PROJECT TABLE OF CONTENTS

DIVISION 05 - METALS

05 12 00	08/18, CHG 1: 11/18	STRUCTURAL STEEL
05 21 00	05/15, CHG 1: 08/18	STEEL JOIST FRAMING
05 51 00	02/17, CHG 1: 05/17	METAL STAIRS
05 52 00	02/18	METAL RAILINGS

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

07 42 13	05/11, CHG 2: 02/18	METAL WALL PANELS
07 60 00	05/17, CHG 2: 11/18	FLASHING AND SHEET METAL
07 61 15.00 20	08/16, CHG 2: 11/18	ALUMINUM STANDING SEAM ROOFING

DIVISION 08 - OPENINGS

08 11 13	08/20	STEEL DOORS AND FRAMES

DIVISION 09 - FINISHES

09 90 00	02/21	PAINTS AND COATINGS
09 96 00	11/14	HIGH-PERFORMANCE COATINGS
09 97 13.27	02/21, CHG 1: 08/22	HIGH PERFORMANCE COATING FOR STEEL STRUCTURES

DIVISION 26 - ELECTRICAL

26 05 19.10 10	05/16	INSULATED WIRE AND CABLE
26 05 48.00 10	10/07	SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT
26 05 75	03/15	POWER SYSTEM STUDY
26 08 00	08/08	APPARATUS INSPECTION AND TESTING
26 08 01.00 50	01/18	COMMISSIONING OF ELECTRICAL SYSTEMS
26 12 19.10	05/19	THREE-PHASE, LIQUID-FILLED PAD-MOUNTED TRANSFORMERS
26 20 00	08/19	INTERIOR DISTRIBUTION SYSTEM
26 24 13	05/15	SWITCHBOARDS
26 27 14.00 20		ELECTRICITY METERING
26 28 01.00 10	10/07	COORDINATED POWER SYSTEM PROTECTION
26 29 23	02/20	ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS
26 31 00	11/21	FACILITY-SCALE SOLAR PHOTOVOLTAIC (PV) SYSTEMS
26 32 15.00	05/20	ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES
26 35 43	08/21	400-HERTZ (HZ) SOLID STATE FREQUENCY CONVERTER
26 35 44	08/21	270 VDC SOLID STATE CONVERTER
26 36 23	05/20	AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH
26 41 00	11/13	LIGHTNING PROTECTION SYSTEM

DIVISION 27 - COMMUNICATIONS

27 10 00	08/11	BUILDING TELECOMMUNICATIONS CABLING SYSTEM
27 51 16	05/20	PUBLIC ADDRESS SYSTEMS

DIVISION 32 - EXTERIOR IMPROVEMENTS

32 12 16.16 11/20 ROAD-MIX ASPHALT PAVING

DIVISION 46 - WATER AND WASTEWATER EQUIPMENT

46 25 15 BJWSA GREASE TRAP

-- End of Project Table of Contents --

SECTION 05 12 00

STRUCTURAL STEEL
08/18, CHG 1: 11/18
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 207	(2016; R 2017) Certification Standard for Steel Fabrication and Erection, and Manufacturing of Metal Components
AISC 303	(2016) Code of Standard Practice for Steel Buildings and Bridges
AISC 325	(2017) Steel Construction Manual
AISC 326	(2009) Detailing for Steel Construction
AISC 341	(2016) Seismic Provisions for Structural Steel Buildings
AISC 360	(2016) Specification for Structural Steel Buildings
AISC 420	(2010) Certification Standard for Shop Application of Complex Protective Coating Systems
AISC DESIGN GUIDE 10	(1997) Erection Bracing of Low-Rise Structural Steel Buildings

AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)

ANSI/ASNT CP-189	(2016) ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel (ANSI/ASNT CP-105-2006)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B46.1	(2020) Surface Texture, Surface Roughness, Waviness and Lay

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	(2012) Standard Symbols for Welding, Brazing and Nondestructive Examination
AWS D1.1/D1.1M	(2020) Structural Welding Code - Steel

AWS D1.8/D1.8M	(2016) Structural Welding Code—Seismic Supplement
AWS QC1	(2016) Specification for AWS Certification of Welding Inspectors

ASTM INTERNATIONAL (ASTM)

ASTM A6/A6M	(2017a) Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
ASTM A29/A29M	(2020) Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought
ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A143/A143M	(2007; R 2020) Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A500/A500M	(2020) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A563	(2015) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A992/A992M	(2020) Standard Specification for Structural Steel Shapes
ASTM A1085/A1085M	(2015) Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS)
ASTM B695	(2004; R 2016) Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel

ASTM C827/C827M	(2016) Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures
ASTM C1107/C1107M	(2020) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM F436/F436M	(2019) Standard Specification for Hardened Steel Washers Inch and Metric Dimensions
ASTM F844	(2019) Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use
ASTM F959/F959M	(2017a) Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners, Inch and Metric Series
ASTM F1136/F1136M	(2011) Standard Specification for Zinc/Aluminum Corrosion Protective Coatings for Fasteners
ASTM F1554	(2020) Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
ASTM F2329/F2329M	(2015) Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners
ASTM F2833	(2011; R 2017) Standard Specification for Corrosion Protective Fastener Coatings with Zinc Rich Base Coat and Aluminum Organic/Inorganic Type
ASTM F3125/F3125M	(2019) Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

CRANE MANUFACTURERS ASSOCIATION OF AMERICA (CMAA)

CMAA 70	(2015) Specification for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC PA 1	(2016) Shop, Field, and Maintenance Coating of Metals
SSPC Paint 20	(2019) Zinc-Rich Primers (Type I,

	Inorganic, and Type II, Organic)
SSPC Paint 29	(2002; E 2004) Zinc Dust Sacrificial Primer, Performance-Based
SSPC SP 3	(2018) Power Tool Cleaning
SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019) Structural Engineering

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR Part 1926, Subpart R	Steel Erection

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Erection and Erection Bracing Drawings; G

SD-02 Shop Drawings

Fabrication Drawings Including Details of Connections; G

SD-03 Product Data

Shop Primer

Welding Electrodes and Rods

Direct Tension Indicator Washers

Non-Shrink Grout

Recycled Content for Structural Steel; S

Recycled Content for Structural Steel Tubing; S

Recycled Content for Steel Pipe; S

SD-06 Test Reports

Weld Inspection Reports

Direct Tension Indicator Washer Inspection Reports

Embrittlement Test Reports

SD-07 Certificates

AISC Structural Steel Fabricator Quality Certification

AISC Structural Steel Erector Quality Certification

Welding Procedures and Qualifications

Welding Electrodes and Rods

Certified Welding Inspector

NDT Technician

Welding Procedure Specifications (WPS)

Overhead, Top Running Crane Rail Beam

1.3 AISC QUALITY CERTIFICATION

Work must be fabricated by an AISC Certified Structural Steel Fabricator, in accordance with AISC 207, Category BU. Submit AISC Structural Steel Fabricator quality certification.

Work must be erected by an AISC Structural Steel Certified Erector, in accordance with AISC 207, Category CSE. Submit AISC Structural Steel erector quality certification.

1.4 SEISMIC PROVISIONS

Provide the structural steel system in accordance with AISC 341, Chapter J as amended by UFC 3-301-01.

1.5 QUALITY ASSURANCE

1.5.1 Preconstruction Submittals

1.5.1.1 Erection and Erection Bracing Drawings

Submit for record purposes. Indicate the sequence of erection, temporary shoring and bracing. The erection drawings must conform to AISC 303.

1.5.2 Fabrication Drawing Requirements

Submit fabrication drawings for approval prior to fabrication. Prepare in accordance with AISC 303, AISC 326 and AISC 325. Fabrication drawings must not be reproductions of contract drawings. Include complete information for the fabrication and erection of the structure's components, including the location, type, and size of bolts, welds, member sizes and lengths, connection details, blocks, copes, and cuts. Use AWS A2.4 standard welding symbols. Clearly highlight any deviations from the details shown on the contract drawings highlighted on the fabrication drawings. Explain the reasons for any deviations from the contract drawings. During the development of fabrication drawings and the submittal review process, conduct four virtual meetings with the steel detailer, fabricator, structural engineer of record, general contractor and contracting officer. Allow for each meeting length to be three hours. The focus of the meeting must be a discussion of the steel detailing and to allow the steel detailer, fabricator and structural engineer an opportunity to ask questions regarding the steel details, steel design and

erection. The time of the meetings must be submitted to the contracting officer prior to the start of steel detailing.

1.5.3 Certifications

1.5.3.1 Welding Procedures and Qualifications

Prior to welding, submit certification for each welder stating the type of welding and positions qualified for, the code and procedure qualified under, date qualified, and the firm and individual certifying the qualification tests. If the qualification date of the welder or welding operator is more than 6 months old, the welding operator's qualification certificate must be accompanied by a current certificate by the welder attesting to the fact that he has been engaged in welding since the date of certification, with no break in welding service greater than 6 months.

Conform to all requirements specified in AWS D1.1/D1.1M and AWS D1.8/D1.8M.

1.5.3.2 Overhead, Top Running Crane Rail Beam

Submit written field survey results for overhead, top running crane rail beam verifying tolerance requirements per CMAA 70.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide the structural steel system, including galvanizing, complete and ready for use. Provide structural steel systems including design, materials, installation, workmanship, fabrication, assembly, erection, inspection, quality control, and testing in accordance with AISC 303, AISC 360, AISC 341, and UFC 3-301-01 except as modified in this contract.

2.2 STEEL

2.2.1 Structural Steel

Wide flange and WT shapes, ASTM A992/A992M. Angles, Channels and Plates, that are not part of the Seismic Force Resisting System ASTM A36/A36M. Angles, Channels and Plates that are part of the Seismic Force Resisting System, ASTM A572 (Fy=50 Ksi).Provide structural steel containing a minimum of 50 percent recycled content. Submit data identifying percentage of recycled content for structural steel.

2.2.2 Structural Steel Tubing

ASTM A500/A500M, Grade C. ASTM A1085/A1085M. Provide structural steel tubing containing a minimum of 25 percent recycled content. Submit data identifying percentage of recycled content for structural steel tubing.

2.2.3 Steel Pipe

ASTM A53/A53M, Type E or S, Grade B, weight class. Provide steel pipe containing a minimum of 50 percent recycled content. Submit data identifying percentage of recycled content for steel pipe.

2.3 BOLTS, NUTS, AND WASHERS

Submit the certified manufacturer's mill reports which clearly show the

applicable ASTM mechanical and chemical requirements together with the actual test results for the supplied fasteners.

2.3.1 Common Grade Bolts

2.3.1.1 Bolts

ASTM A307, Grade A, plain finish. The bolt heads and the nuts of the supplied fasteners must be marked with the manufacturer's identification mark, the strength grade and type specified by ASTM specifications.

2.3.1.2 Nuts

ASTM A563, Grade A, heavy hex style.

2.3.1.3 Self-Locking Nuts

Provide nuts with a locking pin set in the nut. The locking pin must slide along the bolt threads, and by reversing the direction of the locking pin, the nut can be removed without damaging the nut or bolt. Provide stainless steel locking pins.

2.3.1.4 Washers

ASTM F844.

2.3.2 High-Strength Bolts

High strength bolts and nuts must be shipped together in the same shipping container. Fasteners indicated to be galvanized shall be tested by the supplier to show that the galvanized nut with the supplied lubricant provided may be rotated from the snug tight condition well in excess of the rotation required for pretentioned installation without stripping. The supplier shall supply nuts that have been lubricated and tested with the supplied bolts.

2.3.2.1 Bolts

ASTM F3125/F3125M, Grade A325 or A490 where indicated on plan, Type 1 Heavy Hex Head Style, plain finish.

2.3.2.2 Nuts

ASTM A563, Grade and Style as specified in the applicable ASTM bolt standard.

2.3.2.3 Direct Tension Indicator Washers

ASTM F959/F959M. Provide ASTM B695, Class 55, Type 1 galvanizing. Submit product data for direct tension indicator washers.

2.3.2.4 Washers

ASTM F436/F436M, plain carbon steel.

2.3.3 Foundation Anchorage

2.3.3.1 Anchor Rods

ASTM F1554 Gr 55, Class 1A, unless otherwise noted. ASTM F1554 Gr 105, Class 1A at braced frames.

2.3.3.2 Anchor Nuts

ASTM A563, Grade A, hex style.

2.3.3.3 Anchor Washers

ASTM F844.

2.3.3.4 Anchor Plate Washers

ASTM A36/A36M.

2.4 STRUCTURAL STEEL ACCESSORIES

2.4.1 Welding Electrodes and Rods

AWS D1.1/D1.1M and AWS D1.8/D1.8M. Submit product data for welding electrodes and rods.

2.4.2 Non-Shrink Grout

ASTM C1107/C1107M, with no ASTM C827/C827M shrinkage. Submit product data for non-shrink grout.

2.4.3 Welded Shear Stud Connectors

ASTM A29/A29M, Grades 1010 through 1020. AWS D1.1/D1.1M, Table 7.1, Type B.

2.5 GALVANIZING

ASTM F2329/F2329M, ASTM F1136/F1136M, ASTM F2833 or ASTM B695 for threaded parts or ASTM A123/A123M for structural steel members, as applicable, unless specified otherwise galvanize after fabrication where practicable.

2.6 FABRICATION

Fabrication must be in accordance with the applicable provisions of AISC 325. Fabrication and assembly must be done in the shop to the greatest extent possible. Punch, subpunch and ream, or drill bolt holes perpendicular to the surface of the member.

Compression joints depending on contact bearing must have a surface roughness not in excess of 500 micro inch as determined by ASME B46.1, and ends must be square within the tolerances for milled ends specified in ASTM A6/A6M.

Shop splices of members between field splices will be permitted only where indicated on the Contract Drawings. Splices not indicated require the approval of the Contracting Officer.

Do not splice truss top and bottom chords except as approved by the

Contracting Officer. Provide chord splices at panel joints at approximately the third point of the span. The center of gravity lines of truss members must intersect at panel points unless otherwise approved by the Contracting Officer. When the center of gravity lines do not intersect at a panel point, make provisions for the stresses due to eccentricity. Camber of trusses must be 1/8 inch in 10 feet unless otherwise indicated.

2.6.1 Markings

Prior to erection, identify members by a painted erection mark. Connecting parts assembled in the shop for reaming holes in field connections must be match marked with scratch and notch marks. Do not locate erection markings on areas to be welded. Do not locate match markings in areas that will decrease member strength or cause stress concentrations. Affix embossed tags to hot-dipped galvanized members.

2.6.2 Shop Primer

SSPC Paint 20 or SSPC Paint 29. Shop prime structural steel, except as modified herein, in accordance with SSPC PA 1. Do not prime steel surfaces embedded in concrete, galvanized surfaces, or surfaces within 0.5 inch of the toe of the welds prior to welding (except surfaces on which metal decking and shear studs are to be welded). ***For structural steel which requires finish painting under Section 09 90 00 PAINTS AND COATINGS, or Section 09 97 13.27 the primer paint must be compatible with the finish paint. Refer to architectural finish schedule for finish painting requirements.*** If flash rusting occurs, re-clean the surface prior to application of primer. Apply primer in accordance with endorsement "SPE-P1" of AISC 420 or approved equal NACE or SSPC certification to a minimum dry film thickness of 2.0 mil. Submit shop primer product data.

Prime slip critical surfaces with a Class B coating in accordance with AISC 325. Submit test report for Class B coating.

Prior to assembly, prime surfaces which will be concealed or inaccessible after assembly. Do not apply primer in foggy or rainy weather; when the ambient temperature is below 45 degrees F or over 95 degrees F; or when the primer may be exposed to temperatures below 40 degrees F within 48 hours after application, unless approved otherwise by the Contracting Officer. Repair damaged primed surfaces with an additional coat of primer.

2.6.2.1 Cleaning

SSPC SP 6/NACE No.3, except steel exposed in spaces above ceilings, attic spaces, furred spaces, and chases that will be hidden to view in finished construction may be cleaned to SSPC SP 3 when recommended by the shop primer manufacturer. Maintain steel surfaces free from rust, dirt, oil, grease, and other contaminants through final assembly.

2.6.3 Surface Finishes

ASME B46.1 maximum surface roughness of 125 for pin, pinholes, and sliding bearings, unless indicated otherwise.

2.7 DRAINAGE HOLES

Drill adequate drainage holes to eliminate water traps. Hole diameter must be 1/2 inch and location indicated on the detail drawings. Hole size

and locations must not affect the structural integrity.

PART 3 EXECUTION

3.1 ERECTION

a. Erection of structural steel, except as indicated in item b. below, must be in accordance with the applicable provisions of AISC 325, AISC 303 and 29 CFR Part 1926, Subpart R.

b. For low-rise structural steel buildings (60 feet tall or less and a maximum of 2 stories), erect the structure in accordance with AISC DESIGN GUIDE 10.

After final positioning of steel members, provide full bearing under base plates and bearing plates using nonshrink grout. Place nonshrink grout in accordance with the manufacturer's instructions.

3.1.1 STORAGE

Store the material out of contact with the ground in such manner and location as to minimize deterioration.

3.2 CONNECTIONS

Except as modified in this section, design connections indicated in accordance with AISC 360. Build connections into existing work. Do not tighten anchor bolts set in concrete with impact torque wrenches. Holes must not be cut or enlarged by burning. Bolts, nuts, and washers must be clean of dirt and rust, and lubricated immediately prior to installation.

3.2.1 Common Grade Bolts

Tighten ASTM A307 bolts to a "snug tight" fit. "Snug tight" is the tightness that exists when plies in a joint are in firm contact. If firm contact of joint plies cannot be obtained with a few impacts of an impact wrench, or the full effort of a man using a spud wrench, contact the Contracting Officer for further instructions.

3.2.2 High-Strength Bolts

Provide direct tension indicator washers in all ASTM F3125/F3125M, Grade A325 and Grade A490 bolted connections. Bolts must be installed in connection holes and initially brought to a snug tight fit. After the initial tightening procedure, fully tension bolts, progressing from the most rigid part of a connection to the free edges.

Fastener components shall be protected from dirt and moisture in closed containers at the site of the installation. Fastener components that are not incorporated into the work shall be returned to protected storage at the end of the work shift.

3.2.2.1 Installation of Direct Tension Indicator Washers (DTIW)

Where possible, install the DTIW under the bolt head and tighten the nut. If the DTIW is installed adjacent to the turned element, provide a flat washer between the DTIW and nut when the nut is turned for tightening, and between the DTIW and bolt head when the bolt head is turned for tightening. In addition to the LIW, provide flat washers under both the bolt head and nut when ASTM F3125/F3125M, Grade A490 bolts are used.

3.2.3 Tension Control Bolts

Bolts must be installed in connection holes and initially brought to a snug tight fit. After the initial tightening procedure, fully tension bolts, progressing from the most rigid part of a connection to the free edges.

3.3 GAS CUTTING

Use of gas-cutting torch in the field for correcting fabrication errors is not permitted on any major member in the structural framing. Use of a gas cutting torch will be permitted on minor members not under stress only after approval has been obtained from the Contracting Officer.

3.4 WELDING

Welding must be in accordance with AWS D1.1/D1.1M. Grind exposed welds smooth as indicated. Provide AWS D1.1/D1.1M qualified welders, welding operators, and tackers.

Develop and submit the Welding Procedure Specifications (WPS) for all welding, including welding done using prequalified procedures. Submit for approval all WPS, whether prequalified or qualified by testing.

3.4.1 Removal of Temporary Welds, Run-Off Plates, and Backing Strips

Remove from finished areas and remove backing strips from bottom flange of moment connections, backgouge the root pass to sound weld metal and reinforce with a 5/16 inch fillet weld minimum.

3.5 SHOP PRIMER REPAIR

Repair shop primer in accordance with the paint manufacturer's recommendation for surfaces damaged by handling, transporting, cutting, welding, or bolting.

3.5.1 Field Priming

Field prime steel exposed to the weather, or located in building areas without HVAC for control of relative humidity. After erection, the field bolt heads and nuts, field welds, and any abrasions in the shop coat must be cleaned and primed with paint of the same quality as that used for the shop coat. Repair paint must be compatible with the finishing paint. Refer to Section 09 97 13.27 High Performance Coating for Steel.

3.6 GALVANIZING REPAIR

Repair damage to galvanized coatings using ASTM A780/A780M zinc rich paint for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces to which repair paint has been applied.

3.7 FIELD QUALITY CONTROL and Special Inspections

Perform field tests, and provide labor, equipment, and incidentals required for testing, except that electric power for field tests will be furnished as set forth in Division 1. Notify the Contracting Officer in writing of defective welds, bolts, nuts, and washers within 7 working days of the date of the inspection.

3.7.1 Welds

3.7.1.1 Visual Inspection

AWS D1.1/D1.1M. Furnish the services of AWS-certified welding inspectors for fabrication and erection inspection and testing and verification inspections. A Certified Welding Inspector must perform visual inspection on 100 percent of all welds. Document this inspection in the Visual Weld Inspection Log. Submit certificates indicating that certified welding inspectors meet the requirements of AWS QC1.

Inspect proper preparation, size, gaging location, and acceptability of all welds; identification marking; operation and current characteristics of welding sets in use.

3.7.1.2 Nondestructive Testing

Nondestructive testing must be in accordance with AWS D1.1/D1.1M and AWS D1.8/D1.8M. Ultrasonic testing must be performed in accordance with Table 6.2 or 6.3 of AWS D1.1/D1.1M. Test locations must be selected by the Contracting Officer. All personnel performing NDT must be certified in accordance with ANSI/ASNT CP-189 in the method of testing being performed. Submit certificates showing compliance with ANSI/ASNT CP-189 for all NDT technicians. If more than 20 percent of welds made by a welder contain defects identified by testing, then all groove welds made by that welder must be tested by ultrasonic testing, and all fillet welds made by that welder must be inspected by magnetic particle testing (MT) or dye penetrant testing (PT) as approved by the Contracting Officer. When groove welds made by an individual welder are required to be tested, magnetic particle or dye penetrant testing may be used only in areas inaccessible to ultrasonic testing. Retest all repaired areas. Submit weld inspection reports.

Testing frequency: Provide the following types and number of tests:

Test Type	Number of Tests
Ultrasonic	50 percent of CJP Welds
Magnetic Particle	50 percent of PJP and Fillet Welds

3.7.2 Direct Tension Indicator Washers

3.7.2.1 Direct Tension Indicator Washer Compression

Test direct tension indicator washers in place to verify that they have been compressed sufficiently to provide the 0.015 inch gap, as required by ASTM F959/F959M. Submit direct tension indicator washer inspection reports.

3.7.2.2 Direct Tension Indicator Gaps

In addition to the above testing, an independent testing agency as approved by the Contracting Officer, must test in place the direct tension indicator gaps on 20 percent of the installed direct tension indicator washers to verify that the ASTM F959/F959M direct tension indicator gaps

have been achieved. If more than 10 percent of the direct tension indicators tested have not been compressed sufficiently to provide the average gaps required by ASTM F959/F959M, test all in place direct tension indicator washers to verify that the ASTM F959/F959M direct tension indicator gaps have been achieved. Test locations must be selected by the Contracting Officer.

3.7.3 High-Strength Bolts

3.7.3.1 Testing Bolt, Nut, and Washer Assemblies

Test a minimum of 5 bolt, nut, and washer assemblies from each mill certificate batch in a tension measuring device at the job site prior to the beginning of bolting start-up. Demonstrate that the bolts and nuts, when used together, can develop tension not less than the provisions specified in AISC 360, depending on bolt size and grade. The bolt tension must be developed by tightening the nut. A representative of the manufacturer or supplier must be present to ensure that the fasteners are properly used, and to demonstrate that the fastener assemblies supplied satisfy the specified requirements. Submit bolt testing reports.

3.7.3.2 Inspection

Inspection procedures must be in accordance with AISC 360. Confirm and report to the Contracting Officer that the materials meet the project specification and that they are properly stored. Confirm that the faying surfaces have been properly prepared before the connections are assembled. Observe the specified job site testing and calibration, and confirm that the procedure to be used provides the required tension. Monitor the work to ensure the testing procedures are routinely followed on joints that are specified to be fully tensioned.

Inspect calibration of torque wrenches for high-strength bolts.

3.7.3.3 Testing

The Government has the option to perform nondestructive tests on 5 percent of the installed bolts to verify compliance with pre-load bolt tension requirements. Provide the required access for the Government to perform the tests. The nondestructive testing will be done in-place using an ultrasonic measuring device or any other device capable of determining in-place pre-load bolt tension. The test locations must be selected by the Contracting Officer. If more than 10 percent of the bolts tested contain defects identified by testing, then all bolts used from the batch from which the tested bolts were taken, must be tested at the Contractor's expense. Retest new bolts after installation at the Contractor's expense.

3.7.4 Testing for Embrittlement

ASTM A143/A143M for steel products hot-dip galvanized after fabrication. Submit embrittlement test reports.

3.7.5 Inspection and Testing of Steel Stud Welding

Perform verification inspection and testing of steel stud welding conforming to the requirements of AWS D1.1/D1.1M, Stud Welding Clause. The Contracting Officer will serve as the verification inspector. Bend test studs that do not show a full 360 degree weld flash or have been

repaired by welding as required by AWS D1.1/D1.1M, Stud Welding Clause. Studs that crack under testing in the weld, base metal or shank will be rejected and replaced by the Contractor at no additional cost.

-- End of Section --

SECTION 05 21 00

STEEL JOIST FRAMING
05/15, CHG 1: 08/18
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC PA 1	(2016) Shop, Field, and Maintenance Coating of Metals
SSPC Paint 15	(1999; E 2004) Steel Joist Shop Primer/Metal Building Primer
SSPC SP 2	(2018) Hand Tool Cleaning

STEEL JOIST INSTITUTE (SJI)

SJI LOAD TABLES	(2010; Errata 1 2011; Errata 2 2012) 42nd Edition Catalog of Standard Specifications Load Tables and Weight Tables for Steel Joists and Joist Girders

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1926	Safety and Health Regulations for Construction
29 CFR 1926.757	Steel Erection; Open Web Steel Joists

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Welder Qualification

SD-02 Shop Drawings

Steel Joist Framing; G

SD-03 Product Data

Recycled Content Of Steel Products; S

SD-05 Design Data

Design Calculations; G

SD-06 Test Reports

Erection Inspection
Welding Inspections

1.3 QUALITY ASSURANCE

Perform all work in compliance with the requirements set forth in 29 CFR 1926.

1.3.1 Drawing Requirements

Submit drawings of steel joist framing including fabrication, specifications for shop painting, and identification markings of joists. Show joist type and size, layout in plan, all applicable loads, deflection criteria, and erection details including methods of anchoring, framing at openings, type, size, and location and connections for and spacing of bridging, requirements for field welding, and details of accessories as applicable. Show profiles for nonstandard joist configurations.Show steel joist field splice locations and details.

1.3.2 Certification of Compliance

Prior to construction commencement, submit certification for welder qualification, in compliance with AWS D1.1/D1.1M, welding operation, and tacker, stating the type of welding and positions qualified for, the code and procedure qualified under, date qualified, and the firm and individual certifying the qualification tests.

1.4 DELIVERY, STORAGE, AND HANDLING

Handle, transport, and store joists in a manner to prevent damage affecting their structural integrity. Verify piece count of all joist products upon delivery and inspect all joists products for damage. Report any damage to the joist supplier. Store all items off the ground in a well drained location protected from the weather and easily accessible for inspection and handling. Store joists with top chord down and with joists in a vertical position. Store deep joists horizontally if they were shipped on their sides.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Designate steel joists on the drawings in accordance with the standard designations of the Steel Joist Institute. Joists of other standard designations or joists with properties other than those shown may be substituted for the joists designated provided the structural properties are equal to or greater than those of the joists shown and provided all other specified requirements are met.

2.2 STEEL JOISTS

Provide steel joists conforming to SJI LOAD TABLES. Design joists designated K, KCS, LH and DLH to support the loads given in the applicable standard load tables of SJI LOAD TABLES. Submit design calculations for special steel joists, net uplift loads, non-SJI standard details, and field splices. Include cover letter signed and sealed by the joist manufacturer's registered design professional.

2.2.1 Steel Joist Camber

Camber joists according to SJI LOAD TABLES.

2.2.2 Special Steel Joists

Provide special joists and connections capable of withstanding the design loads indicated with a live-load deflection less than L/360 for roof joists and L/360 for floor joists.

2.2.3 Steel Joist Substitutes and Outriggers

Provide joist substitutes and outriggers conforming to SJI LOAD TABLES with steel angle or channel members.

2.3 RECYCLED CONTENT

Provide products with an average recycled content of steel products of postconsumer recycled content plus one half of preconsumer recycled content not less than 50 percent.

2.4 ACCESSORIES AND FITTINGS

2.4.1 Bridging

Provide bridging of material, size, and type required by SJI LOAD TABLES for type of joist, chord size, spacing and span. Furnish additional erection bridging if required for stability.

2.4.2 Bearing Plates

Fabricate steel bearing plats from ASTM A36/A36M steel of size and thickness indicated.

2.4.3 Ceiling Extensions

Furnish ceiling extensions, either bottom-chord elements or a separate extension unit of enough strength to support ceiling construction. Extend ends to within 1/2 inch of finished wall surface unless otherwise

indicated.

2.5 SHOP PAINTING

SSPC Paint 15. Shop prime joists, except as modified herein, in accordance with SSPC PA 1. Clean joists in accordance with SSPC SP 2 before priming. Do not prime joists to receive sprayed-on fireproofing. If flash rusting occurs, re-clean the surface prior to application of primer. For joists which require finish painting under Section 09 90 00 PAINTS AND COATINGS, ***or Section 09 97 13.27 HIGH-PERFORMANCE COATINGS for STEEL STRUCTURES,*** the primer paint must be compatible with the finish paint. ***Refer to architectural finish schedule for finish painting requirements.***

PART 3 EXECUTION

3.1 ERECTION

Install joists in conformance with SJI LOAD TABLES for the joist series indicated, and the requirements of 29 CFR 1926 and 29 CFR 1926.757. Handle and set joists avoiding damage to the members. Place the "tag end" of joists as shown on the joists placement plans. Ensure that square-end joists are erected right side up. Place joists on joist girders in accordance with the joist placement plan, noting that in many instances joist may not need to be placed at a joist girder panel point. Distribute temporary loads so that joist capacity is not exceeded. Remove damaged joists and joist girders from the site, except when field repair is approved and such repairs are satisfactorily made in accordance with the manufacturer's recommendations. Do not repair, field modify, or alter any joists or joist girder without specific written instructions from the Designer of Record and/or joist manufacturer.

Install and connect bridging concurrently with joist erection, before construction loads are applied. Do not apply loads to bridging. Anchor ends of bridging lines at top and bottom chords if terminating at walls or beams. Do not cut away vertical leg of bridging where bridging makes an elevation transition; weld a separate piece of bridging at the transition. Perform all welding in accordance with AWS D1.1/D1.1M.

3.2 BEARING PLATES

Provide bearing plates to accept full bearing after the supporting members have been plumbed and properly positioned, but prior to placing superimposed loads. The area under the plate must be damp-packed solidly with bedding mortar, except where nonshrink grout is indicated on the drawings. Provide bedding mortar and grout as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.3 PAINTING

3.3.1 Field Painting

Paint joists and joist girders requiring a finish coat in conformance with the requirements of Section 09 90 00 PAINTS AND COATINGS.

3.4 SPECIAL INSPECTIONS

Perform the following visual inspections:

a. Verify that all joists are spaced properly.

b. Verify that there is sufficient joist bearing on steel beams, concrete, and masonry.

c. Verify all bridging lines are properly spaced and anchored.

d. Verify that damage has not occurred to the joists and joist girder during erection.

e. Verify the joists are aligned vertically and there is no lateral sweep in the joists.

f. Where concentrated loads are present on the joists verify that they are located in accordance with the joists placement plan.

g. Verify welding of bridging and joist seats in accordance with AWS D1.1/D1.1M, Section 6. Perform erection inspection and field welding inspections with AWS certified welding inspectors.

h. Verify proper bolting of diagonal bridging and joist seats where the bolts are snug-tight.

-- End of Section --

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 05 51 00

METAL STAIRS
02/17, CHG 1: 05/17
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 314	(1990; R 2013) Standard Specification for Steel Anchor Bolts

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360	(2016) Specification for Structural Steel Buildings

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISC/AISI 121	(2007) Standard Definitions for Use in the Design of Steel Structures

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.6.1	(2016) Wood Screws (Inch Series)
ASME B18.6.3	(2013; R 2017) Machine Screws, Tapping Screws, and Machine Drive Screws (Inch Series)
ASME B18.21.1	(2009; R 2016) Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A27/A27M	(2020) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A47/A47M	(1999; R 2018; E 2018) Standard

	Specification for Ferritic Malleable Iron Castings
ASTM A48/A48M	(2003; R 2016) Standard Specification for Gray Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A108	(2013) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A283/A283M	(2013) Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A325	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A449	(2014) Standard Specification for Hex Cap Screws, Bolts, and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
ASTM A500/A500M	(2020) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A512	(2006; R 2012) Standard Specification for Cold-Drawn Buttweld Carbon Steel Mechanical Tubing
ASTM A568/A568M	(2019a) Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
ASTM A575	(2020) Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A1008/A1008M	(2020) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
ASTM A1011/A1011M	(2018a) Standard Specification for Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM C514	(2004; R 2020) Standard Specification for Nails for the Application of Gypsum Board
ASTM C636/C636M	(2013) Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels
ASTM E488/E488M	(2015) Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2018; ERTA 18-1; ERTA 18-2; ERTA 18-3; ERTA 18-4; TIA 18-1; TIA 18-2; TIA 18-3; TIA 18-4) Life Safety Code

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Steel Pan Stairs; G

Steel Tube Railings; G

SD-03 Product Data

Concrete Inserts; G

Masonry Anchorage Devices; G

Protective Coating; G

Recycled Content; S

Product data indicating percentage by weight of post-consumer and pre-consumer recycled content for products having recycled content specified in this Section. Submit per requirements in Section 01 33 29 SUSTAINABILITY REPORTING.

SD-05 Design Data

Performance Requirements Validation; G

For products and systems indicated to validate compliance with specified stairs and railings performance requirements, provide calculations and design criteria, including engineering analysis data, signed and sealed by the qualified registered Professional Engineer responsible for their preparation.

SD-07 Certificates

Welding Procedures; G

Welder Qualification; G

1.3 QUALITY CONTROL

1.3.1 Qualifications for Welding Work

Submit welding procedures in accordance with AWS D1.1/D1.1M. Make test specimens in the presence of the Contracting Officer, and have the specimens tested by an approved testing laboratory at the Contractor's expense.

Certify welder qualification by tests in accordance with AWS D1.1/D1.1M, or under an equivalent approved qualification test. In addition, perform tests on test pieces in positions and with clearances equivalent to those actually encountered. If a test weld fails to meet requirements, ensure that two test welds are retested immediately and that each test weld is made and passes. Failure in the immediate retest requires that the welder be retested after further practice or training and a complete set of test welds be made.

PART 2 PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

See Section 01 33 29 SUSTAINABILITY REPORTING for sustainable design requirements for the following, except as modified herein.

2.1.1 Recycled Content of Products

Provide products with post-consumer recycled content plus one-half of pre-consumer recycled content to the greatest extent possible, but not less than 10 percent.

2.2 SYSTEM DESCRIPTION

Submit complete and detailed fabrication drawings for all iron and steel hardware, and for all steel shapes, plates, bars, and strips used in accordance with the design specifications referenced in this section.

