and authorities having jurisdiction.

2. System Capabilities: Minimum 620-psig calculated working pressure and 360-psig initial charging pressure.
- C. Cross-Zoned Detection: Devices located in two separate zones. Sound alarm on activating single-detection device, and discharge extinguishing agent on actuating single-detection device in other zone.
- D. Verified Detection: Devices located in single zone. Sound alarm on activating single-detection device, and discharge extinguishing agent on actuating second-detection device.
- E. System Operating Sequence: As follows:
 1. Actuating First Detector: Visual indication on annunciator panel, energize audible alarm and visual alarms (slow pulse), shut down air-conditioning and ventilating systems serving protected area, close doors in protected area, and send signal to fire alarm system.
 2. Actuating Second Detector: Visual indication on annunciator panel, energize audible and visual alarms (fast pulse), shut down power to protected equipment, start time delay for extinguishing-agent discharge for **30** seconds, and discharge extinguishing agent. On agent discharge, release pre-action valve to allow water to fill sprinkler system.
 3. Extinguishing-agent discharge will operate audible alarms and strobe lights inside and outside the protected area.
- F. Manual stations shall immediately discharge extinguishing agent when activated.
- G. Operating abort switches will delay extinguishing-agent discharge while being activated, and switches must be reset to prevent agent discharge. Release of hand pressure on the switch will cause agent discharge if the time delay has expired.
- H. EPO: Will terminate power to protected equipment immediately on actuation.
- I. Low-Agent Pressure Switch: Initiate trouble alarm if sensing less than set pressure.
- J. Power Transfer Switch: Transfer from normal to stand-by power source.

1.6 SUBMITTALS

- A. Product Data: For the following:
 1. Extinguishing-agent containers.
 2. Extinguishing agent.
 3. Discharge nozzles.
 4. Control panels.
 5. Detection devices.
 6. Manual stations.
 7. Switches.
 8. Alarm devices.
 9. Pipe hangers and supports.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer. Include design calculations. Include the following for hazard-area enclosure, drawn to scale:

1. Plans, elevations, sections, details, and attachments to other work. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: Power, signal, and control wiring.
3. Design Calculations: For weight, volume, and concentration of extinguishing agent required for each hazard area.
4. Reflected Ceiling Plans: Show ceiling penetrations, ceiling-mounted items, and the following:
 - a. Extinguishing-agent containers, piping, discharge nozzles, detectors, and accessories.
 - b. Method of attaching hangers to building structure.
 - c. Other ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, and access panels.
5. Occupied Work Area Plans: Show the following:
 - a. Controls and alarms.
 - b. Extinguishing-agent containers, piping and discharge nozzles if mounted in space, detectors, and accessories.
 - c. Equipment and furnishings.
6. Access Floor Space Plans: Show the following:
 - a. Extinguishing-agent containers, piping, discharge nozzles, detectors, and accessories.
 - b. Method of supporting piping.
- C. Permit Approved Drawings: Working plans, prepared according to NFPA 2001, that have been approved by authorities having jurisdiction. Include design calculations.
- D. Field quality-control test reports.
- E. Maintenance Data: For components to include in maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of clean-agent extinguishing systems that are similar to those indicated for this Project in material, design, and extent.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of clean-agent extinguishing systems and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.8 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Owner.
 - 1. Detection Devices: Not less than 20 percent of amount of each type installed.
 - 2. Container Valves: Not less than 10 percent of amount of each size and type installed.
 - 3. Nozzles: Not less than 20 percent of amount of each type installed.
 - 4. Extinguishing Agent (Supply Reserve): Not less than 100 percent of amount installed in largest hazard area. Include pressure-rated containers with valves.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles were titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 PIPING MATERIALS

- A. Refer to Part 3 piping applications Article retained for applications of pipe, tube, fitting, and joining materials.
- B. Piping, Valves, and Discharge Nozzles: Comply with types and standards listed in NFPA 2001, Section "Distribution," for charging pressure of system.

2.3 PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, Type S, Grade B or ASTM A 106, Grade B; Schedule 40, or Schedule 80, seamless steel pipe.
 - 1. Threaded Fittings:
 - a. Malleable-Iron Fittings: ASME B16.3, Class 300.
 - b. Flanges and Flanged Fittings: ASME B16.5, Class 300, unless Class 600 is indicated.
 - 2. Forged-Steel Welding Fittings: ASME B16.11, Class 3000, socket pattern.
 - 3. Grooved-End Fittings: FMG approved and NRTL listed, ASTM A 47/A 47M malleable iron or ASTM A 536 ductile iron, with dimensions matching steel pipe and ends factory grooved according to AWWA C606.

- B. Plain-End, Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
 - 1. Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper alloy, pressure.
 - 2. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 300.
- C. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness, unless thickness or specific material is indicated.
- D. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.
- E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing.
- F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- G. Steel, Keyed Couplings: UL 213, AWWA C606, approved or listed for clean-agent service, and matching steel-pipe dimensions. Include ASTM A 536, ductile-iron housing, rubber gasket, and steel bolts and nuts.

2.4 VALVES

- A. General: Brass; suitable for intended operation.
- B. Container Valves: With rupture disc or solenoid and manual-release lever, capable of immediate and total agent discharge and suitable for intended flow capacity.
- C. Valves in Sections of Closed Piping and Manifolds: Fabricate to prevent entrapment of liquid, or install valve and separate pressure relief device.
- D. Valves in Manifolds: Check valve; installed to prevent loss of extinguishing agent when container is removed from manifold.

2.5 EXTINGUISHING-AGENT CONTAINERS

- A. Description: Steel tanks complying with ASME Boiler and Pressure Vessel Code: Section VIII, for unfired pressure vessels. Include minimum working-pressure rating that matches system charging pressure, valve, pressure switch, and pressure gage.
 - 1. Finish: **Manufacturer's standard color**, enamel, or epoxy paint.
 - 2. Manifold: Fabricate with valves, pressure switches, and connections for multiple storage containers.
 - 3. Manifold: Fabricate with valves, pressure switches, selector switch, and connections for main- and reserve-supply banks of multiple storage containers.
 - 4. Storage-Tank Brackets: Factory- or field-fabricated retaining brackets consisting of steel straps and channels; suitable for container support, maintenance, and tank refilling or replacement.

2.6 FIRE-EXTINGUISHING CLEAN AGENT

A. Clean Agent: HFC 227ea, heptafluoropropane.

1. Manufacturers:

- a. Cerberus Pyrotronics.
- b. Chemetron Fire Systems.
- c. Fike Corporation.
- d. Kidde-Fenwal, Inc.
- e. Modular Protection Corp.

2.7 DISCHARGE NOZZLES

A. Equipment manufacturer's standard one-piece brass or aluminum alloy of type, discharge pattern, and capacity required for application.

2.8 MANIFOLD AND ORIFICE UNIONS

A. Description: NRTL-listed device with minimum 2175-psig pressure rating, to control flow and reduce pressure of IG-541 gas in piping.

1. 2 inch and Smaller: Piping assembly with orifice, sized for system design requirements.
2. 2-1/2 inch and Larger: Piping assembly with nipple, sized for system design requirements.

2.9 CONTROL PANELS

A. Description: FMG approved or NRTL listed, including equipment and features required for testing, supervising, and operating fire-extinguishing system.

B. Power Requirements: 120/240-V ac; with electrical contacts for connection to system components and fire alarm system, and transformer or rectifier as needed to produce power at voltage required for accessories and alarm devices.

C. Enclosure: NEMA ICS 6, Type 1, enameled-steel cabinet.

1. Mounting: **Surface**.

D. Supervised Circuits: Separate circuits for each independent hazard area.

1. Detection circuits equal to the required number of zones, or addressable devices assigned to the required number of zones.
2. Manual pull-station circuit.
3. Alarm circuit.
4. Release circuit.
5. Abort circuit.
6. EPO circuit.

E. Provide the following control-panel features:

1. Electrical contacts for shutting down fans, activating dampers, and operating system electrical devices.
2. Automatic switchover to standby power at loss of primary power.
3. Storage container, low-pressure indicator.
4. Service disconnect to interrupt system operation for maintenance with visual status indication on the annunciator panel.

F. Standby Power: Lead-acid or nickel-cadmium batteries with capacity to operate system for 72 hours and alarm for minimum of 15 minutes. Include automatic battery charger, with varying charging rate between trickle and high depending on battery voltage, that is capable of maintaining batteries fully charged. Include manual voltage control, dc voltmeter, dc ammeter, electrical contacts for connection to control panel, and suitable enclosure.

2.10 DETECTION DEVICES

A. Description: Comply with NFPA 2001 and NFPA 72, and include the following types:

1. Ionization Detectors: Comply with UL 268, dual-chamber type, having sampling and referencing chambers, with smoke-sensing element.
2. Photoelectric Detectors: Comply with UL 268, consisting of LED light source and silicon photodiode receiving element.
3. Remote Air-Sampling Detector System: Includes air-sampling pipe network, a laser-based photoelectric detector, a sample transport fan, and a control unit.
 - a. Comply with UL 268 and NRTL listed, operating at 24-V dc, nominal.
 - b. Pipe Network: CPVC tubing connects control unit with calibrated sampling holes.
 - c. Smoke Detector: Particle-counting type with continuous laser beam. Sensitivity adjustable to a minimum of four preset values.
 - d. Sample Transport Fan: Centrifugal type, creating a minimum static pressure of 0.05-inch wg at all sampling ports.
 - e. Control Unit: Multi-zone unit as indicated on Drawings. Provides same system power supply, supervision, and alarm features as specified for the control panel plus separate trouble indication for airflow and detector problems.
 - f. Signals to the Central Fire Alarm Control Panel: Any type of local system trouble is reported to the central fire alarm control panel as a composite "trouble" signal. Alarms on each system zone are individually reported to the central fire alarm control panel as separately identified zones.

2.11 MANUAL STATIONS

- A. General Description: **Semi-recessed** FMG approved or NRTL listed, with clear plastic hinged cover, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.
- B. Manual Release: "MANUAL RELEASE" caption, and red finish. Unit can manually discharge extinguishing agent with operating device that remains engaged until unlocked.