2.3 FABRICATION

Preassemble items in the shop to the greatest extent possible. Disassemble units only to the extent necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

For the fabrication of work exposed to view, use only materials that are smooth and free of surface blemishes, including pitting, seam marks,

roller marks, rolled trade names, and roughness. Remove blemishes by grinding, or by welding and grinding, before cleaning and treating surfaces and applying surface finishes, including zinc coatings.

2.3.1 General Fabrication

Prepare and submit metal stair system shop drawings with detailed plans and elevations at scales not less than 1 inch to 1 foot and with details of sections and connections at scales not less than 3 inches to 1 foot. Also detail the placement drawings, diagrams, and templates for installation of anchorages, including concrete inserts, anchor bolts, and miscellaneous metal items having integral anchorage devices.

Use materials of size and thicknesses indicated or, if not indicated, of the size and thickness necessary to produce a finished product that is strong enough and durable enough for its intended use. Work the materials to the dimensions indicated on approved detail drawings, using proven methods of fabrication and support. Use the type of materials indicated or specified for the various components of work.

Form exposed work true to line and level, with accurate angles and surfaces and with straight sharp edges. Ease exposed edges to a radius of approximately 1/32 inch, and bend metal corners to the smallest radius possible without causing grain separation or otherwise impairing the work.

Continuously weld corners and seams in accordance with the recommendations of AWS D1.1/D1.1M. Grind exposed welds smooth and flush to match and blend with adjoining surfaces.

Form exposed connections with hairline joints that are flush and smooth, using concealed fasteners wherever possible. Use exposed fasteners of the type indicated or, if not indicated, use Phillips flat-head (countersunk) screws or bolts.

Provide and coordinate anchorage of the type indicated for the supporting structure. Fabricate anchoring devices, and space them as indicated and as necessary to provide adequate support for the intended use of the work.

Use hot-rolled steel bars for work fabricated from bar stock unless work is indicated or specified as fabricated from cold-finished or cold-rolled stock.

2.3.2 Steel Pan Stairs

2.3.2.1 General

Joining pieces by welding. Fabricate units so that bolts and other fastenings do not appear on finished surfaces. Make joints true and tight, and connections between parts lighttight. Grind continuous welds smooth where exposed.

Construct metal stair units to sizes and arrangements indicated to support a minimum live load of 100 pounds per square foot. Provide framing, hangers, columns, struts, clips, brackets, bearing plates, and other components as required for the support of stairs and platforms.

2.3.2.2 Stair Framing

Fabricate stringers of structural steel channels, or plates, or a

combination thereof as indicated. Provide closures for exposed ends of strings.

Construct platforms of structural steel channel headers and miscellaneous framing members as indicated. Bolt headers to stringers and newels, and bolt framing members to stringers and headers.

2.3.2.3 Riser, Subtread, and Subplatform Metal Pans

Form metal pans of 0.1084-inch (12-gage) structural steel sheets, conforming to ASTM A1011/A1011M, Grade 36. Shape the pans to the configuration indicated.

Construct risers and subtread metal pans with steel angle supporting brackets, of the size indicated, welded to stringers. Secure metal pans to brackets with rivets or welds. Secure subplatform metal pans to platform frames with welds.

2.3.2.4 Metal Safety Nosings

Between stringers, provide abrasive cast metal safety nosings, 4 inches wide by the full length of the step. Fabricate nosings to the thickness, profile, and surface pattern indicated. Equip each nosing with integral anchors for embedding in the pan fill material, and space the anchors not more than 4 inches from each end and not more than 15 inches on center.

2.3.3 Protective Coating

Shop-prime steelwork as indicated in accordance with AISC/AISI 121, except surfaces of steel encased in concrete; welded surfaces; high-strength, bolt-connected surfaces; and surfaces of crane rails.

2.4 COMPONENTS

2.4.1 Performance Requirements of Stairs

Provide steel stairs complete with stringers, metal-pan concrete-filled treads, landings, columns, handrails, and necessary bolts and other fastenings. Shop-paint steel stairs and accessories.

2.4.1.1 Design Loads

Design stairs to sustain a live load of not less than 100 pounds per square foot, and a concentrated load of 300 pounds applied where it is most critical. Uniform and concentrated loads need not be assumed to act concurrently. Limit deflection of treads, platforms and framing members to L/240 or 1/4 inch, whichever is less. Except for a commercial product, design and fabricate steel stairs to conform to AISC 360. Design fire stairs to conform to NFPA 101.

2.4.1.2 Materials

Provide steel stairs of welded construction except that bolts may be used where welding is not practicable. Do not use screw or screw-type connections.

a. Structural Steel: ASTM A36/A36M.

b. Support metal pan for concrete fill on angle cleats welded to

stringers or treads with integral cleats, welded or bolted to the stringer. Provide sheet-steel landings with angle stiffeners welded on. Close exposed ends.

c. Before fabrication, obtain necessary field measurements and verify drawing dimensions.

d. Clean metal surfaces free of mill scale, flake rust, and rust pitting before shop finishing. Weld permanent connections. Finish welds flush and smooth on surfaces that will be exposed after installation.

2.4.2 Steel Tube Railings

Fabricate railings to comply with requirements indicated for design, dimensions, details, finish, and member sizes, including wall thickness of tube, post spacings, and anchorage, but not less than that needed to withstand indicated loads.

Railings not attached to metal stairs are specified in Section 05 52 00 METAL RAILINGS.

a. Rails and Posts: 1-5/8 inch diameter top and bottom rails and 1-1/2 inch posts.

b. Picket Infill: Where indicated, provide 1/2-inch ***diameter*** pickets spaced less than 4 inches clear.

c. Intermediate Rails Infill: Where indicated, provide 1-5/8 inch diameter intermediate rails spaced as indicated, but not greater than 12 inches clear.

d. Gates: Where gates indicated or required, form gates from steel tube of same size and shape as top rails, with infill to match guards. Provide with spring hinges for fastening to wall or railing system and overlapping stop with rubber bumper to prevent gate from opening in direction opposite egress.

2.4.2.1 Welded Connections

Fabricate railings with welded connections. Cope components at connections to provide close fit. Weld all around at connections.

a. Finish welds to be completely sanded joint; some undercutting and pinholes acceptable.

2.4.2.2 Fabrication

a. Form changes in direction of railings as indicated on Drawings.

b. Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.

c. Close exposed ends of railing members with prefabricated end fittings.

d. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns unless clearance between

end of rail and wall is 1/4 inch or less.

e. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, end closures, flanges, miscellaneous fittings, and anchors for interconnecting components and for attaching to other work. Furnish inserts and other anchorage devices for connecting to concrete or masonry work.

(1) Connect posts to stair framing by direct welding unless otherwise indicated.

(2) For galvanized railings, provide galvanized fittings, brackets, fasteners, sleeves, and other ferrous-metal components.

(3) For nongalvanized railings, provide nongalvanized ferrous-metal fittings, brackets, fasteners, and sleeves, except galvanize anchors embedded in exterior masonry and concrete construction.

f. Fillers: Provide fillers made from steel plate, or other suitably crush-resistant material, where needed to transfer wall bracket loads through wall finishes to structural supports. Size fillers to suit wall finish thicknesses and to produce adequate bearing area to prevent bracket rotation and overstressing of substrate.

2.4.2.3 Performance Requirements of Railings

Railings shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated. Provide calculations, including engineering analysis, by a qualified professional engineer, to validate compiance with performance requirements.

a. Handrails and Top Rails:

(1) Uniform load of 50 pounds per linear foot applied in any direction.

(2) Concentrated load of 200 pounds applied in any direction.

(3) Uniform and concentrated loads need not be assumed to act concurrently.

b. Infill:

(1) Concentrated load of 50 pounds applied horizontally on an area of 1 square foot.

(2) Infill load and other loads need not be assumed to act concurrently.

2.4.3 Concrete Inserts

Threaded-type concrete inserts consisting of galvanized ferrous castings, internally threaded to receive 3/4-inch diameter machine bolts; either malleable iron conforming to ASTM A47/A47M or cast steel conforming to ASTM A27/A27M, and hot-dip-galvanized in accordance with ASTM A153/A153M.

Wedge-type concrete inserts consisting of galvanized box-type ferrous castings designed to accept 3/4-inch diameter bolts having special wedge-shaped heads; either malleable iron conforming to ASTM A47/A47M or cast steel conforming to ASTM A27/A27M and hot-dip-galvanized in

accordance with ASTM A153/A153M.

Carbon steel bolts having special wedge-shaped heads, nuts, washers, and shims and galvanized in accordance with ASTM A153/A153M. Provide slotted-type concrete inserts consisting of galvanized 1/8-inch thick pressed steel plate conforming to ASTM A283/A283M; of box-type welded construction with slot designed to receive 3/4-inch diameter square-head bolt with knockout cover; and be hot-dip-galvanized in accordance with ASTM A123/A123M.

2.4.4 Masonry Anchorage Devices

Provide masonry anchorage devices consisting of expansion shields complying with AASHTO M 314, ASTM E488/E488M and ASTM C514 as follows:

a. Lead expansion shields for machine screws and bolts larger than 1/4 inch in size; head-out embedded-nut type, multiple unit class, Group I, Type 1, Class 2.

b. Bolt anchor expansion shields for lag bolts; zinc-alloy, long-shield anchors class, Group II, Type 1, Class 1.

Use toggle bolts of the tumble-wing type, conforming to ASTM A325, ASTM A449, and ASTM C636/C636M, type, class, and style as required.

2.4.5 Fasteners

Select galvanized zinc-coated fasteners conforming to ASTM A153/A153M for exterior applications or where the fasteners are built into exterior walls or floor systems. Select the fasteners for the type, grade, and class required for the installation of steel stair items:

a. Standard/regular hexagon-head bolts and nuts, conforming to ASTM A307, Grade A.

b. Square-head lag bolts conforming to ASME B18.2.1.

c. Cadmium-plated steel machine screws, conforming to ASME B18.6.3.

d. Flat-head carbon steel wood screws, conforming to ASME B18.6.1.

e. Plain, round, general-assembly-grade, carbon steel washers, conforming to ASME B18.21.1.

f. Helical-spring, carbon steel lockwashers, conforming to ASME B18.2.1.

2.5 MATERIALS

2.5.1 Structural Steel Plates, Shapes and Bars

Structural size shapes and plates, conforming to ASTM A36/A36M, unless otherwise noted, except bent or cold-formed plates.

Steel plates - bent or cold-formed, conforming to ASTM A283/A283M, Grade C.

Steel bars and bar-size shapes, conforming to ASTM A36/A36M, unless otherwise noted for steel bars and bar-size shapes.

2.5.2 Structural Steel Tubing

Provide the following:

a. Structural steel tubing, hot-formed, welded or seamless, conforming to ASTM A500/A500M, Grade b, unless otherwise noted.

2.5.3 Hot-Rolled Carbon Steel Bars

Provide the following:

a. Hot-rolled carbon steel bars and bar-size shapes, conforming to ASTM A575, grade as selected by the fabricator.

2.5.4 Cold-Finished Steel Bars

Provide the following:

a. Cold-finished steel bars conforming to ASTM A108, grade as selected by the fabricator.

2.5.5 Hot-Rolled Carbon Steel Sheets and Strips

Provide the following:

a. Hot-rolled carbon sheets and strips conforming to ASTM A568/A568M and ASTM A1011/A1011M, pickled and oiled.

2.5.6 Cold-Rolled Carbon Steel Sheets

Provide the following:

a. Cold-rolled carbon steel sheets conforming to ASTM A1008/A1008M.

2.5.7 Galvanized Carbon Steel Sheets

Provide the following:

a. Galvanized carbon steel sheets conforming to ASTM A653/A653M, with galvanizing conforming to ASTM A653/A653M and ASTM A924/A924M.

2.5.8 Cold-Drawn Steel Tubing

Provide the following:

a. Cold-drawn steel tubing conforming to ASTM A512, sunk drawn, butt-welded, cold-finished, and stress-relieved.

2.5.9 Gray Iron Castings

Provide the following:

a. Gray iron castings conforming to ASTM A48/A48M, Class 30.

2.5.10 Malleable Iron Castings

Provide the following:

a. Malleable iron castings conforming to ASTM A47/A47M, grade as selected.

2.5.11 Steel Pipe

Provide the following:

a. Steel pipe conforming to ASTM A53/A53M, type as selected, Grade B; primed finish, unless galvanizing is required; standard weight (Schedule 40).

PART 3 EXECUTION

3.1 PREPARATION

Clean surfaces thoroughly before installation. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions. Examine materials upon arrival at site. Notify the carrier and manufacturer of any damage.

Protect installed products until completion of project. Touch up, repair or replace, damaged products before substantial completion

3.2 INSTALLATION

Install in accordance with the manufacturer's written instructions and approved submittals. Install in proper relationship with adjacent construction.

Install items at locations indicated, according to the manufacturer's instructions. Verify all measurements and take all field measurements necessary before fabrication. Ensure that exposed fastenings are compatible with generally match the color and finish of, and harmonize with the material to which they are applied. Include materials and parts necessary to complete each item, even though such work is not definitely shown or specified. Poor matching of holes for fasteners is cause for rejection. Conceal fastenings where practicable. Select thickness of metal and details of assembly and supports that adequately strengthen and stiffen the construction. Form joints exposed to the weather to exclude water.

3.2.1 Field Preparation

Remove rust-preventive coating just before field erection, using a remover approved by the coating manufacturer. Provide surfaces, when assembled, free of rust, grease, dirt and other foreign matter.

3.2.2 Field Welding

Comply with AWS D1.1/D1.1M in executing manual shielded-metal arc welding, (for appearance and quality of new welds) and in correcting existing welding.

3.2.3 Touchup Painting

Immediately after installation, clean all field welds, bolted connections,

and abraded areas of the shop-painted material, and repaint exposed areas with the same paint used for shop painting. Apply paint by brush or spray to provide a minimum dry-film thickness of 2 mils.

3.3 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

SECTION 05 52 00

METAL RAILINGS
02/18
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 2605	(2020) Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 314	(1990; R 2013) Standard Specification for Steel Anchor Bolts

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020) Structural Welding Code - Steel
AWS D1.2/D1.2M	(2014; Errata 1 2014; Errata 2 2020) Structural Welding Code - Aluminum

ASTM INTERNATIONAL (ASTM)

ASTM A27/A27M	(2020) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A283/A283M	(2013) Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates

ASTM A500/A500M	(2020) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM B26/B26M	(2014; E 2015) Standard Specification for Aluminum-Alloy Sand Castings
ASTM B429/B429M	(2010; E 2012) Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube
ASTM C514	(2004; R 2020) Standard Specification for Nails for the Application of Gypsum Board
ASTM C1107/C1107M	(2020) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM D1187/D1187M	(1997; E 2011; R 2011) Asphalt-Base Emulsions for Use as Protective Coatings for Metal
ASTM E488/E488M	(2015) Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements
ASTM F 2329	(2015) Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners
ASTM F1554	***(2020) Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength***

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Steel Railings and Handrails; G

Aluminum Railings and Handrails; G

SD-03 Product Data

Concrete Inserts; G

Masonry Anchorage Devices; G

Steel Railings and Handrails; G

Aluminum Railings and Handrails; G

Fasteners; G

Recycled Content; S

Product data indicating percentage by weight of post-consumer and pre-consumer recycled content for products having recycled content specified in this Section. Submit per requirements in Section 01 33 29 SUSTAINABILITY REPORTING.

SD-05 Design Data

Performance Requirements Verification; G

For products and systems indicated to validate compliance with specified railings performance requirements, provide calculations and design criteria, including engineering analysis data, signed and sealed by the qualified registered Professional Engineer responsible for their preparation.

SD-07 Certificates

Welding Procedures; G

Welder Qualification; G

SD-08 Manufacturer's Instructions

Installation Instructions

SD-11 Closeout Submittals

All sustainable design Submittals for recycled content are included under SD-03 Product Data.

1.3 QUALITY CONTROL

1.3.1 Welding Procedures

Submit results of welding procedures testing in accordance with AWS D1.1/D1.1M or AWS D1.2/D1.2M, as applicable, made in the presence of the Contracting Officer and by an approved testing laboratory at the Contractor's expense.

1.3.2 Welder Qualification

Submit certified welder qualification by tests in accordance with AWS D1.1/D1.1M or AWS D1.2/D1.2M, as applicable. In addition, perform tests on test pieces in positions and with clearances equivalent to those actually encountered. If a test weld fails to meet requirements, conduct an immediate retest of two test welds and ensure that each test weld passes. Failure in the immediate retest will require that the welder be retested after further practice or training and make a complete set of test welds.

PART 2 PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

See Section 01 33 29 SUSTAINABILITY REPORTING for sustainable design

requirements for the following, except as modified herein.

2.1.1 Recycled Content of Products

Provide products with post-consumer recycled content plus one-half of pre-consumer recycled content to the greatest extent possible, but not less than 10 percent.

2.2 FABRICATION

Provide complete and detailed fabrication drawings for railing systems, either steel railing sytems or aluminum railing systems, or both, as indicated. Include detailed setting drawings, diagrams, templates for installation of anchorages, including concrete inserts, anchor bolts, and miscellaneous metal items having integral anchors.

Preassemble items in the shop to the greatest extent possible. Disassemble units only to the extent necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

For the fabrication of work exposed to view, use only materials that are smooth and free of surface blemishes, including pitting, seam marks, roller marks, rolled trade names, and roughness. Remove blemishes by grinding, or by welding and grinding, before cleaning, treating, and applying surface finishes, including zinc coatings.

Use materials of size and thicknesses indicated or, if not indicated, of the size and thickness necessary to produce adequate strength and durability in the finished product for its intended use. Work the materials to the dimensions indicated on approved detail drawings, using proven details of fabrication and support. Use the type of materials indicated or specified for the various components of work.

Form exposed work true to line and level, with accurate angles and surfaces and straight sharp edges. Ensure that all exposed edges are eased to a radius of approximately 1/32 inch. Bend metal corners to the smallest radius possible without causing grain separation or otherwise impairing the work.

Weld corners and seams continuously and in accordance with the recommendations of AWS D1.1/D1.1M for steel, or AWS D1.2/D1.2M for aluminum. Grind exposed welds smooth and flush to match and blend with adjoining surfaces.

Form the exposed connections with hairline joints that are flush and smooth, using concealed fasteners wherever possible. Use exposed fasteners of the type indicated or, if not indicated, use countersunk Phillips flathead screws or bolts.

Provide anchorage of the type indicated and coordinated with the supporting structure. Fabricate anchoring devices and space as indicated and as required to provide adequate support for the intended use of the work.

2.2.1 Performance Requirements of Railings

Railings shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated.

2.2.1.1 Handrails and Top Rails

a. Uniform load of 50 pounds per linear foot applied in any direction.

b. Concentrated load of 200 pounds applied in any direction.

c. Uniform and concentrated loads need not be assumed to act concurrently.

2.2.1.2 Infill

a. Concentrated loads of 50 pounds applied horizontally on an area of 1 square foot.

b. Infill load and other loads need not be assumed to act concurrently.

2.2.2 Aluminum Railings and Handrails

Fabricate railings to comply with requirements indicated for design, dimensions, details, finish, and member sizes, including wall thickness of tube, post spacings, and anchorage, but not less than that needed to withstand indicated loads. Provide railings and handrails consisting of 1-1/2 inch nominal size, unless otherwise indicated; schedule 40 pipe, ASTM B429/B429M.

a. Rails and Posts: Provide top and bottom rails and posts of sizes and configurations indicated.

b. Picket Infill: Where indicated, provide pickets of sizes, configurations and spacing indicated.

c. Intermediate Rails Infill: Where indicated, provide intermediate rails of sizes and configurations indicated, and spaced as indicated, but not greater than 12 inches clear.

d. Gates: Where indicated, provide gates of same material as railings in configurations indicated. Provide standard gate latching system of corrosion-resistant materials.

e. Removable Railings: Provide removable railing sections matching fixed railings as indicated.

f. Kickplates: Provide kickplates between railing posts where indicated, and consisting of 1/8 inch extruded aluminum flat bars not less than 6 inches high. Secure kickplates as indicated.

2.2.2.1 Jointing

Provide fabrication jointing by one of the following methods as required to suit project-specific conditions.

a. Use flush-type rail fittings, welded and ground smooth with splice locks secured with 3/8 inch recessed-head set screws.

b. Ensure that mitered and welded joints made by fitting; post to top rail; intermediate rail to post; and corners, are groove welded and ground smooth. Where allowed by the Contracting Officer, provide butt splices reinforced by a tight-fitting dowel or sleeve not less than 6 inches in length. Tack-weld or epoxy-cement the dowel or sleeve to one side of the splice.

c. Assemble railings using slip-on aluminum-magnesium alloy fittings for joints. Fasten fittings to pipe or tube with 1/4 or 3/8 inch stainless-steel recessed-head setscrews. Provide assembled railings with fittings only at vertical supports or at rail terminations attached to walls. Provide expansion joints at the midpoint of panels. Provide a setscrew in only one side of the slip-on sleeve. Provide alloy fittings to conform to ASTM B26/B26M.

2.2.3 Steel Railings and Handrails

Fabricate railings to comply with requirements indicated for design, dimensions, details, finish, and member sizes, including wall thickness of tube, post spacings, and anchorage, but not less than that needed to withstand indicated loads. Provide steel pipe conforming to ASTM A53/A53M or structural tubing conforming to ASTM A500/A500M, Grade A or B of equivalent strength. Provide steel railings of 1-1/2 inch nominal size, unless otherwise indicated.

a. Rails and Posts: Provide top and bottom rails and posts of sizes and configurations indicated.

b. Picket Infill: Where indicated, provide pickets of sizes, configurations and spacing indicated.

c. Intermediate Rails Infill: Where indicated, provide intermediate rails of sizes and configurations indicated, and spaced as indicated, but not greater than 12 inches clear.

d. Gates: Where indicated, provide gates of same material as railings in configurations indicated. Provide standard gate latching system of corrosion-resistant materials.

e. Removable Railings: Provide removable railing sections matching fixed railings as indicated.

f. Kickplates: Provide kickplates between railing posts where indicated, and consisting of 1/8 inch steel flat bars not less than 6 inches high. Secure kickplates as indicated.

2.2.3.1 Jointing

Provide fabrication jointing by one of the following methods as required to suit project-specific conditions.

a. Flush-type rail fittings of commercial standard, welded and ground smooth, with railing splice locks secured with 3/8 inch hexagonal-recessed-head setscrews.

b. Mitered and welded joints made by fitting post to top rail and intermediate rail to post, mitering corners, groove-welding joints, and grinding smooth. Butt railing splices and reinforce them by a tight-fitting interior sleeve not less than 6 inches long.

c. Railings may be bent at corners in lieu of jointing, provided that bends are made in suitable jigs and the pipe is not crushed.

2.3 STEEL FINISHES

2.3.1 Galvanized Railings

For galvanized railings, provide hot-dip galvanized fittings, brackets, fasteners, sleeves and other ferrous components. Galvanize exterior railings, including pipe, fittings, brackets, fasteners, and other ferrous metal components.

a. Hot-dip galvanize steel railings, including hardware, after fabrication.

b. Comply with ASTM A123/A123M for hot-dip galvanized railings.

c. Comply with ASTM A153/A153M for hot-dip galvanized hardware.

d. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.

e. Fill vent and drain holes that are exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.

2.3.2 Shop-Painted Finish

Comply with Section 09 96 00 HIGH-PERFORMANCE COATINGS.

2.3.2.1 Color

Provide colors as indicated; colors listed are not intended to limit the selection of equal colors from other manufacturers.

2.4 ALUMINUM FINISHES

2.4.1 High Performance Organic Finish

Two-coat fluoropolymer finish complying with AAMA 2605 and containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

2.4.1.1 Color

Provide colors as indicated; colors listed are not intended to limit the selection of equal colors from other manufacturers.

2.5 COMPONENTS

2.5.1 Structural-Steel Tubing

provide structural-steel tubing, hot-formed, welded or seamless, conforming to ASTM A500/A500M, Grade B, unless otherwise noted.

2.5.2 Steel Rods

Provide steel rods for horizontal infill where indicated conforming to ASTM F1554, with 36 or 55 ksi yield strength.

2.5.3 Concrete Inserts

Provide threaded-type concrete inserts consisting of galvanized ferrous castings, internally threaded to receive 3/4 inch diameter machine bolts; either malleable iron conforming to ASTM A47/A47M or cast steel conforming to ASTM A27/A27M, hot-dip galvanized in accordance with ASTM A153/A153M.

Provide wedge-type concrete inserts consisting of galvanized box-type ferrous castings designed to accept 3/4 inch diameter bolts having special wedge-shaped heads, made of either malleable iron conforming to ASTM A47/A47M or cast steel conforming to ASTM A27/A27M and hot-dip galvanized in accordance with ASTM A153/A153M.

Provide carbon steel bolts having special wedge-shaped heads, nuts, washers, and shims, galvanized in accordance with ASTM A153/A153M. Provide slotted-type concrete inserts consisting of a galvanized 1/8 inch thick pressed-steel plate conforming to ASTM A283/A283M, made of box-type welded construction with a slot designed to receive 3/4 inch diameter square-head bolt with knockout cover; and hot-dip galvanized in accordance with ASTM A123/A123M.

2.5.4 Masonry Anchorage Devices

Provide masonry anchorage devices consisting of expansion shields complying with AASHTO M 314, ASTM E488/E488M and ASTM C514 as follows:

Provide lead expansion shields for machine screws and bolts 1/4 inch and smaller; head-out embedded nut type, single-unit class, Group I, Type 1, Class 1.

Provide lead expansion shields for machine screws and bolts larger than 1/4 inch in size; head-out embedded nut type, multiple-unit class, Group I, Type 1, Class 2.

Provide bolt anchor expansion shields for lag bolts; zinc-alloy, long-shield anchor class, Group II, Type 1, Class 1.

Provide bolt anchor expansion shields for bolts; closed-end bottom-bearing class, Group II, Type 2, Class 1.

2.5.5 Fasteners

Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings capable of meeting specified performance requirements.

2.5.5.1 Galvanized Railings

Type 304 stainless-steel or hot-dip zinc-coated steel fasteners complying with ASTM A153/A153M or ASTM F 2329 for zinc coating.

2.5.5.2 Aluminum Railings

Type 304 stainless-steel fasteners.

2.6 MISCELLANEOUS MATERIALS

2.6.1 Galvanizing Repair Paint

High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

2.6.2 Bituminous Paint

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

2.6.3 Nonshrink, Nonmetallic Grout

Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.

2.6.4 Anchoring Cement

Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound.

PART 3 EXECUTION

3.1 INSTALLATION

Submit manufacturer's written installation instructions for the following railing systems, as applicable:

a. Steel railings and handrails.

b. Aluminum railings and handrails.

3.1.1 Steel Railings and Handrails

3.1.1.1 Adjustment

Adjust railing systems before anchoring to ensure matching alignment at abutting joints. Space posts at spacing as indicated and as required by design loads. Plumb posts in each direction. Secure posts and rail ends to building construction as follows:

a. Anchor posts to steel by welding directly to steel supporting members.

b. Anchor handrail ends to concrete and masonry with steel round flanges welded to rail ends and anchored with postinstalled anchors and bolts.

3.1.1.2 Attachment

Attach handrails to wall with wall brackets. Use type of bracket with flange tapped for concealed anchorage to threaded hanger bolt. Provide bracket with 1-1/2-inch clearance from inside face of handrail and finished wall surface. Locate brackets at spacing required to support structural loads. Secure wall brackets to building construction as required to comply with performance requirements.

3.1.2 Aluminum Railings and Handrails

Affix to base structure by flanges anchored to concrete or other existing masonry by expansion shields. Provide Series 300 stainless-steel bolts to anchor aluminum alloy flanges, of a size appropriate to the standard product of the manufacturer. Where aluminum or alloy fittings or extrusions are to be in contact with dissimilar metals or concrete, coat the contact surface with a heavy coating of specified bituminous paint.

3.2 FIELD QUALITY CONTROL

3.2.1 Field Welding

Ensure that procedures of manual shielded metal arc welding, appearance and quality of welds made, and methods used in correcting welding work comply with AWS D1.1/D1.1M for steel and AWS D1.2/D1.2M for aluminum.

3.3 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

SECTION 07 42 13

METAL WALL PANELS
05/11, CHG 2: 02/18
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 501.1	(2017) Standard Test Method for Water Penetration of Windows, Curtain Walls and Doors Using Dynamic Pressure
AAMA 501.2	(2015) Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls and Sloped Glazing Systems
AAMA 621	(2002) Voluntary Specifications for High Performance Organic Coatings on Coil Coated Architectural Hot Dipped Galvanized and Zinc-Aluminum Coated Steel Substrates
AAMA 2605	(2020) Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 341	(2016) Seismic Provisions for Structural Steel Buildings

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISI S100	(2012) North American Specification for the Design of Cold-Formed Steel Structural Members

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16	(2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN WELDING SOCIETY (AWS)

AWS A5.1/A5.1M	(2012) Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding
AWS D1.1/D1.1M	(2020) Structural Welding Code - Steel

AWS D1.2/D1.2M	(2014; Errata 1 2014; Errata 2 2020) Structural Welding Code - Aluminum

ASTM INTERNATIONAL (ASTM)

ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A755/A755M	(2018) Standard Specification for Steel Sheet, Metallic Coated by the Hot-Dip Process and Prepainted by the Coil-Coating Process for Exterior Exposed Building Products
ASTM B211/B211M	(2019) Standard Specification for Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod, and Wire
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM C273/C273M	(2020) Standard Test Method for Shear Properties of Sandwich Core Materials
ASTM D1621	(2016) Compressive Properties of Rigid Cellular Plastics
ASTM D1622	(2014) Apparent Density of Rigid Cellular Plastics
ASTM D2244	(2016) Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
ASTM D4214	(2007; R 2015) Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films
ASTM D6226	(2015) Standard Test Method for Open Cell Content of Rigid Cellular Plastics
ASTM E283	(2019) Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM E331	(2000; R 2016) Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
ASTM E1592	(2017) Standard Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure

Difference

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC (2018) International Building Code

METAL BUILDING MANUFACTURERS ASSOCIATION (MBMA)

MBMA MBSM (2018) Metal Building Systems Manual

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1793 (2012) Architectural Sheet Metal Manual, 7th Edition

1.2 DESCRIPTION OF EXTERIOR WALL PANEL SYSTEM

Factory-finished, metal wall panel system with concealed fastening attachment. Panel profile shall be as indicated on drawings.

1.2.1 Metal Wall Panel General Performance

Comply with performance requirements, conforming to AISI S100, without failure due to defective manufacture, fabrication, installation, or other defects in construction.

1.2.2 Structural Performance Requirements

Midspan deflection under maximum design loads is limited to L/180. Drawings show the extent and general assembly details of wall panel systems. Wall panels and accessories shall be the products of the same manufacturer.

Provide metal wall panel system complying with the load and stress requirements in accordance with ASTM E1592. Wind Load force due to wind action governs the design for panels.

Design and fabricate exterior metal wall panels provided to resist wind and seismic load criteria as indicated on Structural drawings in accordance with ICC IBC and ASCE 7-16 requirements for Components and Cladding.

1.2.3 Air Infiltration

Air leakage must conform to the limits through the wall assembly area when tested according to ASTM E283.

1.2.4 Water Penetration Under Static Pressure

No water penetration when tested according to ASTM E331.

1.2.5 Water Penetration Under Dynamic Pressure

No evidence of water leakage when tested according to AAMA 501.1.

1.2.6 Thermal Movements

Allow for thermal movements from ambient and surface temperature changes

by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

a. Temperature Change (Range): 120 deg F , ambient; 180 deg F , material surfaces.

1.3 DESCRIPTION OF EXTERIOR WALL GRILLE SYSTEM

1.3.1 Screenwall/Vision Barrier Grille

Factory-finished, metal screenwall/vision barrier grille system with concealed fastening attachment. Grille profile shall be as indicated on drawings.

1.3.2 Performance Requirements for Grille System

Comply with performance requirements, without failure due to defective manufacture, fabrication, installation, or other defects in construction.

Design and fabricate exterior metal grille system provided to resist wind load criteria as indicated on Structural drawings in accordance with ICC IBCand ASCE 7-16 requirements for Components and Cladding

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings; G

SD-03 Product Data

Wall Panels; G

Screenwall/Vision Barrier Grille; G

Draft Curtain Panels, Interior; G

Translucent Panel; G

Accessories; G

Recycled Content; S

Product data indicating percentage by weight of post-consumer and pre-consumer recycled content for products having recycled content specified in this Section. Submit per requirements in Section 01 33 29 SUSTAINABILITY REPORTING.

SD-04 Samples

Wall Panels, 12 inches long by actual panel width; G

Screenwall/Vision Barrier Grille; G

Draft Curtain Panels, Interior; G

Translucent Panel; G

Factory Finish; G

SD-05 Design Data

Performance Requirements Validation; G

For exterior wall panel system indicated to validate compliance with specified performance requirements, provide calculations and design criteria, including engineering analysis data, signed and sealed by the qualified registered Professional Engineer responsible for their preparation.

SD-06 Test Reports

Field Reports

SD-07 Certificates

Manufacturer's Technical Representative

Qualifications of Installation Contractor

SD-08 Manufacturer's Instructions

Installation

SD-10 Operation and Maintenance Data

Maintenance Instructions, Data Package 1; G

Submit in accordance with Section 01 78 23 OPERATIONS AND MAINTENANCE DATA.

SD-11 Closeout Submittals

All sustainable design Submittals for recycled content are included under SD-03 Product Data.

Warranty

1.5 QUALITY ASSURANCE

1.5.1 Pre-Installation Conference

Upon notification of submittal receipt and approval by the Contracting Officer; and prior to the commencement of the work, the Contractor must attend a pre-installation conference to review the following:

a. Drawings and Specifications.

b. Qualification of Installer.

c. Sustainable acquisition

d. Approved Warranty

e. Sample wall panels and grilles, 12 inches long by actual panel width

f. Sample metal closure strips, 10 inches long of each type

g. Color charts and chips

h. Coatings and base metal tests, chalking tests

i. Construction schedule, availability of materials, Installer's personnel, equipment and facilities required to progress with the work without delay.

j. Methods and procedures related to installation of wall panels, including manufacturer's written instructions. Explicitly identify in writing, differences between manufacturer's instructions and the specified requirements.

k. Support conditions for compliance with requirements, including alignment between and attachment to structural members.

l. Flashing, special siding details, wall penetrations, openings, and condition of other construction that will affect metal wall panels.

m. Governing regulations and requirements for insurance, certificates, and tests and inspections if applicable.

n. Temporary protection requirements for metal wall panel and grille systems during and after installation.

1.5.1.1 Installation Drawings

Installation shop drawings for wall panels and grilles, flashing, accessories, and anchorage systems must indicate completely dimensioned structural frame and erection layouts, openings in the wall, special framing details, and construction details at corners, building intersections and flashing, location and type of mastic and metal filler strips.

1.5.2 Qualifications of Manufacturer's Technical Representative

The representative must have authorization from manufacturer to approve field changes and be thoroughly familiar with the products and installations in the geographical area where construction will take place.

1.5.3 Qualification of Manufacturer

Certify that metal wall panel system manufacturer has a minimum of five (5) years experience in manufacturing metal wall system and accessory products.

Manufacturer must also provide engineering services by an authorized engineer; currently licensed in the geographical area where construction will take place, having a minimum of four (4) years experience as an engineer knowledgeable in wind load design analysis, protocols and procedures per MBMA MBSM, "Metal Building Systems Manual"; ASCE 7-16, and ASTM E1592 and seismic design conforming to AISC 341.