- C. Abort Switch: "ABORT" caption, momentary contact, with green finish.
- D. EPO Switch: "EPO" caption, with yellow finish.

2.12 SWITCHES

- A. Description: FMG approved or NRTL listed, where available, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.
 - 1. Low-Agent Pressure Switches: Pneumatic operation.
 - 2. Power Transfer Switches: Key-operation selector, for transfer of release circuit signal from main supply to reserve supply.
 - 3. Door Closers: Magnetic retaining and release device or electrical interlock to cause the door operator to drive the door closed.

2.13 ALARM DEVICES

- A. Description: FMG approved or NRTL listed, low voltage, and surface mounting, unless otherwise indicated.
- B. Horns: 90 to 94 dBA.
- C. Strobe Lights: Translucent lens, with "FIRE" or similar caption.

2.14 ELECTRICAL POWER AND WIRING

- A. Electrical power, wiring, and devices are specified in Division 26.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with hazard-area leakage requirements, installation tolerances, and other conditions affecting work performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PIPING APPLICATIONS

- A. Flanged pipe and fittings and flanged joints may be used to connect to specialties and accessories and where required for maintenance.
- B. Fittings Working Pressure: 620 psig minimum.
- C. Flanged Joints: Class 300 minimum.

- D. 2 inch and Smaller: ASTM B 88, L copper tube; copper, solder-joint fittings; and brazed joints.
- E. 2 inch and Smaller: Schedule 40, steel pipe; malleable-iron threaded fittings; and threaded joints.
- F. 2-1/2 inch and 3 inch: ASTM B 88, Type L copper tube; copper, solder-joint fittings; and brazed joints.
- G. 2-1/2 inch and 3 inch: Schedule 40, steel pipe; forged-steel welding fittings; and welded joints.
- H. 2-1/2 inch and 3 inch: Schedule 40, steel pipe; steel, grooved-end fittings; steel, keyed couplings; and grooved joints.

3.3 PIPING APPLICATIONS

- A. Piping between Storage Containers and Orifice Union:
 - 1. Flanged pipe and fittings and flanged joints may be used to connect to specialties and accessories and where required for maintenance.
 - 2. Fittings Working Pressure: 2175 psig minimum.
 - 3. Flanged Joints: Class 600 minimum.
 - 4. All Sizes: Schedule 80, steel pipe; forged-steel welding fittings; and welded joints.
- B. Piping Downstream from Orifice Union:
 - 1. Flanged pipe and fittings and flanged joints may be used to connect to specialties and accessories and where required for maintenance.
 - 2. Fittings Working Pressure: 1000 psig minimum.
 - 3. Flanged Joints: Class 300 minimum.
 - 4. All Sizes: Schedule **80**, steel pipe; forged-steel welding fittings; and welded joints.

3.4 CLEAN-AGENT EXTINGUISHING PIPING INSTALLATION

- A. Install clean-agent extinguishing piping and other components level and plumb and according to manufacturers' written instructions.
- B. Refer to Division 21 Section "Common Work Results for Fire Suppression" for basic pipe installation and joint construction.
- C. Grooved Piping Joints: Groove pipe ends according to AWWA C606 dimensions. Assemble grooved-end steel pipe and steel, grooved-end fittings with steel, keyed couplings and lubricant according to manufacturer's written instructions.
- D. Install extinguishing-agent containers anchored to substrate.
- E. Install pipe and fittings, valves, and discharge nozzles according to requirements listed in NFPA 2001, Section "Distribution," and in ASME B31.1.
 - 1. Install valves designed to prevent entrapment of liquid or install pressure relief devices in valved sections of piping systems.

2. Support piping using supports and methods according to NFPA 13.
3. Install seismic restraints for extinguishing-agent containers and piping systems.
4. Install control panels, detection system components, alarms, and accessories, complying with requirements of NFPA 2001, Section "Detection, Actuation, and Control Systems," as required for supervised system application.

3.5 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to extinguishing-agent containers to allow service and maintenance.
- C. Connect electrical devices to control panel and to building's fire alarm system. Electrical power, wiring, and devices are specified in Division 28 Section "Fire Detection and Alarm."

3.6 LABELING

- A. Install labeling on piping, extinguishing-agent containers, other equipment, and panels according to NFPA 2001.
- B. Install signs at entry doors for protected areas to warn occupants that they are entering a room protected with a clean-agent fire extinguishing system.
- C. Install signs at entry doors to advise persons outside the room the meaning of the horn(s), bell(s), and strobe light(s) outside the protected space.

3.7 FIELD QUALITY CONTROL

- A. Comply with operating instructions and procedures of NFPA 2001, Section "Approval of Installations." Include the following tests and inspections to demonstrate compliance with requirements:
 1. Check mechanical items.
 2. Inspect extinguishing-agent containers and extinguishing agent, and check mountings for adequate anchoring to substrate.
 3. Check electrical systems.
 4. Check enclosure integrity. Comply with NFPA 2001, Section "Enclosure Inspection," and Appendix C, "Enclosure Integrity Procedure."
 5. Perform functional pre-discharge test.
 6. Perform system functional operational test including, EPO, abort, and manual release.
 7. Check remote monitoring operations.
 8. Check control-panel primary power source.
 9. Perform "puff" test on piping system, using nitrogen.
- B. Perform field-acceptance tests of each clean-agent extinguishing system when installation is complete. Perform system testing only after hazard-area enclosure construction has been completed and openings sealed. Comply with operating instructions and procedures of

NFPA 2001, Section "Approval of Installations." Include the following to demonstrate compliance with requirements:

1. Perform functional predischARGE test.
 2. Perform system functional operational test.
 3. Check remote monitoring operations.
 4. Check control-panel primary power source.
 5. Perform "puff" test on piping system, using nitrogen.
- C. Correct malfunctioning equipment, then retest to demonstrate compliance. Replace equipment that cannot be corrected or does not perform as specified and indicated, then retest to demonstrate compliance. Repeat procedure until satisfactory results are obtained.
1. Report test results promptly and in writing to Architect and authorities having jurisdiction.
- D. Perform the following field tests and inspections and prepare test reports:
1. After installing clean-agent extinguishing piping system and after electrical circuitry has been energized, test for compliance with requirements.
 2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections "Inspection and Test Procedures" and "System Function Tests." Certify compliance with test parameters.
 3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Remove and replace malfunctioning units and retest as specified above.

3.8 CLEANING

- A. Each pipe section shall be cleaned internally after preparation and before assembly by means of swabbing, using a suitable nonflammable cleaner. Pipe network shall be free of particulate matter and oil residue before installing nozzles or discharge devices.

3.9 SYSTEM FILLING

- A. Preparation:
1. Verify that piping system installation is completed and cleaned.
 2. Check for complete enclosure integrity.
 3. Check operation of ventilation and exhaust systems.
- B. Filling Procedures:

1. Fill extinguishing-agent containers with extinguishing agent and pressurize to indicated charging pressure.
2. Install filled extinguishing-agent containers.
3. Energize circuits.
4. Adjust operating controls.

3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain clean-agent extinguishing systems. Refer to Division 01.

END OF SECTION 21 22 00

**SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS Addendum 1
(Revision 2)**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes methods and materials for grounding systems and equipment.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:
 - 1. Test wells.
 - 2. Ground rods.
 - 3. Grounding arrangements and connections for separately derived systems.
 - 4. Grounding for sensitive electronic equipment.
- C. Qualification Data: For testing agency and testing agency's field supervisor.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals:
 - 1. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, and grounding connections for separately derived systems based on NETA MTS and NFPA 70B.
 - a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
 - b. Include recommended testing intervals.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association to supervise on-site testing specified in Part 3.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction or because of adjacent surface material.
- B. Bare Copper Conductors:
 1. Solid Conductors: ASTM B 3.
 2. Stranded Conductors: ASTM B 8.
 3. Tinned Conductors: ASTM B 33.
 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 5. Bonding Conductor: **Sized per TIA 607 and R56 for distance and resistance**, stranded conductor.
 6. Bonding Jumper: **Tinned-copper, stranded conductors**, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
 7. Tinned Bonding Jumper: **Tinned-copper, stranded conductors**, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
- C. Bare Grounding Conductor and Conductor Protector for Wood Poles:
 1. **No. 2 AWG minimum**, soft-drawn copper.
 2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.
- D. Grounding Bus: Rectangular bars of annealed copper, 1/4 by 2 inches (6 by 50 mm) in cross section, unless otherwise indicated; with insulators.

2.2 CONNECTORS

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

- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad; 3/4 inch diameter by 10 feet length (19 mm by 3 m).

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors:
 - 1. **Indoor: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger, unless otherwise indicated.**
 - 2. **Outdoor: Install solid conductor for No. 2 AWG and smaller, and stranded conductors for No. 1 AWG and larger, unless otherwise indicated.**
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
 - 1. **Bury at least 30 inches minimum or below frost line (whichever is greater) below grade.**
 - 2. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.
- C. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus on insulated spacers **2 inch minimum**, from wall 6 inches (150 mm) above finished floor, unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.
- D. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: **Welded connections at all locations.**
 - 3. Connections to Ground Rods at Test Wells: **Exothermic Welded connections below grade. Above ground requires irreversible crimp.**
 - 4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.
 - 6. Flexible raceway runs.
 - 7. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 - 8. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
- C. **Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment: provide No. 4 AWG minim Size per R56 table 5-3. (When installed in metallic conduit the conduit shall be bonded on both ends). insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.**
 - 1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch (6-by-50-by-300-mm) grounding bus.
 - 2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.3 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- C. Ground Rods: Drive rods until tops are **30 inches** below finished floor or final grade, unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
 2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.
1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
 3. Use **exothermic-welded connectors for outdoor locations**
- F. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- B. Perform the following tests and inspections and prepare test reports:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Test completed grounding system at the service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 - c. **The ground resistance shall be less than 5 ohms per TIA 607 and R56.**
 - 3. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- C. **Report measured ground resistances that exceed the following values:**
 - 1. **Power and Lighting Equipment or System with Capacity 500 kVA and Less: 100 milli-ohms.**
 - 2. **Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 100 milli-ohms.**
 - 3. **Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 100 milli-ohms.**
 - 4. **Power Distribution Units or Panelboards Serving Electronic Equipment: 100 milli-ohms.**
- D. **Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.**

END OF SECTION 26 05 26

SECTION 26 05 36 - CABLE TRAYS FOR ELECTRICAL SYSTEMS **Addendum 1 (Revision 2)**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes steel, aluminum, stainless-steel, and fiberglass cable trays and accessories.

1.3 SUBMITTALS

- A. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.
- B. Shop Drawings: For each type of cable tray.
 - 1. Show fabrication and installation details of cable tray, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
- C. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements. Show the following:
 - 1. Vertical and horizontal offsets and transitions.
 - 2. Clearances for access above and to side of cable trays.
 - 3. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
- D. Field quality-control reports.
- E. Operation and Maintenance Data: For cable trays to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store indoors to prevent water or other foreign materials from staining or adhering to cable tray. Unpack and dry wet materials before storage.
- B. Steel cable tray shall be stored in a well-ventilated, dry location. Unpack and dry wet materials before storage.
- C. PVC-coated and Field-painted cable tray shall be stored indoors. Protect cable tray from scratching and marring of finish. Unpack and dry wet materials before storage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper B-Line, Inc.
 - 2. MONO-SYSTEMS, Inc.
 - 3. MPHusky.

2.2 MATERIALS AND FINISHES

- A. Cable Trays, Fittings, and Accessories: Steel, complying with NEMA VE 1.
 - 1. Factory-standard primer, ready for field painting; with cadmium-plated hardware according to ASTM B 766.
 - 2. Mill galvanized before fabrication, complying with ASTM A 653/A 653M, G90 (Z275) coating; with hardware galvanized according to ASTM B 633.
 - 3. Electrogalvanized before fabrication, complying with ASTM B 633; with hardware galvanized according to ASTM B 633.
 - 4. Hot-dip galvanized after fabrication, complying with ASTM A 123/A 123M, Class B2; with Type 316 stainless-steel hardware.
 - 5. PVC coating applied in a fluidized bed or by electrostatic spray; with Type 316 stainless-steel hardware.
 - 6. Epoxy-resin paint over paint manufacturer's recommended primer and corrosion-inhibiting treatment; with Type 316 stainless-steel hardware.
- B. Cable Trays, Fittings, and Accessories: Aluminum, complying with NEMA VE 1, Aluminum Association's Alloy 6063-T6 for rails, rungs, and cable trays, and Alloy 5052-H32 or

Alloy 6061-T6 for fabricated parts; with Type 316 stainless-steel splice-plate fasteners, bolts, and screws

- C. Cable Trays, Fittings, and Accessories: Stainless steel, Type 304 or 316, complying with NEMA VE 1.
- D. Cable Trays, Fittings, and Accessories: Fiberglass, complying with NEMA FG 1 and UL 568. Splice-plate fasteners, bolts, and screws shall be fiberglass-encapsulated stainless steel. Design fasteners so that no metal is visible when fully assembled and tightened. Fastener encapsulation shall not be damaged when torqued to manufacturer's recommended value.
- E. Sizes and Configurations: Refer to the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.
 - 1. Center-hanger supports may be used only when specifically indicated.

2.3 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
- B. Covers: Solid, Louvered, Ventilated-hat, or 2-in-3 pitch cover type of same materials and finishes as cable tray.
- C. Barrier Strips: Same materials and finishes as cable tray.
- D. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.4 WARNING SIGNS

- A. Lettering: 1-1/2-inch- (40-mm-) high, black letters on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."
- B. Materials and fastening are specified in Division 26 Section "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

- A. Perform design and production tests according to NEMA VE 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

- A. Comply with recommendations in NEMA VE 2. Install as a complete system, including all necessary fasteners, hold-down clips, splice-plate support systems, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees, and crosses.
- B. Remove burrs and sharp edges from cable trays.

- C. Fasten cable tray supports to building structure and install restraints.
 - 1. Place supports so that spans do not exceed maximum spans on schedules.
 - 2. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
 - 3. Support bus assembly to prevent twisting from eccentric loading.
 - 4. Manufacture center-hung support, designed for 60 percent versus 40 percent eccentric loading condition, with a safety factor of 3.
 - 5. Locate and install supports according to NEMA VE 1.
 - D. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independent of fittings. Do not carry weight of cable tray on equipment enclosure.
 - E. Install expansion connectors where cable tray crosses building expansion joint and in cable tray runs that exceed dimensions recommended in NEMA VE 1. Space connectors and set gaps according to applicable standard.
 - F. Make changes in direction and elevation using standard fittings.
 - G. Make cable tray connections using standard fittings.
 - H. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Fire-Stopping".
 - I. Sleeves for Future Cables: Install capped sleeves for future cables through fire-stop-sealed cable tray penetrations of fire and smoke barriers.
 - J. Workspace: Install cable trays with enough space to permit access for installing cables.
 - K. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15,000 V.
 - L. After installation of cable trays is completed, install warning signs in visible locations on or near cable trays.
- 3.2 CABLE INSTALLATION
- A. Install cables only when cable tray installation has been completed and inspected.
 - B. Fasten cables on horizontal runs with cable clamps or cable ties as recommended by NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.
 - C. On vertical runs, fasten cables to tray every 18 inches (457 mm). Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

- D. In existing construction, remove inactive or dead cables from cable tray.
- E. Install covers after installation of cable is completed.

3.3 CONNECTIONS

- A. **Ground cable trays according to manufacturer's written instructions and per R56, the more stringent shall apply.**
- B. Install an insulated equipment grounding conductor with cable tray, in addition to those required by NFPA 70.

3.4 FIELD QUALITY CONTROL

- A. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements. Perform the following field quality-control survey:
 - 1. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.
 - 2. Verify that the number, size, and voltage of cables in cable tray do not exceed that permitted by NFPA 70. Verify that communication or data-processing circuits are separated from power circuits by barriers.
 - 3. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.
 - 4. Remove deposits of dust, industrial process materials, trash of any description, and any blockage of tray ventilation.
 - 5. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
 - 6. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
 - 7. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable tray.
- B. Report results in writing.

3.5 PROTECTION

- A. Protect installed cable trays.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray manufacturer.

3. Install temporary protection for cables in open trays to protect exposed cables from falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials until the risk of damage is over.

END OF SECTION 26 05 36

SECTION 26 32 13 - ENGINE GENERATORS **Addendum 1 (Revision 2)**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes packaged engine-generator sets for emergency and standby power supply with the following features:
 - 1. Diesel engine.
 - 2. Unit-mounted cooling system.
 - 3. Unit- and Remote-mounting control and monitoring.
 - 4. Performance requirements.
 - 5. Outdoor enclosure.
- B. Related Sections include the following:
 - 1. Division 26 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.3 DEFINITIONS

- A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.4 SUBMITTALS

- A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
 - 1. Thermal damage curve for generator.
 - 2. Time-current characteristic curves for generator protective device.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.

2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
 3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
 4. Wiring Diagrams: Power, signal, and control wiring.
- C. Qualification Data: For installer, manufacturer, and testing agency.
- D. Source quality-control test reports.
1. Certified summary of prototype-unit test report.
 2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
 3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
 4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
 5. Report of sound generation.
 6. Report of exhaust emissions showing compliance with applicable regulations.
 7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
- G. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
1. Maintenance Proximity: Not more than one hours' normal travel time from Installer's place of business to Project site.
 2. Engineering Responsibility: Preparation of data for vibration isolators of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

- B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL), and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- D. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- F. Comply with ASME B15.1.
- G. Comply with NFPA 37.
- H. Comply with NFPA 70.
- I. Comply with NFPA 99.
- J. Comply with NFPA 110 requirements for Level 1 emergency power supply system.
- K. Comply with UL 2200.
- L. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
- M. Noise Emission: Comply with applicable state and local government requirements for maximum noise level due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.6 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify Construction Manager and Owner no fewer than seven days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Construction Manager's and Owner's permission.
- B. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: Minus 15 to plus 40 deg C.
2. Relative Humidity: 0 to 95 percent.
3. Altitude: Sea level to 1000 feet (300 m).

1.7 COORDINATION

- A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Division 07 Section "Roof Accessories."

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: 5 years from date of Substantial Completion.

1.9 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.10 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
 2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Caterpillar; Engine Div. (Basis of design, compliance for substitutions, including size, space requirements/availability, ratings, etc. shall be the responsibility of the electrical

contractor. Any costs associated with re-design to accommodate substitutions shall be at the EC's expense.)

2. MTU
3. Onan/Cummins Power Generation; Industrial Business Group.
4. **Kohler Power Systems.**
5. **Generac**

2.2 ENGINE-GENERATOR SET

- A. Factory-assembled and -tested, engine-generator set.
- B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
- C. Capacities and Characteristics:
 1. Power Output Ratings: Nominal ratings as indicated.
 2. Output Connections: Three-phase, four wire.
 3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- D. Generator-Set Performance:
 1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
 - a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
 2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
 3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
 4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.

5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
 - a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE

- A. Fuel: Fuel oil, Grade DF-2.
- B. Rated Engine Speed: 1800 rpm.
- C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).
- D. Lubrication System: The following items are mounted on engine or skid:
 1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
 3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- E. Engine Fuel System:
 1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
 2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

- F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.
- G. Governor: Adjustable isochronous, with speed sensing.
- H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
 - 1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 - 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 - 3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 - 4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 - 5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
 - a. Rating: 100-psig maximum working pressure with coolant at 300 deg F, and noncollapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- I. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - 1. Minimum sound attenuation of 25 dB at 500 Hz.
 - 2. Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 85 dBA or less.
- J. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- K. Starting System: 24-V electric, with negative ground.
 - 1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum.
 - 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
 - 3. Cranking Cycle: 60 seconds at 32 degrees F at firing speed.