1.5.4 Certified Qualifications of Installation Contractor

The installation contractor must be approved and certified by the metal wall panel manufacturer prior to beginning the installation of the metal wall panel system. Subcontracting by Certified Contractor for the metal wall panel work is not permitted.

1.5.4.1 Qualifications for Welding Work

Qualification of welders and welding must conform to AWS A5.1/A5.1M, AWS D1.1/D1.1Mfor steel or AWS D1.2/D1.2M for aluminum.

1.5.5 Single Source

Obtain each type of metal wall panels and grilles, clips, closure materials and other accessories from the standard products of the single source from a single manufacturer to operate as a complete system for the intended use. ***Rainscreen assemblies incorporate two manufacturers including one for the insulated metal panels and one for the standing seam metal roof panels used as cladding.***

1.5.6 Manufacturer's Maintenance Instructions

Provide manufacturer's detailed written instructions including copies of Safety Data Sheets for maintenance and repair materials.

1.5.7 Mockups

Build mockups to demonstrate aesthetic effects and set quality standards for fabrication and installation.

a. Build mockups of exterior wall panel and grille systems as indicated on drawings and as approved by the Contracting Officer.

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

c. Subject to compliance with requirements, approved mockups may become part of the completed work if undisturbed at time of final acceptance of the work, subject to Contracting Officer's approval

1.6 DELIVERY, HANDLING, AND STORAGE

Deliver and protect package components, sheets, panels and grilles, and other manufactured items to prevent damage or deformation during transportation and handling.

Unload, store, and erect panels and grilles in a manner to prevent bending, warping, twisting, and surface damage including, but not limited to, denting and scratching.

Stack and store panels and grilles horizontally on platforms or pallets, covered with suitable weather-tight and ventilated covering to ensure dryness, with positive slope for drainage of water. Do not store panels in contact with other materials that might cause staining, denting, or other surface damage.

Retain strippable protective covering on panels and grilles until actual installation. Do not use markers of any kind on protective covering as some types of ink will permeate the covering and mark the material surface.

1.7 PROJECT CONDITIONS FOR WALL PANELS

1.7.1 Field Measurements

Verify locations of wall framing and opening dimensions by field measurements to the greatest extent possible before metal wall panel and grille systems fabrication and indicate measurements on Shop Drawings.

1.7.2 Weather Limitations

Proceed with installation preparation only when existing and forecasted weather conditions permit Work to proceed without water entering into wall system or building.

1.8 WARRANTY

Warranty must conform to the Sample Warranty as reviewed and approved by the Contracting Officer.

1.8.1 Warranty

Manufacturer agrees to repair or replace components of exterior wall panel and grille systems that fail in materials or workmanship within specified warranty period.

a. Failures include, but are not limited to, the following:

(1) Structural failures including rupturing, cracking, or puncturing.

(2) Deterioration of metals and other materials beyond normal weathering.

b. Warranty Period: Two years from date of final acceptance of the work.

c. Finish and Warranty for standing seam metal roof panels used in rainscreen assemblies: In accordance with Section 07 61 15.00 20 ALUMINUM STANDING SEAM ROOFING.

1.8.2 Warranty on Panel and Grille Finishes

Manufacturer agrees to repair finish or replace exterior wall panels and grilles that show evidence of deterioration of factory-applied finishes within specified warranty period.

a. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:

(1) Color fading more than 5 Hunter units when tested according to ASTM D2244.

(2) Chalking in excess of a No. 8 rating when tested according to ASTM D4214.

(3) Cracking, checking, peeling, or failure of paint to adhere to bare metal.

b. Finish Warranty Period: 10 years from date of final acceptance of the work.

PART 2 PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

See Section 01 33 29 SUSTAINABILITY REPORTING for sustainable design requirements for the following, except as modified herein.

2.1.1 Recycled Content of Products

Provide products with post-consumer recycled content plus one-half of pre-consumer recycled content to the greatest extent possible, but not less than 10 percent.

2.2 FABRICATION

Fabricate and finish metal wall panels, grilles and accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes and as necessary to fulfill indicated and specified performance requirements. Comply with indicated profiles and with dimensional and structural requirements.

2.3 WALL PANELS

2.3.1 Metallic-Coated Sheet

Zinc-coated (galvanized) steel sheet complying with ASTM A653/A653M, G90 coating designation, structural quality. Prepainted by the coil-coating process to comply with ASTM A755/A755M. Nominal thickness shall be minimum 20 gauge for each face sheet and liner sheet.

a. Surface: Smooth, flat finish, as indicated on drawings.

b. Individual panels shall be formed without warping, waviness, or ripples that are not part of the panel profile and free of damage to the finish coating system.

c. Provide panels with thermal expansion and contraction consistent with the type of system specified.

2.3.2 Foam-Insulation Core Wall Panel System

Factory-formed steel wall panel assembly fabricated from two sheets of metal with modified polyisocyanurate foam insulation core foamed-in-place during fabrication with joints between panels designed to form weather-tight seals. Laminated insulation is not acceptable. Include accessories required for weather-tight installation.

a. Closed-Cell Content: 90 percent when tested according to ASTM D6226.

b. Density: 2.0 to 2.6 lb/cu. ft. when tested according to ASTM D1622.

c. Compressive Strength: Minimum 20 psi when tested according to ASTM D1621.

d. Shear Strength: 26 psi when tested according to ASTM C273/C273M.

e. Panel Thickness: Minimum thickness for profiled panels as indicated on drawings.

f. Profile: As indicated on drawings with concealed fasteners. Panels shall have end caps set in routed foam at both ends to complete panel fabrication.

2.3.3 Standing Seam Metal Roof Panels

Comply with Section 07 61 15.00 20 ALUMINUM STANDING SEAM ROOFING for factory-formed aluminum roof panels used in rainscreen assemblies.

2.3.4 Factory Finish

2-coat Fluoropolymer finish complying with AAMA 621 and containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to expose metal surfaces to comply with coating and resin manufacturers written instructions.

2.3.4.1 Color

Color as indicated on the drawings. Adjacent panels shall be from same color run for best color match.

2.3.5 Translucent Panel

Minimum 8 mm thick translucent polycarbonate panels with manufacturer's standard metal frame support system; clear matt color, unless otherwise indicated. Finish of metal frame support system to match specified insulated metal panels. Width of translucent panel assembly shall match specified insulated metal panels.

2.4 MISCELLANEOUS METAL FRAMING

Cold-formed metallic-coated steel sheet conforming to ASTM A653/A653M and specified in Section 05 40 00 COLD-FORMED METAL FRAMING; sizes and configurations as indicated on drawings.

2.5 WALL PANEL FASTENERS

2.5.1 General

2.5.1.1 Hidden (Concealed) Fasteners

Provide corrosion resistant fasteners recommended by the manufacturer to meet specified performance requirements.

Refer to Section 07 27 26 FLUID-APPLIED MEMBRANE AIR BARRIERS for strip flashing to be applied over fasteners.

2.5.1.2 Attachment Clips

Fabricate clips from steel hot-dipped galvanized in accordance with ASTM A653/A653M, Z275 G 90 or Series 300 stainless steel. Size, shape, thickness and capacity as required meeting the insulation thickness and specified performance requirements.

2.6 ACCESSORIES

2.6.1 General

All accessories must be compatible with the metal wall panels. Sheet metal flashing, trim, metal closure strips, caps and similar metal accessories must not be less than the minimum thickness specified for the wall panels. Exposed metal accessories/finishes to match the panels furnished, except as otherwise indicated. Molded foam rib, ridge and other closure strips must be non-absorbent closed-cell or solid-cell synthetic rubber or pre-molded neoprene to match configuration of the panels.

2.6.2 Metal Closure Strips and Trim

Provide panel manufacturer's standard factory fabricated closure strips and trim to match the specified metal panel.

2.6.3 Joint Sealants

Refer to Section 07 92 00 JOINT SEALANTS.

2.7 SOFFIT PANELS

Refer to Section 07 61 15.00 20 ALUMINUM STANDING SEAM ROOFING

2.8 DRAFT CURTAIN PANELS, INTERIOR

Provide factory-formed metal panels designed to be field assembled by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps.

2.8.1 Corrugated-Profile, Exposed-Fastener Metal Wall Panels

Formed with alternating curved ribs spaced at 2.67 inches o.c. across width of panel, unless otherwiise indicated.

a. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with ASTM A653/A653M, G90 coating designation; structural quality.

b. Nominal Thickness: Minimum 0.040 inch.

2.9 EXTERIOR WALL GRILLE SYSTEM

2.9.1 Screenwall/Vision Barrier Grille

Blades to be fabricated from extruded aluminum sections in 6063-T52 alloy, minimum 0.063 inch thick and spaced approximately 5 inches on center. Blades to be nominal 2 inches deep and mechanically secured to continuous extruded aluminum horizontal supports. Aluminum supports fixed directly to horizontal or vertical steel supports or to spandrel beams with extruded aluminum clip angles, as indicated on drawings. All fasteners to be stainless steel or aluminum. Material shall be shipped knocked down for field assembly by the Installer. Aluminum supports to match grille finish.

a. Materials: Aluminum extrusions shall comply with ASTM B211/B211M requirements. Aluminum sheet shall comply with ASTM B209 requirements.

b. Fabrication, General: Materials, sizes, depths, arrangements and

material thickness to be as indicated and as required to meet specified performance requirements. Include supports, anchorage, and accessories required for complete assembly.

c. Factory Finish: 2-coat Fluoropolymer finish complying with AAMA 2605 and containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to expose metal surfaces to comply with coating and resin manufacturers written instructions.

(1) Color: Color as indicated on the drawings. Adjacent grilles shall be from same color run for best color match.

PART 3 EXECUTION

3.1 EXAMINATION

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

Examine primary and secondary wall framing to verify that rafters, purlins, angles, channels, and other structural panel support members and anchorages have been installed within alignment tolerances required by metal wall panel manufacturer, UL, ASTM, ASCE 7-16 and as required for the geographical area where construction will take place.

Examine roughing-in for components and systems penetrating metal wall panels to verify actual locations of penetrations relative to seam locations of metal wall panels before metal wall panel installation.

Submit to the Contracting Officer a written report, endorsed by Installer, listing conditions detrimental to performance of the Work. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

Clean substrates of substances harmful to insulation, including removing projections capable of interfering with insulation attachment. Miscellaneous framing installation, including sub-purlins, girts, angles, furring, and other miscellaneous wall panel support members and anchorage must be according to metal wall panel manufacturer's written instructions.

3.3 WALL PANEL INSTALLATION

Provide exterior metal wall panels as indicated. Anchor metal wall panels and other components of the Work securely in place, with provisions for thermal and structural movement in accordance with panel manufacturer's written installation instructions.

Erect wall panel system in accordance with the approved erection drawings, the printed instructions and safety precautions of the manufacturer.

Panels are not to be subjected to overloading, abuse, or undue impact. Bent, chipped, or defective sheets shall not be applied.

Panels must be erected true and plumb and in exact alignment with the horizontal and vertical edges of the building, securely anchored, and with the indicated eave, and sill.

Field cutting metal wall panels by torch is not permitted.

3.3.1 Metal Protection

Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by metal wall panel manufacturer.

3.3.2 Joint Sealers

Install gaskets, joint fillers, and sealants where indicated and where required for weatherproof performance of metal wall panel assemblies. Provide types of gaskets, fillers, and sealants indicated or, if not indicated, types recommended by metal wall panel manufacturer.

3.3.3 Fasteners Installation

Anchor metal wall panels and other components of the Work securely in place, using manufacturer's approved fasteners according to manufacturer's written instructions.

Apply strip flashing over fasteners in accordance with requirements of Section Section 07 27 26 FLUID-APPLIED MEMBRANE AIR BARRIERS.

3.4 INSTALLATION OF EXTERIOR WALL GRILLE SYSTEM

Install Screenwall/Vision Barrier Grille as detailed on drawings, and in accordance with manufacturer's written instrucitons, in sizes and configurations indicated.

3.5 INSTALLATION OF DRAFT CURTAIN PANELS, INTERIOR

Install as detailed on drawings in sizes and configurations indicated.

3.6 SHEET METAL FLASHING INSTALLATION

3.6.1 General Requirements

Comply with performance requirements, metal panel and metal grille manufacturers' written installation instructions, and SMACNA 1793. Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams to form permanently watertight and weather resistant.

Install sheet metal work is to form weather-tight construction without waves, warps, buckles, fastening stresses or distortion, and allow for expansion and contraction. Cutting, fitting, drilling, and other operations in connection with sheet metal required to accommodate the work of other trades is to be performed by panel and grille installers.

3.7 WORKMANSHIP

Make lines, arises, and angles sharp and true. Free exposed surfaces from visible wave, warp, buckle, and tool marks. Fold back exposed edges neatly to form a 1/2 inch hem on the concealed side. Make sheet metal exposed to the weather watertight with provisions for expansion and contraction.

Make surfaces to receive sheet metal plumb and true, clean, even, smooth, dry, and free of defects and projections which might affect the application. For installation of items not shown in detail or not covered by specifications conform to the applicable requirements of SMACNA 1793. Provide sheet metal flashing wherever indicated and as required for complete metal panel and grille systems installation.

3.8 ACCEPTANCE PROVISIONS

3.8.1 Erection Tolerances

Erect metal wall panels straight and true with plumb vertical lines correctly lapped and secured in accordance with the manufacturer's written instructions. Maximum acceptable deviations:

a. 1/4 inch in 20 feet vertically or horizontally from face plane of framing.

b. 1/2 inch maximum deviation from framing face plane on any building evaluation.

c. 1/8 inch in 5 feet.

3.8.2 Repairs to Finish

Scratches, abrasions, and minor surface defects of finish shall be repaired with the specified repair materials. Finished repaired surfaces must be uniform and free from variations of color and surface texture.

Repaired metal surfaces that are not acceptable to the project requirements and/or Contracting Officer are to be immediately removed and replaced with new material.

3.9 FIELD QUALITY CONTROL

3.9.1 Construction Monitoring

Make visual inspections as necessary to ensure compliance with specified requirements. Additionally, verify the following:

a. Materials comply with the specified requirements.

b. Panels are installed without buckles, ripples, or waves and in uniform alignment and modulus.

c. The proper number, type, and spacing of attachment clips and fasteners are installed.

d. Installer adheres to specified and detailed application parameters.

e. Associated flashing and components are installed in a timely manner in accord with the specified requirements.

3.9.2 Field Testing

Engage a qualified testing agency to perform tests and inspections.

3.9.2.1 Water-Spray Test for Exterior Wall Panel System

After installation of clips, fasteners and strip flashing, test areas of assembly as directed by Contracting Officer for water penetration according to AAMA 501.2. Also, after complete installation of wall panel system, test areas of assembly as directed by Contracting Officer for water penetration according to AAMA 501.2.

3.9.2.2 Defective Wall Panels and Components

Remove and replace metal wall panels and components where tests and inspections indicate that they do not comply with specified requirements. Additional tests and inspections, at Contractor's expense, shall be performed to determine compliance of replaced or additional work with specified requirements.

3.9.2.3 Field Reports

Prepare test and inspection reports.

3.10 CLEANING AND PROTECTION

Remove temporary protective coverings and strippable films as panels and grilles are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of panel and grille installation, clean finished surfaces as recommended by panel and grille manufacturers. Maintain in a clean condition during construction.

After exterior panel installation, clear weep holes and drainage channels of obstructions, dirt, and sealant.

3.11 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 07 60 00

FLASHING AND SHEET METAL
05/17, CHG 2: 11/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 2605	(2020) Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16	(2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN WELDING SOCIETY (AWS)

AWS D1.2/D1.2M	(2014; Errata 1 2014; Errata 2 2020) Structural Welding Code - Aluminum

ASTM INTERNATIONAL (ASTM)

ASTM A480/A480M	(2020a) Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM D 1970	(2019) Standard Specification for Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection
ASTM D 2244	(2016) Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
ASTM D 4214	(2007; R 2015) Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films
ASTM D4586/D4586M	(2007; E 2012; R 2012) Asphalt Roof Cement, Asbestos-Free

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2018) International Building Code

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1793	(2012) Architectural Sheet Metal Manual, 7th Edition

SINGLE PLY ROOFING INDUSTRY (SPRI)

ANSI/SPRI RD-1	(2014) Performance Standard for Retrofit Drains

1.2 GENERAL REQUIREMENTS

Finished sheet metal assemblies must form a weathertight enclosure without waves, warps, buckles, fastening stresses or distortion, while allowing for expansion and contraction without damage to the system. The sheet metal installer is responsible for cutting, fitting, drilling, and other operations in connection with sheet metal modifications required to accommodate the work of other trades. Coordinate installation of sheet metal items used in conjunction with roofing with roofing work to permit continuous, uninterrupted roofing operations.

1.2.1 Performance Requirements

Design and fabricate all exterior sheet metal flashing and trim provided to meet wind and seismic load criteria indicated on the Structural drawings, in accordance with the ICC IBC and ASCE 7-16 requirements for Components and Cladding.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Roof Expansion Joint System; G

Flashing for Roof Drains; G

Counterflashing; G

Flashing at Roof Penetrations and Equipment Supports; G

Reglet System; G

Scuppers; G

Parapet Coping System; G

Roof Edging System; G

Conductor Heads; G

SD-03 Product Data

Roof Expansion Joint System; G

Reglet System; G

Parapet Coping System; G

Roof Edging System; G

Underlayment; G

Recycled Content; S

Product data indicating percentage by weight of post-consumer and pre-consumer recycled content for products having recycled content specified in this Section. Submit per requirements in Section 01 33 29 SUSTAINABILITY REPORTING.

SD-04 Samples

Finish Samples; G

SD-05 Design Data

Performance Requirements Validation; G

For products and systems indicated to validate compliance with specified wind and seismic load performance requirements, provide calculations and design criteria, including engineering analysis data, signed and sealed by the qualified registered Professional Engineer responsible for their preparation.

SD-08 Manufacturer's Instructions

Instructions for Installation; G

SD-10 Operation and Maintenance Data

Cleaning and Maintenance; G

SD-11 Closeout Submittals

All sustainable design Submittals for recycled content are included under SD-03 Product Data.

1.4 MISCELLANEOUS REQUIREMENTS

1.4.1 Product Data

Indicate thicknesses, dimensions, fastenings, anchoring methods, expansion joints, and other provisions necessary for thermal expansion and contraction. Scaled manufacturer's catalog data may be submitted for factory fabricated systems.

1.4.2 Finish Samples

Submit two color charts and two finish sample chips from manufacturer's

standard color and finish for each type of finish indicated.

1.4.3 Operation and Maintenance Data

Submit detailed instructions for installation and quality control during installation, cleaning and maintenance, for each type of assembly indicated.

1.5 DELIVERY, HANDLING, AND STORAGE

Package and protect materials during shipment. Uncrate and inspect materials for damage, dampness, and wet-storage stains upon delivery to the job site. Remove from the site and replace damaged materials that cannot be restored to like-new condition. Handle sheet metal items to avoid damage to surfaces, edges, and ends. Store materials in dry, weather-tight, ventilated areas until installation.

1.6 FINISH WARRANTY

Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal components that show evidence of deterioration of factory-applied finishes within specified warranty period.

1.6.1 Exposed Finish

Deterioration includes, but is not limited to, the following:

a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.

b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.

c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

1.6.2 Finish Warranty Period

10 years from date of final acceptance of the work.

PART 2 PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

See Section 01 33 29 SUSTAINABILITY REPORTING for sustainable design requirements for the following, except as modified herein.

2.1.1 Recycled Content of Products

Provide products with post-consumer recycled content plus one-half of pre-consumer recycled content to the greatest extent possible, but not less than 10 percent.

2.2 MATERIALS

Furnish sheet metal items in 8 to 10 foot lengths. Single pieces less than 8 feet long may be used to connect to factory-fabricated inside and outside corners, and at ends of runs. Factory fabricate corner pieces with minimum 12 inch legs. Provide accessories and other items essential

to complete the sheet metal installation. Provide accessories made of the same or compatible materials as the items to which they are applied.

2.2.1 Lead Sheet

Provide in a minimum weight of 4 pounds per square foot.

2.2.2 Stainless Steel

Provide in accordance with ASTM A480/A480M, Type 302 or 304, 2D Finish, fully annealed, dead-soft temper.

2.2.3 Aluminum Alloy Sheet and Plate

Provide in accordance with ASTM B209 form alloy, and temper appropriate for use.

2.2.4 Scuppers

Line interiors of scupper openings with sheet metal. Provide a drip edge at bottom edges with returns of not less than one inch against the face of the outside wall at the top and sides. Provide the perimeter of the lining approximately 1/2 inch less than the perimeter of the scupper.

2.2.5 Conductor Heads

Provide conductor heads and screens in the same material as downspouts. Provide outlet tubes not less than 4 inches long.

2.2.6 Fasteners

Use the same metal as, or a metal compatible with the item fastened. Use stainless steel fasteners to fasten dissimilar materials.

2.3 ALUMINUM FINISHES

2.3.1 2-Coat Fluoropolymer

AAMA 2605. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

2.3.2 Color

Color as indicated on drawings.

2.4 FACTORY FABRICATED SYSTEMS

2.4.1 Parapet Coping System

2.4.1.1 Coping

Metal coping system with ***stainless*** steel anchor cleats and gutter support chairs for capping parapet wall. The system shall be watertight, maintenance free, and not require exposed fasteners or sealant. Joints shall be butt type with concealed splice plates. Coping system shall be sized for maximum 1/4 inch clearance on each side of each parapet wall condition.

2.4.1.2 Performance Characteristics

a. Coping sections shall expand and contract freely while mechanically locked in place on anchor cleats.

b. Coping sections shall lock to anchor cleats by mechanical pressure from support chairs.

c. All coping cover joints shall be underlayed with gutter/support chairs capable of draining water.

2.4.1.3 Exposed Surfaces

Exposed surfaces shall be minimum 0.050 inch aluminum in 10-foot lengths. Width as indicated and as required. Coping vertical face and back leg shall be standard 4 inches nominal.

2.4.1.4 Internal Splice Plates

Shall be concealed with matching finish to maintain outside face continuity.

2.4.1.5 Coping Cleat

Shall be minimum 20 gauge ***stainless*** steel anchor cleat and as required to meet performance requirements. Adhesive bonded or mechanically fastened as required per manufacturer's written instructions.

2.4.1.6 Fasteners

Shall be corrosion resistant screw type with a minimum pull-out resistance of 240 pounds as supplied by the manufacturer per substrate application. No exposed fasteners shall be permitted. Fasteners shall be electrolytically compatible.

2.4.1.7 Accessories

Provide corners, end caps, pier caps, gutter/support chairs, etc., fabricated by the coping manufacturer as required for a complete assembly.

2.4.2 Reglet System

2.4.2.1 Reglets

Units of type, material, and profile indicated, formed to provide secure interlocking of separate reglet and counterflashing pieces, and compatible with flashing indicated with factory-mitered and welded corners and junctions and with interlocking counterflashing on exterior face, of same metal as reglet.

2.4.2.2 Material

Material shall be aluminum, minimum 0.024 inch thick; counterflashing shall be aluminum, minimum 0.032 inch thick.

2.4.2.3 Reglet Types

Provide reglet types per the following as indicated and as required:

a. Surface-Mounted Type: Provide with slotted holes for fastening to substrate, with neoprene or other suitable weatherproofing washers, and with channel for sealant at top edge.

b. Concrete Type: Provide temporary closure tape to keep reglet free of concrete materials, special fasteners for attaching reglet to concrete forms, and guides to ensure alignment of reglet section ends.

2.4.2.4 Accessories

Provide accessories as indicated and as required for a complete assembly including the following:

a. Counterflashing Wind-Restraint Clips: Provide clips to be installed before counterflashing to prevent wind uplift of counterflashing lower edge.

2.4.2.5 Fasteners

Fasteners shall be manufacturer's standard corrosion resistant screw type.

2.4.3 Roof Expansion Joint System

2.4.3.1 System

Multi-part assembly designed to facilitate the horizontal and lateral movement of the roof sections. The system shall consist of a membrane condensate and air seal with insulation continuous ***stainless steel*** rails and anchor cleat, fasteners and a formed metal cover. The system shall be watertight, maintenance free, and not require exposed fasteners. Joints shall be butt type with concealed splice plates.

2.4.3.2 Performance Characteristics

Expansion joint sections shall expand and contract freely while mechanically locked in place on anchor cleats. Provide additional components as required to meet specified seismic criteria.

2.4.3.3 Exposed Surfaces

Exposed surfaces shall be minimum 0.050 inch aluminum in 10-foot lengths. Width as indicated and as required.

2.4.3.4 Internal Splice Plates

Shall be concealed with matching finish to maintain outside face continuity.

2.4.3.5 Cleat and Rails

Cleat shall be minimum 20 gauge ***stainless*** steel continuous anchor cleat and as required to meet performance requirements. Rails shall be minimum 24 gauge ***stainless*** steel continuous rails and as required to meet performance requirements; rails permit unrestricted movement between cleat and rails. Mechanically fastened as required per manufacturer's written instructions.

2.4.3.6 Fasteners

Shall be corrosion resistant screw type with a minimum pull-out resistance of 240 pounds as supplied by the manufacturer per substrate application. No exposed fasteners shall be permitted. Fasteners shall be electrolytically compatible.

2.4.3.7 Accessories

Provide corners, end caps, pier caps, condensate and air seal, etc., fabricated by the roof expansion joint manufacturer as required for a complete assembly.

2.4.4 Roof Edging System

2.4.4.1 Roof Edging

Provide assembly with a continuous anchor cleat and a snap-on aluminum fascia cover for modified bitumen roofs. The system shall have all concealed fasteners with no penetratoin on horizontal roof surface. Size and configuration as indicated.

2.4.4.2 Continuous Anchor Cleat

Shall be manufacturer's standard aluminum or ***stainless steel*** metal with slotted holes for fasteners in 10-foot standard lengths.

2.4.4.3 Exterior Fascia Covers

Shall be 0.050 inch aluminum in 10-foot lengths with concealed, matching joint splice plates.

2.4.4.4 Fasteners

Fasteners shall be manufacturer's standard corrosion resistant screw type.

2.4.4.5 Accessories

Provide corners, end caps, facia sumps, or spillouts, etc., fabricated by the roof edging manufacturer as required for a complete assembly. Factory fabricated mitered corners shall have 12 inch nominal leg lengths.

2.5 GUTTERS AND DOWNSPOUTS

Refer to Section 07 61 15.00 20 ALUMINUM STANDING SEAM ROOFING for gutters and downspouts.

2.6 UNDERLAYMENT

Self-adhering, high-temperature sheet, 30 to 40 mils thick minimum, consisting of slip-resisting, polyethylene-film top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by underlayment manufacturer.

2.6.1 Properties

a. Thermal Stability: Stable after testing at 240 deg F; ASTM D 1970.

b. Low-Temperature Flexibility: Passes after testing at minus 20 deg F; ASTM D 1970.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Workmanship

Make lines and angles sharp and true. Free exposed surfaces from visible wave, warp, buckle, and tool marks. Fold back exposed edges neatly to form a 1/2 inch hem on the concealed side. Make sheet metal exposed to the weather watertight with provisions for expansion and contraction.

Make surfaces to receive sheet metal plumb and true, clean, even, smooth, dry, and free of defects and projections. For installation of items not shown in detail or not covered by specifications conform to the applicable requirements of SMACNA 1793, Architectural Sheet Metal Manual.

3.1.1.1 Factory Fabricated Systems

Installation per respective manufacturer's written instructions in accordance with specified performance requirements.

3.1.1.2 Self-Adhering Sheet Underlayment Installation

Apply primer if required by manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation. Cover underlayment within 14 days.

a. Apply continuously under copings and roof edging.

b. Coordinate application of self-adhering sheet underlayment with requirements for continuity with adjacent air barrier materials.

3.1.2 Welding and Mechanical Fastening

Use welding for aluminum of thickness greater than 0.040 inch. Aluminum 0.040 inch or less in thickness must be butted and the space backed with formed flashing plate; or lock joined, mechanically fastened, and filled with sealant as recommended by the aluminum manufacturer.

3.1.2.1 Welding of Aluminum

Use welding of the inert gas, shield-arc type. For procedures, appearance and quality of welds, and the methods used in correcting welding work, conform to AWS D1.2/D1.2M.

3.1.2.2 Mechanical Fastening of Aluminum

Use No. 12, aluminum alloy, sheet metal screws or other suitable aluminum alloy or stainless steel fasteners. Drive fasteners in holes made with a No. 26 drill in securing side laps, end laps, and flashings. Space fasteners 12 inches maximum on center. Where end lap fasteners are required to improve closure, locate the end lap fasteners not more than 2 inches from the end of the overlapping sheet.

3.1.3 Protection from Contact with Dissimilar Materials

3.1.3.1 Aluminum

Do not allow aluminum surfaces in direct contact with other metals except stainless steel, zinc, or zinc coating. Where aluminum contacts another metal, paint the dissimilar metal with a primer followed by two coats of aluminum paint. Where drainage from a dissimilar metal passes over aluminum, paint the dissimilar metal with a non-lead pigmented paint.

3.1.3.2 Metal Surfaces

Paint surfaces in contact with mortar, concrete, or other masonry materials with alkali-resistant coatings such as heavy-bodied bituminous paint.

3.1.3.3 Wood or Other Absorptive Materials

Paint surfaces that may become repeatedly wet and in contact with metal with two coats of aluminum paint or a coat of heavy-bodied bituminous paint.

3.1.4 Counterflashing

Except where indicated or specified otherwise, provide minimum 0.032 inch thick aluminum counterflashing in sizes and configurations indicated, and as required to suit conditions. Fold the exposed edges of counterflashings 1/2 inch. Provide end laps in counterflashings not less than 3 inches and make it weathertight with plastic cement. Do not make lengths of metal counterflashings exceed 10 feet. Form the flashings to the required shapes before installation. Factory-form the corners not less than 12 inches from the angle. Where bituminous base flashings are provided, the counter flashing shall extend down as close as practicable to the top of the cant strip. Counter flashing shall be factory formed to provide spring action against the base flashing.

3.1.5 Flashing for Roof Drains

Provide a 30 inches square sheet indicated. Taper insulation to drain from 24 inches out. Set flashing on finished felts in a full bed of asphalt roof cement, ASTM D4586/D4586M. Heavily coat the drain flashing ring with asphalt roof cement. Clamp the roof membrane, flashing sheet, and stripping felt in the drain clamping ring. Secure clamps so that felts and drain flashing are free of wrinkles and folds. Retrofit roof drains must conform to ANSI/SPRI RD-1.

3.1.6 Scuppers

Except where indicated or specified otherwise, provide minimum 0.040 inch thick aluminum scuppers in sizes and configurations indicated. Extend the scupper liner through and project outside of, the wall it penetrates to form a bottom drip edge against the face of the wall. Fold outside edges under 1/2 inch on all sides. Join the top and sides of the lining on the roof deck side to a closure flange by a locked and soldered joint. Join the bottom edge by a locked and soldered joint to the closure flange, where required, form with a ridge to act as a gravel stop around the scupper inlet. Provide surfaces to receive the scupper lining and coat with bituminous plastic cement.

3.1.7 Conductor Heads

Except where indicated or specified otherwise, provide minimum 0.040 inch thick aluminum conductor heads in sizes and configurations indicated. Set the depth of the top opening equal to two-thirds of the width or the conductor head. Flat-lock solder seams. Where conductor heads are used in conjunction with scuppers, set the conductor a minimum of 2 inches wider than the scupper. Attach conductor heads to the wall with masonry fasteners. Securely fasten screens to heads.

3.1.8 Flashing at Roof Penetrations and Equipment Supports

Provide metal flashing for all pipes, ducts, and conduits projecting through the roof surface and for equipment supports, guy wire anchors, and similar items supported by or attached to the roof deck.

3.1.9 Single Pipe Vents

Set flange of sleeve in bituminous plastic cement and nail 3 inches on center. Bend the top of sleeve over and extend down into the vent pipe a minimum of 2 inches. For long runs or long rises above the deck, where it is impractical to cover the vent pipe with lead, use a two-piece formed metal housing. Set metal housing with a metal sleeve having a 4 inches roof flange in bituminous plastic cement and nailed 3 inches on center. Extend sleeve a minimum of 8 inches above the roof deck and lapped a minimum of 3 inches by a metal hood secured to the vent pipe by a draw band. Seal the area of hood in contact with vent pipe with an approved sealant.

3.2 CLEANING

Clean exposed sheet metal work at completion of installation. Remove grease and oil films, handling marks, contamination from steel wool, fittings and drilling debris, and scrub-clean. Free the exposed metal surfaces of dents, creases, waves, scratch marks, and solder or weld marks.

3.3 REPAIRS TO FINISH

Scratches, abrasions, and minor surface defects of finish may be repaired in accordance with the manufacturer's printed instructions and as approved. Repair damaged surfaces caused by scratches, blemishes, and variations of color and surface texture. Replace items which cannot be repaired.

3.4 FIELD QUALITY CONTROL

Contractor to establish and maintain a Quality Control Plan for sheet metal used in conjunction with roofing to assure compliance of the installed sheet metalwork with the contract requirements. Remove work that is not in compliance with the contract and replace or correct. Include quality control, but not be limited to, the following:

a. Observation of environmental conditions; number and skill level of sheet metal workers; condition of substrate.

b. Verification that specified material is provided and installed.

c. Inspection of sheet metalwork, for proper size(s) and thickness(es), fastening and joining, and proper installation.

3.5 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

SECTION 07 61 15.00 20

ALUMINUM STANDING SEAM ROOFING
08/16, CHG 2: 11/18
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA ADM	(2020) Aluminum Design Manual

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 2605	(2020) Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16	(2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM D522/D522M	(2017) Mandrel Bend Test of Attached Organic Coatings
ASTM D523	(2014; R 2018) Standard Test Method for Specular Gloss
ASTM D714	(2002; R 2017) Standard Test Method for Evaluating Degree of Blistering of Paints
ASTM D968	(2017) Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive
ASTM D1654	(2008; R 2016; E 2017) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

ASTM D 1970	(2019) Standard Specification for Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection
ASTM D2244	(2016) Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
ASTM D2247	(2015) Testing Water Resistance of Coatings in 100% Relative Humidity
ASTM D2565	(2016) Standard Practice for Xenon Arc Exposure of Plastics Intended for Outdoor Applications
ASTM D4214	(2007; R 2015) Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films
ASTM E330/E330M	(2014) Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference
ASTM E 1646	(1995; R 2003) Standard Test Method for Water Penetration of Exterior Metal Roof Panel Systems by Uniform Air Pressure Difference
ASTM G152	(2013) Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
ASTM G153	(2013) Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2018) International Building Code

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1793	(2012) Architectural Sheet Metal Manual, 7th Edition

1.2 DEFINITIONS

1.2.1 Field-Formed Seam

Seams of panels so configured that when adjacent sheets are installed the seam is sealed utilizing mechanical or hand seamers. Crimped (45 degree bend), roll formed (180 degree bend), double roll formed (2 - 180 degree bend), and roll and lock systems are types of field-formed seam systems.

1.2.2 Roofing System

The roofing system is defined as the assembly of roofing components, including roofing panels, soffit panels, fasica panels, fascia, flashing,expansion joints, fasteners, gutters, downspouts and accessories as indicated and as required for a watertight installation. Complete roof covering assembly shall include roof insulation and related components specified in Section 07 22 00 ROOF AND DECK INSULATION.