4. Battery: Adequate capacity within ambient temperature range to provide specified cranking cycle at least three times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature. Include accessories required to support and fasten batteries in place.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
 - a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
 - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
 - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
 - d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
 - e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
 - f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.4 FUEL OIL STORAGE

- A. Comply with NFPA 30.
- B. Base-Mounted Fuel Oil Tank: Comply with UL 142, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:
 1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of tank.

- a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of tank leak.
2. Tank Capacity: As required for an uninterrupted period of **75 hours'** operation at 100 percent of rated power output of engine-generator system without being refilled.
3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
5. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.
6. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.
7. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine-generator set.

2.5 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
- B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
- C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
- D. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel.
- E. Configuration: Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and

monitoring section of panel shall be isolated from power sections by steel barriers. Panel features shall include the following:

1. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6. Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.
 2. Current and Potential Transformers: Instrument accuracy class.
- F. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 system, and the following:
1. AC voltmeter.
 2. AC ammeter.
 3. AC frequency meter.
 4. DC voltmeter (alternator battery charging).
 5. Engine-coolant temperature gage.
 6. Engine lubricating-oil pressure gage.
 7. Running-time meter.
 8. Ammeter-voltmeter, phase-selector switch(es).
 9. Generator-voltage adjusting rheostat.
 10. Fuel tank derangement alarm.
 11. Fuel tank high-level shutdown of fuel supply alarm.
 12. Generator overload.
- G. Indicating and Protective Devices and Controls:
1. AC voltmeter.
 2. AC ammeter.
 3. AC frequency meter.
 4. DC voltmeter (alternator battery charging).
 5. Engine-coolant temperature gage.
 6. Engine lubricating-oil pressure gage.
 7. Running-time meter.

8. Ammeter-voltmeter, phase-selector switch(es).
 9. Generator-voltage adjusting rheostat.
 10. Start-stop switch.
 11. Overspeed shutdown device.
 12. Coolant high-temperature shutdown device.
 13. Coolant low-level shutdown device.
 14. Oil low-pressure shutdown device.
 15. Fuel tank derangement alarm.
 16. Fuel tank high-level shutdown of fuel supply alarm.
 17. Generator overload.
- H. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
- I. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals.
- J. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.
1. Overcrank shutdown.
 2. Coolant low-temperature alarm.
 3. Control switch not in auto position.
 4. Battery-charger malfunction alarm.
 5. Battery low-voltage alarm.
- K. Common Remote Audible Alarm: Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.
1. Engine high-temperature shutdown.
 2. Lube-oil, low-pressure shutdown.
 3. Overspeed shutdown.
 4. Remote emergency-stop shutdown.

5. Engine high-temperature prealarm.
 6. Lube-oil, low-pressure prealarm.
 7. Fuel tank, low-fuel level.
 8. Low coolant level.
- L. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.
- M. Emergency-Stop Switch: Push button shall be protected from accidental operation.

2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.
1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
 2. Trip Settings: Selected to coordinate with generator thermal damage curve.
 3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
 4. Mounting: Adjacent to or integrated with control and monitoring panel.
- B. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:
1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
 2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
 3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
 4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

- C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.7 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: Class H or Class F.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- F. Enclosure: Dripproof.
- G. Instrument Transformers: Mounted within generator enclosure.
- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
 - 1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
- I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- K. Subtransient Reactance: 12 percent, maximum.

2.8 OUTDOOR GENERATOR-SET ENCLOSURE

- A. Description: Vandal-resistant, sound-attenuated, weatherproof steel housing, wind resistant up to 100 mph (160 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.
- B. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range.
 - 1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
 - 2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.

2.9 VIBRATION ISOLATION DEVICES

- A. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.10 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.11 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.
- B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
 2. Full load run.
 3. Maximum power.
 4. Voltage regulation.
 5. Transient and steady-state governing.
 6. Single-step load pickup.
 7. Safety shutdown.
 8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.

9. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
- B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C. Install packaged engine generator with restrained spring isolators having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base. Secure sets to anchor bolts installed in concrete bases.
- D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- C. Connect engine exhaust pipe to engine with flexible connector.
- D. Connect fuel piping to engines with a gate valve and union and flexible connector.
- E. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 IDENTIFICATION

- A. Identify system components according to Division 23 Section "Identification for HVAC Piping and Equipment" and Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- C. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Tests and Inspections:
 - 1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
 - 3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.
 - 4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 - 5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
 - 6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
 - 7. Exhaust Emissions Test: Comply with applicable government test criteria.

8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
 9. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
 10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the project site, and compare measured levels with required values.
- E. Coordinate tests with tests for transfer switches and run them concurrently.
- F. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- G. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- H. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- I. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- J. Remove and replace malfunctioning units and retest as specified above.
- K. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- L. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- M. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 MANUFACTURER'S START-UP

- A. An outline detailing all start-up activities to be performed by the manufacturer shall be provided to the Owner, Owner's representative, and Engineer.
- B. In addition to detailed items required as part of the start-up, the outline shall include verification of settings and operations of all protective relays, alarms, shutdowns, controls, interlocks, and interfaces for the generator and associated components such as motorized louvers, exhaust fans, batteries, heaters, paralleling switchgear, ATS's, monitoring systems, etc.
- C. The outline shall be submitted a minimum of 2 months prior to the scheduled delivery date to allow for incorporation into the project schedule.
- D. The start-up outline shall state anticipated durations for each activity.
- E. Where required, the start-up outline shall list specific items to be performed by others.
- F. The manufacturer shall provide written documentation showing each start-up activity has been completed. Site testing and commissioning shall not begin until this record documentation has been provided by the manufacturer.

3.7 SITE TESTING

- A. IF ANY TESTS REQUIRED BY THIS SECTION EXCEED THE CAPABILITIES OR RECOMMENDATIONS OF THE GENERATOR SET MANUFACTURER, THOSE LIMITATIONS SHALL BE EXPLICITLY STATED IN THE VENDOR'S PROPOSAL.
- B. The manufacturer shall be required to participate in all site testing (including independent third party commissioning) as specified herein and as required by the Owner's Commissioning Agent (CxA). The Vendor's proposal shall include the minimum testing specified herein and a separate line item shall list cost and time assumptions for work associated with the detailed commissioning plan to be provided by the Owner's CxA.
- C. Perform battery tests as follows:
 - 1. Equalize batteries according to battery manufacturer's written instructions and record individual cell voltages.
 - 2. Measure charging voltage and voltages between battery terminals for full-charging and float charging conditions.
 - 3. Test for contact integrity of all connections. Perform an integrity load test and a capacity load test.
 - 4. Verify acceptance of charge for each element of the battery after discharge.

5. Verify that measurements are within the battery manufacturer's specifications.
- D. The site testing listed below shall be with the generators operating in parallel as a single generator plant. All load required for the testing shall be via manufacturer supplied portable resistive load bank(s), 4.5 MW total.
- E. A cold, single-step, full rated reactive load at 0.8 power factor shall be applied to, and accepted by, the generator plant within the time requirements of NFPA 110.
- F. An uninterrupted, 8-hour, full load test (reactive), at 0.8 power factor, shall be conducted. The following data shall be recorded at 15 minute intervals:
 1. Time stamp
 2. Output voltage (line-to-line and line-neutral)
 3. Output current (each phase)
 4. Output frequency
 5. Total kW output
 6. Total kVA output
 7. Power factor
 8. Engine RPM
 9. Coolant temperature
 10. Oil temperature
 11. Oil pressure
 12. Fuel pressure
 13. Ambient temperature
- G. Voltage regulation shall be calculated.
 1. $V_{\text{regulation}} = 100\% \times (V_{\text{no load}} - V_{\text{full load}}) / V_{\text{no load}}$
- H. The following transient tests shall be performed and recorded:
 1. No load to 25% load to no load
 2. No load to 50% load to no load
 3. No load to 75% load to no load
 4. No load to 100% load to no load

5. 25% load to 50% load to 25% load
 6. 25% load to 75% load to 25% load
 7. 25% load to 100% load to 25% load
 8. 50% load to 75% load to 50% load
 9. 50% load to 100% load to 50% load
 10. 75% load to 100% load to 75% load
- I. At the end of site testing and commissioning, an oil sample shall be taken and analyzed. The results shall be provided with the final report as specified below.
 - J. Test all alarms and safety shutdown devices for proper operation and annunciation.
 - K. Check for exhaust leaks, oil leaks, fuel leaks, excessive vibration, etc.
 - L. Verify generator pitch with an oscilloscope and verify all generators are matched where applicable.
 - M. Measure sound levels at several locations periodically during testing and verify compliance with requirements listed in Part 2 of these specifications.
 - N. At the end of site testing and commissioning, the manufacturer or authorized dealer shall provide a complete and neatly compiled report with all alarm setpoints, relay settings, recordings, measurements, calculations, findings, etc. in both hard copy and electronic format. This report may be incorporated into reports by the Engineer or CxA, but does not relieve the manufacturer from the requirement of providing a separate report.
 - O. All consumables necessary for the test shall be furnished by the generator manufacturer or authorized dealer. These shall include, but not be limited to, load bank and cables, fuel, oil, coolant, and filters.
 - P. All fluid levels shall be checked at the end of site testing and commissioning.
 - Q. The condition of all filters items shall be checked at the end of site testing and commissioning and replaced by the generator manufacturer or authorized dealer as needed.
- 3.8 DEMONSTRATION
- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 26 32 13

SECTION 26 41 13 - LIGHTNING PROTECTION FOR STRUCTURES **Addendum 1 (Revision 2)**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes lightning protection for building elements. Specification is provided for performance specification and shall be used to provide a contract price for lightning protection system. Contractor shall provide a UL master label lightning protection system for the building including all required conductors, equipment, raceways and design.

1.3 DEFINITIONS

- A. LPI: Lightning Protection Institute.
- B. NRTL: National recognized testing laboratory.

1.4 SUBMITTALS

- A. Product Data: For air terminals and mounting accessories.
- B. Shop Drawings: Detail lightning protection system, including air-terminal locations, conductor routing and connections, and bonding and grounding provisions. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.
- C. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by an NRTL or LPI.
- D. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply membrane roofing material.
- E. Field inspection reports indicating compliance with specified requirements.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer who is an NRTL or who is certified by LPI as a Master Installer/Designer.
- B. Listing and Labeling: As defined in NFPA 780, "Definitions" Article.