1.3 SYSTEM DESCRIPTION

1.3.1 Design Requirements

a. Provide continuous length panels with no joints or seams, except where recommended by the manufacturer. Individual panels must be removable for replacement of damaged material.

b. There must be no exposed or penetrating fasteners except where shown on the approved shop drawings. Fasteners into wood must be stainless steel sheet metal screws with full length threads. Fasteners into steel must be stainless steel or cadmium plated stainless steel screws inserted into predrilled holes. Length and diameter of screws must be sufficient to meet the design loads with a suitable factor of safety for the material to which the roofing components are attached. Calculate fastener capacity in accordance with AA ADM.

c. Roof panel standing seam must include a capillary break and be mechanically locked closed by the manufacturer's locking tool. The seam must include a continuous sealant when required by the manufacturer to withstand the rainfall and wind specified in paragraph entitled "Performance Requirements.

d. Roof panel anchor clips must be concealed and designed to allow for thermal movement of the panels, except where specific fixed points are as recommended by the manufacturer.

e. The system must resist the positive and negative loads specified herein in accordance with "Sheet Building Sheathing Design Guide" of the AA ADM. Determine capacity in accordance with principles of ASTM E330/E330M modified as follows:

(1) Test panels must be production material of the type proposed for use. Use either full length or partial length panels with attachment representative of the main part of the roof.

(2) Test specimens must be five panels wide, span one or more supports, and must have no end or edge attachment or seals that will restrict crosswise movement of the panels under load. Do not bridge longitudinal seams with tape or film that can restrict separation.

(3) Test panels to failure. Report load at failure.

f. Panels must support walking loads without excessive distortion or telegraphing of the structural supports. Panels must support a 250 pound load concentrated on a 4 square inch area at the center of the panel without buckling or permanent distortion.

1.3.2 Performance Requirements

1.3.2.1 Wind and Seismic Loads

The system shall be designed to resist wind and seismic load criteria indicated on the Structural drawings in accordance with the ICC IBC and ASCE 7-16 for Components and Cladding.

1.3.2.2 Resistance to Water Infiltration

No water penetration when tested according to ASTM E 1646 criteria.

1.3.2.3 Thermal Movement

Allow for thermal movements resulting from ambient and surface temperature changes. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

a. Temperature Change (Range): 120 deg F., ambient; 180 deg F material surfaces.

1.3.2.4 Deflection

Panel deflection must not exceed L/140.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Erection Drawings; G

Submit erection drawings to supplement the instructions and diagrams. Drawings shall include an isometric view of the roof showing the design uplift pressures and dimensions of edge, ridge and corner zones. Show typical and special conditions including flashings, accessories installation, materials and thicknesses, all dimensions, panel attachment clip layouts, sealant locations, sealant tape locations, fastener layout, sizes, spacing, provisions for thermal and building movement, terminations, edge conditions such as fascia or rakes, penetrations, and attachments. Fabrication and installation details of gutters and downspouts, and soffit and fascia panels. Details of installation must be in accordance with the manufacturer's Standard Instructions and details or the SMACNA 1793. The manufacturer's technical engineering department must approve the drawings before they are submitted.

SD-03 Product Data

Roofing Panels; G

Soffit and fascia panels; G

Gutters and downspouts; G

Attachment Clips

Accessories; G

Underlayment; G

Recycled Content; S

Product data indicating percentage by weight of post-consumer and pre-consumer recycled content for products having recycled content specified in this Section. Submit per requirements in Section 01 33 29 SUSTAINABILITY REPORTING.

SD-04 Samples

Roofing Panels

Soffit and fascia panels; G

Gutters and downspouts; G

Accessories; G

Submit each type of accessory item used in the project including, but not limited to, each type of anchor clip, closures, fasteners and leg clamps.

SD-05 Design Data

Performance Requirements Validation; G

For products and systems indicated to comply with specified aluminum standing seam roofing system and related components performance requirements and design criteria, including analysis data signed and sealed by the qualified registered Professional Engineer responsible for their preparation. ***Rainscreen engineering analysis using roof panels will be provided under Section 07 42 13 METAL WALL PANELS.***

SD-06 Test Reports

Panel Finish

Test and inspection reports

Submit manufacturer's technical representative's inspection reports as required in paragraph entitled "Field Quality Control".

SD-07 Certificates

Manufacturer

Technical Representative

Qualification of Installer

Coil Stock Compatibility

Provide certification of coil compatibility with roll forming machinery to be used for forming panels without warping, waviness, and rippling not part of panel profile; to be done without damage, abrasion or marking of finish coating.

SD-08 Manufacturer's Instructions

Installation Manual

Submit manufacturer's printed installation manual/instructions and standard details.

SD-11 Closeout Submittals

Information Card

Warranties

All sustainable design Submittals for recycled content are included under SD-03 Product Data.

1.5 QUALITY ASSURANCE

1.5.1 Preroofing Conference

After submittals are received and approved but before roofing and insulation work, including associated work, is preformed, the Contracting Officer will hold a preroofing conference to review the following:

a. The drawings and specifications

b. Procedure for on site inspection and acceptance of the roofing substrate and pertinent structural details relating to the roofing system

c. Contractor's plan for coordination of the work of the various trades involved in providing the roofing system and other components secured to the roofing

d. Safety requirements.

The preroofing conference must be attended by the Contractor and personnel directly responsible for the roofing and insulation installation, mechanical and electrical work, and the roofing manufacturer's technical representative. Conflicts among those attending the preroofing conference must be resolved and confirmed in writing before roofing work, including associated work, is begun. Prepare written minutes of the preroofing conference and submit to the Contracting Officer.

1.5.2 Manufacturer's Technical Representative

The representative must have authorization from manufacturer to approve field changes and be thoroughly familiar with the products and with installations in the geographical area where construction will take place. The manufacturer's representative must be an employee of the manufacturer with at least 5 years experience in installing the roof system. The representative must be available to perform field inspections and attend meetings as required herein, and as requested by the Contracting Officer.

1.5.3 Qualification of Installer

The roofing system installer must be factory-trained, approved by the aluminum roofing system manufacturer to install the system, and must have a minimum of three years experience as an approved applicator with that manufacturer. The applicator must have applied five installations of similar size and scope to this project within the previous 3 years.

1.5.4 Single Source

Provide roofing panels, soffit and fascia panels, clips, closures and other required accessories from a single manufacturer.

1.5.5 Manufacturer

The aluminum standing seam roofing system must be the product of an aluminum roofing industry recognized manufacturer who has been in the practice of manufacturing aluminum standing seam roofing systems and related component for a period of not less than 5 years and who has been involved in at least 5 projects similar in size and complexity to this project.

1.5.6 Laboratory Tests For Panel Finish

Previously manufactured panels of the same type and finish as proposed for the project must have been tested by an approved testing laboratory to ensure conformance to specifications. The term "appearance of base metal" refers to the aluminum base metal. Panels must meet the following test requirements.

1.5.6.1 Salt Spray Test

Panels must withstand a salt spray test for a minimum of 2000 hours in accordance with ASTM B117, including the scribe requirement in the test. Immediately upon removal of the panel from the test, coating must receive a rating of 10, no blistering, as determined by ASTM D714; and a rating of 7, 1/16 inch failure at scribe, as determined by ASTM D1654, Rating Schedule No. 1.

1.5.6.2 Formability Test

For formability test, when subjected to a 180 degree bend over a 1/8 inch diameter mandrel in accordance with ASTM D522/D522M, exterior coating film must show only microchecking of the exterior film and there must be no loss of adhesion.

1.5.6.3 Accelerated Weathering Test

Panels must withstand an accelerated weathering test for a minimum of 2000 hours in accordance with ASTM G152, ASTM G153 or ASTM D2565 without cracking, peeling, blistering, loss of adhesion of the protective coating, or corrosion of the base metal. Protective coating that can be readily removed from the base metal with a penknife blade or similar instrument will be considered to indicate loss of adhesion.

1.5.6.4 Chalking Resistance

After the 2000-hour weatherometer test, exterior coating may not chalk

greater than No. 8 rating when measured in accordance with ASTM D4214 test procedures.

1.5.6.5 Abrasion Resistance Test for Color Coating

When subjected to the falling sand test in accordance with ASTM D968, coating system must withstand a minimum of 100 liters of sand per 0.025 mm (mil) of coating thickness before appearance of base metal.

1.5.6.6 Humidity Test

When subjected to a humidity cabinet test in accordance with ASTM D2247 for 1000 hours, a scored panel must show no signs of blistering, cracking, creepage, or corrosion.

1.5.6.7 Gloss

The gloss of the finish must be 30 plus or minus 5 at an angle of 60 degrees, when measured in accordance with ASTM D523.

1.5.6.8 Glare Resistance

Surfaces of panels that will be exposed to the exterior must have a specular reflectance of not more than 10 when measured in accordance with ASTM D523 at an angle of 85 degrees.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver, store, and handle preformed panels, bulk roofing products and other manufactured items in a manner to prevent damage or deformation.

1.6.1 Delivery

Provide adequate packaging to protect materials during shipment. Do not uncrate materials until ready for use except for inspection. Immediately upon arrival of materials at jobsite, inspect materials for damage, dampness, and staining. Replace damaged or permanently stained materials that cannot be restored to like-new condition with new material. If materials are wet, remove moisture, restack and protect panels until used.

1.6.2 Handling

Handle material carefully to avoid damage to surfaces, edges and ends.

1.6.3 Storage

Stack materials stored on the site on platforms or pallets and cover with tarpaulins or other suitable weathertight coverings which prevent water trapping or condensation. Store panels so that water which might have accumulated during transit or storage will drain off. Do not store the panels in contact with materials that might cause staining, such as mud, lime, cement, fresh concrete or chemicals. Protect stored panels from wind damage.

1.7 WARRANTIES

Provide metal roof system material and workmanship warranties meeting specified requirements. Provide revision or amendment to manufacturer's standard warranty as required to comply with the specified requirements.

1.7.1 Metal Roof Panel Manufacturer Warranty

Furnish the metal roof panel manufacturer's 20-year no dollar limit roof system materials and installation workmanship warranty, including roof panels, flashing, components, trim, gutters and downspouts, soffit and fascia panels, and accessories required for a watertight roof system construction. Make warranty directly to the Government, commencing at final acceptance of the work. The warranty must state that:

a. If within the warranty period, the metal roof system, as installed for its intended use in the normal climatic and environmental conditions of the facility, becomes non-watertight, shows evidence of moisture intrusion within the assembly, displaces, corrodes, perforates, separates at the seams, or shows evidence of excessive weathering due to defective materials or installation workmanship, the repair or replacement of the defective and damaged materials of the metal roof system and correction of defective workmanship is the responsibility of the metal roof panel manufacturer. All costs associated with the repair or replacement work are the responsibility of the metal roof panel manufacturer.

b. If the manufacturer or its approved applicator fail to perform the repairs within 48 hours of notification, emergency temporary repairs performed by others does not void the warranty.

1.7.2 Manufacturer's Finish Warranty

Provide a manufacturer's no-dollar-limit 20 year warranty for the roofing system finish. Issue the warranty directly to the Government commencing at final acceptance of the work, warranting that the factory color finish, under normal atmospheric conditions at the site, will not crack, peel, or delaminate; chalk in excess of a numerical rating of 8 when measured in accordance with ASTM D4214; or fade or change colors in excess of 5 NBS units as measured in accordance with ASTM D2244.

1.7.3 Metal Roof System Installer Warranty

Provide roof system Installer warranty for a period of not less than five years that the roof system, as installed, is free from defects in installation workmanship, to include the roof panel installation, flashing, accessories, attachments, gutters and downspouts, soffit and fascia panels and accessories required for a complete watertight roof system assembly. Issue warranty directly to the Government commencing at final acceptance of the work. Correction of defective workmanship and replacement of damaged or affected materials is the responsibility of the metal roof system Installer. All costs associated with the repair or replacement work are the responsibility of the Installer.

PART 2 PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

See Section 01 33 29 SUSTAINABILITY REPORTING for sustainable design requirements for the following, except as modified herein.

2.1.1 Recycled Content of Products

Provide products with post-consumer recycled content plus one-half of

pre-consumer recycled content to the greatest extent possible, but not less than 10 percent.

2.2 ROOFING PANELS

2.2.1 Material

3004 aluminum, ASTM B209.

2.2.1.1 Thickness

0.040 inch minimum; provide greater thickness as required to comply with specified performance requirements criteria.

2.2.1.2 Finish

AAMA 2605. Exposed surfaces of roofing panels shall have a factory applied two-coat fluoropolymer finish containing not less than 70 percent polyvinylidene fluoride PVDF resin by weight in color coat. Prepare, pretreat and apply coating to exposed metal surfaces to comply with coating and resin manufacturer's written instructions. Non-exposed surfaces shall have manufacturer's standard finish.

2.2.1.3 Texture

Smooth with raised intermediate ribs for added stiffness.

2.2.1.4 Color

Provide colors as indicated; colors listed are not intended to limit the selection of equal colors from other manufacturers.

2.2.1.5 Configuration

Provide panels of continuous lengths from ridge to eaves or from top to eaves on shed roof designs. Panels must be nominal 16 inches wide with minimum 1-1/2 inch high vertical legs and two nominal 0.37 inch stiffening ribs at 4 inches on center between the legs to minimize oil-canning and telegraphing of structural members. Leading vertical leg must have a continuous groove in the rib top for anti-siphon protection when hook-rib top of next panel is locked over leading vertical leg to form the standing seam. Panels from coil stock must be formed without warping, waviness or ripples not a part of the panel profile, and must be free of damage to the finish coating system.

2.2.1.6 Radius Edge Metal

Edges such as rake trim or similar components that will be arched/radiused in elevation view, shall be factory fabricated and continuously welded.

2.2.1.7 Attachment Clips

Manufacturer's standard corrosion-resistant metal clips.

2.3 SOFFIT AND FASCIA PANELS

2.3.1 General

Provide metal soffit and fascia panels designed to be installed by lapping

and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners in side laps. Include accessories required for weathertight installation

2.3.2 Reveal-Joint-Profile Metal Soffit and Fascia Panels

Solid panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced between panel edges; with recessed reveal joint between panels.

a. Aluminum Sheet: coil-coated sheet, ASTM B209, alloy as standard with manufacturer, with temper as required to suit forming operations and structural performance required.

(1) Thickness: 0.040 inch.

(2) Surface: Smooth, flat finish.

b. Exterior Finish: Two-coat fluoropolymer to match roof panel finish.

(1) Color: Provide colors as indicated; colors listed are not intended to limit the selection of equal colors from other manufacturers.

c. Panel Coverage: 12 inches, unless otherwise indicated or required.

d. Panel Height: 0.75 inch, unless otherwise indicated.

2.4 GUTTERS AND DOWNSPOUTS

2.4.1 Gutters

Fabricate to cross section indicated, complete with end pieces, outlet tubes, and other accessories as required. Fabricate in minimum 96-inch long sections. Furnish flat-stock gutter brackets and straps fabricated from same metal as gutters, of size recommended by cited sheet metal standard but with thickness not less than twice the gutter thickness. Fabricate expansion joints, expansion-joint covers, and gutter accessories from same metal as gutters. Shop fabricate interior and exterior corners.

2.4.1.1 Gutter Accessories

Provide stainless steel wire-ball strainer at each downspout outlet location. Provide strainers to fit tightly into outlets.

2.4.2 Downspouts

Fabricate to dimensions indicated, complete with mitered elbows. Fabricate in minimum 10 foot long sections. Furnish with metal hangers from same material as downspouts and anchors. Shop fabricate elbows.

Provide a downspout spreader with gaps or holes spaced per the corresponding spacing of the standing seam metal roof panel ribs, at locations indicated on drawings.

2.4.3 Material and Thickness

Aluminum sheet same roof panels, not less than 0.040 inch thick.

2.4.4 Finish

Two-coat fluoropolymer to match roof panel finish.

2.4.4.1 Color

Provide colors as indicated; colors listed are not intended to limit the selection of equal colors from other manufacturers.

2.5 ACCESSORIES

Sheet metal flashings, trim, moldings, closure strips, caps, preformed crickets, equipment curbs, rainwater diverters, gutters and downspouts as specified, and other similar sheet aluminum accessories provided in conjunction with preformed aluminum panels must be of the same material and finish as panels, except that such items which will be concealed after installation may be provided without the finish if they are aluminum or stainless steel. Provide ridge and rib closures, as specified. Aluminum must be of thickness not less than that of panels. Provide metal roofing manufacturer's standard roof penetration boot suitable for each condition. Molded closure strips must be closed-cell synthetic rubber, neoprene, or polyvinyl chloride premolded to match configurations of preformed aluminum panels. Thermal spacer blocks and other thermal barriers at concealed fasteners must be as recommended by the roofing panel manufacturer.

2.5.1 Closures

2.5.1.1 Ridge Closure

Aluminum closure with foam secondary closure matching panel configuration for installation on surface of roof panel between panel ribs at ridge and headwall roof panel flashing conditions and terminations. Foam material must not absorb water.

2.5.1.2 Rib Closure

Aluminum, closed-cell or solid-cell synthetic rubber, neoprene or polyvinyl chloride pre-molded to match configuration of rib opening. Material for closures must not absorb water.

2.5.2 Fasteners

Series 300 stainless steel with composite metal and neoprene composition washers. Fasteners for attachment to structural supports and fasteners for attachment of panels must be as approved and in accordance with manufacturer's recommendation. Unless specified otherwise herein, fasteners must be either self-tapping screws, bolts and nuts, or self-locking bolts. Design fastening system to withstand design loads indicated. Fasteners must not be over-torqued and must develop full capacity of attachment clips.

2.5.2.1 Screws

Provide not less than No. 14 diameter for self-tapping type and not less than No. 12 diameter for self-drilling and self-tapping. Length shall be sufficient to penetrate insulation and secure to the structural deck.

2.5.2.2 Bolts

Provide not less than 1/4 inch diameter, shouldered or plain shank as required, with proper nuts.

2.5.2.3 Rivets

Blind rivets must be aluminum with 3/16 inch nominal diameter shank or stainless steel with 1/8 inch nominal diameter shank. Rivets must be threaded stem type if used for other than fastening trim. Rivets with hollow stems must have closed ends.

2.5.3 Sealant

Elastomeric type containing no oil or asphalt. Exposed sealant must cure to a rubberlike consistency. Concealed sealant must be the non-hardening type. Seam sealant must be factory-applied, non-skinning, non-drying, and must conform to the roofing panel manufacturer's recommendations. Do not use silicone-based sealants in contact with finished metal panels and components unless approved otherwise by the Contracting Officer.

2.5.4 Sealant Tape

Polyvinyl chloride closed cell foam tape or composed of 99 percent solids in a base of butyl polyisobutylene rubber as recommended by the roofing panel manufacturer as required to suit conditions.

2.6 UNDERLAYMENT MATERIALS

Self-adhering, high-temperature sheet, 30 to 40 mils thick minimum, consisting of slip-resisting, polyethylene-film top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by underlayment manufacturer.

2.6.1 Properties

a. Thermal Stability: Stable after testing at 240 deg F; ASTM D 1970.

b. Low-Temperature Flexibility: Passes after testing at minus 20 deg F; ASTM D 1970.

PART 3 EXECUTION

3.1 EXAMINATION

Do not use building construction materials that show visible evidence of biological growth.

Examine surfaces to receive standing seam aluminum roofing and flashing. Provide plumb and true surfaces, clean, even, smooth and as dry as possible. Ensure that surfaces are free from defects and projections which might affect the installation. Report unsuitable conditions to Contracting Officer.

3.2 PROTECTION OF DISSIMILAR METALS

Where an aluminum component is in contact with, fastened to, or contacted by drainage from dissimilar metals other than stainless steel, give such

dissimilar metals one of the following treatments:

a. A heavy brush coat of primer followed by two coats of aluminum metal and masonry paint.

b. A heavy coat of alkali-resistant bituminous paint.

c. Separate contact surfaces with non-absorptive tape or gasket.

3.2.1 Contact with Masonry

Where aluminum is in contact with masonry, concrete, or plaster, apply a heavy coat of alkali-resistant bituminous paint.

3.2.2 Contact with Wood

Where aluminum is in contact with wood or other absorptive material subject to wetting, or with wood treated with a preservative not compatible with aluminum, seal joints with sealing compound and apply one heavy brush coat of aluminum pigmented bituminous paint.

3.3 INSTALLATION

Install in accordance with approved roofing panel manufacturer's Erection Drawings, and diagrams, except as specified otherwise herein. Provide panels in full and firm contact with clips. Obtain approval prior to installation on prefinished panels cut in the field, and factory applied coverings or coatings that were repaired after being abraded or damaged during handling or installation. Make repairs with material of same color as weather coating. Completely seal openings through panels. Correct defects or errors in materials in an approved manner. Replace materials which cannot be corrected in an approved manner with new materials. Provide molded closure strips where indicated and where necessary for weathertight construction. Use shims as required to ensure clip line is true. Use a spacing gage at each row of panels to ensure that panel width is not stretched or shortened.

3.3.1 Self-Adhering Sheet Underlayment Installation

Apply primer if required by manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation. Apply over the entire area, wrinkle free, in shingle fashion to shed water, and with end laps of not less than 6 inches staggered 24 inches between courses. Overlap side edges not less than 3-1/2 inches. Roll laps with roller. Cover underlayment within 14 days.

a. Coordinate application of self-adhering sheet underlayment with requirements for continuity with adjacent air barrier materials.

3.3.2 Roof Panels

Apply roofing panels with standing seams parallel to slope of roof as indicated. Provide roofing panels in full lengths from ridge to eaves (top to eaves on shed roofs), with no transverse joints except at the junction of ventilators, curbs, skylights, chimneys, and similar openings. Form interlocking rib type panel seams in the field with an automatic mechanical seamer approved by the manufacturer. Attach panels to structure with concealed clips which are incorporated into the panel seams. Clip attachment must allow roof to move freely and independently

of the structure, except at fixed points as recommended by the roofing panel manufacturer and as indicated on erection drawings.

3.3.2.1 Clip Fastening

Clip spacing shall be as required to resist specified wind loads and be secured to structural deck.

3.3.3 Metal Soffit and Fascia Panels

Install as indicated in accordance with manufacturer's written instructions.

3.3.4 Flashings

Provide flashing and related closures and accessories in connection with preformed metal panels as indicated and as necessary to provide a weathertight installation. Install flashing to ensure positive water drainage away from roof penetrations. Flash and seal roof at ridge, eaves and rakes, at projections through roof, and elsewhere as necessary. Accomplish placement of closure strips, flashing, and sealing material in an approved manner that will ensure complete weathertightness. Details of installation which are not indicated must be in accordance with the roofing panel manufacturer's printed instructions and details of the approved erection drawings. Installation must allow for expansion and contraction of flashing.

3.3.5 Flashing Fasteners

Fastener spacings must be in accordance with the panel manufacturer's recommendations and as necessary to withstand the indicated design loads.

3.3.6 Closure/Closure Strips

Set closure/closure strips in joint sealant material.

3.3.7 Gutters

Lap the sections a minimum of one inch in the direction of flow or provide with concealed splice plate 6 inch minimum. Join aluminum gutters with riveted sealed joints. Provide expansion-type slip joints midway between outlets. Install gutters below slope line of the roof so that snow and ice can slide clear. Support gutters on adjustable hangers spaced not more than30 inch on center. Adjust gutters to slope uniformly to outlets, with high points occurring midway between outlets. Fabricate hangers and fastenings from metals.

3.3.7.1 Gutter Accessories

Provide stainless steel wire ball strainer at each downspout outlet location. Provide strainers to fit tightly into outlets.

3.3.8 Downspouts

Space supports for downspouts according to the manufacturer's recommendation for the substrate. Keep downspouts not less than one inch away from walls. Fasten to the walls at top, bottom, and at an intermediate point not to exceed 5 feet on center with leader straps or concealed rack-and-pin type fasteners. Form straps and fasteners of metal

compatible with the downspouts.

3.4 CLEANING

Clean exposed sheet metal work at completion of installation. Remove metal shavings, filings, nails, bolts, and wires from roofs on completion to prevent discoloration and harm to the panels and flashing. Remove grease and oil films, excess sealants handling marks, contamination from steel wool, fittings and drilling debris and scrub the work clean. Exposed metal surfaces must be free of dents, creases, waves, scratch marks, and solder or weld marks.

3.5 FIELD QUALITY CONTROL

Engage a factory-authorized service representative to test and inspect completed metal roof panel system installation, including accessories.

Remove and replace applications where tests and inspections indicate that they do not comply with specified requirements.

Additional tests and inspections, at Contractor’s expense, shall be performed as directed by the Contracting Officer to determine compliance of replaced or additional work with specified requirements.

Prepare test and inspection reports.

3.6 INSTRUCTIONS TO GOVERNMENT PERSONNEL

Furnish written and verbal instructions on proper maintenance procedures to designated Government personnel. Furnish instructions by a competent representative of the panel manufacturer and include a minimum of 2 hours on maintenance and emergency repair of the roofing system. Furnish information on safety requirements during maintenance and emergency repair operations.

3.7 INFORMATION CARD

For each roof, provide a typewritten card, laminated in plastic and framed for interior display or a photoengraved 0.032 inch thick aluminum card for exterior display. Card to be 8 1/2 by 11 inches minimum. Information card shall identify facility name and number; location; contract number; approximate roof area; detailed roof system description; date of completion; installing contractor identification and contact information; panel manufacturer warranty expiration, warranty reference number, and contact information. Install card at roof top or access location as directed by the Contracting Officer and provide a paper copy to the Contracting Officer.

3.8 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

SECTION 08 11 13

STEEL DOORS AND FRAMES
08/20
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A250.13	***(2003) Testing and Rating of Severe Windstorm Resistant Components for Swinging Door Assemblies***

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7	(2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A924/A924M	(2020) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM A1008/A1008M	(2020) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
ASTM A1011/A1011M	(2018a) Standard Specification for Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM C591	(2021) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM D2863	(2019) Standard Test Method for Measuring

	the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
ASTM E90	(2009; R2016) Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements
ASTM E413	(2016) Classification for Rating Sound Insulation
ASTM E1300	(2016) Standard Practice for Determining Load Resistance of Glass in Buildings
ASTM F2247	(2018) Standard Test Method for Metal Doors Used in Blast Resistant Applications (Equivalent Static Load Method)
ASTM F2248	(2012) Standard Practice for Specifying an Equivalent 3-Second Duration Design Loading for Blast Resistant Glazing Fabricated with Laminated Glass
ASTM F2927	(2012) Standard Test Method for Door Systems Subject to Airblast Loadings

BUILDERS HARDWARE MANUFACTURERS ASSOCIATION (BHMA)

ANSI/BHMA A156.115	(2016) Hardware Preparation in Steel Doors and Steel Frames

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2018) International Building Code

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 80	(2019) Standard for Fire Doors and Other Opening Protectives
NFPA 105	(2019) Standard for Smoke Door Assemblies and Other Opening Protectives
NFPA 252	(2017) Standard Methods of Fire Tests of Door Assemblies

STEEL DOOR INSTITUTE (SDI/DOOR)

SDI/DOOR 111	(2009) Recommended Details for Standard Steel Doors, Frames, and Accessories and Related Components
SDI/DOOR 113	(2013; R2018) Standard Practice for Determining the Steady-State Thermal Transmittance of Steel Door and Frame Assemblies
SDI/DOOR A250.6	(2015) Recommended Practice for Hardware

	Reinforcing on Standard Steel Doors and Frames
SDI/DOOR A250.8	(2017) Specifications for Standard Steel Doors and Frames
SDI/DOOR A250.11	(2012) Recommended Erection Instructions for Steel Frames

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 4-010-01	(2018;with Change 1, 2020) DoD Minimum Antiterrorism Standards for Buildings

UNDERWRITERS LABORATORIES (UL)

UL 10C	(2016) UL Standard for Safety Positive Pressure Fire Tests of Door Assemblies

1.2 SUBMITTALS

Group submittals of complementary and related products and materials as needed to represent total assemblies and facilitate concurrent coordination review. Example: Submit doors, door frames, door hardware and door operators together. The Government may withhold action on submittals requiring coordination with other submittals until related submittals are received.

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Doors; G

Frames; G

Accessories

Schedule of Doors; G

Schedule of Frames; G

Hurricane Resistent Exterior Openings; G

SD-03 Product Data

Doors; G

Frames; G

Accessories

Sound Transmission Class (STC) Rating; G

Recycled Content; S

Product data indicating percentage by weight of post-consumer and pre-consumer recycled content for products having recycled content specified in this Section. Submit per requirements in Section 01 33 29 SUSTAINABILITY REPORTING.

SD-05 Design Data

Performance Requirements Validation; G

For products and systems indicated to validate compliance with specified performance requirements, provide calculations and design criteria, including engineering analysis data, signed and sealed by the qualified registered Professional Engineer responsible for their preparation.

SD-11 Closeout Submittals

All sustainable design Submittals for recycled content are included under SD-03 Product Data.

1.3 PERFORMANCE REQUIREMENTS

1.3.1 Structural

Exterior steel door and frame assemblies, shall be designed as a system to resist minimum load requirements as indicated below. Meeting UFC 4-010-01, Article 3-11, Standard 10, "Glazing" for exterior windows, skylights, and glazed sidelights, storefront and curtain wall assemblies, and Article 3-13 Standard 12, "Exterior Doors" for exterior glazed and non-glazed doors. Design of the assembly shall include associated hardware, connections of the hardware, anchorage components and supporting structural connections.

1.3.1.1 Frames

Use ASTM F2248 for glazing bite requirements for structurally or non-structurally exterior steel door and frame assemblies.

1.3.1.2 Connections

The design of connections of exterior steel door and frame assemblies to surrounding walls, of hardware and associated connections, of glazing stop connections, and of other elements in shear will be based on allowable stress levels. The allowable fastener loads will be as recommended by the fastener manufacturer for the materials to which the door systems are being connected.

Connections must be capable of preventing the frame from being dislodged from the supporting structural element.

1.3.1.3 Wind and Seismic Load Criteria

Design and fabricate all exterior steel door and frame assemblies provided to resist wind and seismic load criteria as indicated on Structural drawings in accordance with ICC IBC and ASCE 7 requirements for Components and Cladding.

1.3.2 Shielding Effectiveness for RF Shielded Door and Window Assemblies

Refer to section 13 49 20.00 10 RFI/EMI SHIELDING.

1.3.3 Sound Transmission Class (STC) Rating for Acoustic Windows

Minimum STC rating of 50, unless otherwise indicated on Drawings, when tested for laboratory sound transmission loss according to ASTM E90 and determined by ASTM E413.

1.3.4 Hurricane Resistent Exterior Openings

Provide copy of current Product Approval as proof of compliance that doors, frames and hardware for exterior opening assemblies have been tested and approved for use at the design pressure level and debris impact resistance requirements specified for the Project.

a. Hurricane Resistant Components: Provide copy of independent, third-party certified listing conforming to ANSI A250.13.

b. Hurricane Resistant Exterior Openings (including High Velocity Hurricane Zone (HVHZ): Provide exterior hollow metal doors and frames as complete and tested assemblies, or component assemblies, including approved hardware specified under Section 08 71 00 DOOR HARDWARE, to meet the design pressures, debris impact resistance, and glass and glazing requirements as detailed in the current building code sections applicable to the Project.

(1) Each unit to bear third party permanent label in accordance with Building Code requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver doors, frames, and accessories undamaged and with protective wrappings or packaging. Provide temporary steel spreaders securely fastened to the bottom of each welded frame. Store doors and frames on platforms under cover in clean, dry, ventilated, and accessible locations, with 1/4 inch airspace between doors. Remove damp or wet packaging immediately and wipe affected surfaces dry. Replace damaged materials with new.

PART 2 PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

See Section 01 33 29 SUSTAINABILITY REPORTING for sustainable design requirements for the following, except as modified herein.

2.1.1 Recycled Content of Products

Provide products with post-consumer recycled content plus one-half of pre-consumer recycled content to the greatest extent possible, but not less than 10 percent.

2.2 STANDARD STEEL DOORS

SDI/DOOR A250.8, except as specified otherwise. Prepare doors to receive door hardware as specified in Section 08 71 00 DOOR HARDWARE. Undercut where indicated. Provide exterior doors with top welded edge closed flush

(snap in top caps not permitted) and sealed to prevent water intrusion. Provide weep-hole openings in bottom of exterior doors to permit moisture to escape. Provide doors at 1-3/4 inch thick, unless otherwise indicated. Provide door material that uses a minimum of 25 percent recycled content. Provide data indicating percentage of recycled content for steel door product. Provide exterior glazing in accordance with ASTM F2248 and ASTM E1300. Exterior doors must be tested in accordance with ASTM F2247 or ASTM F2927 to meet requirements of UFC 4-010-01.

2.2.1 Classification - Level, Performance, Model

2.2.1.1 Heavy Duty Doors

SDI/DOOR A250.8, Level 2, physical performance Level B, Model 2, with core construction as required by the manufacturer for interior doors, of size(s) and design(s) indicated. Fabricate of cold-rolled or hot-rolled steel sheet. Provide Level 2 typically at mechanical rooms, stairwells, cross corridor and other interior locations as indicated.

a. Refer to section 13 49 20.00 10 RFI/EMI SHIELDING.

2.2.1.2 Maximum Duty Doors

SDI/DOOR A250.8, Level 4, physical performance Level A, Model 2 with core construction as required by the manufacturer for interior doors specified herein and for exterior doors, of size(s) and design(s) indicated. Where vertical stiffener cores are required, the space between the stiffeners must be filled with board insulation. Provide Level 4 typically at secured rooms for interior doors, and at all exterior doors. Fabricate from metallic-coated steel sheet for exterior doors, and cold-rolled or hot-rolled steel sheet for interior doors.

2.3 INSULATED STEEL DOOR SYSTEMS

Door size(s), design, and material shall be as specified for maximum duty doors for exterior locations. Insulated steel doors shall have a core specified polyisocyanurate foam.

2.4 ACCESSORIES

2.4.1 Shelves for Dutch Doors

SDI/DOOR 111. Fabricate shelves of steel not lighter than 16 gage on both sides of opening, 8 inches wide. Provide brackets of stock type fabricated of the same metal used to fabricate shelves.

2.4.2 Louvers

2.4.2.1 Interior Louvers

SDI/DOOR 111. Where indicated, provide louvers of stationary sightproof type where scheduled. Detachable moldings on room or non-security side of door; on security side of door, moldings to be integral part of louver. Form louver frames of 20 gage steel and louver blades of a minimum 24 gage. Sightproof louvers to be inverted "V" blade design with minimum 55 percent net-free opening.

2.4.2.2 Exterior Louvers

Provide louvers of the inverted "Y" type with minimum of 30 percent net-free opening. Weld or tenon louver blades to continuous channel frame and weld assembly to door to form watertight assembly. Form louvers of hot-dip galvanized steel of same gage as door facings. At louvers provide steel-framed bird screens secured to room side and readily removable. Provide galvanized steel, 1/2 by 1/2 inch mesh hardware cloth, for bird screens. Net-free louver area to be before screening.

2.4.3 Astragals

For pairs of exterior steel doors which will not have astragals or removable mullions as specified in Section 08 71 00 DOOR HARDWARE, provide overlapping steel astragals with the doors.

2.4.4 Moldings

Provide moldings around glass of interior and exterior doors and louvers of interior doors. Provide nonremovable moldings on outside of exterior doors and on unsecure side of interior doors. Other moldings may be stationary or removable. Secure inside moldings to stationary moldings, or provide snap-on moldings.

2.5 INSULATION CORES

Provide insulating cores at all exterior doors, and provide an apparent U-factor of 0.48 in accordance with SDI/DOOR 113 and conforming to:

a. Rigid Cellular Polyisocyanurate Foam: ASTM C591, Type I or II, foamed-in-place or in board form, with oxygen index of not less than 22 percent when tested in accordance with ASTM D2863.