1.6 COORDINATION

- A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

- B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Automatic Lightning Protection.
 - 2. ERICO International Corporation.
 - 3. Harger Lightning Protection, Inc.
 - 4. Heary Bros. Lightning Protection Co. Inc.
 - 5. Independent Protection Co.
 - 6. Robbins Lightning Inc.
 - 7. Thompson Lightning Protection, Inc.

2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS

- A. Comply with UL 96.
- B. Roof-Mounting Air Terminals: NFPA **Class II, aluminum**, solid, unless otherwise indicated.
 - 1. Single-Membrane, Roof-Mounting Air Terminals: Designed for single-membrane roof materials.
- C. Stack-Mounting Air Terminals: Stainless steel.
- D. Ground Rods, Ground Loop Conductors, and Concrete-Encased Electrodes: Comply with Division 26 Section "Grounding and Bonding for Electrical Systems" and with standards referenced in this Section.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lightning protection components and systems according to UL 96A and NFPA 780.
- B. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops.
- C. Conceal the following conductors:

1. System conductors.
 2. Down conductors.
 3. Interior conductors.
 4. Conductors within normal view from exterior locations at grade within 200 feet of building.
 5. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.
- D. Cable Connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components, except those above single-ply membrane roofing.
- E. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.
- F. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.
- G. A counterpoise installation based on requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" may be used as a ground loop required by NFPA 780, provided counterpoise conductor meets or exceeds minimum requirements in NFPA 780.
1. Bond ground terminals to counterpoise conductor.
 2. Bond grounded metal bodies on building within 12 feet of ground to counterpoise conductor.
 3. Bond grounded metal bodies on building within 12 feet of roof to counterpoise conductor.
- H. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot intervals.

3.2 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.3 FIELD QUALITY CONTROL

- A. UL Inspection: Provide inspections as required to obtain a UL Master Label for system.

END OF SECTION 26 41 13

SECTION 26 43 13 - SURGE-PROTECTIVE DEVICES (SPDs) FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS (1kV OR LESS) **Addendum 1 (Revision 2)**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Refer to Power riser diagram for more information on the number and types of SPDs required. All SPDs are to be **Normal Mode type and approved to be utilized on Motorola R56 Systems.**

1.2 SUMMARY

- A. This Section includes SPDs for low-voltage power (1kV or less), control, and communication equipment.

1.3 DEFINITIONS

- A. ATS: Acceptance Testing Specifications.
- B. SPD: Surge-Protective Device.
- C. VPR: Voltage Protection Ratings

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating weights, operating characteristics, furnished specialties, and accessories.
- B. Product Certificates: For transient voltage suppression devices, signed by product manufacturer certifying compliance with the latest editions of the following standards:
 - 1. UL 1283.
 - 2. UL 1449.
- C. Qualification Data: For testing agency.
- D. Field quality-control test reports, including the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Failed test results and corrective action taken to achieve requirements.
- E. Operation and Maintenance Data: For transient voltage suppression devices to include in emergency, operation, and maintenance manuals.

- F. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Source Limitations: Obtain surge-protective devices and accessories through one source from a single manufacturer.
- C. Product Options: Drawings indicate size, dimensional requirements, and electrical performance of SPDs and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with IEEE C62.41, "IEEE Guide for Surge Voltages in Low Voltage AC Power Circuits," and test devices according to IEEE C62.45, "IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits."
- F. Comply with NEMA LS 1, "Low Voltage Surge Protection Devices."
- G. Comply with the latest editions of UL 1283, "Electromagnetic Interference Filters," and UL 1449, "Surge-Protective Devices."

1.6 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
1. Notify Architect not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.
- B. Service Conditions: Rate surge-protective devices for continuous operation under the following conditions, unless otherwise indicated:
1. Maximum Continuous Operating Voltage: **Shall not be greater than 115 percent of nominal system operating voltage.**
2. Operating Temperature: 30 to 120 deg F.
3. Humidity: 0 to 85 percent, non-condensing.

4. Altitude: Less than 20,000 feet above sea level.

1.7 COORDINATION

- A. Coordinate location of field-mounted surge-protective devices to allow adequate clearances for maintenance.
- B. Coordinate surge-protective devices with Division 26 Section "Electrical Power Monitoring and Control."

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge-protective devices which fail in materials or workmanship within five years from date of Substantial Completion.
- B. Special Warranty for Cord-Connected, Plug-in Surge-Protective Devices: Manufacturer's standard form in which manufacturer agrees to repair or replace electronic equipment connected to circuits protected by surge-protective devices.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following

- 1. ASCO or approved equal.**

2.2 SERVICE ENTRANCE SPDs (TYPE 1 SPDs)

- A. Surge-Protective Device Description: Modular design with field-replaceable modules, sine-wave-tracking type with the following features and accessories:
 1. Fuses, rated at 200-kA interrupting capacity.
 2. Fabrication using bolted compression lugs for internal wiring.
 3. Integral disconnect switch.
 4. Redundant suppression circuits.
 5. Redundant replaceable modules.
 6. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
 7. Arrangement with wire connections to phase buses, neutral bus, and ground bus.

8. LED indicator lights for power and protection status.
 9. Audible alarm, with silencing switch, to indicate when protection has failed.
 10. One set of dry contacts rated at 5-A and 250-VAC, for remote monitoring of protection status. Coordinate with building power monitoring and control system.
 11. Surge-event operations counter.
- B. Peak Single-Impulse Surge Current Rating: 240 kA per phase.
- C. Connection Means: Permanently wired, integral or external as indicated on the drawings.
- D. **Protection modes and UL 1449 VPR for 3-phase, 4-wire, grounded wye circuits with voltages of 480Y/277, 208Y/120, or 600Y/347 as indicated on the drawings shall be as follows:**
1. **Line to Neutral: 1200 V for 480Y/277, 800 V for 208Y/120, 1500 V for 600Y/347.**
- E. **Protection modes and UL 1449 VPR for 240/120-V, single-phase, 3-wire circuits shall be as follows:**
1. **Line to Neutral: 800 V.**
- F. **Protection modes and UL 1449 VPR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:**
1. **Line to Neutral: 800 V, 1200 V from high leg.**
- G. Protection modes and UL 1449 VPR for 3-phase, 3-wire delta circuits with voltages of 240, 480, or 600 as indicated on the drawings shall be as follows:
1. Line to Line: 2000 V for 480 V, 1200 V for 240 V, 2500 V for 600 V.
 2. Line to Ground: 2000 V for 480 V, 1200 V for 240 V, 2500 V for 600 V.
- 2.3 PANELBOARD SURGE-PROTECTIVE DEVICES (TYPE 2 SPDs)
- A. Surge-Protective Device Description: Modular design with field-replaceable modules, sign-wave-tracking type with the following features and accessories:
1. Fuses, rated at 200-kA interrupting capacity.
 2. Fabrication using bolted compression lugs for internal wiring.
 3. Integral disconnect switch.
 4. Redundant suppression circuits.
 5. Redundant replaceable modules.
 6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.

7. LED indicator lights for power and protection status.
 8. Audible alarm, with silencing switch, to indicate when protection has failed.
 9. One set of dry contacts rated at 5-A and 250-VAC, for remote monitoring of protection status. Coordinate with building power monitoring and control system.
 10. Surge-event operations counter.
- B. Peak Single-Impulse Surge Current Rating: 160 kA per phase.
- C. Protection modes and UL 1449 VPR for 3-phase, 4-wire, grounded wye circuits with voltages of 480Y/277, 208Y/120, or 600Y/347 as indicated on the drawings shall be as follows:
1. Line to Neutral: 1200 V for 480Y/277, 800 V for 208Y/120, 1500 V for 600Y/347.
 2. Line to Ground: 1200 V for 480Y/277, 900 V for 208Y/120, 1500 V for 600Y/347.
 3. Neutral to Ground: 1000 V for 480Y/277, 700 V for 208Y/120, 1200 V for 600Y/347.
- D. Protection modes and UL 1449 VPR for 240/120-V, single-phase, 3-wire circuits shall be as follows:
1. Line to Neutral: 800 V.
 2. Line to Ground: 900 V.
 3. Neutral to Ground: 700 V.
- E. Protection modes and UL 1449 VPR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:
1. Line to Neutral: 800 V, 1200 V from high leg.
 2. Line to Ground: 900 V.
 3. Neutral to Ground: 700 V.
- F. Protection modes and UL 1449 VPR for 3-phase, 3-wire delta circuits with voltages of 240, 480, or 600 as indicated on the drawings shall be as follows:
1. Line to Line: 2000 V for 480 V, 1200 V for 240 V, 2500 V for 600 V.
 2. Line to Ground: 1800 V for 480 V, 1200 V for 240 V, 2000 V for 600 V.

2.4 SURGE-PROTECTIVE DEVICES FOR ELECTRONIC-GRADE PANELBOARDS (TYPE 2A SPDs)

- A. Surge Protection Device Description: Sine-wave-tracking type, panel-mounted design with the following features and accessories:
1. LED indicator lights for power and protection status.