2.6 STANDARD STEEL FRAMES

SDI/DOOR A250.8, Level 2 for interior doors, and Level 4 for exterior doors, and interior doors where specified herein. Form frames to sizes and shapes indicated, with welded corners. Provide steel frames for doors, mullion and transom bars, sidelights, cased openings, and interior glazed panels, unless otherwise indicated. Fabricate Level 4 exterior frames from metallic-coated steel sheet, and fabricate Level 2 and Level 4 interior frames from cold-rolled or hot-rolled steel sheet. Provide all frames with a phosphate treatment and rust-inhibitive primer.

2.6.1 Welded Frames

Continuously weld frame faces at corner joints. Continuously weld stops and rabbets. Grind welds smooth.

Weld frames in accordance with the recommended practice of the Structural Welding Code Sections 1 through 6, AWS D1.1/D1.1M and in accordance with the practice specified by the producer of the metal being welded.

2.6.2 Mullions and Transom Bars

Provide mullions and transom bars of closed or tubular construction with heads and jambs butt-welded together. Bottom of door mullions must have

adjustable floor anchors and spreader connections.

2.6.3 Stops and Beads

Provide form and loose stops and beads from 20 gage steel. Provide for glazed and other openings in standard steel frames. Secure beads to frames with oval-head, countersunk Phillips self-tapping sheet metal screws or concealed clips and fasteners. Space fasteners approximately 12 to 16 inch on center. Miter molded shapes at corners. Butt or miter square or rectangular beads at corners.

2.6.4 Cased Openings

Fabricate frames for cased openings of same material, gage, and assembly as specified for metal door frames, except omit door stops and preparation for hardware.

2.6.5 Anchors

Provide anchors to secure the frame to adjoining construction. Provide steel anchors, zinc-coated not lighter than 18 gage.

2.6.5.1 Wall Anchors

Provide at least three anchors for each jamb. For frames which are more than 7.5 feet in height, provide one additional anchor for each jamb for each additional 2.5 feet or fraction thereof.

a. Masonry: Provide anchors of corrugated or perforated steel straps or 3/16 inch diameter steel wire, adjustable or T-shaped;

b. Stud partitions: Weld anchors to back of frames. Design anchors to be fastened to closed steel studs with sheet metal screws;

c. Completed openings: Secure frames to previously placed concrete or masonry with expansion bolts in accordance with SDI/DOOR 111; and

2.6.5.2 Floor Anchors

Provide floor anchors drilled for 3/8 inch anchor bolts at bottom of each jamb member. Where floor fill occurs, terminate bottom of frames at the indicated finished floor levels and support by adjustable extension clips resting on and anchored to the structural slabs.

2.7 FIRE AND SMOKE DOORS AND FRAMES

Provide fire and smoke doors and frames in accordance with NFPA 80 and NFPA 105 and this specification.

2.7.1 Labels

Provide fire doors and frames bearing the label of Underwriters Laboratories (UL), Factory Mutual Engineering and Research (FM), or Warnock Hersey International (WHI) attesting to the rating required. Testing must be in accordance with NFPA 252 or UL 10C. Provide labels that are metal with raised letters, bearing the name or file number of the

door and frame manufacturer. Labels must be permanently affixed at the factory to frames and to the hinge edge of the door. Do not paint door and labels.

2.7.2 Oversized Doors

For fire doors and frames which exceed the size for which testing and labeling are available, furnish certificates stating that the doors and frames are identical in design, materials, and construction to a door which has been tested and meets the requirements for the class indicated.

2.7.3 Astragal on Fire and Smoke Doors

On pairs of labeled fire doors, conform to NFPA 80 and UL requirements. On smoke control doors, conform to NFPA 105.

2.8 HARDWARE PREPARATION

Drill and tap doors and frames to receive finish hardware. Prepare doors and frames for hardware in accordance with the applicable requirements of SDI/DOOR A250.8 and SDI/DOOR A250.6. For additional requirements refer to ANSI/BHMA A156.115. Drill and tap for surface-applied hardware at the project site. Build additional reinforcing for surface-applied hardware into the door at the factory. Punch door frames, with the exception of frames that will have weatherstripping or soundproof gasketing, to receive a minimum of three rubber or vinyl door silencers on lock side of single doors and one silencer for each leaf at heads of double doors. Set lock strikes out to provide clearance for silencers.

2.9 MATERIALS AND FINISHES

2.9.1 Cold-Rolled Steel Sheet

ASTM A1008/A1008M, Commercial Steel (CS), Type B; suitable for exposed applications.

2.9.2 Hot-Rolled Steel Sheet

ASTM A1011/A1011M, Commercial Steel (CS), Type B; free of scale, pitting, or surface defects; pickled and oiled.

2.9.3 Metallic-Coated Steel Sheet

ASTM A653/A653M, Commercial Steel (CS), Type B.

2.9.4 Factory-Primed Finish

Thoroughly clean all surfaces of doors and frames then chemically treat and factory prime with a rust inhibiting coating as specified in SDI/DOOR A250.8.

a. Refer to section 13 49 20.00 10 RFI/EMI SHIELDING.

2.9.5 Hot-Dip Zinc-Coated and Factory-Primted Finish

Fabricate all exterior and additional scheduled doors and frames from hot dipped zinc coated steel, alloyed type, that complies with ASTM A924/A924M and ASTM A653/A653M. The coating weight must meet or exceed the minimum requirements for coatings having 0.4 ounces per square foot, total both

sizes, i.e., A40. Repair damaged zinc-coated surfaces by the application of zinc dust paint. Thoroughly clean and chemiccaly treat to insure maximum paint adhesion. Factory prime as specified in SDI/DOOR A250.8. Provide for all exterior doors and additional scheduled door openings.

2.10 FABRICATION AND WORKMANSHIP

Provide finished doors and frames that are strong and rigid, neat in appearance, and free from defects, waves, scratches, cuts, dents, ridges, holes, warp, and buckle. Provide molded members that are clean cut, straight, and true, with joints coped or mitered, well formed, and in true alignment. Dress exposed welded and soldered joints smooth. Design door frame sections for use with the wall construction indicated. Corner joints must be well formed and in true alignment. Conceal fastenings where practicable.

2.11 ACOUSTIC WINDOWS

Hollow metal framed, factory glazed, acoustic windows; interior applications.

2.11.1 Frames

Frames shall be 1-1/4 inch by 6-inch width, unless otherwise indicated or required for specified STC rating, fabricated to manufacturer's standard profile from minimum 12 gauge cold-rolled or hot-rolled steel sheet, filled with manufacturer's standard sound-absorbing acoustic fill. Inside and outside corners shall be mitered and interlocked to manufacturer's hairline measurements, continuously welded and ground smooth. Provide frames with a phosphate treatment and rust-inhibitive primer.

a. Refer to section 13 49 20.00 10 RFI/EMI SHIELDING.

2.12 PROVISIONS FOR GLAZING

Materials are specified in Section 08 81 00, GLAZING.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Frames

Set frames in accordance with SDI/DOOR A250.11. Plumb, align, and brace securely until permanent anchors are set. Anchor bottoms of frames with expansion bolts or powder-actuated fasteners. Build in or secure wall anchors to adjoining construction.

a. Refer to section 13 49 20.00 10 RFI/EMI SHIELDING.

3.1.2 Doors

Hang doors in accordance with clearances specified in SDI/DOOR A250.8. After erection and glazing, clean and adjust hardware.

a. Refer to section 13 49 20.00 10 RFI/EMI SHIELDING.

3.1.3 Fire and Smoke Doors and Frames

Install fire doors and frames, including hardware, in accordance with NFPA 80. Install fire rated smoke doors and frames in accordance with NFPA 80 and NFPA 105.

3.1.4 Acoustic Windows

Install in accordance with door manufacturer's written instructions.

a. Refer to section 13 49 20.00 10 RFI/EMI SHIELDING.

3.2 PROTECTION

Protect doors and frames from damage. Repair damaged doors and frames prior to completion and acceptance of the project or replace with new, as directed. Wire brush rusted frames until rust is removed. Clean thoroughly. Apply an all-over coat of rust-inhibitive paint of the same type used for shop coat.

3.3 CLEANING

Upon completion, clean exposed surfaces of doors and frames thoroughly. Remove mastic smears and other unsightly marks.

3.4 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 09 90 00

PAINTS AND COATINGS
02/21
AMENDMENT 01

PART 1 GENERAL

1.1 RELATED REQUIREMENTS

1.1.1 Painting Included

Where a space or surface is indicated to be painted, include the following unless indicated otherwise.

1.1.1.1 Exterior Painting

Includes new surfaces, and existing coated surfaces, as applicable, of the building and appurtenances, as indicated. Also included are existing coated surfaces made bare by cleaning operations.

1.1.1.2 Interior Painting

Includes new surfaces, and existing uncoated surfaces, as applicable, of the building and appurtenances as indicated and existing coated surfaces made bare by cleaning operations. Where a space or surface is indicated to be painted, include the following items, unless indicated otherwise.

a. Exposed columns, girders, beams, joists, and metal deck; and

b. Other contiguous surfaces.

1.1.2 Painting Excluded

Do not paint the following unless indicated otherwise.

a. Surfaces concealed and made inaccessible by panelboards, fixed ductwork, machinery, and equipment fixed in place.

b. Surfaces in concealed spaces. Concealed spaces are defined as enclosed spaces above suspended ceilings, furred spaces, attic spaces, crawl spaces, elevator shafts and chases.

c. Steel to be embedded in concrete.

d. Copper, stainless steel, aluminum, anodized aluminum, brass, and lead except existing coated surfaces.

e. Hardware, fittings, and other factory finished items.

1.1.3 Mechanical and Electrical Painting

Includes field coating of interior and exterior new and applicable existing surfaces.

a. Where a space or surface is indicated to be painted, include the following items unless indicated or specified otherwise.

(1) Exposed piping, conduit, and ductwork;

(2) Supports, hangers, air grilles, and registers;

(3) Miscellaneous metalwork and insulation coverings.

b. Do not paint the following, unless indicated or specified otherwise:

(1) New zinc-coated, aluminum, and copper surfaces under insulation

(2) New aluminum jacket on piping

(3) New interior ferrous piping under insulation.

1.1.3.1 Fire Extinguishing Sprinkler Systems

Clean, pretreat, prime, and paint new fire extinguishing sprinkler systems including valves, piping, conduit, hangers, supports, miscellaneous metalwork, and accessories. Apply coatings to clean, dry surfaces, using clean brushes. Also, refer to Paragraph entitled "Piping in Finished Areas" for additional painting requirements.

1.1.4 Rated Wall Identification

Above decorative ceilings and in concealed spaces, identify with sign stencils, all rated corridor partitions, smoke stop partitions, horizontal exit partitions, exit enclosures and fire rated walls. Lettering shall be minimum 6 inches high and read as follows:

a. On 1 hour fire barrier type partitions: "1 Hour Fire Barrier - Protect All Openings".

b. On 2 hour fire barrier type partitions: "2 Hour Fire Barrier - Protect All Openings".

c. On 1 hour smoke barrier type partitions: "1 Hour Smoke Barrier - Protect All Openings".

d. On 2 hour smoke barrier type partitions: "2 Hour Smoke Barrier - Protect All Openings".

In sprinklered Storage Rooms, paint a graphic line on the walls at 18 inches below the sprinkler head. Width of line and color as required; place a visible sign above the line stating "STORAGE NOT PERMITTED ABOVE LINE".

1.1.5 Exterior Painting of Site Work Items

Field coat the following items:

	New Surfaces	Existing Surfaces
a.	Backflow Preventers	Not Applicable
b.	Other items as indicated	Other items as indicated

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

ACGIH 0100	(2017; Suppl 2020) Documentation of the Threshold Limit Values and Biological Exposure Indices

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A13.1	(2020) Scheme for the Identification of Piping Systems

ELECTROSTATIC DISCHARGE ASSOCIATION (ESD)

ASTM INTERNATIONAL (ASTM)

ASTM D235	(2002; R 2012) Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)
ASTM D523	(2014; R 2018) Standard Test Method for Specular Gloss
ASTM D 1308	(2002; R 2007) Effect of Household Chemicals on Clear and Pigmented Organic Finishes
ASTM D2240	(2015; E 2017) Standard Test Method for Rubber Property - Durometer Hardness
ASTM D2486	(2017) Standard Test Methods for Scrub Resistance of Wall Paints
ASTM D2794	(1993; R 2019) Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
ASTM D4214	(2007; R 2015) Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films
ASTM D4263	(1983; R 2018) Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
ASTM D4444	(2013; R 2018) Standard Test Method for Laboratory Standardization and Calibration of Hand-Held Moisture Meters
ASTM D6386	(2016a) Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting
ASTM E 84	(2020) Standard Test Method for Surface

	Burning Characteristics of Building Materials
ASTM F1869	(2016a) Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride

CENTERS FOR DISEASE CONTROL AND PREVENTION (CDC)

Intelligence Bulletin 65	(2013) Occupational Exposure to Carbon Nanotubes and Nanofibers

MASTER PAINTERS INSTITUTE (MPI)

MPI 3	(2016) Primer, Alkali Resistant, Water Based
MPI 4	(2016) Interior/Exterior Latex Block Filler
MPI 9	(2016) Alkyd, Exterior Gloss (MPI Gloss Level 6)
MPI 10	(2016) Latex, Exterior Flat (MPI Gloss Level 1)
MPI 11	(2016) Latex, Exterior Semi-Gloss, MPI Gloss Level 5
MPI 17	(2016) Primer, Bonding, Water Based
MPI 23	(2015) Primer, Metal, Surface Tolerant
MPI 47	(2016) Alkyd, Interior, Semi-Gloss (MPI Gloss Level 5)
MPI 48	(2016) Alkyd, Interior, Gloss (MPI Gloss Level 6-7)
MPI 50	(2015) Primer Sealer, Latex, Interior
MPI 56	(2012) Varnish, Interior, Polyurethane, Oil Modified, Gloss
MPI 57	(2012) Varnish, Interior, Polyurethane, Oil Modified, Satin
MPI 72	(2016) Polyurethane, Two-Component, Pigmented, Gloss (MPI Gloss Level 6-7)
MPI 76	(2016) Primer, Alkyd, Quick Dry, for Metal
MPI 77	(2015) Epoxy, Gloss
MPI 79	(2016) Primer, Alkyd, Anti-Corrosive for Metal
MPI 90	(2012) Stain, Semi-Transparent, for Interior Wood

MPI 94	(2016) Alkyd, Exterior, Semi-Gloss (MPI Gloss Level 5)
MPI 95	(2015) Primer, Quick Dry, for Aluminum
MPI 101	(2016) Primer, Epoxy, Anti-Corrosive, for Metal
MPI 107	(2016) Primer, Rust-Inhibitive, Water Based
MPI 116	(2012) Block Filler, Epoxy
MPI 119	(2016) Latex, Exterior, Gloss (MPI Gloss Level 6)
MPI 144	(2016) Latex, Interior, Institutional Low Odor/VOC, (MPI Gloss Level 2)
MPI 145	(2016) Latex, Interior, Institutional Low Odor/VOC, (MPI Gloss Level 3)
MPI 146	(2016) Latex, Interior, Institutional Low Odor/VOC, (MPI Gloss Level 4)
MPI 147	(May 2016) Latex, Interior, Institutional Low Odor/VOC, Semi-Gloss (MPI Gloss Level 5)
MPI 149	(2016) Primer Sealer, Interior, Institutional Low Odor/VOC
MPI ASM	(2019) Architectural Painting Specification Manual
MPI GPS-1-14	(2014) Green Performance Standard GPS-1-14
MPI MRM	(2015) Maintenance Repainting Manual

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC 7/NACE No.4	(2007) Brush-Off Blast Cleaning
SSPC Glossary	(2011) SSPC Protective Coatings Glossary
SSPC Guide 6	(2015) Guide for Containing Surface Preparation Debris Generated During Paint Removal Operations
SSPC Guide 7	(2015) Guide to the Disposal of Lead-Contaminated Surface Preparation Debris
SSPC PA 1	(2016) Shop, Field, and Maintenance Coating of Metals
SSPC SP 1	(2015) Solvent Cleaning
SSPC SP 2	(2018) Hand Tool Cleaning

SSPC SP 3	(2018) Power Tool Cleaning
SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning
SSPC SP 10/NACE No. 2	(2007) Near-White Blast Cleaning
SSPC VIS 1	(2002; E 2004) Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning
SSPC VIS 3	(2004) Guide and Reference Photographs for Steel Surfaces Prepared by Hand and Power Tool Cleaning
SSPC-SP WJ-3/NACE WJ-3	(2012) Thorough Cleaning, Waterjet Cleaning of Metals

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety and Health Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA Method 24	(2000) Determination of Volatile Matter Content, Water Content, Density, Volume Solids, and Weight Solids of Surface Coatings

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-313	(2018) Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.1000	Air Contaminants
29 CFR 1910.1001	Asbestos
29 CFR 1910.1025	Lead
29 CFR 1926.62	Lead

1.3 DEFINITIONS

1.3.1 Qualification Testing

Qualification testing is the performance of all test requirements listed in the product specification. This testing is accomplished by MPI to qualify each product for the MPI Approved Product List, and may also be accomplished by Contractor's third-party testing lab if an alternative to Batch Quality Conformance Testing by MPI is desired.

1.3.2 Batch Quality Conformance Testing

Batch quality conformance testing determines that the product provided is

the same as the product qualified to the appropriate product specification. This testing must be accomplished by an MPI testing lab.

1.3.3 Coating

SSPC Glossary; (1) A liquid, liquefiable, or mastic composition that is converted to a solid protective, decorative, or functional adherent film after application as a thin layer; (2) Generic term for paint, lacquer, enamel.

1.3.4 DFT or dft

Dry film thickness, the film thickness of the fully cured, dry paint or coating.

1.3.5 DSD

Degree of Surface Degradation, the MPI system of defining degree of surface degradation. Five levels are generically defined under the Assessment sections in the MPI MRM, MPI Maintenance Repainting Manual.

1.3.6 EXT

MPI short term designation for an exterior coating system.

1.3.7 INT

MPI short term designation for an interior coating system.

1.3.8 Loose Paint

Paint or coating that can be removed with a dull putty knife.

1.3.9 mil / mils

The English measurement for 0.001 in or one one-thousandth of an inch.

1.3.10 MPI Gloss Levels

MPI system of defining gloss. Seven gloss levels (G1 to G7) are generically defined under the Evaluation sections of the MPI Manuals. Traditionally, Flat refers to G1/G2, Eggshell refers to G3, Semigloss refers to G5, and Gloss refers to G6.

Gloss levels are defined by MPI as follows:

Gloss Level	Description	Units at 60 degree angle	Units at 80 degree angle
G1	Matte or Flat	0 to 5	10 max
G2	Velvet	0 to 10	10 to 35
G3	Eggshell	10 to 25	10 to 35
G4	Satin	20 to 35	35 min

Gloss Level	Description	Units at 60 degree angle	Units at 80 degree angle
G5	Semi-Gloss	35 to 70	
G6	Gloss	70 to 85	
G7	High Gloss		

Gloss is tested in accordance with ASTM D523. Historically, the Government has used Flat (G1 / G2), Eggshell (G3), Semi-Gloss (G5), and Gloss (G6).

1.3.11 MPI System Number

The MPI coating system number in each MPI Division found in either the MPI Architectural Painting Specification Manual or the Maintenance Repainting Manual and defined as an exterior (EXT/REX) or interior system (INT/RIN).

1.3.12 Paint

SSPC Glossary; (1) Any pigmented liquid, liquefiable, or mastic composition designed for application to a substrate in a thin layer that is converted to an opaque solid film after application. Used for protection, decoration, identification, or to serve some other functional purposes; (2) Application of a coating material.

1.3.13 REX

MPI short term designation for an exterior coating system used in repainting projects or over existing coating systems.

1.3.14 RIN

MPI short term designation for an interior coating system used in repainting projects or over existing coating systems.

1.4 SCHEDULING

Allow paint, polyurethane, varnish, and wood stain installations to cure prior to the installation of materials that adsorb VOCs, including carpets, textiles, unprimed gypsum wallboard, and acoustical ceiling panels.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

Samples of specified materials may be taken and tested for compliance with specification requirements.

SD-02 Shop Drawings

Piping Identification

SD-03 Product Data

Coating; G

Specialty Paints; G

Product Data Sheets

Low-Emitting Paints and Coatings; S

Manufacturers' product data for paints and coatings used on the interior of the building (defined as inside of the weatherproofing system), indicating VOC content and laboratory test reports showing compliance with requirements for low-emitting materials as specified. Submit per requirements in Section 01 33 29 SUSTAINABILITY REPORTING.

SD-04 Samples

Color; G

SD-07 Certificates

Qualification Testing laboratory for coatings

Coating Contractor's Qualification

SD-08 Manufacturer's Instructions

Application Instructions

Mixing

Manufacturer's Safety Data Sheets

SD-10 Operation and Maintenance Data

Coatings, Data Package 1; G

SD-11 Closeout Submittals

All sustainable design Submittals for low-emitting paints and coatings are included under SD-03 Product Data.

1.6 QUALITY ASSURANCE

1.6.1 Regulatory Requirements

1.6.1.1 Environmental Protection

In addition to requirements specified elsewhere for environmental protection, provide coating materials that conform to the restrictions of the local Air Pollution Control District and regional jurisdiction. Notify Contracting Officer of any paint specified herein which fails to conform.

1.6.1.2 Lead Content

Do not use coatings having a lead content over 0.06 percent by weight of nonvolatile content.

1.6.1.3 Chromate Content

Do not use coatings containing zinc-chromate or strontium-chromate.

1.6.1.4 Asbestos Content

Provide asbestos-free materials.

1.6.1.5 Mercury Content

Provide materials free of mercury or mercury compounds.

1.6.1.6 Silica

Provide abrasive blast media containing no free crystalline silica.

1.6.1.7 Human Carcinogens

Provide materials that do not contain ACGIH 0100 confirmed human carcinogens (A1) or suspected human carcinogens (A2).

1.6.1.8 Carbon Based Fibers / Tubes

Materials must not contain carbon based fibers such as carbon nanotubes or carbon nanofibers. Intelligence Bulletin 65 ranks toxicity of carbon nanotubes on a par with asbestos.

1.6.2 Coating Contractor's Qualification

Submit the name, address, telephone number, and e-mail address of the Contractor that will be performing all surface preparation and coating application. Submit evidence that key personnel have successfully performed surface preparation and application of coatings on on a minimum of three similar projects within the past three years. List information by individual and include the following:

a. Name of individual and proposed position for this work.

b. Information about each previous assignment including:

Position or responsibility

Employer (if other than the Contractor)

Name of facility owner

Mailing address and telephone number of facility owner

Name of individual in facility owner's organization who can be contacted as a reference

Location, size and description of structure

Dates work was carried out

Description of work carried out on structure

1.6.3 Approved Products List

The current MPI, "Approved Product List" which lists paint by brand, label, product name and product code as of the date of Contract award, will be used to determine compliance with the submittal requirements of this specification. The Contractor may choose to use a subsequent MPI "Approved Product List", however, only one list may be used for the entire Contract and each coating system is to be from a single manufacturer. Provide all coats on a particular substrate from a single manufacturer. No variation from the MPI Approved Products List is acceptable.

1.6.4 Field Samples and Tests

The Contracting Officer may choose up to two coatings that have been delivered to the site to be tested at no cost to the Government. Take samples of each chosen product as specified in the paragraph SAMPLING PROCEDURE. Test each chosen product as specified in the paragraph TESTING PROCEDURE. Remove products from the job site which do not conform, and replace with new products that conform to the referenced specification. Test replacement products that failed initial testing as specified in the paragraph TESTING PROCEDURE at no cost to the Government.

1.6.4.1 Sampling Procedure

Select paint at random from the products that have been delivered to the job site for sample testing. The Contractor must provide one quart samples of the selected paint materials. Take samples in the presence of the Contracting Officer, and label, and identify each sample. Provide labels in accordance with the paragraph PACKAGING, LABELING, AND STORAGE.

1.6.4.2 Testing Procedure

Provide Batch Quality Conformance Testing for specified products, as defined by and performed by MPI. As an alternative to Batch Quality Conformance Testing, the Contractor may provide Qualification Testing for specified products above to the appropriate MPI product specification, using the third-party laboratory approved under the paragraph QUALIFICATION TESTING laboratory for coatings. Include the backup data and summary of the test results within the qualification testing lab report. Provide a summary listing of all the reference specification requirements and the result of each test. Clearly indicate in the summary whether the tested paint meets each test requirement. Note that Qualification Testing may take 4 to 6 weeks to perform, due to the extent of testing required.

Submit name, address, telephone number, FAX number, and e-mail address of the independent third party laboratory selected to perform testing of coating samples for compliance with specification requirements. Submit documentation that laboratory is regularly engaged in testing of paint samples for conformance with specifications, and that employees performing testing are qualified. If MPI is chosen to perform the Batch Quality Conformance testing, the above submittal information is not required, only a letter is required from the Contractor stating that MPI will perform the testing.

1.7 PACKAGING, LABELING, AND STORAGE

Provide paints in sealed containers that legibly show the Contract specification number, designation name, formula or specification number,

batch number, color, quantity, date of manufacture, manufacturer's formulation number, manufacturer's directions including any warnings and special precautions, and name and address of manufacturer. Furnish pigmented paints in containers not larger than 5 gallons. Store paints and thinners in accordance with the manufacturer's written directions, and as a minimum, stored off the ground, under cover, with sufficient ventilation to prevent the buildup of flammable vapors, and at temperatures between 40 to 95 degrees F. Do not store paint, polyurethane, varnish, or wood stain products with materials that have a high capacity to absorb VOC emissions. Do not store paint, polyurethane, varnish, or wood stain products in occupied spaces.

1.8 SAFETY AND HEALTH

Comply with applicable Federal, State, and local laws and regulations, and with the ACCIDENT PREVENTION PLAN, including the Activity Hazard Analysis as specified in Section 01 35 26 GOVERNMENTAL SAFETY REQUIREMENTS and in Appendix A of EM 385-1-1. Include in the Activity Hazard Analysis the potential impact of painting operations on painting personnel and on others involved in and adjacent to the work zone.

1.8.1 Toxic Materials

To protect personnel from overexposure to toxic materials, conform to the most stringent guidance of:

a. The applicable manufacturer's Safety Data Sheets (SDS) or local regulation.

b. 29 CFR 1910.1000.

c. ACGIH 0100, threshold limit values.

d. The appropriate OSHA standard in 29 CFR 1910.1025 and 29 CFR 1926.62 for surface preparation on painted surfaces containing lead. Removal and disposal of coatings which contain lead is specified in Section 02 83 00 LEAD REMEDIATION. Additional guidance is given in SSPC Guide 6 and SSPC Guide 7. Refer to drawings for list of hazardous materials located on this project. Coordinate paint preparation activities with this specification section.

e. The appropriate OSHA standards in 29 CFR 1910.1001 for surface preparation of painted surfaces containing asbestos. Removal and disposal of coatings which contain asbestos materials is specified in Section 02 82 00 ASBESTOS REMEDIATION. Refer to drawings for list of hazardous materials located on this project. Coordinate paint preparation activities with this specification section.

Submit manufacturer's Safety Data Sheets for coatings, solvents, and other potentially hazardous materials, as defined in FED-STD-313.

1.9 ENVIRONMENTAL REQUIREMENTS

Comply, at minimum, with manufacturer recommendations for space ventilation during and after installation. Isolate area of application from rest of building when applying high-emission paints or coatings.

1.9.1 Coatings

Do not apply coating when air or substrate conditions are:

a. Less than 5 degrees F above dew point;

b. Below 50 degrees F or over 95 degrees F, unless specifically pre-approved by the Contracting Officer and the product manufacturer. Do not, under any circumstances, violate the manufacturer's application recommendations.

1.9.2 Post-Application

Vacate space for as long as possible after application. Wait a minimum of 48 hours before occupying freshly painted rooms. Maintain one of the following ventilation conditions during the curing period, or for 72 hours after application:

a. Supply 100 percent outside air 24 hours a day.

b. Supply airflow at a rate of 6 air changes per hour, when outside temperatures are between 55 degrees F and 85 degrees F and humidity is between 30 percent and 60 percent.

c. Supply airflow at a rate of 1.5 air changes per hour, when outside air conditions are not within the range stipulated above.

PART 2 PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

See Section 01 33 29 SUSTAINABILITY REPORTING for sustainable design requirements for the following, except as modified herein.

2.1.1 Low-Emitting Paints and Coatings

For field applications that are used on the interior of the building, paints and coatings shall comply with low-emitting limits specified in Section 01 33 29 SUSTAINABILITY REPORTING.

2.2 MATERIALS

Conform to the coating specifications and standards referenced in PART 3. Submit Product Data Sheets for specified coatings and solvents. Provide preprinted cleaning and maintenance instructions for all coating systems. Submit Manufacturer's Instructions on Mixing: Detailed mixing instructions, minimum and maximum application temperature and humidity, pot life, and curing and drying times between coats.

2.3 SPECIALTY PAINTS

2.3.1 Abrasion Resistant Paint

Water based polyurethane/acrylic eggshell coating which produces a durable and cleanable finish. Formulation shall be low-odor and contain an anti-microbial to inhibit the growth of mold, mildew and bacteria. Provide in color(s) indicated.

2.3.1.1 Performance Criteria

a. VOC: Content shall be less than 110 g/L.

b. Fire Rating: Type I or Class A fire-rated per ASTM E 84.

c. Scrub Test: Greater than 25,000 cycles per ASTM D2486.

d. Impact Resistance: Greater than 160 in/lbs, ASTM D2794.

e. Chemical Resistance: 10 (test maximum) for all chemicals tested, ASTM D 1308.

f. Stain Removal: 8 to 10 (test maximum) for all stains tested, four-hour Open Spot Test.

2.3.2 Penetrating Liquid Floor Treatment (CONCS-1)

Chemically reactive, waterborne solution of inorganic silicate or siliconate materials and proprietary components; odorless; that penetrates, and densifies concrete surfaces. Provide in color(s) indicated.

2.3.3 Static Control Sealer (CONCS-2)

Static conductive concrete primer with manufacturer's standard static control epoxy topical concrete coating. Provide in color(s) indicated.

2.3.3.1 Performance Criteria

a. Hardness, Shore D: ASTM D2240, Result 70.

b. Impact Resistance: ASTM D2794, 160 inches per pound (pass).

c. Static Charge Decay: MIL-B-81705B, Dissipates a 5,000 volt charge zero in less than 0.1 seconds

2.3.3.2 Grounding System

Static control sealer manufacturer's standard ground kit designed for static control sealers, including ground connection plates, cables, fasteners, high conductivity fabric or copper tape, conductive adhesives, and ancillary items as required for a complete grounding system. Provide ground kit quantities as required to suit conditions per manufacturer's written instructions.

2.3.4 RF Shielding Floor Coating System

Electro-conductive acrylate binder floor coating system to shield high-frequency electromagnetic fields and low-frequency electric fields; manufacturer's standard black color. Refer to drawings for finish flooring material. Provide in specific locations indicated.

a. Grounding System: Provide manufacturer's standard ground system in quantities as required to suit conditions per manufacturer's written instructions.

2.4 COLOR SELECTION OF FINISH COATS

Provide colors of finish coats as indicated; colors listed are not intended to limit the selection of equal colors from other manufacturers. Allow Contracting Officer to select colors not indicated or specified.

Submit manufacturer's samples of paint colors. Cross reference color samples to color scheme as indicated. Submit color stencil codes. Tint each coat progressively darker to enable confirmation of the number of coats.

PART 3 EXECUTION

3.1 PROTECTION OF AREAS AND SPACES NOT TO BE PAINTED

Prior to surface preparation and coating applications, remove, mask, or otherwise protect hardware, hardware accessories, machined surfaces, radiator covers, plates, lighting fixtures, public and private property, and other such items not to be coated that are in contact with surfaces to be coated. Following completion of painting, reinstall removed items by workmen skilled in the trades. Restore surfaces contaminated by coating materials, to original condition and repair damaged items.

3.2 SURFACE PREPARATION

Remove dirt, splinters, loose particles, grease, oil, and other foreign matter and substances deleterious to coating performance as specified for each substrate before application of paint or surface treatments. Remove oil and grease prior to mechanical cleaning. Schedule cleaning so that dust and other contaminants will not fall on wet, newly painted surfaces. Spot-prime exposed ferrous metals such as nail heads on or in contact with surfaces to be painted with water-thinned paints, with a suitable corrosion-inhibitive primer capable of preventing flash rusting and compatible with the coating specified for the adjacent areas. Refer to MPI ASM and MPI MRM for additional more specific substrate preparation requirements.

3.2.1 Additional Requirements for Preparation of Surfaces With Existing Coatings

Before application of coatings, perform the following on surfaces covered by soundly-adhered coatings, defined as those which cannot be removed with a putty knife:

a. Test existing finishes for lead before sanding, scraping, or removing. If lead is present, refer to paragraph Toxic Materials.

b. Wipe previously painted surfaces to receive solvent-based coatings, except stucco and similarly rough surfaces clean with a clean, dry cloth saturated with mineral spirits, ASTM D235 or as specified in MPI MRM. Wipe the surfaces dry with a clean, dry, lint free cloth. Wipe immediately preceding the application of the first coat of any coating, unless specified otherwise.

c. Sand existing glossy surfaces to be painted to reduce gloss. Brush, and wipe clean with a damp cloth to remove dust.

d. The requirements specified are minimum. Comply also with the application instructions of the paint manufacturer and specific

surface preparation requirements as outlined in MPI MRM Exterior Surface Preparation and Interior Surface Preparation.

e. Thoroughly clean previously painted surfaces specified to be repainted of all grease, dirt, dust or other foreign matter.

f. Remove blistering, cracking, flaking and peeling or otherwise deteriorated coatings.

g. Remove chalk so that when tested in accordance with ASTM D4214, the chalk resistance rating is no less than 8.

h. Roughen slick surfaces. Repair damaged areas such as, but not limited to, nail holes, cracks, chips, and spalls with suitable material to match adjacent undamaged areas.

i. Feather and sand smooth edges of chipped paint.

j. Clean rusty metal surfaces in accordance with SSPC requirements. Use solvent, mechanical, or chemical cleaning methods to provide surfaces suitable for painting.

k. Provide new, proposed coatings that are compatible with existing coatings.

3.2.2 Existing Coated Surfaces with Minor Defects

Sand, spackle, and treat minor defects to render them smooth. Minor defects are defined as scratches, nicks, cracks, gouges, spalls, alligatoring, chalking, and irregularities due to partial peeling of previous coatings. Remove chalking by sanding or blasting so that when tested in accordance with ASTM D4214, the chalk rating is not less than 8.

3.3 PREPARATION OF METAL SURFACES

3.3.1 Existing and New Ferrous Surfaces

a. Ferrous Surfaces including Shop-coated Surfaces and Small Areas That Contain Rust, Mill Scale and Other Foreign Substances: Solvent clean or detergent wash in accordance with SSPC SP 1 to remove oil and grease. Where shop coat is missing or damaged, clean according to SSPC SP 2, SSPC SP 3, SSPC SP 6/NACE No.3, or SSPC SP 10/NACE No. 2. Protect shop-coated ferrous surfaces from corrosion by treating and touching up corroded areas immediately upon detection.

b. Surfaces With More Than 20 Percent Rust, Mill Scale, and Other Foreign Substances: Clean entire surface in accordance with SSPC SP 6/NACE No.3 / SSPC-SP WJ-3/NACE WJ-3.

3.3.2 Final Ferrous Surface Condition:

3.3.2.1 Tool Cleaned Surfaces

Comply with SSPC SP 2 and SSPC SP 3. Use as a visual reference, photographs in SSPC VIS 3 for the appearance of cleaned surfaces.

3.3.2.2 Abrasive Blast Cleaned Surfaces

Comply with SSPC 7/NACE No.4, SSPC SP 6/NACE No.3, and

SSPC SP 10/NACE No. 2. Use as a visual reference, photographs in SSPC VIS 1 for the appearance of cleaned surfaces.

3.3.3 Galvanized Surfaces

a. New or Existing Galvanized Surfaces With Only Dirt and Zinc Oxidation Products: Clean with solvent, steam, or non-alkaline detergent solution in accordance with SSPC SP 1. Completely remove coating by brush-off abrasive blast if the galvanized metal has been passivated or stabilized. Do not "passivate" or "stabilize" new galvanized steel to be coated. If the absence of hexavalent stain inhibitors is not documented, test as described in ASTM D6386, Appendix X2, and remove by one of the methods described therein.

b. Galvanized with Slight Coating Deterioration or with Little or No Rusting: Water jetting to SSPC-SP WJ-3/NACE WJ-3 to remove loose coating from surfaces with less than 20 percent coating deterioration and no blistering, peeling, or cracking. Use inhibitor as recommended by the coating manufacturer to prevent rusting.

c. Galvanized With Severe Deteriorated Coating or Severe Rusting: Spot abrasive blast rusted areas as described for steel in SSPC SP 6/NACE No.3, and waterjet to SSPC-SP WJ-3/NACE WJ-3 to remove existing coating.

3.3.4 Non-Ferrous Metallic Surfaces

Aluminum and aluminum-alloy, lead, copper, and other nonferrous metal surfaces.

Surface Cleaning: Solvent clean in accordance with SSPC SP 1 and wash with mild non-alkaline detergent to remove dirt and water soluble contaminants.

3.4 PREPARATION OF CONCRETE AND CEMENTITIOUS SURFACE

3.4.1 Concrete and Masonry

a. Curing: Allow concrete, stucco and masonry surfaces to cure at least 30 days before painting, and concrete slab on grade to cure at least 90 days before painting.

b. Surface Cleaning: Remove the following deleterious substances.

(1) Dirt, Chalking, Grease, and Oil: Wash new and existing uncoated surfaces with a solution composed of 1/2 cup trisodium phosphate, 1/4 cup household detergent, and 4 quarts of warm water. Then rinse thoroughly with fresh water. Wash existing coated surfaces with a suitable detergent and rinse thoroughly. For large areas, water blasting may be used.

(2) Fungus and Mold: Wash new, existing coated, and existing uncoated surfaces with a solution composed of 1/2 cup trisodium phosphate, 1/4 cup household detergent, one quart 5 percent sodium hypochlorite solution and 3 quarts of warm water. Rinse thoroughly with fresh water.

(3) Paint and Loose Particles: Remove by wire brushing.

(4) Efflorescence: Remove by scraping or wire brushing followed by washing with a 5 to 10 percent by weight aqueous solution of hydrochloric (muriatic) acid. Do not allow acid to remain on the surface for more than five minutes before rinsing with fresh water. Do not acid clean more than 4 square feet of surface, per workman, at one time.

c. Cosmetic Repair of Minor Defects: Repair or fill mortar joints and minor defects, including but not limited to spalls, in accordance with manufacturer's recommendations and prior to coating application.

d. Allowable Moisture Content: Latex coatings may be applied to damp surfaces, but not to surfaces with droplets of water. Do not apply epoxies to damp vertical surfaces as determined by ASTM D4263 or horizontal surfaces that exceed 3 lbs of moisture per 1000 square feet in 24 hours as determined by ASTM F1869. In all cases follow manufacturer's recommendations. Allow surfaces to cure a minimum of 30 days before painting.

3.4.2 Gypsum Board, Plaster, and Stucco

3.4.2.1 Surface Cleaning

Verify that plaster and stucco surfaces are free from loose matter and that gypsum board is dry. Remove loose dirt and dust by brushing with a soft brush, rubbing with a dry cloth, or vacuum-cleaning prior to application of the first coat material. A damp cloth or sponge may be used if paint is water-based.

3.4.2.2 Repair of Minor Defects

Prior to painting, repair joints, cracks, holes, surface irregularities, and other minor defects with patching plaster or spackling compound and sand smooth.

3.4.2.3 Allowable Moisture Content

Latex coatings may be applied to damp surfaces, but not surfaces with droplets of water. Do not apply epoxies to damp surfaces as determined by ASTM D4263. Verify that new plaster to be coated has a maximum moisture content of 8 percent, when measured in accordance with ASTM D4444, Method A, unless otherwise authorized. In addition to moisture content requirements, allow new plaster to age a minimum of 30 days before preparation for painting.

3.5 PREPARATION OF WOOD AND PLYWOOD SURFACES

3.5.1 New Plywood and Wood Surfaces, Except Floors:

a. Surface Cleaning: Clean wood surfaces of foreign matter. Verify that surfaces are free from dust and other deleterious substances and in a condition approved by the Contracting Officer prior to receiving paint or other finish. Do not use water to clean uncoated wood.

b. Do not exceed 12 percent moisture content of the wood as measured by a moisture meter in accordance with ASTM D4444, Method A, unless otherwise authorized.

c. Prime or touch up wood surfaces adjacent to surfaces to receive

water-thinned paints before applying water-thinned paints.

d. Cracks and Nailheads: Set and putty stop nailheads and putty cracks after the prime coat has dried.

e. Cosmetic Repair of Minor Defects:

(1) Knots and Resinous Wood: Prior to application of coating, cover knots and stains with two or more coats of 3-pound-cut shellac varnish, plasticized with 5 ounces of castor oil per gallon. Scrape away existing coatings from knotty areas, and sand before treating. Prime before applying any putty over shellacked area.

(2) Open Joints and Other Openings: Fill with whiting putty, linseed oil putty. Sand smooth after putty has dried.

(3) Checking: Where checking of the wood is present, sand the surface, wipe and apply a coat of pigmented orange shellac. Allow to dry before paint is applied.

3.5.2 Interior Wood Surfaces, Stain Finish

Sand interior wood surfaces to receive stain. Fill oak and other open-grain wood to receive stain with a coat of wood filler not less than 8 hours before the application of stain; remove excess filler and sand the surface smooth.

3.6 APPLICATION

3.6.1 Coating Application

a. Comply with applicable federal, state and local laws enacted to ensure compliance with Federal Clean Air Standards. Apply coating materials in accordance with SSPC PA 1. SSPC PA 1 methods are applicable to all substrates, except as modified herein.

b. At the time of application, paint must show no signs of deterioration. Maintain uniform suspension of pigments during application.

c. Unless otherwise specified or recommended by the paint manufacturer, paint may be applied by brush, roller, or spray. Use trigger operated spray nozzles for water hoses. Use rollers for applying paints and enamels of a type designed for the coating to be applied and the surface to be coated. Wear protective clothing and respirators when applying oil-based paints or using spray equipment with any paints.

d. Only apply paints, except water-thinned types, to surfaces that are completely free of moisture as determined by sight or touch.

e. Thoroughly work coating materials into joints, crevices, and open spaces. Pay special attention to ensure that all edges, corners, crevices, welds, and rivets receive a film thickness equal to that of adjacent painted surfaces.

f. Apply each coat of paint so that dry film is of uniform thickness and free from runs, drops, ridges, waves, pinholes or other voids, laps, brush marks, and variations in color, texture, and finish. Completely hide all blemishes.

g. Touch up damaged coatings before applying subsequent coats. Broom clean and clear dust from interior areas before and during the application of coating material.

h. Fire Extinguishing Sprinkler Systems: Apply paint to new fire extinguishing sprinkler systems including valves, piping, conduit, hangers, supports, miscellaneous metal work, and accessories. Shield sprinkler heads with protective coverings while painting is in progress. Remove sprinkler heads which have been painted and replace with new sprinkler heads. Unfinished spaces include attic spaces, spaces above suspended ceilings, crawl spaces, pipe chases, mechanical equipment room, and space where walls or ceiling are not painted or not constructed of a prefinished material. Upon completion of painting, remove protective covering from sprinkler heads.

i. Piping in Unfinished Areas: Provide one coat of red alkyd gloss enamel (MPI 9) applied to a minimum dry film thickness of 1.0 mil in attic spaces, spaces above suspended ceilings, crawl spaces, pipe chases, mechanical equipment room, and spaces where walls or ceiling are not painted or not constructed of a prefinished material.

   (1) Fire Standpipe System in Parking Garage: Provide two coats of red alkyd gloss enamel (MPI 9) applied to a minimum dry film thickness of 1.0 mil per coat.

j. Piping in Finished Areas: Provide two coats of paint to match adjacent surfaces, except provide valves and operating accessories with one coat of red alkyd gloss enamel (MPI 9) applied to a minimum dry film thickness of 1.0 mil or two component gloss polyurethane (MPI 72) in exterior applications. Fire sprinkler piping in finished areas that do not have sprinklers directly connected to them may be painted to match adjacent surfaces, provided piping is identified by painting 2-inch wide red alkyd gloss enamel (MPI 9) bands every 10 feet and on both sides of wall, ceiling, or floor penetrations.

k. Provide labeling on the surfaces of all feed and cross mains to show the pipe function such as "Sprinkler System", "Fire Department Connection", "Standpipe". For pipe sizes 4-inch and larger provide white painted stenciled letters and arrows, a minimum of 2 in in height and visible from at least two sides when viewed from the floor. For pipe sizes less than 4-inch, provide white painted stenciled letters and arrows, a minimum of 0.75 in in height and visible from the floor.

l. All fire suppression system valves must be marked with permanent tags indicating normally open or normally closed.

m. Drying Time: Allow time between coats, as recommended by the coating manufacturer, to permit thorough drying, but not to present topcoat adhesion problems. Provide each coat in specified condition to receive next coat.

n. Primers, and Intermediate Coats: Do not allow primers or intermediate coats to dry more than 30 days, or longer than recommended by manufacturer, before applying subsequent coats. Follow manufacturer's recommendations for surface preparation if primers or intermediate coats are allowed to dry longer than recommended by manufacturers of subsequent coatings. Cover each preceding coat or surface completely

by ensuring visually perceptible difference in shades of successive coats. Apply as many primer coats as necessary to produce a uniform substrate appearance.

o. Finished Surfaces: Provide finished surfaces free from runs, drops, ridges, waves, laps, brush marks, and variations in colors.

p. Thermosetting Paints: Apply topcoats over thermosetting paints (epoxies and urethanes) within the overcoat window recommended by the manufacturer.

3.6.2 Mixing and Thinning of Paints

Reduce paints to proper consistency by adding fresh paint, except when thinning is mandatory to suit surface, temperature, weather conditions, application methods, or for the type of paint being used. Obtain written permission from the Contracting Officer to use thinners. Verify that the written permission includes quantities and types of thinners to use.

When thinning is allowed, thin paints immediately prior to application with not more than one pint of suitable thinner per gallon. The use of thinner does not relieve the Contractor from obtaining complete hiding, full film thickness, or required gloss. Thinning cannot cause the paint to exceed limits on volatile organic compounds. Do not mix paints of different manufacturers.

3.6.3 Two-Component Systems

Mix two-component systems in accordance with manufacturer's instructions. Follow recommendation by the manufacturer for any thinning of the first coat to ensure proper penetration and sealing for each type of substrate.

3.6.4 Coating Systems

a. Systems by Substrates: Apply coatings that conform to the respective specifications listed in the following Tables:

Table for Exterior Applications	
MPI Division	Substrate Application
MPI Division 3	Exterior Concrete Paint Table
MPI Division 4	Exterior Concrete Masonry Units Paint Table
MPI Division 5	Exterior Metal, Ferrous and Non-Ferrous Paint Table

Table for Interior Applications	
MPI Division	Substrate Application
MPI Division 3	Interior Concrete Paint Table
MPI Division 4	Interior Concrete Masonry Units Paint Table

Table for Interior Applications	
MPI Division 5	Interior Metal, Ferrous and Non-Ferrous Paint Table
MPI Division 6	Interior Wood Paint Table
MPI Division 9	Interior Plaster, Gypsum Board, Textured Surfaces Paint Table

b. Minimum Dry Film Thickness (DFT): Apply paints, primers, varnishes, enamels, undercoats, and other coatings to a minimum dry film thickness of 1.5 mil each coat unless specified otherwise in the Tables. Coating thickness, where specified, refers to the minimum dry film thickness.

c. Coatings for Surfaces Not Specified Otherwise: Coat unspecified surfaces the same as surfaces having similar conditions of exposure.

d. Existing Surfaces Damaged During Performance of the Work, Including New Patches In Existing Surfaces: Coat surfaces with the following:

(1) One coat of primer.

(2) One coat of undercoat or intermediate coat.

(3) One topcoat to match adjacent surfaces.

e. Existing Coated Surfaces To Be Painted: Apply coatings conforming to the respective specifications listed in the Tables herein, except that pretreatments, sealers and fillers need not be provided on surfaces where existing coatings are soundly adhered and in good condition. Do not omit undercoats or primers.

3.7 COATING SYSTEMS FOR METAL

Apply coatings of Tables in MPI Division 5 for Exterior and Interior.

a. Apply specified ferrous metal primer to steel surfaces on the same day that surface is cleaned, to surfaces that meet all specified surface preparation requirements at time of application.

b. Inaccessible Surfaces: Prior to erection, use one coat of specified primer on metal surfaces that will be inaccessible after erection.

c. Shop-primed Surfaces: Touch up exposed substrates and damaged coatings to protect from rusting prior to applying field primer.

d. Surface Previously Coated with Epoxy or Urethane: Apply MPI 101, 1.5 mils DFT immediately prior to application of epoxy or urethane coatings.

e. Pipes and Tubing: The semitransparent film applied to some pipes and tubing at the mill is not to be considered a shop coat. Overcoat these items with the specified ferrous-metal primer prior to application of finish coats.

f. Exposed Nails, Screws, Fasteners, and Miscellaneous Ferrous Surfaces.

On surfaces to be coated with water thinned coatings, spot prime exposed nails and other ferrous metal with latex primer MPI 107.

3.8 COATING SYSTEMS FOR CONCRETE AND CEMENTITIOUS SUBSTRATES

Apply coatings of Tables in MPI Division 3, 4 and 9 for Exterior and Interior.

3.9 COATING SYSTEMS FOR WOOD AND PLYWOOD

a. Apply coatings of Tables in MPI Division 6 for Exterior and Interior.

b. Prior to erection, apply two coats of specified primer to treat and prime wood and plywood surfaces which will be inaccessible after erection.

c. Apply stains in accordance with manufacturer's printed instructions.

3.10 PIPING IDENTIFICATION

Piping Identification, Including Surfaces In Concealed Spaces: Provide in accordance with ASME A13.1. Place stenciling in clearly visible locations. On piping not covered by ASME A13.1, stencil approved names or code letters, in letters a minimum of 1/2 inch high for piping and a minimum of 2 inches high elsewhere. Stencil arrow-shaped markings on piping to indicate direction of flow using black stencil paint.

3.11 INSPECTION AND ACCEPTANCE

In addition to meeting previously specified requirements, demonstrate mobility of moving components, including swinging and sliding doors, cabinets, and windows with operable sash, for inspection by the Contracting Officer. Perform this demonstration after appropriate curing and drying times of coatings have elapsed and prior to invoicing for final payment.

3.12 CONSTRUCTION WASTE MANAGEMENT

As specified in the Waste Management Plan and as follows. Do not use kerosene or any such organic solvents to clean up water based paints. Properly dispose of paints or solvents in designated containers. Close and seal partially used containers of paint to maintain quality as necessary for reuse. Store in protected, well-ventilated, fire-safe area at moderate temperature. Place materials defined as hazardous or toxic waste in designated containers. Set aside extra paint for future color matches or reuse by the Government. Where local options exist for leftover paint recycling, collect all waste paint by type and provide for delivery to recycling or collection facility for reuse by local organizations.

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

3.13 PAINT TABLES

All DFT's are minimum values. Use only materials with a MPI GPS-1-14 green check mark having a minimum MPI "Environmentally Friendly" E1, E2 or E3 rating, as applicable, based on VOC (EPA Method 24) content levels. Acceptable products are listed in the MPI Green Approved Products List,

available at http://www.specifygreen.com/APL/ProductIdxByMPInum.asp.

3.13.1 Exterior Paint Tables

3.13.1.1 MPI Division 3: Exterior Concrete Paint Table

A. Concrete; Vertical Surfaces, Undersides of Balconies and Soffits

(1) New and Existing concrete; vertical surfaces, including undersides of balconies and soffits but excluding tops of slabs

Latex					
New and uncoated existing	Existing, previously painted	Primer	Intermediate	Topcoat	System DFT
MPI EXT 3.1A-G1 (Flat)	MPI REX 3.1A-G1 (Flat)	MPI 3	MPI 10	MPI 10	3.5 mils
MPI EXT 3.1A-G5 (Semigloss)	MPI REX 3.1A-G5 (Semigloss)	MPI 3	MPI 11	MPI 11	3.5 mils
MPI EXT 3.1A-G6 (Gloss)	MPI REX 3.1A-G6 (Gloss)	MPI 3	MPI 119	MPI 119	3.5 mils
Primer as recommended by manufacturer. Topcoat: Coating to match adjacent surfaces.					

3.13.1.2 MPI Division 4: Exterior Concrete Masonry Units Paint Table

A. New and Existing concrete masonry on uncoated surface

Latex						
New	Existing	Block Filler	Primer	Intermediate	Topcoat	System DFT
MPI EXT 4.2A-G1 (Flat)	MPI REX 4.2A-G1 (Flat)	MPI 4	N/A	MPI 10	MPI 10	11 mils
MPI EXT 4.2A-G5 (Semigloss)	MPI REX 4.2A-G5 (Semigloss)	MPI 4	N/A	MPI 11	MPI 11	11 mils
MPI EXT 4.2A-G6 (Gloss)	MPI REX 4.2A-G6 (Gloss)	MPI 4	N/A	MPI 119	MPI 119	11 mils
Topcoat: Coating to match adjacent surfaces.						

3.13.1.3 MPI Division 5: Exterior Metal, Ferrous and Non-Ferrous Paint Table

A. Steel / Ferrous Surfaces

(1) New Steel that has been hand or power tool cleaned to SSPC SP 2 or

SSPC SP 3

Alkyd					
New	Existing, uncoated	Primer	Intermediate	Topcoat	System DFT
MPI EXT 5.1Q-G5 (Semigloss	MPI REX 5.1D-G5 (Semigloss)	MPI 23	MPI 94	MPI 94	5.25 mils
MPI EXT 5.1Q-G6 (Gloss)	MPI REX 5.1D-G6 (Gloss)	MPI 23	MPI 9	MPI 9	5.25 mils
Topcoat: Coating to match adjacent surfaces.					

(2) New Steel that has been blast-cleaned to SSPC SP 6/NACE No.3

Alkyd					
New	Existing, uncoated	Primer	Intermediate	Topcoat	System DFT
MPI EXT 5.1D-G5 (Semigloss)	MPI REX 5.1D-G5 (Semigloss)	MPI 79	MPI 94	MPI 94	5.25 mils
MPI EXT 5.1D-G6 (Gloss)	MPI REX 5.1D-G6 (Gloss)	MPI 79	MPI 9	MPI 9	5.25 mils
Topcoat: Coating to match adjacent surfaces.					

Pigmented Polyurethane				
Galvanized Surfaces with slight coating deterioration	Primer	Intermediate	Topcoat	System DFT
MPI REX 5.3D-G6 (Gloss)	MPI 101	N/A	MPI 72	5 mils
Topcoat: Coating to match adjacent surfaces.				

C. Exterior Surfaces, Other Metals (Non-Ferrous)

(1) Aluminum, aluminum alloy and other miscellaneous non-ferrous metal items not otherwise specified except hot metal surfaces, roof surfaces, and new prefinished equipment

Alkyd

New Aluminum Surfaces	Primer	Intermediate	Topcoat	System DFT
MPI EXT 5.4F-G5 (Semigloss)	MPI 95	MPI 94	MPI 94	5 mils
MPI EXT 5.4F-G6 (Gloss)	MPI 95	MPI 9	MPI 9	5 mils
Topcoat: Coating to match adjacent surfaces.				

(2) Surfaces adjacent to painted surfaces; Mechanical, Electrical, Fire extinguishing sprinkler systems including valves, conduit, hangers, supports,and miscellaneous metal items not otherwise specified except floors, hot metal surfaces, and new prefinished equipment

Alkyd				
New	Primer	Intermediate	Topcoat	System DFT
MPI EXT 5.1D-G5 (Semigloss)	MPI 79	MPI 94	MPI 94	5.25 mils
MPI EXT 5.1D-G6 (Gloss)	MPI 79	MPI 9	MPI 9	5.25 mils
Topcoat: Coating to match adjacent surfaces.				

3.13.2 Interior Paint Tables

3.13.2.1 MPI Division 3: Interior Concrete Paint Table

A. New Concrete Ceilings

Institutional Low Odor / Low VOC Latex					
New, uncoated Existing	Existing, previously painted	Primer	Intermediate	Topcoat	System DFT
MPI INT 3.1M-G2 (Flat)	N/A	MPI 149	MPI 144	MPI 144	4 mils
MPI INT 3.1M-G3 (Eggshell)	N/A	MPI 149	MPI 145	MPI 145	4 mils
MPI INT 3.1M-G4 (satin)	N/A	MPI 149	MPI 146	MPI 146	4 mils
MPI INT 3.1M-G5 (Semigloss)	N/A	MPI 149	MPI 147	MPI 147	4 mils

Topcoat: Coating to match adjacent surfaces.

B. New concrete floors as indicated for CONCS-1 and CONCS-2

CONCS-1					
New	Not Used	Primer	Intermediate	Topcoat	System DFT
Mfr Std	N/A	Mfr Std	Mfr Std	Mfr Std	Mfr Std
Note: "Mfr Std" represents manufacturer's standard requirements.					

CONCS-2					
New	Not Used	Primer	Intermediate	Topcoat	System DFT
Mfr Std	N/A	Mfr Std	Mfr Std	Mfr Std	Mfr Std
Note: "Mfr Std" represents manufacturer's standard requirements.					

C. New concrete floor surfaces requiring RF shielding: Apply specified RF Shielding Floor Coating System as underlayment for finish flooring at locations indicated on Architectural drawings.

3.13.2.2 MPI Division 4: Interior Concrete Masonry Units Paint Table

A. New and Existing Concrete Masonry

Institutional Low Odor / Low VOC Latex					
New, uncoated Existing	Filler	Primer	Intermediate	Topcoat	System DFT
MPI INT 4.2E-G2 (Flat)	MPI 4	N/A	MPI 144	MPI 144	4 mils
MPI INT 4.2E-G3 (Eggshell)	MPI 4	N/A	MPI 145	MPI 145	4 mils
MPI INT 4.2E-G5 (Semigloss)	MPI 4	N/A	MPI 147	MPI 147	4 mils
Fill all holes in masonry surface					

B. Existing, Previously Painted Concrete Masonry

Institutional Low Odor / Low VOC Latex					
Existing, previously painted	Filler	Primer	Intermediate	Topcoat	System DFT
MPI RIN 4.2L-G2 (Flat)	N/A	MPI 144	MPI 144	MPI 144	4 mils
MPI RIN 4.2L-G3 (Eggshell)	N/A	MPI 145	MPI 145	MPI 145	4 mils
MPI RIN 4.2L-G5 (Semigloss)	N/A	MPI 147	MPI 147	MPI 147	4 mils

C. New and Existing Concrete masonry units in toilets, food-preparation, food-serving, areas requiring a high degree of sanitation and other areas as indicated

Epoxy					
New, uncoated Existing	Filler	Primer	Intermediate	Topcoat	System DFT
MPI INT 4.2G-G6 (Gloss)	MPI 116	N/A	MPI 77	MPI 77	10 mils
Fill all holes in masonry surface					

D. Existing, previously painted, concrete masonry units in toilets, food-preparation, food-serving, areas requiring a high degree of sanitation and other areas as indicated

Epoxy					
Existing, previously painted	Filler	Primer	Intermediate	Topcoat	System DFT
MPI RIN 4.2D-G6 (Gloss)	N/A	MPI 77	MPI 77	MPI 77	5 mils

3.13.2.3 MPI Division 5: Interior Metal, Ferrous and Non-Ferrous Paint Table

A. Interior Steel / Ferrous Surfaces

(1) Metal, Mechanical, Electrical, Fire extinguishing sprinkler systems including valves, conduit, hangers, supports, and miscellaneous metal items not otherwise specified except floors, hot metal surfaces, and new prefinished equipment

Alkyd

New, uncoated Existing	Primer	Intermediate	Topcoat	System DFT
MPI INT 5.1E-G5 (Semigloss)	MPI 76	MPI 47	MPI 47	5.25 mils
MPI INT 5.1E-G6 (Gloss)	MPI 76	MPI 48	MPI 48	5.25 mils
Topcoat: Coating to match adjacent surfaces.				

(2) Metal in toilets, food-preparation, food-serving, areas requiring a high degree of sanitation, and other areas as indicated except floors, hot metal surfaces, and new prefinished equipment

Alkyd				
New, uncoated Existing	Primer	Intermediate	Topcoat	System DFT
MPI INT 5.1E-G5 (Semigloss)	MPI 76	MPI 47	MPI 47	5.25 mils
MPI INT 5.1E-G6 (Gloss)	MPI 76	MPI 48	MPI 48	5.25 mils
Topcoat: Coating to match adjacent surfaces.				

(3) Miscellaneous non-ferrous metal items not otherwise specified except floors, hot metal surfaces, and new prefinished equipment. Match surrounding finish

Alkyd				
New, uncoated Existing	Primer	Intermediate	Topcoat	System DFT
MPI INT 5.4J-G5 (Semigloss)	MPI 95	MPI 47	MPI 47	5 mils
MPI INT 5.4J-G6 (Gloss)	MPI 95	MPI 48	MPI 48	5 mils
Topcoat: Coating to match adjacent surfaces.				

3.13.2.4 MPI Division 6: Interior Wood Paint Table

A. Interior New Wood and Plywood, except floors; stained

Stained, oil-modified polyurethane						
New	Existing	Stain	Primer	Intermediate	Topcoat	System DFT

MPI INT 6.4E-G4	MPI RIN 6.4G-G4	MPI 90	MPI 57	MPI 57	MPI 57	4 mils
MPI INT 6.4E-G6 (Gloss)	MPI RIN 6.4G-G6 (Gloss)	MPI 90	MPI 56	MPI 56	MPI 56	4 mils

3.13.2.5 MPI Division 9: Interior Plaster, Gypsum Board, Textured Surfaces Paint Table

A. Interior New and Existing, previously painted Wallboard not otherwise specified

Institutional Low Odor / Low VOC Latex, New

Institutional Low Odor / Low VOC Latex				
New	Primer	Intermediate	Topcoat	System DFT
MPI INT 9.2M-G2 (Flat)	MPI 149	MPI 144	MPI 144	4 mils
MPI INT 9.2M-G3 (Eggshell)	MPI 149	MPI 145	MPI 145	4 mils
MPI INT 9.2M-G4 (Satin)	MPI 149	MPI 146	MPI 146	4 mils
MPI INT 9.2M-G5 (Semigloss)	MPI 149	MPI 147	MPI 147	4 mils
Topcoat: Coating to match adjacent surfaces.				

Institutional Low Odor / Low VOC Latex, Existing, previously painted

Institutional Low Odor / Low VOC Latex				
Existing, previously painted	Primer	Intermediate	Topcoat	System DFT
MPI RIN 9.2M-G2 (Flat)	MPI 144	MPI 144	MPI 144	4 mils
MPI RIN 9.2M-G3 (Eggshell)	MPI 144	MPI 145	MPI 145	4 mils
MPI RIN 9.2M-G4 (Satin)	MPI 144	MPI 146	MPI 146	4 mils
MPI RIN 9.2M-G5 (Semigloss)	MPI 144	MPI 147	MPI 147	4 mils
Topcoat: Coating to match adjacent surfaces.				

B. Interior New and Existing, previously painted Wallboard in toilets, food-preparation, food-serving, shower areas, areas requiring a high

degree of sanitation, and other areas as indicated

Epoxy, New, uncoated Existing

Epoxy				
New, uncoated Existing	Primer	Intermediate	Topcoat	System DFT
MPI INT 9.2E-G6 (Gloss)	MPI 50	MPI 77	MPI 77	4 mils
Topcoat: Coating to match adjacent surfaces.				

Epoxy, Existing, previously painted

Epoxy				
Existing, previously painted	Primer	Intermediate	Topcoat	System DFT
MPI RIN 9.2D-G6 (Gloss)	MPI 17	MPI 77	MPI 77	4 mils
Topcoat: Coating to match adjacent surfaces.				

-- End of Section --

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 09 96 00

HIGH-PERFORMANCE COATINGS
11/14
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D523	(2014; R 2018) Standard Test Method for Specular Gloss

MASTER PAINTERS INSTITUTE (MPI)

MPI 101	(2016) Primer, Epoxy, Anti-Corrosive, for Metal
MPI 72	(2016) Polyurethane, Two-Component, Pigmented, Gloss (MPI Gloss Level 6-7)
MPI 77	(2015) Epoxy, Gloss

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC 7/NACE No.4	(2007) Brush-Off Blast Cleaning

1.2 SUMMARY

Section includes surface preparation and the application of high-performance coating systems for painting of concrete housekeeping pads, ferrous pipe support components; pipe hangers, trapeze pipe hangers, metal framing systems, exterior pipe supports, steel railing system, and non-insulated carbon steel piping on the following substrates ***except ferrous metal primary and secondary steel framing inside the aircraft maintenance bays and hangar doors will be finished according to Section 09 97 13.27 HIGH PERFORMANCE COATING FOR STEEL STRUCTURES***

1.2.1 Exterior Substrates

a. Steel and Carbon (Black) Steel, including steel door canopy and related components.

b. ***Galvanized*** metal/steel.

c. Copper.

1.2.2 Interior Substrates

Located in areas exposed to the exterior and in areas not environmentally controlled.

a. Concrete, ***-housekeeping pads***.

b. Steel and Carbon (Black) Steel.

c. Galvanized metal/steel.

d. Copper.

e. Hangar Bay ceiling ***metal decking,*** ducts, pipes, etc.) and structual steel members ***not part of primary and secondary framing.***

1.2.3 Related Requirements

a. Section 09 90 00 PAINTS AND COATINGS for general field painting.

b. Division 22, 23, 26, 27, and 28 Sections for specific steel, carbon (black) steel, galvanized metal and copper items to received high-performance coatings.

c. Divisions 22, 23 and 26 Sections for concrete housekeeping pads to receive high-performance coatings.

d. Ferrous metal for hangar doors will be finished according to Section 09 97 13.27 HIGH PERFORMANCE COATING FOR STEEL STRUCTURES

1.3 DEFINITIONS

1.3.1 MPI Gloss Lvel 6 ***Level 6***

70 to 85 units at 60 degrees, according to ASTM D523.

1.3.2 MPI Gloss Level 7

More than 85 units at 60 degrees, according to ASTM D523.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Product List; G

Submit product list for each product indicated, including the following:

a. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.

b. Printout of current "MPI Approved Products List" for each product category specified in Part 2, with the proposed product highlighted.

SD-03 Product Data

Low-Emitting Paints and Coatings; S

Manufacturers' product data for paints and coatings used on the interior of the building (defined as inside of the weatherproofing system), indicating VOC content and laboratory test reports showing compliance with requirements for low-emitting materials as specified. Submit per requirements in Section 01 33 29 SUSTAINABILITY REPORTING.

Metal Primers; G

Epoxy Coatings; G

Polyurethane Coatings; G

SD-04 Samples

Color; G

Submit samples for verification for each type of coating system and in each color and gloss of topcoat indicated.

a. Submit Samples on ridid backing, 8 inches square.

b. Apply coats on Samples in steps to show each coat required for system.

c. Label each coat of each Sample.

d. Label each Sample for location and application area.

SD-11 Closeout Submittals

All sustainable design Submittals for low-emitting paints and coatings are included under SD-03 Product Data.

1.5 FIELD CONDITIONS

Apply coatings only when temperature of surfaces to be coated and ambient air tempreatures are between 50 and 95 deg F.

Do not apply coatings when relative humidity exceeds 85 percent; at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

Do not apply exterior coatings in snow, rain, fog, or mist.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver special coating materials to the project in their original containers bearing manufacturer's name, descriptive label, and coating formulations. Provide new and unopened containers.

Store special coating materials in tightly closed containers in a covered, well-ventilated area where they are not exposed to excessive heat, fumes, sparks, flame, or direct sunlight. Protect water-based coatings against freezing.

Store solvents, thinners, and equipment cleaners with the same care as the coating materials with ambient temperatures continuously maintained at a minimum 45 degrees F.

PART 2 PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

See Section 01 33 29 SUSTAINABILITY REPORTING for sustainable design requirements for the following, except as modified herein.

2.1.1 Low-Emitting Paints and Coatings

For field applications that are used on the interior of the building, paints and coatings shall comply with low-emitting limits specified in Section 01 33 29 SUSTAINABILITY REPORTING.

2.2 PERFORMANCE REQUIREMENTS

2.2.1 Master Painters Institute (MPI) Standards

Products shall comply with MPI standards indicated and shall be listed in its "MPI Approved Products Lists".

2.2.2 Material Compatibility

a. All coatings specified herein to be indicated in Product List.

b. Materials for use within each paint system shall be compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.

c. For each coat in a paint system, products shall be recommended in writing by topcoat manufacturers for use in paint system and on substrate indicated.

d. Products shall be of same manufacturer for each coat in a coating system.

2.2.3 Color

Provide color as indicated, and as specified in applicable Division 22 and 23 Sections for pipe color coding; colors listed are not intended to limit the selection of equal colors from other manufacturers.

2.3 METAL PRIMERS

2.3.1 Primer, Epoxy, Anti-Corrosive, for Metal

MPI 101.

2.4 EPOXY COATINGS

2.4.1 Epoxy, Gloss (Gloss Level 6)

MPI 77.

2.5 POLYURETHANE COATINGS

2.5.1 Polyurethane, Two-Component, Pigmented, Gloss (Gloss Level 6)

MPI 72.

PART 3 EXECUTION

3.1 EXAMINATION

Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

3.1.1 Maximum Moisture Content of Substrates

When measured with an electronic moisture meter as follows:

a. Concrete shall be 12 percent.

Verify suitability of substrates, including surface conditions and compatibility, with existing finishes and primers.

Proceed with coating application only after unsatisfactory conditions have been corrected.

a. Beginning coating application constitutes Contractor's acceptance of substrates and conditions.

3.2 PREPARATION

Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates and coating systems indicated.

Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.

a. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.

Clean substrates of substances that could impair bond of coatings, including dust, dirt, oil, grease, and incompatible paints and encapsulants.

a. Remove incompatible primers and reprime substrates with compatible primers or apply tie coat as required to produce coating systems indicated.

3.2.1 Concrete Substrates

Remove release agents, curing compounds, efflorescence, and chalk. Do not coat surfaces if moisture content or alkalinity of surfaces to be coated exceeds that permitted in manufacturer's written instructions.

3.2.2 Steel Substrates

Remove rust, loose mill scale, and shop primer if any. Clean using methods recommended in writing by paint manufacturer, but not less than the following:

a. SSPC 7/NACE No.4, "Brush-Off Blast Cleaning."