2. Audible alarm, with silencing switch, to indicate when protection has failed.
 3. One set of dry contacts rated at 5-A and 250-VAC, for remote monitoring of protection status.
 4. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
- B. Peak Single-Impulse Surge Current Rating: 160 kA per phase.
- C. **Protection modes and UL 1449 VPR for 3-phase, 4-wire, grounded wye circuits with voltages of 480Y/277, 208Y/120, or 600Y/347 as indicated on the drawings shall be as follows:**
1. **Line to Neutral: 1200 V for 480Y/277, 800 V for 208Y/120, 1200 V for 600Y/347.**
- D. **Protection modes and UL 1449 VPR for 240/120-V, single-phase, 3-wire circuits shall be as follows:**
1. **Line to Neutral: 800 V.**
- E. **Protection modes and UL 1449 VPR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:**
1. **Line to Neutral: 800 V, 1200 V from high leg.**
- F. **Protection modes and UL 1449 VPR for 3-phase, 3-wire delta circuits with voltages of 240, 480, or 600 as indicated on the drawings shall be as follows:**
1. Line to Line: 2000 V for 480 V, 1200 V for 240 V, 2500 V for 600 V.
- 2.5 PLUG-IN SURGE-PROTECTIVE DEVICES (TYPE 3 SPDs)
- A. Description: Non-modular, plug-in surge-protective devices with at least four 15-A, 120-V ac, NEMA WD 6, Configuration 15-15R receptacles, suitable to plug into a NEMA WD 6, Configuration 15-15R receptacle; with the following features and accessories:
1. LED indicator lights for power and protection status (Direct plug-in).
 2. LED indicator lights for power, protection status, reverse polarity and open outlet ground (Cord connected).
 3. Circuit breaker and thermal fusing. When protection is lost, circuit opens.
 4. Close-coupled direct plug-in or cord connected with 15-foot line cord as indicated on the drawings.
- B. Peak Single-Impulse Surge Current Rating: 33 kA per phase.
- C. Protection modes and UL 1449 VPR shall be as follows:
1. Line to Neutral: 475 V.

2.6 ENCLOSURES

- A. NEMA 250, with type matching the enclosure of panel or device being protected.

PART 3 - EXECUTION

3.1 INSTALLATION OF SURGE-PROTECTIVE DEVICES

- A. Install devices at service entrance on load side, with ground lead bonded to service entrance ground.
- B. Install devices for panelboard and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
 - 1. Provide multi-pole circuit breaker as a dedicated disconnect for the SPD, unless otherwise indicated. Amperage rating and conductor sizes shall be per the manufacturer's requirements. Where a conflict exists between the drawings and the manufacturer, the manufacturer's requirements shall supersede the drawings.

3.2 PLACING SYSTEM INTO SERVICE

- A. Do not energize or connect service entrance equipment or panelboards to their sources until surge protection devices are installed and connected.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust equipment installation, including connections, and to assist in field testing. Report results in writing.
 - 1. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. Testing: Engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports:
- C. Testing: Perform the following field tests and inspections and prepare test reports:
 - 1. After installing surge protection devices, but before electrical circuitry has been energized, test for compliance with requirements.
 - 2. Complete startup checks according to manufacturer's written instructions.
 - 3. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.
- D. Remove and replace malfunctioning units and retest as specified above.

SURGE-PROTECTIVE DEVICES (SPDs)
FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS (1kV OR LESS)

SECTION 26 43 13

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transient voltage suppression devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 26 43 13

SECTION 27 53 19 - EMERGENCY RESPONDER RADIO ANTENNA/REPEATER SYSTEM
Addendum 1 (Revision 2)

PART 1 GENERAL

1.0 **This system is to comply with R56.**

1.01 SUMMARY

- A. Furnish, install, and test a complete and operating Emergency Responder Radio Antenna/Repeater System.

1.02 SECTION INCLUDES

- A. This Section includes the requirements for an Emergency Responder Radio Antenna/Repeater System for the purposes of assuring reliable communications by providing a minimum signal strength and minimum voice quality in 95% of all areas of the building.
- B. Components Include
 1. Bi-directional amplifiers ("BDA" or "BDAs")
 2. Donor antenna
 3. Indoor coverage antennas
 4. Distributed Antenna System ("DAS")
 5. Coaxial cable
 6. Splitters and directional couplers
 7. Backup power
 8. All other equipment and components necessary for a complete and functioning Emergency Responder Radio Antenna/Repeater System.

1.03 RELATED CODES AND STANDARDS

- A. All aspects of system design, installation, testing and maintenance shall comply with the current versions of the following:
 1. NFPA 1 – The National Fire Code (including Annex O from 2009)
 2. NFPA 70 – The National Electrical Code
 3. NFPA 101, Life Safety Code
 4. NFPA 72-07 National Fire Alarm Code
 5. FCC 47 CFR Part 90.219: Private Land Mobile Radio, Use of Signal Boosters
 6. Section 510 International Fire Code
 7. TSB-88-B, The Telecommunications Industry Association's (TIA) Technical Service Bulletin 88
 8. Equipment manufacturers' installation and maintenance specifications
- B. The requirements established by the AHJ in effect at the time of system installation supersede the specifications in this section. It is the contractor's responsibility to assure the installed system complies with all currently applicable local, national and industry codes as adopted by the AHJ.

1.04 DEFINITIONS

A. Definitions:

1. Authority Having Jurisdiction (“AHJ”): The local authority responsible for establishing requirements for Emergency Responder Radio Coverage Systems consistent with local codes and policies.
2. Critical Areas: Spaces within a building that require an extra assurance of radio coverage. These areas include emergency command centers, fire pump rooms, exit stairs, exit passageways, elevator lobbies, standpipe cabinets and other areas deemed critical by the AHJ.
3. Contractor: The entity bidding the project.
4. Owner: The entity who commissioned the project and will own the finished building.
5. Bi-Directional Amplifier or “BDA”: An electronic device designed to provide amplification of uplink and downlink channels of radio services. These devices can be configured for operation on specific narrow-band frequencies, on a specific frequency band or on multiple frequency bands.
6. Distributed Antenna System (“DAS”): A network typically consisting of coaxial cable, fiber cable, splitters, taps, couplers and antennas designed for delivering radio signals to and from spatially separated antenna nodes or other intentional radiators, such as leaky coaxial cable, within a building or area where traditional off-air signal delivery is compromised.
7. Backup Power Supply: A secondary power source to support uninterrupted system operation in case of a failure of the primary power source. This system is configured to automatically transfer its load upon failure and restoration of the primary power source.
8. Donor Antenna: An antenna installed and directed to intercept over-the-air downlink and uplink radio signals on one or more channels from a specific base station or fixed repeater facility. A donor antenna usually is located on a roof or other location where reliable signal reception can be achieved. This antenna conveys radio signals delivered to and from a distributed antenna system.
9. Emergency Responder Radio Coverage System: A two-way radio communication system installed to assure the effective operation of radio communications systems specifically for fire, emergency medical services or law enforcement agencies within a structure where radio reception may otherwise be too weak for reliable communications.
10. Delivered Audio Quality Definitions (“DAQ”): This is a universal standard adopted from TSB-88-B and often cited in system designs and specifications.
 - a. DAQ 1: Unusable, speech present but unreadable.
 - b. DAQ 2: Understandable with considerable effort. Frequent repetition due to noise/distortion.
 - c. DAQ 3: Speech understandable with slight effort. Occasional repetition required due to noise/distortion.
 - d. DAQ 3.4: Speech understandable with repetition only rarely required. Some noise/distortion
 - e. DAQ 4: Speech easily understood. Occasional noise/distortion.
 - f. DAQ 4.5: Speech easily understood. Infrequent noise/distortion.
 - g. DAQ 5: Speech easily understood.
11. Active System Components: System components, such as amplifiers, that require power. These components typically are utilized to provide amplification or “gain” to signals on the system.
12. Passive System Components: These components introduce signal loss in an RF system. Splitters, combiners, taps, directional couplers and cable are examples of passive system components.

13. Passive InterModulation (“PIM”): Unwanted signals generated due to non-linear connections or junctions in an RF path.
14. FCC: Federal Communications Commission
15. OET 65 Standards: FCC's Bulletin 65 provides Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields.
16. Public Safety/First Responder: Public Safety or First Responder agencies which are charged with the responsibility of responding to emergency situations. These include, but are not limited to: law enforcement departments, fire departments, and emergency medical companies.
17. RF: Radio Frequency

1.05 Design Approval

Plans shall be submitted and approved by the AHJ prior to installation. The Owner will submit the proposed design along with the full building plans as part of its Scheduled Plan Review. The following information shall be provided by the system designer/Contractor:

1. Detailed drawings showing the location of the amplification equipment and associated antenna systems.
 - a. System Block Diagram including the donor antenna(s), BDA(s), passive components and in-building antennas. Include the RF link budget.
 - b. Overlay of the system design on building floor plan drawings
2. Manufacturer's data sheets on all equipment to be installed.

1.06 PERFORMANCE REQUIREMENTS

A. Frequencies

1. *Two* sets of frequencies are to be utilized on the system.
2. The following FCC-licensed facilities are to be carried on the system:

	Downstream/ Base-to-mobile	Upstream/ Mobile-to-base	Channel Bandwidth
FCC Call Sign	Frequency	Frequency	

3. Transmissions on each set of frequencies must individually meet the coverage, minimum signal and minimum voice quality requirements.
4. Frequency Changes: Equipment selected for this system must be capable of being configured to different frequency pairs in the Public Safety frequency bands. These changes may later be necessary due to future additions or optimization of radio systems maintained by the AHJ.
5. It is the responsibility of the contractor to confirm the frequencies in use with the AHJ before proceeding with the system installation.

B. Minimum Received Signal Levels

1. Downstream signals: -95 dBm; The minimum signal strength that shall be received inside the building.
2. Upstream signals: -95 dBm; The minimum signal strength that shall be received at the Authority's repeater site.
3. Received signals in the building and at the Authority's repeater facility shall have a minimum Signal-to-Noise ratio of 15 dB.
4. Minimum received signal levels must be maintained regardless of seasonal and occasional signal path propagation conditions including those caused by weather and seasonal foliage changes.

5. Donor antennas utilized for the system must be directional and directed toward the respective repeater(s).
6. The minimum isolation between the donor antenna and system antennas shall be 15 dB or higher as necessary to prevent system oscillation based on the operating parameters required to meet the minimum coverage requirements.

C. Coverage

1. Signals at or above the minimum levels are to be receivable to and from 95% of all areas within the building. Spaces or rooms defined as critical areas require 99% coverage. For purposes of this Section, 95% coverage is considered to be all areas of the building.
2. The contractor is responsible for providing a system design and installation that provides enhancement only to those areas of the building where existing off-air service does not meet the minimum levels as described above. Signal strength surveys to confirm coverage enhancement requirements are the responsibility of the contractor. Care must be taken in engineering a system that will not cause interference to the Authority's radio system outside the building.