3.2.3 Shop-Primed Steel Substrates

As recommended in writing by topcoat manufacturer.

3.2.4 Galvanized-Metal Substrates

Remove grease and oil residue from galvanized sheet metal by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied coatings.

3.2.5 Copper Substrates

As recommended in writing by topcoat manufacturer.

3.3 APPLICATION

Apply high-performance coatings according to manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual."

a. Use applicators and techniques suited for coating and substrate indicated.

b. Coat surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, coat surfaces behind permanently fixed equipment or furniture with prime coat only.

c. Coat backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.

d. Do not apply coatings over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.

Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of the same material are to be applied. Tint undercoats to match color of finish coat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.

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

Apply coatings to produce surface films without cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface

imperfections. Produce sharp glass lines and color breaks.

3.4 FIELD QUALITY CONTROL

3.4.1 Dry Film Thickness Testing

Engage the services of a qualified testing and inspecting agency to inspect and test coatings for dry film thickness.

a. Contractor shall touch up and restore coated surfaces damaged by testing.

b. If test results show that dry film thickness of applied coating does not comply with coating manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with coating manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

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

After completing coating application, clean spattered surfaces. Remove spattered coatings by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

Protect work of other trades against damage from coating operation. Correct damage to work of other trades by cleaning, repairing, replacing, and recoating, as approved by Contracting Officer, and leave in an undamaged condition.

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

3.6 EXTERIOR HIGH-PERFORMANCE COATING SCHEDULE

3.6.1 Steel and Carbon (Black) Steel Substrates; and steel sliding hangar door framing components, both exterior and interior surfaces

3.6.1.1 Pigmented Polyurethane Over Epoxy System (EXT 5.1H, except as modified herein:

a. Prime Coat: Primer, epoxy, anti-corrosive, for metal, MPI 101, except as otherwise recommended in writing by topcoat manufacturer.

b. Intermediate Coat: Epoxy, gloss, MPI 77.

c. First Topcoat: Polyurethane, two-component, pigmented, gloss (Gloss Level 6), MPI 72.

d. Second topcoat: Polyurethane, two-component, pigmented, gloss (Gloss Level 6), MPI 72.

3.6.2 Galvanized-Metal/Steel and Copper Substrates; both exterior and interior surfaces

3.6.2.1 Pigmented Polyurethane System (EXT 5.3L for Galvanized; EXT 5.5B for Copper):

a. Prime Coat: Primer, epoxy, anti-corrosive, for metal, MPI 101.

b. Intermediate Coat: Polyurethane, two-component, pigmented, gloss (Gloss Level 6), MPI 72.

c. Topcoat: Polyurethane, two-component, pigmented, gloss (Gloss Level 6), MPI 72.

3.7 INTERIOR HIGH PERFORMANCE COATING SCHEDULE

3.7.1 Concrete Substrates, Horizontal Surfaces, Housekeeping Pads and Safety Striping

3.7.1.1 Epoxy System (INT 3.2C-G6):

a. Prime Coat: Epoxy gloss, MPI 77.

b. Intermediate Coat: Epoxy, gloss, MPI 77.

c. Topcoat: Epoxy, gloss, MPI 77.

3.7.2 Steel Substrates and Carbon (Black) Steel

3.7.2.1 Epoxy System (INT 5.1L-G6, except as modified herein):

a. Prime Coat: Primer, epoxy, anti-corrosive, for metal, MPI 101, except as otherwise recommended in writing by topcoat manufacturer.

b. Intermediate Coat: Epoxy, gloss, MPI 77.

c. Topcoat: Epoxy, gloss, MPI 77.

3.7.3 Galvanized-Metal/Steel and Copper Substrates (INT 5.3D for Galvanized; INT 5.5B for Copper)

3.7.3.1 Epoxy System:

a. Prime Coat: Primer, epoxy, anti-corrosive, for metal, MPI 101.

b. Intermediate Coat: Epoxy, gloss, MPI 77.

c. Topcoat: Epoxy, gloss, MPI 77.

3.7.4 Hangar Bay ceiling ***metal decking,*** (including ducts, pipes, etc.) and structural steel members ***not part of primary or secondary framing***

3.7.4.1 Pigmented Polyurethane Over Epoxy System (P-9e)
MPI INT 5.1G-G6, except as modified herein.

a. Prime Coat: Primer, epoxy, anti-corrosive, for metal, MPI 101, except as otherwise recommended in writing by topcoat manufacturer.

b. Intermediate Coat: Epoxy, gloss, MPI 77.

c. First Topcoat: Polyurethane, two-component, pigmented, gloss (Gloss Level 6), MPI 72.

d. Second topcoat: Polyurethane, two-component, pigmented, gloss (Gloss Level 6), MPI 72.

3.8 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 09 97 13.27

HIGH PERFORMANCE COATING FOR STEEL STRUCTURES
02/21, CHG 1: 08/22
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM D1200	(2010; R 2014) Viscosity by Ford Viscosity Cup
ASTM D1640/D1640M	(2014) Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings
ASTM D3276	(2015; E 2016) Standard Guide for Painting Inspectors (Metal Substrates)
ASTM D3925	(2002; R 2015) Sampling Liquid Paints and Related Pigmented Coatings
ASTM D4285	(1983; R 2018) Indicating Oil or Water in Compressed Air
ASTM D7127	(2017) Standard Test Method for Measurement of Surface Roughness of Abrasive Blast Cleaned Metal Surfaces using a Portable Stylus Instrument
ASTM E11	(2020) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 9001	(2015) Quality Management Systems-Requirements

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC 7/NACE No.4	(2007) Brush-Off Blast Cleaning
SSPC AB 2	(2015; E 2016) Cleanliness of Recycled Ferrous Metallic Abrasive
SSPC AB 3	(2003; E 2004) Ferrous Metallic Abrasive
SSPC Guide 6	(2015) Guide for Containing Surface

	Preparation Debris Generated During Paint Removal Operations
SSPC Guide 12	(1998; E 2004) Guide for Illumination of Industrial Painting Projects
SSPC PA 1	(2016) Shop, Field, and Maintenance Coating of Metals
SSPC PA 2	(2015; E 2018) Procedure for Determining Conformance to Dry Coating Thickness Requirements
SSPC QP 1	(2019) Standard Procedure for Evaluating the Qualifications of Industrial/Marine Painting Contractors (Field Application to Complex Industrial Steel Structures and Other Metal Components)
SSPC QP 5	(2012) Standard Procedure for Evaluating the Qualifications of Coating and Lining Inspection Companies
SSPC QS 1	(2015) Standard Procedure for Evaluating a Contractor's Advanced Quality Management System
SSPC SP 1	(2015) Solvent Cleaning
SSPC SP 10/NACE No. 2	(2007) Near-White Blast Cleaning
SSPC SP COM	(2016; E 2017) Surface Preparation Commentary for Steel and Concrete Substrates
SSPC VIS 1	(2002; E 2004) Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS-STD-595A	(2017) Colors used in Government Procurement

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-22262	(1993; Rev B; Am 1 1994; Am 2 1996; Notice 1 2021) Abrasive Blasting Media Ship Hull Blast Cleaning
MIL-DTL-24441	(2009; Rev D; Notice 1 2021) Paint, Epoxy-Polyamide, General Specification for
MIL-DTL-24441/19	(2009; Rev C) Paint, Epoxy-Polyamide, Zinc Primer, Formula 159, Type III
MIL-DTL-24441/31	(2009; Rev B; Notice 1 2021) Paint, Epoxy-Polyamide, White, Formula 152, Type IV

MIL-PRF-85285	(2022; Rev F) Topcoat, Aircraft and Support Equipment

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910-SUBPART Z	Toxic and Hazardous Substances
29 CFR 1910.134	Respiratory Protection
29 CFR 1910.1000	Air Contaminants
29 CFR 1926.59	Hazard Communication

1.2 DEFINITIONS

Definitions are provided throughout this Section, generally in the paragraph where used, and denoted by capital letters.

1.3 RELATED REQUIREMENTS

a. Section 09 90 00 PAINTS AND COATINGS for general field painting.

b. Division 22, 23, and 26 Sections for specific steel, carbon (black) steel, galvanized metal and copper items to received high-performance coatings.

c. Section 09 96 00 HIGH-PERFORMANCE COATINGS for general painting information and requirements.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-05, Design Data

Containment System

SD-06 Test Reports

Joint Sealant Qualification Test Reports

Coatings Qualification Test Reports

Metallic Abrasive Qualification Test Reports

Coating Sample Test Reports

Abrasive Sample Test Reports

Inspection Report Forms

Daily Inspection Reports

Recycled Metallic Abrasive Field Test Reports (Daily and Weekly)

SD-07 Certificates

Contract Errors, Omissions, and Other Discrepancies

Corrective Action Procedures

Coating Work Plan

Qualifications of Certified Industrial Hygienist (CIH)

Qualifications Of Individuals Performing Abrasive Blasting

Qualifications of Certified Protective Coatings Specialist (PCS)

Qualifications of Coating Inspection Company

Qualifications of QC Specialist Coating Inspector

Qualifications of Testing Laboratory for Coatings

Qualifications of Testing Laboratory for Abrasive

Qualifications of Coating Contractors

Joint Sealant Materials

Coating Materials

Coating System Component Compatibility

Non-metallic Abrasive

Metallic Abrasive

SD-08 Manufacturer's Instructions

Joint Sealant Instructions

Coating System Instructions

SD-11 Closeout Submittals

Disposal of Used Abrasive

Inspection Logbook

1.5 QUALITY ASSURANCE

1.5.1 Contract Errors, Omissions, and Other Discrepancies

Submit all errors, omissions, and other discrepancies in contract documents the Contracting Officer within 30 days of contract award for all work covered in this Section, other than the work that will not be uncovered until a later date. All such discrepancies shall be addressed and resolved, and the Coating Work Plan modified, prior to beginning the Initial and Follow-Up phases of work. Discrepancies that become apparent only after work is uncovered shall be identified at the earliest discoverable time and submitted for resolution. Schedule time (Float) should be built into the project schedule at those points where old work

is to be uncovered or where access is not available during the first 30 days after award, to allow for resolution of contract discrepancies.

1.5.2 Corrective Action (CA)

CA shall be included in the Quality Control Plan.

1.5.2.1 Corrective Action Procedures

Develop procedures for determining the root cause of each non-compliance, developing a plan to eliminate the root cause so that the non-compliance does not recur, and following up to ensure that the root cause was eliminated. Develop Corrective Action Request (CAR) forms for initiating CA, and for tracking and documenting each step.

1.5.2.2 Implement Corrective Action

The Contractor shall take action to identify and eliminate the root cause of each non-compliance so as to prevent recurrence. These procedures shall apply to non-compliance in the work, and to non-compliance in the QC System. Corrective actions shall be appropriate to the effects of the non-compliance encountered. Each CAR shall be serialized, tracked in a Log to completion and acceptance by the Contracting Officer, and retained in project records. The Corrective Action Log, showing status of each CAR, shall be submitted to the Contracting Officer monthly. A CAR may be initiated by either the Contractor or the Contracting Officer. The Contracting Officer must approve each CAR at the root cause identification stage, the plan for elimination stage, and the close out stage after verification that the root cause has been eliminated.

1.5.3 Coating Work Plan

This work plan shall be considered as part of the Quality Control Plan.

Provide procedures for reviewing contract documents immediately after award to identify errors, omissions, and discrepancies so that any such issues can be resolved prior to project planning and development of detailed procedures.

Provide procedures for verification of key processes during Initial Phase to ensure that contract requirements can be met. Key processes shall include surface preparation, coating application and curing, inspection, and documentation, and any other process that might adversely impact orderly progression of work.

Provide procedures for all phases of coating operations, including planned work, rework, repair, inspection, and documentation. Address mobilization and setup, surface preparation, coating application, coating initial cure, tracking and correction of noncompliant work, and demobilization. Coordinate work processes with health and safety plans and confined space entry plans. For each process, provide procedures that include appropriate work instructions, material and equipment requirements, personnel qualifications, controls, and process verification procedures. Provide procedures for inspecting work to verify and document compliance with contract requirements, including inspection forms and checklists, and acceptance and rejection criteria.

Provide procedures for correcting noncompliant work. Detailed procedures are required in advance to avoid delays in meeting overcoat windows as

well as to avoid delays in production. Provide procedures for repairing defects in the coating film, such as runs, drips, sags, holidays, overspray, as well as how to handle correct coating thickness noncompliance, any other areas of repair or rework that might be adversely affected by delays in preparing and approving new procedures.

If a procedure is based on a proposed or approved request for deviation, the deviation shall be referenced. Changes to procedures shall be noted by submittal number and date approved, clearly delineating old requirements and new requirements, so that the records provide a continuous log of requirements and procedures.

1.5.4 Design Data

1.5.4.1 Containment System

Submit complete design drawings and calculations for the scaffolding and containment system, including an analysis of the loads which will be added to the structure by the containment system and waste materials. A registered engineer shall approve calculations and scaffold system design.

1.5.5 Test Reports

1.5.5.1 Joint Sealant Qualification Test Reports

Submit test results from independent laboratory of representative samples of joint sealant material. Samples must have been tested within the last three years. Submit results as required in paragraph QUALITY ASSURANCE PROVISIONS of ASTM C920. Note that testing in accordance with QUALITY ASSURANCE PROVISIONS is a pre-qualification requirement.

1.5.5.2 Coatings Qualification Test Reports

Submit test results from independent laboratory of representative samples of each coating material. U.S. Department of Defense laboratories are considered to be independent laboratories for purposes of compliance with "QUALIFICATION INSPECTION" requirements herein. Samples must have been tested within the last three years. Submit results for epoxy materials as required in paragraph QUALIFICATION INSPECTION of MIL-DTL-24441, and as revised by paragraph COATING SYSTEM herein. Submit results for polyurethane materials as required in paragraph QUALIFICATION INSPECTION of MIL-PRF-85285, and as revised by paragraph COATING SYSTEM herein. Note that requirement for QUALIFICATION INSPECTION is a pre-qualification requirement, and involves the same testing required for listing in the Qualified Products List of the respective material. See appropriate Military Specification for specific test requirements.

1.5.5.3 Metallic Abrasive Qualification Test Reports

Submit results for abrasive as required in paragraph 4 REQUIREMENTS of SSPC AB 3. Submit test results from independent laboratory of representative samples of each abrasive to be used on the jobsite. Samples must have been tested within the last three years. Note that this testing is for the purpose of prequalifying the abrasive.

1.5.5.4 Recycled Metallic Abrasive Field Test Reports (Daily and Weekly)

Submit test results from independent laboratory of daily and weekly Quality Control testing required by SSPC AB 2, as modified in paragraph

ABRASIVE.

1.5.6 Qualifications

1.5.6.1 Qualifications of Certified Industrial Hygienist (CIH)

Submit name, address, telephone number, FAX number, and e-mail address of the independent third party CIH. Submit documentation that hygienist is certified by the American Board of Industrial Hygiene in comprehensive practice, including certification number and date of certification/recertification. Provide evidence of experience with hazards involved in industrial coating application work.

1.5.6.2 Qualifications of Certified Protective Coatings Specialist (PCS)

Submit name, address, telephone number, FAX number, and e-mail address of the independent third party PCS. Submit documentation that specialist is certified by SSPC: The Society for Protective Coatings (SSPC) as a PCS, including certification number and date of certification/recertification. If the PCS is employed by the same coating inspection company to which the coating inspector is employed, this does not violate the independent third-party requirements. The PCS shall remain certified during the entire project, and the Contracting Officer shall be notified of any change in certification status within 10 days of the change. The PCS shall not be the designated coating inspector.

1.5.6.3 Qualifications of Coating Inspection Company

Submit documentation that the coating inspection company that will be performing all coating inspection functions is certified by SSPC to the requirements of SSPC QP 5 prior to contract award, and shall remain certified while accomplishing any coating inspection functions. The coating inspection company must remain so certified for the duration of the project. If a coating inspection company's certification expires, the firm will not be allowed to perform any inspection functions, and all surface preparation and coating application work must stop, until the certification is reissued. Requests for extension of time for any delay to the completion of the project due to an inactive certification will not be considered and liquidated damages will apply. Notify the Contracting Officer of any change in coating inspection company certification status.

1.5.6.4 Qualifications of QC Specialist Coating Inspector

Submit documentation that each coating inspector is employed, and qualified to SSPC QP 5, Level III, by the selected coating inspection company. Each inspector shall remain employed by the coating inspection company while performing any coating inspection functions.

1.5.6.5 Qualifications Of Individuals Performing Abrasive Blasting

Submit name, address, and telephone number of each person that will be performing abrasive blasting. Submit documentation that each blaster is qualified by SSPC to the SSPC C-7 Dry Abrasive Blaster Qualification Program. Each blaster shall remain qualified during the entire period of abrasive blasting, and the Contracting Officer shall be notified of any change in qualification status.

1.5.6.6 Qualifications of Testing Laboratory for Coatings

Submit name, address, telephone number, FAX number, and e-mail address of the independent third party laboratory selected to perform testing of coating samples for compliance with specification requirements. Submit documentation that laboratory is regularly engaged in testing of paint samples for conformance with specifications, and that persons performing analyses are qualified.

1.5.6.7 Qualifications of Testing Laboratory for Abrasive

Submit name, address, telephone number, FAX number, and e-mail address of the independent third party laboratory selected to perform testing of abrasive for compliance with specification requirements. Submit documentation that laboratory has experience in testing samples of abrasive for conformance with specifications, and that persons performing analyses are qualified.

1.5.6.8 Qualifications of Coating Contractors

All Contractors and Subcontractors that perform surface preparation or coating application shall be certified to either ISO 9001 or SSPC QP 1 and SSPC QS 1 prior to contract award, and shall remain certified while accomplishing any surface preparation or coating application. The painting Contractors and painting Subcontractors must remain so certified for the duration of the project. If a Contractor's or Subcontractor's certification expires, the firm will not be allowed to perform any work until the certification is reissued. Requests for extension of time for any delay to the completion of the project due to an inactive certification will not be considered and liquidated damages will apply. Notify the Contracting Officer of any change in Contractor certification status.

1.5.6.9 Joint Sealant Materials

Provide manufacturer's certification of conformance to contract requirements.

1.5.6.10 Coating Materials

Provide manufacturer's certification of conformance to contract requirements.

1.5.6.11 Coating System Component Compatibility

Provide certification from each manufacturer of components of the coating system, epoxy primer, epoxy intermediate, and polyurethane topcoat, that the supplied coating material is suitable for use in the specified coating system. Each manufacturer shall identify the specific products, including manufacturer's name, which their product may be used with. The certification shall provide the name of the manufacturer that will provide technical support for the entire system. When all coating materials are manufactured by one manufacturer, this certification is not required.

1.5.6.12 Non-metallic Abrasive

Provide manufacturer's certification that the materials are currently approved by the Naval Sea Systems Command and listed on the Qualified Products Lists (QPL) for the specified materials.

1.5.6.13 Metallic Abrasive

Provide manufacturer's certification of conformance to contract requirements and provide copies of test results.

1.5.7 Protective Coating Specialist (PCS)

The PCS shall be considered a QC Specialist and shall report to the QC Manager, as specified in Section 01 45 00 QUALITY CONTROL. The PCS shall approve all submittals prior to submission to the QC Manager for approval or submission to the government for approval.

1.5.8 Pre-Application Meeting

After approval of submittals but prior to the initiation of coating work, Contractor representatives, including at a minimum, project superintendent and QC manager, paint foreman, coating inspector, and PCS shall have a pre-application coating preparatory meeting. This meeting shall be in addition to the pre-construction conference. Specific items addressed shall include: corrective action requirements and procedures, coating work plan, safety plan, coordination with other Sections, inspection standards, inspection requirements and tools, test procedures, environmental control system, safety plan, and test logs. Notify Contracting Officer at least ten days prior to meeting.

1.6 PRODUCT DATA

1.6.1 Joint Sealant Instructions

Submit manufacturer's printed instructions including detailed application procedures, minimum and maximum application temperatures, and curing procedures. Include Safety Data Sheets (SDS) for materials to be used at the job site in accordance with 29 CFR 1926.59.

1.6.2 Coating System Instructions

Submit manufacturer's printed instructions including detailed mixing and application procedures, number and types of coats required, minimum and maximum application temperatures, and curing procedures. Include Safety Data Sheets (SDS) for materials to be used at the job site in accordance with 29 CFR 1926.59.

1.7 DELIVERY AND STORAGE

Ship, store, and handle materials in accordance with SSPC PA 1, and as modified in this Section. Maintain temperature in storage spaces between 40 and 85 degrees F, and air temperature more than 5 degrees F above the dew-point at all times. Inspect materials for damage prior to use and return non-compliant materials to manufacturer. Remove materials with expired shelf life from government property immediately and notify the Contracting Officer.

If materials are approaching shelf life expiration and an extension is desired, samples may be sent to the manufacturer, along with complete records of storage conditions, with a request for shelf life extension. If the manufacturer finds the samples and storage data suitable for shelf life extension, the manufacturer may issue an extension, referencing the product evaluation and the review of storage records. Products may not be

extended longer than allowed in the product specification.

1.8 COATING HAZARDS

Ensure that employees are trained in all aspects of the safety plan. Specified coatings may have potential health hazards if ingested or improperly handled. The coating manufacturer's written safety precautions shall be followed throughout mixing, application, and curing of the coatings. During all cleaning, cleanup, surface preparation, and paint application phases, ensure that employees are protected from toxic and hazardous chemical agents which exceed concentrations in 29 CFR 1910.1000. Comply with respiratory protection requirements in 29 CFR 1910.134. The CIH shall approve work procedures and personal protective equipment.

1.9 JOB SITE REFERENCES

Make available to the Contracting Officer at least one copy each of ASTM D3276, ASTM D3925, ASTM D4285, ASTM D7127, SSPC SP COM, SSPC SP 1, SSPC 7/NACE No.4, SSPC SP 10/NACE No. 2, SSPC PA 1, SSPC PA 2, SSPC Guide 6, SSPC VIS 1, SSPC QP 1, SSPC QS 1, and an SSPC Certified Contractor Evaluation Form at the job site.

PART 2 PRODUCTS

2.1 JOINT SEALANT

TT-S-00230, Type II, Class B

2.2 COATING SYSTEM

Alternate systems or products will not be considered. Provide a complete system (primer, intermediate coat, top coat) material from one supplier.

Primary method of application is to be shop applied but on minor areas as coordinated with the Contracting Officer for field application, confirm compatibility of shop-applied primer with coating system and if shop-applied primer is not compatible with final coating system, remove all shop-applied primer prior to final field surface preparation and coating system application. Adjust all shop preparation to avoid conflicts with final surface preparation requirements.

Prepare surface and apply the complete coating system in the shop. Follow all temperature, humidity, and testing requirements listed herein.

The Military specification epoxy and polyurethane products specified in this Section do not require approval for listing on the QPL prior to contract award, as indicated in paragraph 3.2 of MIL-DTL-24441 and paragraph 3.1 of MIL-PRF-85285. Testing of products by an independent laboratory to the QUALIFICATION INSPECTION requirements of MIL-DTL-24441 and MIL-PRF-85285prior to contract award is required. See specific submittal requirements in paragraph QUALITY ASSURANCE.

2.2.1 Zinc-Rich Epoxy Primer Coat

Epoxy polyamide, MIL-DTL-24441/19 (Formula 159, Type III).

2.2.2 Epoxy Intermediate Coat

Epoxy polyamide, MIL-DTL-24441/31 (Formula 152, Type IV, White (Tinted)).

Tint to approximately SAE AMS-STD-595A color number 27778 parchment using pigment dispersions prepared for epoxy paint tinting. Manufacturer shall tint material and appropriately label. All other requirements of this Military Specification apply.

2.2.3 Polyurethane Topcoat

Polyurethane coating topcoat of MIL-PRF-85285, Type II, White SAE AMS-STD-595A color number 17925.

Modify paragraph 3.6.4 of MIL-PRF-85285, Viscosity and Pot Life, as follows:

The viscosity of the admixed coating, when tested in accordance with ASTM D1200 through a No. 4 Ford cup, shall be as follows:

Time from mix (minimum)	Maximum time through a No. 4 Ford cup
Initially	30 seconds
2 hours	60 seconds
4 hours	No gel

Modify paragraph 3.7.1 of MIL-PRF-85285, Drying Time, as follows:

When applied by spray techniques and when tested in accordance with ASTM D1640/D1640M, the coating shall be set-to-touch within four hours and dry-hard within eight hours (see 4.6 and table I).

Color to match adjacent surface color as identified in the Architectural exterior finish information in the drawings, finish schedule. Items not identified, confirm with Government or Architect before application.

Provide color as indicated, and as specified in applicable Division 22, 23, and 26 Sections for pipe color coding; colors listed are not intended to limit the selection of equal colors from other manufacturers.

2.3 COATING SAMPLE COLLECTION AND SHIPPING KIT

Provide a kit that contains one quart can for the base of each coating material, an appropriately sized can for each activator, dipping cups for each component to be sampled, a shipping box sized for the samples to to be shipped, and packing material. Mark cans for the appropriate component. Provide shipping documents, including either pre-paid shipping or a shipper number that can be used by the QC Manager to arrange pickup, addressed to the approved coating testing laboratory.

2.4 ABRASIVE SAMPLE COLLECTION AND SHIPPING KIT

Provide a kit that contains one suitable plastic bag or container for each sample to be collected. Mark containers for the appropriate component. Provide shipping documents, including either pre-paid shipping or a shipper number that can be used by the QC Manager to arrange pickup, addressed to the approved coating testing laboratory.

2.5 TEST KITS

2.5.1 Test Kit for Measuring Chloride, Sulfate and Nitrate Ions on Steel and Coated Surfaces

Provide test kits that meet all of the following requirements:

a. Contains all materials,supplies, tools, and instructions for field testing and on-site quantitative evaluation of chloride, sulfate, and nitrate ions;

b. Extract solution is acidic, factory pre-measured, pre-packaged, and of uniform concentration;

c. Components and solutions are mercury free and environmentally friendly;

d. Contains new materials and solutions for each test extraction;

e. Contains an extraction test container (vessel, sleeve, cell) that creates a sealed, encapsulated environment during salt ion extraction;

f. Contains a test extract container suitable for testing the following steel surfaces: horizontal (up/down configuration), vertical, flat, curved, smooth, pitted, and rough;

g. All salt ion concentrations are directly measured in micrograms per square centimeter.

2.5.2 Test Kit for Identifying Amine Blush on Epoxy Surfaces

Provide test kits that meet all of the following requirements:

a. Is a completely self-contained field test kit with all materials, supplies, tools, and instructions to perform tests and indicate the presence of unreacted amines;

b. Uses an identifiable, consistent, uniform, pre-packaged, factory pre-measured indicating solution;

c. Contains no mercury or lead and is environmentally friendly;

d. Contains a solution of an unreacted amine for the purpose of "self checking" the indicator solution;

2.6 ABRASIVE

The referenced abrasive specifications have maximum limits for soluble salts contamination, however, this maximum level of contamination does not guarantee that contamination will not be transferred to the steel surface during abrasive blasting. Other factors such as on-site handling and recycling can allow contamination of abrasive. Contractors are cautioned to verify that the chosen abrasive, along with work and storage processes, allow the final surface cleanliness requirements to be achieved. Successful testing of chlorides in abrasive does not negate the final acceptance testing of steel surfaces.

Interpret MIL-A-22262 to include the meaning that abrasive material contains a maximum one percent by weight of any toxic substance listed in either Table Z-1, Z-2, or Z-3 or 29 CFR 1910-SUBPART Z, with the

exception of inert or nuisance dust materials, arsenic, beryllium, cadmium, cobalt, lead, mercury, rhodium, silver, tellurium, thallium, and uranium.

2.6.1 Non-metallic Abrasive

Conform to MIL-A-22262, Type I (Inorganic materials) except that the gross gamma radioactivity shall not exceed 5 picocuries per gram. Abrasive shall be approved by the Naval Sea Systems Command and listed on the appropriate Qualified Products List (QPL) for the specified materials. Use sampling procedures and testing frequencies as prescribed in MIL-A-22262. Use abrasive that is specifically selected and graded to provide a sharp, angular profile to the specified depth. Do not use ungraded abrasive. Make adjustments to processes or abrasive gradation to achieve specified surface profile. Recycled non-metallic abrasive shall meet all requirements of the specification each time that it is placed in the blast pot.

2.6.2 Metallic Abrasive

2.6.2.1 New and Remanufactured Steel Grit

Conform to the chemical and physical properties of SSPC AB 3 Class 1 (Steel) only, except that the gross gamma radioactivity shall not exceed 5 picocuries per gram. Class 2 (Iron) abrasive shall not be used.

To develop a suitable work mix from new steel abrasive, a minimum of 200 - 400 recycles is required, therefore, it is advantageous for a Contractor to use remanufactured steel grit or grit reclaimed from a previous project. Such grit shall be considered to conform if it can be traced to new grit conforming to SSPC AB 3 Class 1 and it meets all cleanliness requirements of SSPC AB 3 Class 1 when brought to the current jobsite. Submit one representative sample of this work mix to the laboratory for testing, along with samples of new material. Acceptance and use of this work mix shall not be used to justify any deviation from surface preparation requirements.

2.6.2.2 Recycled Steel Grit

Conform to the chemical and physical properties of SSPC AB 2

2.7 WHITE ALUMINUM OXIDE NON-SKID GRIT

Size #60, dust free (washed and dry), minimum 99 percent pure, having the following sieve analysis when tested in accordance with ASTM E11 using a 2.2 pound sample:

Sieve #	Percent Retained
40	0
50	15-40
60	60-85

PART 3 EXECUTION

Perform all work, rework, and repair in accordance with approved procedures in the Coating Work Plan.

3.1 COATING AND ABRASIVE SAMPLE COLLECTION AND TESTING

Sample and test materials delivered to the jobsite. Notify Contracting Officer three days in advance of sampling. The QC Manager and either the PCS or coating inspector shall witness all sampling.

3.1.1 Coating Sample Collection

Provide a sample collection kit as required in paragraph COATING SAMPLE COLLECTION AND SHIPPING KIT. From each lot, obtain a one quart sample of each base material, and proportional samples of each activator based on mix ratio, by random selection from sealed containers in accordance with ASTM D3925. Prior to sampling, mix contents of each sealed container to ensure uniformity. As an alternative to collecting small samples from kits, entire kits may be randomly selected and shipped to laboratory, observing all requirements for witnessing and traceability. For purposes of quality conformance inspection, a lot is defined as that quantity of materials from a single, uniform batch produced and offered for delivery at one time. A batch is defined as that quantity of material processed by the manufacturer at one time and identified by number on the label. Identify samples by designated name, specification number, batch number, project contract number, sample date, intended use, and quantity involved. The QC manager will take possession of the packaged samples, contact the shipping company to arrange for pickup, and relinquish the samples only to the shipping representative for shipment to the approved laboratory for testing as required by the paragraph COATING SAMPLE TEST REPORTS.

3.1.2 Abrasive Sample Collection

Provide a sample collection kit as required in paragraph ABRASIVE SAMPLE COLLECTION AND SHIPPING KIT. For purposes of quality conformance inspection, a lot shall consist of all abrasive materials of the same type from a single, uniform batch produced and offered for delivery at one time. Obtain samples of each abrasive lot using the sampling techniques and schedule of MIL-A-22262. The addition of any substance to a batch shall constitute a new lot. Identify samples by designated name, specification number, lot number, project contract number, sample date, intended use, and quantity involved. The QC manager will take possession of the packaged samples, contact the shipping company to arrange for pickup, and relinquish the samples only to the shipping representative for shipment to the approved laboratory for testing as required by the paragraph ABRASIVE SAMPLE TEST REPORTS.

3.1.3 Coating Sample Test Reports

Submit test results for each lot of coating material delivered to the jobsite. Test samples of primer, intermediate, and topcoat materials for compliance with requirements of Table I. Reject entire lot represented by samples that fail one or more tests, select new lots, and test samples.

3.1.4 Abrasive Sample Test Reports

Submit test results for each lot of abrasive delivered to the jobsite. Test samples of metallic abrasive to the requirements of paragraph REQUIREMENTS of SSPC AB 3, except paragraph 4.1.5 DURABILITY. Test samples of non-metallic abrasive as required in paragraph QUALITY CONFORMANCE INSPECTION of MIL-A-22262. Reject entire lot represented by

samples that fail one or more tests, select new lots, and test samples.

3.2 SURFACES TO BE COATED

Coat ferrous metal primary and secondary steel framing inside the aircraft maintenance bays and hangar doors according to this section.

3.3 LIGHTING

Provide lighting for all work areas as prescribed in SSPC Guide 12.

3.4 ENVIRONMENTAL CONDITIONS

3.4.1 Containment

Design and provide a containment system for the capture, containment, collection, storage and disposal of the waste materials generated by the work under this Section, to meet the requirements of SSPC Guide 6, Class 1. Vapor concentrations shall be kept at or below 10 percent of Lower Explosive Limit (LEL) at all times. Containment may be designed as fixed containment for complete structure or portable containment for sections of structure, however, containment shall remain in any one place from beginning of abrasive blasting through initial cure of coating. Waste materials covered by this paragraph shall not include any material or residue from removal of coatings containing lead, chromium, cadmium, PCB, or any other hazardous material.

It is the Contractors responsibility to insure the feasibility and workability of the containment system. The Contractor shall perform his operations and work schedule in a manner as to minimize leakage of the containment system. The containment system shall be properly maintained and shall not deviate from the approved drawings. If the containment system fails to function satisfactorily, the Contractor shall suspend all operations, except those required to minimize adverse impact on the environment or government property. Operations shall not resume until modifications have been made to correct the cause of the failure.

3.4.2 Automated Monitoring Requirements

Provide continuous monitoring of temperature, relative humidity, and dew point data at pertinent points on the structure, during surface preparation, coating application, and initial cure. Locate sensors to provide pertinent data for the surface preparation and coat application being performed. Monitor any heating, cooling, or dehumidification equipment used. Make data available to the Contracting Officer through Internet access. Provide monitoring equipment to perform as follows:

a. Data is collected in the field unit in one minute increments, and available for download (on-site) in a standard format. Contractor shall collect this data and make available to the Contracting Officer;

b. Monitoring equipment shall have backup power such that data collection and transmission to web server will be uninterrupted during the entire period of the dehumidification requirement;

c. Monitoring equipment shall have capability to measure surface temperatures at a minimum of four locations anywhere on a 150 foot diameter by 50 foot high tank;

d. Monitoring equipment shall have capability to measure interior and exterior dry bulb temperature (DB), relative humidity (RH), and dewpoint temperature (DP);

e. Data shall be available continuously through secure Internet connection, using widely available web browsers;

f. Internet accessible data shall be collected and stored in maximum 15 minute increments, and lag time between data collection and online availability shall be no greater than 70 minutes;

g. Internet accessible data shall be available for viewing online in tabular format, and graphical format using selected data;

h. Internet accessible data shall be available for download in user-defined segments, or entire project to date, in a standard format usable by Microsoft Excel and other spreadsheet programs.

i. Internet-based controls shall provide alerts to pre-designated parties through email messaging;

j. Internet-based controls shall monitor data uploads from field unit and issue alert if data not initiated within 60 minutes of last upload;

k. Internet-based controls shall monitor operation of DH equipment and issues alert when power remains off for more than 15 seconds, or if pre-determined temperature, RH, or DP conditions are exceeded;

The requirements listed here were developed around the Munters Exactaire Monitoring System, as this was the only monitoring system having Internet connectivity known to be commercially available. There is no requirement for connectivity of the monitoring system to control the DH equipment, therefore, any combination of equipment having the required functionality will be accepted.