D. Equipment Locations

1. BDA: Wall space has been allocated for system electronic and headend components in the upper level Telecommunication Room (I.T.), (T.R.). The wall space is 4 feet wide by 8 feet tall.
2. Donor Antenna(s): A preferred antenna location on the building roof has been specified by the owner. The contractor is responsible for providing and installing the antenna(s), mounting hardware, roof penetration and conduit from the antenna mast to the Fire Control Room. Provide a 4" conduit from the room housing the BDA to the roof. At the roof level provide a weather-head on the conduit. Coordinate roof penetrations and sealing with the General Contractor.
3. Electronic components, including secondary power, shall be designed for operation in a NEMA 4 non-vented weather tight box. These components must be capable of reliable operation at temperatures ranging from -22 degrees F to +120 degrees F (-30 degrees C to +50 degrees C) minimum.

E. System Power Source

1. A dedicated, 120-volt, 20 A circuit has been specified as primary power for the BDA or any other required electronic components located in the Telecommunication Room (I.T.), (T.R.). If additional power is required at this or other locations such must be clearly specified as part of the submitted system design. The electrical contractor shall include the cost of additional power sources in the bid.
2. A secondary automatic transfer power source for all active electronic components in the system shall be provided. Supplier shall provide battery back-up for 24 hours of operation minimum. When the back-up system includes a generator, provide a UPS to support the 100 percent operation of the system for a minimum of two (2) hours. The emergency generator system serves the UPS system and shall provide power to the UPS system for a minimum of 24 hours. If the back-up system does not include a generator provide a UPS system to support the 100 percent operation of the system for a minimum of twenty-four (24) hours.

F. Mode of Operation

The system shall be designed for continuous, always-on service. A malfunction alarm for the BDA shall be provided and connected to the building fire alarm system.

G. System Frequency Response

All cable and passive electronic components shall have a minimum pass band of 400 – 2700 MHz. Systems that utilize a higher band, 698-2700 MHz shall be permitted if the band falls within that range.

H. Survivability

1. Physical Protection: All wiring and cabling, with the exception of radiating cable and antenna jumper cables measuring less than 2 feet in length, shall be installed in conduit.
2. All exposed cable, including flexible jumper cables, shall be plenum rated, utilizing a jacket of non-halogenated, fire retardant polyolefin.
3. Survivability levels shall be verified with local AHJ prior to construction. A survivability level of 2 (2 hour rated cabling) is required unless otherwise indicated by the AHJ.

I. Compatibility

Provide class-A BDA.

J. RF Exposure

The system shall meet the RF exposure guidelines of FCC Bulletin OET 65.

1.07 SUBMITTALS

A. Submittal Requirements with Bid Response

1. Product Data: Submit the manufacturer datasheets for the following components:
 - a. Donor Antennas
 - b. Coverage Antennas and/or Radiating Cable
 - c. Coaxial Cable and Connectors
 - d. Passive Devices including Splitters, Taps, Combiners and Couplers
 - e. Bi-Directional Amplifiers (BDA)
 - f. Secondary Power Supplies
 - g. Surge Protection
2. Shop Drawings
 - a. System Block Diagram including the donor antenna(s), BDA(s), passive components and in-building antennas. Include the RF link budget for Uplink and Downlink Path. Provide all assumptions.
 - b. Overlay of the system design on building floor plan drawings
 - c. Overlay on floor plan drawings of the predicted signal strength within the coverage area indicating, at a minimum, the -95 dBm downlink (base to mobile) signal strength for all coverage areas.
 - d. Building elevation and plan views depicting the location of any outdoor antennas associated with the proposed system. Include the antenna centerline height above building, orientation, mounting method, cabling, conduit route and the location of all external grounding connections.
 - e. BDA and Secondary Power Supply installation. Include plan and elevation views indicating equipment dimensions, mounting methods, enclosure type, cable and conduit routing, voltage required, power required, label locations and required clearance from other equipment. Identify each piece of equipment by brand, model number and equipment type.
 - f. Drawings and block diagrams are to be provided in AutoCAD format and accompanied by two (2) printed copies.
 - g. Shop drawings shall be 8.5 inch x 11 inch or greater, scaled or dimensioned, with dimensions or scale clearly noted. Floor plan drawings shall be 24 inch x 36 inch minimum with drawings scaled to legible size.

- h. All components shall be consistently named or labeled for reference in other drawings, diagrams and tables.
- 3. Other Submissions
 - a. Specify antenna grounding and surge protection in accordance with NEC Article 810 and these specifications.
 - b. Specify the backup/secondary power source, and include calculations to ensure the backup power requirements as specified in this standard are met.
 - c. List of Individuals Responsible for the system design, planning and installation along with their qualifications and experience.
- B. Submittal Requirements Prior to the Start of System Installation
 - 1. Documentation confirming the latest information from the AHJ of the frequencies to be supported by the system.
 - 2. List of any approved system design changes required since the original bid and the reason for each change. This list includes any design changes required for approval by the AHJ.
 - 3. Updated Product Data, Shop Drawings and Diagrams reflecting any changes.
 - 4. Bill of Materials ("BOM")
 - 5. Provide the names, addresses, and telephone numbers of service organizations that carry stock of repair parts for the system to be installed.
 - 6. System Installation Schedule as approved by the Owner, General Contractor and AHJ.
- C. Submittal Requirements at Project Close Out
 - 1. As-Built Drawings of all items required and in the formats listed in item A and B above.
 - 2. Test Reports
 - a. In-Building Coverage Test Results
 - b. Donor Antenna Isolation
 - c. Spectrum Analysis Report demonstrating only the intended frequencies are being carried on the system.
 - d. Spectrum Analysis Report demonstrating no spurious oscillations, PIM or other intermodulation products are being produced that would affect other services or system performance.
 - e. Sweep test results of all coaxial cable runs
 - f. System Malfunction Alarm and its connection to the fire alarm panel.
 - 3. Record of system operating parameters including:
 - a. Signal levels received at the donor antenna
 - b. Signal levels at the input and output of the BDA
 - c. BDA Gain Settings
 - 4. Operation and Maintenance Data: Submit hardware and software manuals for all products including all features and operating parameters.
 - 5. Warranty Documents:
 - a. Submit for all manufactured components utilized in the system
 - b. Submit Manufacturer's Extended Warranty
 - c. Submit Contractor's System Warranty
 - 6. Submit the agenda for the training class along with copies of handouts to be utilized in the class.
 - 7. Compile the items listed in this section into a single Operations and Maintenance Manual to be provided in electronic format. Include drawings and block diagrams in Adobe Acrobat (.pdf) and in AutoCAD format. Include a section containing a copy of the latest maintenance, testing and reporting requirements of the AHJ.

1.08 QUALITY ASSURANCE

A. Minimum Qualifications of Personnel

1. Engineering and Design:

- a. A valid Professional Engineering Certification and Certification of in-building system training issued by the manufacturer of the equipment being installed or
- b. Approval issued by the AHJ
- c. Include GROL requirement as stated by the latest IFC code.

2. Installer Qualifications:

- a. Minimum five years of experience installing systems of similar scope and complexity
- b. Certified by the manufacturer of the BDA equipment to be installed

B. All equipment shall be UL listed and labeled, and in accordance with applicable NEMA and ANSI Standards.

C. All parts of racks and enclosures shall be welded or assembled with paint piercing ground washers, grounding strip and bonding jumper.

1.09 WARRANTY

The contractor shall warrant system performance as specified in this section for one year starting on the date of final system acceptance.

1.10 MAINTENANCE AND ANNUAL TESTING

A. The contractor shall provide the first full year of maintenance for the system. The term of this maintenance period begins on the date of final system acceptance.

B. Maintenance shall include

1. 24-hour by 7-day emergency response within two hours after notification
2. Annual testing

C. Annual Tests

1. BDA Operating Parameters:

- a. Record signal and power levels
- b. Review self-diagnostics and other items as recommended by the manufacturer
- c. Note any parameter changes from previous tests, investigate causes

2. Backup/Secondary Power Supply

- a. Record voltage and charging of batteries before testing under load
- b. Test batteries under full load for at least one hour or until the integrity of the batteries can be determined.

3. Test system malfunction alarm and its connection to the fire alarm panel

4. Maintain documentation on-site with a backup copy off-site.

PART 2 PRODUCTS

1.02 MANUFACTURERS

Subject to compliance with the requirements of this Section, manufacturers of the products that may be utilized in the system include, but are not limited to, the following:

1. CommScope/Andrew
2. Cobham
3. PCTEL
4. Times Microwave
5. RFS – Radio Frequency Systems
6. Microlab/FXR
7. Bird Technologies
8. EMR Corp.
9. Galtronics
10. ADRF
11. Notifier

1.03 SYSTEM COMPONENTS

A. Donor Antennas

1. Electrical:
 - a. Frequency band: covering the frequencies specified by the AHJ.
 - b. VSWR \leq 1.5:1
 - c. Gain: \geq 10.0 dBi
 - d. Maximum Input Power: 100 watts
 - e. Polarization: Vertical
 - f. Front-to-back ratio: \geq 15 dB
 - g. Vertical Beamwidth: \leq 30 degrees
 - h. Horizontal Beamwidth: \leq 60 degrees
 - i. Impedance: 50 Ω
2. Mechanical:
 - a. Connector: 50 Ω type N Female
 - b. Mounting: Mast on a non-penetrating mount utilizing concrete block ballast
 - c. Grounding/Bonding: **Pursuant to NFPA 70 NEC Article 810 requirements and comply with R56, the more stringent shall apply.**
3. Environmental:
 - a. Temperature: -40°C to +60°C
 - b. Lightning Protection: Direct Ground
 - c. Maximum Rated Wind Velocity: 125 mph
4. Antenna Cable:
 - a. All exposed cable shall have a UV stable black jacket for protection from sunlight
 - b. Cable feed to the BDA shall be ½” copper corrugated outer conductor foam dielectric coax.
 - c. Weatherproofing: exposed connectors protected from the effects of weather
 - d. Rigid conduit between the Donor location and BDA location shall be provided and installed by the contractor.

B. Omni-Directional In-Building Coverage Antennas

- a. Frequency band: 698-900 MHz
 - b. $VSWR \leq 1.8:1$
 - c. Gain: ≥ 1.0 dBi
 - d. Maximum Input Power: 25 watts
 - e. Polarization: Vertical
 - f. Vertical Beamwidth: ≥ 65 degrees
 - g. Horizontal Beamwidth: 360 degrees
 - h. PIM: < -150 dBc
 - i. Impedance: 50Ω
 - 2. Mechanical:
 - a. Connector: 50Ω type N Female
 - b. Mounting: ceiling mount or securely mounted above ceiling
 - 3. Environmental:
 - a. Temperature: -20°C to $+70^{\circ}\text{C}$
 - b. Plenum rated
- C. Directional Coverage Antennas
- 1. Electrical
 - a. Frequency band: 698-900 MHz
 - b. $VSWR \leq 1.8:1$
 - c. Gain: ≥ 1.0 dBi
 - d. Maximum Input Power: 25 watts
 - e. Polarization: Vertical
 - f. Vertical Beamwidth: ≥ 65 degrees
 - g. Horizontal Beamwidth: 90 degrees - 180 degrees nominal
 - h. PIM: < -150 dBc
 - i. Impedance: 50Ω
 - 2. Mechanical:
 - a. Connector: 50Ω type N Female
 - b. Mounting: ceiling or wall mount
 - 3. Environmental:
 - a. Temperature: -20°C to $+70^{\circ}\text{C}$
 - b. Plenum rated
- D. Radiating Cable
- 1. Material:
 - a. Nominal size: $\frac{1}{2}$ " or $\frac{7}{8}$ "
 - b. Outer conductor: Corrugated copper
 - c. Slot Design: milled, two rows
 - d. Jacket Material: Non-halogenated, fire retardant polyolefin
 - e. Dielectric Material: Foam PE

- f. Inner Conductor Material: Copper wire, copper tube or Copper-clad aluminum wire
 - g. Mounting: Minimum clearance of 2" from walls or other structure, secured at intervals and with hardware pursuant to manufacturer's specifications
 - 2. Electrical
 - a. Frequency Range: 30 – 2650 MHz
 - b. Impedance: $50\Omega \pm 1$
 - 3. Environmental:
 - 4. Temperature: -20°C to +80°C
- E. Foam Dielectric Cable
 - 1. Material:
 - a. Nominal size: ½" or 7/8"
 - b. Outer conductor: Corrugated copper
 - c. Dielectric Material: Foam PE
 - d. Inner Conductor Material: Copper wire, copper tube or Copper-clad aluminum wire
 - 2. Electrical
 - a. Frequency Range: 30 – 2650 MHz
 - b. Impedance: $50\Omega \pm 1$
 - 3. Environmental:
 - 4. Temperature: -20°C to +80°C
- F. Splitters, Combiners, Couplers, Taps, Coax Jumpers and Connectors:
 - 1. Electrical
 - a. Frequency Range: 698 – 2700 MHz
 - b. $VSWR \leq 1.3:1$
 - c. Maximum Input Power: ≥ 50 watts
 - d. PIM: < -150 dBc
 - e. Impedance: 50Ω
 - 2. Mechanical:
 - a. Connector: 50Ω type N Female
 - 3. Environmental:
 - a. Temperature: -20°C to +70°C
- G. BDA: Bi-Directional Amplifiers utilized on the system must meet the following requirements:
 - 1. Electrical
 - a. Frequency agility: The unit shall have the capability to change operating frequencies within the 700 – 800 MHz Public Safety Band as may be required due to licensing changes of the AHJ or actions of the FCC.

- b. Alarming Functions: The BDA shall be linked to the building's fire alarm panel and configured to signal an alarm in the event of a failure with the BDA or donor antenna system.
 - c. The BDA shall have received FCC Certification prior to installation.
 - d. The system must be compatible with both analog and digital transmissions.
 - e. Automatic gain and level controls shall be integrated into the BDA with a minimum dynamic range of 60 dB, less any gain reduction setting.
 - 2. Mechanical
 - a. All BDA components shall be housed in a single, NEMA4 cabinet. The cabinet must be waterproof and capable of dissipating all heat without the use of ventilation.
 - b. The BDA cabinet shall be painted fire engine red and display the following labeling in bright yellow letters: "RADIO REPEATER" unless alternate labeling is specified by the AHJ.
 - c. The name and telephone number of the vendor responsible for system maintenance also must be marked on the cabinet.
 - d. If the BDA is not located in the same room as the fire alarm panel, a sign shall be placed at the fire alarm panel with the name and telephone number of the local Fire Department indicating that they shall be notified of any failures that extend past two hours.
 - e. The cabinet shall be securely locked to prevent unauthorized access.
 - 3. Environmental
 - a. The BDA, as installed in the approved NEMA4 cabinet, shall be designed for operating in temperatures ranging from -22 degrees F to +120 degrees F (-30 degrees C to +50 degrees C).
- H. Power Supplies: At least two (2) independent and reliable power supplies shall be provided, one primary and one secondary.
- 1. Primary Power: The primary power source shall be supplied from a dedicated 20 Ampere branch circuit. The presence of primary power shall be monitored by the BDA monitoring system and provide notification upon loss of primary power.
 - 2. Secondary Power: The secondary power source shall be capable of operating the in-building radio system for at least 24 hours of 100% system operation. This system shall utilize a dedicated battery system or a self-starting generator with dedicated storage batteries.
 - a. The battery system shall automatically charge in the presence of the external/primary power input.
 - b. The secondary power system shall be engaged automatically upon loss of primary power.
 - c. The secondary power system shall be contained in one NEMA 4 enclosure.
 - d. An alarm shall be configured to signal failure of the battery charging system or if the battery charge falls below 70% of capacity.
 - 3. Environmental
 - a. The secondary power system, as installed in the approved NEMA4 cabinet, shall be designed for operating in temperatures ranging from -22 degrees F to +120 degrees F (-30 degrees C to +50 degrees C).

PART 3 EXECUTION

3.1 INSTALLATION

- A. System Signal Wires, Power Conductors and Cables
 1. Wires and cables shall enter each equipment enclosure, cabinet or rack in such a manner that all doors or access panels can be opened and closed unobstructed by cables.
 2. Routing and Interconnection
 - a. Wires or cables routed between cabinets, racks, and other equipment shall be installed in an approved conduit or cable tray that is secured to the building structure.
 3. All cable shall be sweep tested for detection of any faults prior to and after installation. Sweep results shall be recorded for future reference.
 4. Coaxial cable shall be carefully installed in strict compliance with the manufacturers' recommended procedures with special attention given to pulling tensions, bending radius and proper support.
 5. Coaxial antenna cabling, except for radiating cable, shall be installed in its own metallic conduit.
 6. All equipment, cable and components shall be installed and connected according to the OEM's specifications to insure correct installation and system performance.
 7. Coordinate all roof penetrations with Owner and/or roofing contractor.

3.2 GROUNDING

- A. Ground and bond cable shields and equipment per Manufacturer's requirements and NFPA 70 NEC requirements and **comply with R56, the more stringent shall apply.**
- B. The Donor antenna mast shall be grounded per NFPA 70 NEC requirements. Grounding blocks and surge protection shall be provided for outside coaxial cabling.

3.3 ACCEPTANCE TESTING

- A. An initial set of system Commissioning Tests shall be performed for the Owner prior to final Acceptance Testing with the AHJ. The commissioning tests will include all tests outlined in Part 1.07 C.2., "Submittal Requirements at Project Closeout", "Test Reports".
- B. Tests shall be made using frequencies close to the frequencies used by the appropriate emergency services. If testing is done on the actual frequencies, then this testing must be coordinated with the local Department unit. All testing must be done on frequencies authorized by the FCC. A valid FCC license will be required if testing is done on frequencies different from the licensed department frequencies.
- C. Final Acceptance Test Procedures

Acceptance testing shall consist of the following tests or those tests as may be directed by the AHJ and local County emergency response.

 1. Coverage Testing: For testing system signal strength and quality, the testing shall be based on the delivered audio quality (DAQ) system. A DAQ level below 3.4 shall be considered a failed test for a given grid cell. See Part 1.04, DEFINITIONS for descriptions of each DAQ level.

- a. Each floor of the building shall be divided into 20 grid divisions. Increase to 40 if there is a failure. Critical areas tested separately.
 - b. The tests will be conducted by using a calibrated portable two-way radio of the latest brand and model as currently in use by the local Department.
 - c. Small scale drawings (11 inch x 17 inch maximum) of the structure shall be provided by the Contractor for use and documentation of the test results. The plans shall show each floor divided into the grids as described above, and the results of any pre-testing. Each grid shall be labeled to indicate the DAQ result from the final acceptance testing.
 - d. DAQ tests shall be made with the antenna held in a vertical position at 3 to 4 feet above the floor to simulate a typical portable radio worn on the belt or turnout coat pocket.
 - e. A test location shall be selected near the center of each grid square. Once the test location of a grid area is selected, prospecting for a better spot within the area is permitted only within three feet (3') in any direction of the selected test location.
 - f. The two-way radio will be utilized to transmit voice transmissions to verify communications to and from the outside area covered by the Department's radio system. For each grid location, the DAQ of the transmission shall be determined.
 - g. A maximum of two non-adjacent areas will be allowed to fail the DAQ test.
 - h. In the event that three or more of the grid test locations fail the test, the floor may be re-tested by creating a new grid consisting of 80 equal areas and test locations selected within each area. In testing the new grid, a maximum of four non-adjacent areas may fail the test. If the system fails the 80 area test, then the system must be revised to meet the coverage requirement.
2. Isolation and Spectrum Analysis Testing:
 - a. Measurement of the isolation between the donor antenna(s) and the system antennas shall be performed utilizing a spectrum analyzer and appropriate signal generator.
 - b. A Spectrum Analysis Report demonstrating only the intended frequencies are being carried on the system.
 - c. Spectrum Analysis Report demonstrating no spurious oscillations or intermodulation products are being produced that would affect other services or system performance.
 3. Other tests as requested by the AHJ.

END OF SECTION