3.5 SURFACE PREPARATION

3.5.1 Abrasive Blasting Equipment

Use abrasive blasting equipment of conventional air, force-feed, or pressure type. Maintain a minimum pressure of 95 psig at nozzle. Confirm that air supply for abrasive blasting is free of oil and moisture when tested in accordance with ASTM D4285. Test air quality at each startup, but in no case less often than every five operating hours.

3.5.2 Operational Evaluation of Abrasive

Test abrasive for salt contamination and oil contamination as required by the appropriate abrasive specification daily at startup and every five operating hours thereafter.

3.5.3 Surface Standard

Inspect surfaces to be coated, and select plate with similar properties and surface characteristics for use as a surface standard. Blast clean one or more one foot square steel panels as specified in paragraph SURFACE PREPARATION. Record blast nozzle type and size, air pressure at nozzle and compressor, distance of nozzle from panel, and angle of blast to establish procedures for blast cleaning. Measure surface profile in

accordance with ASTM D7127. When the surface standard complies with all specified requirements, seal with a clearcoat protectant. Use the surface standard for comparison to abrasive blasted surfaces throughout the course of work.

3.5.4 Pre-Preparation Testing for Surface Contamination

Perform testing, abrasive blasting, and testing in the prescribed order.

3.5.4.1 Pre-Preparation Testing for Oil and Grease Contamination

Inspect all surfaces for oil and/or grease contamination using two or more of the following inspection techniques: 1) Visual inspection, 2) WATER BREAK TEST, 3) CLOTH RUB TEST. Reject oil and/or grease contaminated surfaces, clean using a water based pH neutral degreaser in accordance with SSPC SP 1, and recheck for contamination until surfaces are free of oil and grease.

WATER BREAK TEST - Spray atomized mist of distilled water onto surface, and observe for water beading. If water "wets" surface rather than beading up, surface can be considered free of oil or grease contamination. Beading of water (water forms droplets) is evidence of oil or grease contamination.

CLOTH RUB TEST - Rub a clean, white, lint free, cotton cloth onto surface and observe for discoloration. To confirm oil or grease contamination in lightly stained areas, a non-staining solvent may be used to aid in oil or grease extraction. Any visible discoloration is evidence of oil or grease contamination.

3.5.4.2 Pre-Preparation Testing for Soluble Salts Contamination

Test surfaces for soluble salts, and wash as required, prior to abrasive blasting. Soluble salt testing is also required in paragraph PRE-APPLICATION TESTING FOR SOLUBLE SALTS CONTAMINATION as a final acceptance test of prepared surfaces after abrasive blasting, and successful completion of this phase does not negate that requirement. This phase is recommended since pre-preparation testing and washing are generally more advantageous than attempting to remove soluble salt contamination after abrasive blasting. Effective removal of soluble salts will require removal of any barrier to the steel surface, including rust. This procedure may necessitate combinations of wet abrasive blasting, high pressure water rinsing, and cleaning using a solution of water washing and soluble salts remover. The soluble salts remover shall be acidic, biodegradable, nontoxic, noncorrosive, and after application, will not interfere with primer adhesion. Delays between testing and preparation, or testing and coating application, may allow for the formation of new contamination. Use potable water, or potable water modified with soluble salt remover, for all washing or wet abrasive blasting. Test methods and equipment used in this phase are selected at the Contractor's discretion.

3.5.5 Abrasive Blasting

Abrasive blast steel surfaces to near-white metal in accordance with SSPC SP 10/NACE No. 2. Prepared surfaces shall conform to SSPC VIS 1 and shall match the prepared test-panels. Provide a 2 to 3 mil surface profile. Reject profile greater than 3 mils, discontinue abrasive blasting, and modify processes and materials to provide the specified profile. Measure surface profile in accordance with ASTM D7127, using

Rmax as the measure of profile height. Record all measurements required in this standard. Measure profile at rate of three test areas for the first 1000 square feet plus one test area for each additional 1000 square feet or part thereof. When surfaces are reblasted for any reason, retest profile as specified. Following abrasive blasting, remove dust and debris by vacuum cleaning. Do not attempt to wipe surface clean.

3.5.6 Disposal of Used Abrasive

Dispose of used abrasive off Government property in accordance with Federal, State, and Local mandated regulations.

3.5.7 Pre-Application Testing For Surface Contamination

3.5.7.1 Pre-Application Testing for Oil and Grease Contamination

Ensure surfaces are free of contamination as described in paragraph PRE-PREPARATION TESTING FOR OIL AND GREASE CONTAMINATION, except that only questionable areas need be checked for beading of water misted onto surface.

3.5.7.2 Pre-Application Testing for Soluble Salts Contamination

Test surfaces for chloride contamination using the Test Kit described in TEST KIT FOR MEASURING CHLORIDE, SULFATE AND NITRATE IONS ON STEEL AND COATED SURFACES. Test all surfaces at rate of three tests for the first 1000 square feet plus one test for each additional 2000 square feet or part thereof. Concentrate testing of bare steel at areas of coating failure to bare steel and areas of corrosion pitting. Perform 30 percent of tests on bare steel at welds, divided equally between horizontal and vertical welds. One or more readings greater than 3 micrograms per square centimeter of chlorides or 10 micrograms per square centimeter of sulfates or 5 micrograms per square centimeter of nitrates is evidence of soluble salt contamination. Reject contaminated surfaces, wash as discussed in paragraph PRE-PREPARATION TESTING FOR SOLUBLE SALTS CONTAMINATION, allow to dry, and re-test until all required tests show allowable results. Reblast tested and cleaned areas as required. Label all test tubes and retain for test verification.

3.5.7.3 Pre-Application Testing for Surface Cleanliness

Apply coatings to dust free surfaces. To test surfaces, apply strip of clear adhesive tape to surface and rub onto surface with finger. When removed, the tape should show little or no dust, blast abrasive, or other contaminant. Reject contaminated surfaces and retest. Test surfaces at rate of three tests for the first 1000 square feet plus one test for each additional 1000 square feet or part thereof. Provide two additional tests for each failed test or questionable test. Attach test tapes to Daily Inspection Reports.

3.6 MIXING AND APPLICATION OF SEALANT AND COATING SYSTEM

3.6.1 Preparation of Sealant and Coating Materials for Application

Each of the sealant, primer, intermediate, and topcoat materials is a two-component material supplied in separate containers.

3.6.1.1 Mixing Sealant, Primer and Intermediate Coat Materials

Mix in accordance with manufacturer's instructions, which may differ for each product. Do not mix partial kits, or alter mix ratios. Mix materials in same temperature and humidity conditions specified in paragraph DELIVERY AND STORAGE. Allow mixed material to stand for the required induction time based on its temperature.

3.6.1.2 Mixing Topcoat Material

Do not mix partial kits, or alter mix ratios. Mix polyurethane coating materials in same temperature conditions specified in paragraph DELIVERY AND STORAGE. The polyurethane coating material is moisture sensitive and any introduction of moisture or water into the material during mixing or application will shorten usable pot life. Use a mixer that does not create a vortex. Do not add solvent without specific written recommendation from the manufacturer. No induction time is required, only thorough agitation of the mixed material.

3.6.1.3 Pot Life

Apply mixed products within stated pot life for each product. Stop applying when material becomes difficult to apply in a smooth, uniform wet film. Add all required solvent at time of mixing. Do not add solvent to extend pot life. Pot life is based on standard conditions at 70 degrees F and 50 percent relative humidity. For every 18 degrees F rise in temperature, pot life is reduced by approximately half, and for every 18 degrees F drop it is approximately doubled. Usable pot life depends on the temperature of the material at the time of mixing and the sustained temperature at the time of application. Other factors such as the shape of the container and volume of mixed material may also affect pot life. Precooling or exterior icing of components for at least 24 hours to a minimum of 50 degrees F in hot climates will extend pot life. High humidity at time of mixing and application shortens pot life of the Polyurethane topcoat material. Following are approximate pot life times:

Sealant	As specified by manufacturer
Epoxy primer and intermediate materials	4 hours
Polyurethane topcoat materials	2 hours.

3.6.1.4 Application Conditions and Recoat Windows

The application condition requirements for the coating system are very time and temperature sensitive, and are intended to avoid the delamination problems frequently found on industrial structures. Plan coating application to ensure that specified temperature, humidity, and condensation conditions are met. If conditions do not allow for orderly application of sealant, primer, stripe coat, intermediate coat and topcoat, use appropriate means of controlling air and surface temperatures, as required. Partial or total enclosures, insulation, heating or cooling, or other appropriate measures may be required to control conditions to allow for orderly application of all required coats.

Maintain air and steel surface temperature between 60 and 100 degrees F during application and the first four hours of cure for epoxy coats and the first eight hours of cure for polyurethane coats. Maintain steel surface temperature more than 5 degrees F above the dew-point of the ambient air for the same period.

Use Table entitled "RECOAT WINDOWS" to determine appropriate recoat windows for each coat after the initial coat. Apply each coat during appropriate RECOAT WINDOW of preceding coat. If a RECOAT WINDOW is missed, the minimum and maximum primer and intermediate coat thickness may be adjusted to accommodate a FILL COAT, however, requirements for total epoxy coating thickness and total coating thickness will not be modified. Missing more than one RECOAT WINDOW may require complete removal of coating if maximum total coating thickness requirements cannot be achieved.

If coating is not applied during RECOAT WINDOW, or if surface temperature exceeds 120 degrees F between applications, provide GLOSS REMOVAL, apply next coat within 24 hours. If next planned coat is topcoat, apply FILL COAT if required to fill sanding marks. Sanding marks from GLOSS REMOVAL of intermediate coat reflecting through topcoat will be considered as noncompliant. Apply FILL COAT within 24 hours of GLOSS REMOVAL, then apply topcoat within RECOAT WINDOW of FILL COAT.

RECOAT WINDOWS						
EPOXY OVER EPOXY						
Temperature degrees F	60-70	71-80	12-36	91-100	101-110	111-120
RECOAT WINDOW (Hrs.)	24-72	18-60	16-48	12-36	8-18	4-6
POLYURETHANE OVER EPOXY						
Temperature degrees F	60-70	71-80	12-36	91-100	101-110	111-120
RECOAT WINDOW (Hrs.)	24-96	24-72	16-48	12-36	10-24	8-16
POLYURETHANE OVER POLYURETHANE						
Temperature degrees F	60-70	71-80	12-36	91-100	101-110	111-120

RECOAT WINDOWS						
RECOAT WINDOW (Hrs.)	8-48	6-48	4-36	3-24	2-12	1-2

The temperature ranges shown in the table above are for determining recoat windows. Choose recoat window based on the highest surface temperature that was sustained for one or more hours between coats. This applies to the entire time between coats. Measure and record air and surface temperatures on hourly basis to determine appropriate recoat windows. If surface temperature goes above 100 degrees F, measure and record temperatures every half hour.

FILL COAT - Where indicated, apply coat of intermediate coat epoxy, at 2 to 3 mils DFT, then apply next specified full coat within recoat window of FILL COAT. A FILL COAT may be used to adjust coating thickness to comply with requirements or to fill sanding marks in intermediate coat.

GLOSS REMOVAL - Where required, hand sand in a linear fashion to remove gloss using 120-200 grit wet/dry sandpaper, followed by solvent wiping with a clean rag soaked with denatured alcohol to remove all dust. GLOSS REMOVAL of primer coat is to scarify surface and shall consist of removal of approximately 1 mil of coating. If steel is exposed during GLOSS REMOVAL, repair in accordance with paragraph PROCEDURE FOR HOLIDAY AND SPOT REPAIRS OF NEWLY APPLIED COATING. GLOSS REMOVAL of intermediate coat may include removal of up to 3 mils of coating to avoid excess thickness, prior to application of FILL COAT.

3.6.2 Amine Blush Testing of Epoxy Coat Prior to Overcoating

Test epoxy surfaces prior to application of roof joint sealant, epoxy coat, or polyurethane topcoat for amine blush contamination using the Test Kit described in paragraph TEST KIT FOR IDENTIFYING AMINE BLUSH ON EPOXY SURFACES. Test all surfaces at rate of three tests for the first 1000 square feet plus one test for each additional 2000 square feet or part thereof. Remove any identified contamination using an approved procedure.

3.6.3 Application of Coating System and Joint Sealant

Apply coatings in accordance with SSPC PA 1 and as specified herein. Apply coatings to surfaces that meet all stated surface preparation requirements.

After application of primer coat and prior to application of each subsequent coat, perform testing prescribed in paragraph PRE-APPLICATION TESTING FOR SURFACE CONTAMINATION, as necessary, to ensure minimal intercoat contamination. This testing may be reduced to one half of the prescribed rate for bare steel if the testing indicates no contamination when sampling is evenly distributed over surfaces being tested. If contamination is found between coats, revert to the specified testing rate. Generally, oil and grease contamination and soluble salts contamination are not encountered if subsequent coats are applied within specified recoat windows and unusual atmospheric events do not occur. Such atmospheric events as a coastal storm blowing onshore can bring unusual chloride contamination. Concern for intercoat contamination should be continually prevalent, and spot testing should be accomplished

to verify satisfactory conditions. Where visual examination or spot testing indicates contamination, perform sufficient testing to verify non-contamination, or to define extent of contamination for appropriate treatment.

Apply each coat in a consistent wet film, at 90 degrees to previous coat. Ensure that primer and intermediate coat "cold joints" are no less than six inches from welds. Apply stripe coat by brush. For convenience, stripe coat material may be delivered by spray if followed immediately with brush-out and approved procedures include appropriate controls on thickness. Apply all other coats by spray application. Use appropriate controls to prevent airborne coating fog from drifting beyond 15 feet from the structure perimeter. Cover or protect all surfaces that will not be coated. The cleanliness, temperature, recoat windows, and airborne paint containment requirements may necessitate the use of enclosures, portable shelters, or other appropriate controls.

Apply coatings at the following specified thickness:

Coat	Minimum DFT (Mils)	Maximum DFT (Mils)
Primer	3	5
Intermediate	3	5
Top	2	3
Total system	8	13

3.6.3.1 Application of Primer

Apply primer coat, maintaining paint supply container height within 3 feet of the paint nozzle for applying zinc primer. Maintain constant agitation of paint pot to ensure that zinc does not settle in container.

3.6.3.2 Application of Stripe Coat

Apply a stripe coat of intermediate coat epoxy material within RECOAT WINDOW of primer, allowing sufficient dry time to allow application of intermediate coat within RECOAT WINDOW of primer. Apply by brush, working material into corners, crevices, angles, and welds, and onto outside corners and angles.

3.6.3.3 Application of Intermediate Coat

Apply intermediate coat within RECOAT WINDOW of primer coat.

3.6.3.4 Non-skid for Stairs and Top

Where non-skid is required, apply a second intermediate coat, and immediately follow with application of non-skid grit, broadcast at the rate of 2 pounds per 100 square feet, and backroll. Apply topcoat as specified.

3.6.3.5 Application of Topcoat

Make all required repairs to primer and intermediate coats as specified in paragraph entitled "Procedure for Holiday and Spot Repairs of Newly

Applied Coating" prior to applying topcoat. Apply topcoat within RECOAT WINDOW of intermediate coat. The polyurethane topcoat may require multiple passes to achieve desired aesthetics and required thickness. Consult manufacturer for thinning and application procedures for anticipated temperature, humidity, and wind conditions. Touch-up blemishes and defects within recoat window of polyurethane topcoat. Retain sample of polyurethane topcoat, from the same batch used to coat structure, to make touch-ups that might be required later.

3.6.3.6 Application of Joint Sealant

Apply joint sealant to back-to-back steel joints that are less that 3/8 inches wide and are not seal welded. Apply sealant to top and bottom, or each side, of narrow joints. Apply sealant within 48 hours of application of the topcoat, and touch-up with topcoat after appropriate cure of the sealant.

3.6.3.7 Procedure for Holiday and Spot Repairs of Newly Applied Coating

Repair coating film defects at the earliest practicable time, preferably before application of the succeeding coat. Observe all requirements for soluble salts contamination, cleanliness between coats, and application conditions. Prepare defective area in accordance with SSPC SP 10/NACE No. 2, and feather coating as required to leave 4 inches of each succeeding coat feathered and abraded. Protect adjacent areas from damage and overspray. Remove dust and solvent wipe the prepared area plus an additional 4 inches beyond the prepared area with clean denatured alcohol. Apply each coat within RECOAT WINDOW of preceeding coat. Within four hours of preparation, apply zinc-rich primer to prepared steel and feather onto prepared primer. Apply intermediate coat to primed area and feather to prepared intermediate area. Apply topcoat to intermediate coat and feather to prepared topcoat. Apply each repair coat to approximate thickness of surrounding coating system.

3.6.3.8 Structure Occupancy After Coating Application

Use clean canvas or other approved shoe covers when walking on coated surfaces, regardless of curing time allowed. For heavily trafficked areas, provide cushioned mats for additional protection.

3.7 PROJECT IDENTIFICATION

At the completion of the work, stencil the following information on the structure in 3/4 to one inch Helvetica style letters of contrasting color using acrylic stencil paint with final locations coordinated with the Government:

Date exterior coated:
Project Number:
Contractor:
Address:
Coating System
Surface Prep: SSPC SP ____ Profile: _____
Primer: _____ Thickness: ____
Intermediate: _____ Thickness: ____
Topcoat: _____ Thickness: ____
Total Thickness: _____

3.8 FIELD QUALITY CONTROL

3.8.1 Coating Inspector

The coating inspector shall be considered a QC Specialist and shall report to the QC Manager, as specified in Section 01 45 00.00 40 QUALITY CONTROL. The Coating Inspector shall be present during all pre-preparation testing, surface preparation, coating application, initial cure of the coating system, during all coating repair work, and during completion activities as specified in Section 01 45 00 QUALITY CONTROL. The Coating Inspector shall provide complete documentation of conditions and occurrences on the job site, and be aware of conditions and occurrences that are potentially detrimental to the coating system. The requirements for inspection listed in this Section are in addition to the QC inspection and reporting requirements specified in Section 01 45 00 QUALITY CONTROL.

3.8.2 Field Inspection

3.8.2.1 Inspection Requirements

Perform field inspection in accordance with ASTM D3276 and the approved Coating Work Plan. Document Contractor's compliance with the approved Coating Work Plan.

Provide all tools and instruments required to perform the required testing, as well as any tools or instruments that the inspector considers necessary to perform the required inspections and tests. Document each inspection and test, including required hold points and other required inspections and tests, as well as those inspections and tests deemed prudent from on-site evaluation to document a particular process or condition, as follows:

a. Location or area;
b. Purpose (required or special);
c. Method;
d. Criteria for evaluation;
e. Results;
f. Determination of compliance;
g. List of required rework;
h. Observations.

Collect and record Environmental Conditions as described in ASTM D3276 on a 24 hour basis, as follows:

a. During surface preparation, every two hours or when changes occur;

b. During coating application and the first four days of initial cure, every hour, or when changes occur;

c. Note location, time, and temperature of the highest and lowest surface temperatures each day;

d. Use a non-contact thermometer to locate temperature extremes, then verify with contact thermometers.

Document all equipment used in inspections and testing, including manufacturer, model number, serial number, last calibration date and future calibration date, and results of on-site calibration performed.

Document Contractors compliance with the approved Coating Work Plan.

3.8.2.2 Inspection Report Forms

Develop project-specific report forms as required to report measurements, test results, and observations being complete and and conforming to contract requirements. This includes all direct requirements of the contract documents and indirect requirements of referenced documents. Show acceptance criteria with each requirement and indication of conformity of each inspected item. The data may be in any format, but must be legible and presented so that entered data can be quickly compared to the appropriate requirement.

3.8.2.3 Daily Inspection Reports

Submit one copy of daily inspection report completed each day when performing work under this Section, to the Contracting Officer. Note all non-compliance issues, and all issues that were reported for rework in accordance with QC procedures of Section 01 45 00 QUALITY CONTROL. Each report shall be signed by the coating inspector and the QC Manager. Submit report within 24 hours of date recorded on the report.

3.8.2.4 Inspection Logbook

A continuous record of all activity related to this Section shall be maintained in an Inspection Logbook on a daily basis. The logbook shall be hard or spiral bound with consecutively numbered pages, and shall be used to record all information provided in the Daily Inspection Reports, as well as other pertinent observations and information. The Coating Inspector's Logbook that is sold by NACE is satisfactory. Submit the original Inspection Logbook to the Contracting Officer upon completion of the project and prior to final payment.

3.8.2.5 Inspection Equipment

All equipment shall be in good condition, operational within its design range, and calibrated as required by the specified standard for use of each device.

3.9 FINAL CLEANUP

Following completion of the work, remove debris, equipment, and materials from the site. Remove temporary connections to Government or Contractor furnished water and electrical services. Restore existing facilities in and around the work areas to their original condition.

TABLE 1

COATING QUALITY CONFORMANCE INSPECTION REQUIREMENTS

Table Ia - Zinc-rich Epoxy Primer Coat MIL-DTL-24441/19 Formula 159

Test	Component A		Component B		Mixed	
	Min.	Max.	Min.	Max.	Min.	Max.
Pigment content, percent (zinc dust)	---	---	81.5	85.5	---	---
Volatiles, percent	42.8	44.3	8.0	8.4	---	---
Non-volatile vehicle percent	53.7	57.7	8.3	8.7	---	---
Weight, Kilograms/liter	0.87	1.01	3.30	3.40	2.80	2.91
Weight, Pounds/gallon	7.3	8.4	27.5	28.4	23.4	24.4
Flashpoint, Degrees C	35.6	---	37.8	---	---	---
Flashpoint, Degrees F	96	---	100	---	---	---
Consistency, grams	---	---	250	500	150	300
Set to touch time, hours at 23 degrees C, 73 degrees F	---	---	---	---	---	2
Dry hard time, hours at 23 degrees C, 73 degrees F	---	---	---	---	---	8
Pot life, hours at 23 degrees C, 73 degrees F	---	---	---	---	4	---
Sag resistance, Micrometers	---	---	---	---	300	---
Sag resistance, Mils	---	---	---	---	12	---
VOC, Grams/liter	---	---	---	---	---	304
VOC, Pounds/gallon	---	---	---	---	---	2.5

NOTES: Test methods as specified in MIL-DTL-24441.

TABLE 1						
COATING QUALITY CONFORMANCE INSPECTION REQUIREMENTS						
Table Ib. - Epoxy Intermediate Coat MIL-DTL-24441/31 Formula 152 Type IV (White (Tinted))						
Test	Component A		Component B		Mixed	
	Min.	Max.	Min.	Max.	Min.	Max.
Pigment content, percent	44.0	49.0	33.0	38.0	---	---
Volatiles, percent	29.0	35.0	16.0	21.0	---	---
Non-volatile vehicle percent	17.5	23.5	44.0	49.0	---	---
Coarse particles, percent	---	0.3	---	0.3	---	---
Consistency, grams	180	320	300	470	180	245
Weight, Kilograms/liter	1.39	1.45	1.29	1.35	1.34	1.4
Weight, Pounds/gallon	11.6	12.1	10.8	11.3	11.2	11.7
Set to touch time, hours at 23 degrees C, 73 degrees F	---	---	---	---	---	3
Dry hard time, hours at 23 degrees C, 73 degrees F	---	---	---	---	---	8
Fineness of grind, Hegman	4	---	4	---	---	---
Flashpoint, Degrees C	35.5	---	37.8	---	---	---
Flashpoint, Degrees F	96	---	100	---	---	---
Titanium dioxide, percent of pigment	91	---	---	---	---	---
Pot life, hours at 23 degrees C, 73 degrees F	---	---	---	---	4	---
Sag resistance, Micrometers	---	---	---	---	300	---
Sag resistance, Mils	---	---	---	---	12	---

TABLE 1

COATING QUALITY CONFORMANCE INSPECTION REQUIREMENTS

Table Ib. - Epoxy Intermediate Coat MIL-DTL-24441/31 Formula 152 Type IV (White (Tinted))

Test	Component A		Component B		Mixed	
	Min.	Max.	Min.	Max.	Min.	Max.
Color of dry film to approximate color of SAE AMS-STD-595A color 27778	---	---	---	---	---	Conform
Contrast ratio, at 75 micrometers, 3 mils DFT	---	---	---	---	.098	---
Gloss, 60 degree specular	---	---	---	---	35	---
VOC, Grams/liter	---	---	---	---	---	340
VOC, Pounds/gallon	---	---	---	---	---	2.8

GENERAL NOTES: Test methods as specified in MIL-DTL-24441.Where "Conform" is indicated, refer to specific requirements of MIL-DTL-24441/31.

TABLE I

COATING QUALITY CONFORMANCE INSPECTION REQUIREMENTS

Table Ic - Polyurethane TopcoatMIL-PRF-85285 Type II (White and Colors)

Test	Component A		Component B		Mixed	
	Min.	Max.	Min.	Max.	Min.	Max.
Moisture content, percent	---	2	---	---	---	---
Course particles, percent	---	---	---	---	---	.5
Viscosity	---	---	---	---	---	See Note 1
Fineness of grind, Hegman	---	---	---	---	7	---

TABLE I

COATING QUALITY CONFORMANCE INSPECTION REQUIREMENTS

Table Ic - Polyurethane TopcoatMIL-PRF-85285 Type II (White and Colors)

Test	Component A		Component B		Mixed	
	Min.	Max.	Min.	Max.	Min.	Max.
Drying to touch (See Note 2)	---	---	---	---	---	4
Dry-hard (See Note 2)	---	---	---	---	---	8
VOC, grams per liter	---	---	---	---	---	340
Color	---	---	---	---	delta E+-1.0	
Gloss 60 degree specular gloss						
Gloss	---	---	---	---	---	90
Semi-gloss	---	---	---	---	15	45
Opacity	---	---	---	---	0.95	---
Flexibility	---	---	---	---	---	Conform
Fluid resistance	---	---	---	---	---	Conform
Heat resistance (cure)	---	---	---	---	---	Conform
Solvent resistance (cure)	---	---	---	---	---	Conform
Condition in container	---	---	---	---	---	Conform
Odor	---	---	---	---	---	Conform
Lead percent	---	---	---	---	---	0.06
Cadmium percent	---	---	---	---	---	0.06
Chromium percent	---	---	---	---	---	0.00

NOTES:
(1) Modify paragraph 3.6.4 Viscosity and Pot Life, of MIL-PRF-85285 as follows:

The viscosity of the admixed coating, when tested in accordance with ASTM D1200 through a No. 4 Ford cup, shall be as follows:

TABLE I

COATING QUALITY CONFORMANCE INSPECTION REQUIREMENTS

Table Ic - Polyurethane TopcoatMIL-PRF-85285 Type II (White and Colors)

Test	Component A		Component B		Mixed	
	Min.	Max.	Min.	Max.	Min.	Max.

Time from mix (minimum)	Maximum time through a No. 4 Ford Cup
Initially	30 seconds
2 hours	60 seconds
4 hours	No gel

(2) Modify paragraph 3.7.1 Drying Time, of MIL-PRF-85285.
When applied by spray techniques and when tested in accordance with ASTM D1640/D1640M, the coating shall be set-to-touch within four hours and dry-hard within eight hours (see 4.6 and table I).

GENERAL NOTES:
Test methods as specified in MIL-PRF-85285, except those marked with "*".
Where "Conform" is indicated, refer to specific requirements of MIL-PRF-85285.

-- End of Section --

SECTION 26 05 19.10 10

INSULATED WIRE AND CABLE
05/16
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1202	(2006; R 2012; CORR 1 2012) Flame-Propagation Testing of Wire and Cable

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-58-679	(2014) Control, Instrumentation and Thermocouple Extension Conductor Identification
ICEA T-30-520	(1986) Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input Rate of 70,000 B.T.U./Hour

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA WC 71/ICEA S-96-659	(2014) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA WC 26	(2008) Binational Wire and Cable Packaging Standard
NEMA WC 57	(2014) Standard for Control, Thermocouple Extension, and Instrumentation Cables
NEMA WC 70	(2009) Power Cable Rated 2000 V or Less for the Distribution of Electrical Energy--S95-658
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 1-200-01	***(2022; with Change 4, 2024) DoD Building Code***

UNDERWRITERS LABORATORIES (UL)

UL 44	(2018) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 1685	(2015) UL Standard for Safety Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables
UL 2556	(2015) UL Standard for Safety Wire and Cable Test Methods

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Wire and Cable; G

Conductors; G

Cable Manufacturing Data

SD-06 Test Reports

Test Report(s), Inspection Report(s), and Verification Report(s); G

1.3 DELIVERY, STORAGE, AND HANDLING

Furnish cables on reels or coils. Each cable and the outside of each reel or coil, must be plainly marked or tagged to indicate the cable length, voltage rating, conductor size, and manufacturer's lot number and reel number. Each coil or reel of cable must contain only one continuous cable without splices. Cables for exclusively dc applications, as specified in paragraph "High-Voltage Test Source," must be identified as such. Shielded cables rated 2,001 volts and above must be reeled and marked in accordance with NEMA WC 26, as applicable. Reels must remain the property of the Contractor.

1.4 PROJECT/SITE CONDITIONS

Environmental Severity Classification (ESC) the project location is classified As ESC (C4) in accordance with UFC 1-200-01.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Rated Circuit Voltages

All power wire and cable must have minimum rated circuit voltages in accordance with NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable. Power wire and cable for circuit voltages rated 0-600 volts must be rated not less than 600 volts. Control wire and cable must have minimum rated circuit voltages in accordance with NEMA WC 57, but must be rated 600 volts if routed in raceway with other conductors that are rated 600 volts.

2.1.2 Conductors

2.1.2.1 Material for Conductors

Conductors must conform to all the applicable requirements of NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable. Copper conductors must be annealed copper material and they may be bare, or tin- or lead-alloy-coated, if required by the type of insulation used. Aluminum conductors must be Type AA-8000 aluminum conductors. Type 1350 is not acceptable. Intermixing of copper and aluminum conductors in the same raceway is not permitted."

2.1.2.2 Size

Minimum wire size must be No. 12 AWG for power and lighting circuits; No. 10 AWG for current transformer secondary circuits; No. 14 AWG for potential transformer, relaying, and control circuits; No. 16 AWG for annunciator circuits; and No. 19 AWG for alarm circuits. Minimum wire sizes for rated circuit voltages of 2,001 volts and above must not be less than those listed for the applicable voltage in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable.

2.1.2.3 Stranding

Conductor stranding classes cited herein must be as defined for control conductors in NEMA WC 57 or as defined for 0-2,000 volts power conductors in NEMA WC 70, as applicable. Lighting conductors No. 10 AWG and smaller must be solid or have Class B stranding. Any conductors used between stationary and moving devices, such as hinged doors or panels, must have Class H or K stranding. All other conductors must have Class B or C stranding, except that conductors as shown, or in the schedule, as No. 12 AWG may be 19 strands of No. 25 AWG, and conductors shown as No. 10 AWG may be 19 strands of No. 22 AWG. Conductor stranding classes for circuit voltages 2,001 volts and above must be as defined in ANSI/NEMA WC 71/ICEA S-96-659 and NEMA WC 74/ICEA S-93-639, as applicable.

2.1.2.4 Conductor Shielding

Use conductor shielding conforming to NEMA WC 57 for control wire and cable as applicable. Use conductor shielding conforming to ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable, on power cables having a rated circuit voltage above 2,000 volts.

2.1.2.5 Separator Tape

Where conductor shielding, strand filling, or other special conductor treatment is not required, a separator tape between conductor and insulation is permitted.

2.1.3 Insulation

2.1.3.1 Insulation Material

Unless specified otherwise or required by NFPA 70, wires in conduit, other than service entrance, must be 600-volt, Type THWN/THHN conforming to UL 83 or Type XHHW conforming to UL 44. Insulation for control wire and cable must meet the requirements of NEMA WC 57. Insulation requirements for wire and cable rated less than 2,000 volts must meet the requirements of NEMA WC 70. Insulation requirements for wire and cable rated 2,001-5,000 volts must meet the requirements of ANSI/NEMA WC 71/ICEA S-96-659. Insulation requirements for wire and cable rated 5,001 volts and greater must meet the requirements of NEMA WC 74/ICEA S-93-639.

For shielded cables of rated circuit voltages above 2,000 volts, the following provisions must also apply:

a. XLPE, if used, must be tree-retardant.

b. Insulation must be chemically bonded to conductor shielding.

c. The insulation material and its manufacturing, handling, extrusion and vulcanizing processes must all be subject to strict procedures to prevent the inclusion of voids, contamination, or other irregularities on or in the insulation. Insulation material must be inspected for voids and contaminants.

d. Cables with repaired insulation defects discovered during factory testing, or with splices or insulation joints, are prohibited unless specifically approved.

2.1.3.2 Insulation Thickness

The insulation thickness for each conductor must be based on its rated circuit voltage.

2.1.3.2.1 Power Cables, 2,000 Volts and Below

The insulation thickness for single-conductor and multiple-conductor power cables rated 2,000 volts and below must be as required by NEMA WC 70, as applicable. Some thicknesses of NEMA WC 70 will be permitted only for single-conductor cross-linked thermosetting polyethylene insulated cables without a jacket. NEMA WC 70 ethylene-propylene rubber-insulated conductors must have a jacket.

2.1.3.2.2 Power Cables, Rated 2,001 Volts and Above

Thickness of insulation for power cables rated 2,001 volts and above must be in accordance with the following

a. Non-shielded cables, 2,001 to 5,000 volts, must comply with ANSI/NEMA WC 71/ICEA S-96-659, as applicable.

b. Shielded cables rated 5,000 volts to 46,000 volts must comply with NEMA WC 74/ICEA S-93-639, as applicable.

2.1.3.2.3 Single-Conductor and Multiple-Conductor Control Cables

The insulation thickness of control conductor sizes 22 AWG to 10 AWG used for control and related purposes must be as required by NEMA WC 57, as applicable. Control conductors larger than 10 AWG must be as required by NEMA WC 70.

2.1.3.3 Insulation Shielding

Unless otherwise specified, provide insulation shielding for conductors having rated circuit voltages of 2,001 volts and above. The voltage limits above which insulation shielding is required, and the material requirements, are given in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable. The material, if thermosetting, must meet the wafer boil test requirements as described in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable. The method of shielding must be in accordance with the current practice of the industry; however, the application process must include strict precautions to prevent voids or contamination between the insulation and the nonmetallic component. Voids, protrusions, and indentations of the shield must not exceed the maximum allowances specified in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable. The cable must be capable of operating without damage or excessive temperature when the shield is grounded at both ends of each conductor. All components of the shielding system must remain tightly applied to the components they enclose after handling and installation in accordance with the manufacturer's recommendations. Shielding systems which require heat to remove are prohibited unless specifically approved.

2.1.4 Jackets

All cables must have jackets meeting the requirements of NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, and NEMA WC 74/ICEA S-93-639, as applicable, and as specified herein. Individual conductors of multiple-conductor cables must be required to have jackets only if they are necessary for the conductor to meet other specifications herein. Jackets of single-conductor cables and of individual conductors of multiple-conductor cables, except for shielded cables, must be in direct contact and adhere or be vulcanized to the conductor insulation. Multiple-conductor cables and shielded single-conductor cables must be provided with a common overall jacket, which must be tightly and concentrically formed around the core. Repaired jacket defects found and corrected during manufacturing are permitted if the cable, including jacket, afterward fully meets these specifications and the requirements of the applicable standards.

2.1.4.1 Jacket Material

The jacket must be one of the materials listed below. Polyvinyl chloride compounds will not be permitted. Variations from the materials required below will be permitted only if approved for each specific use, upon submittal of sufficient data to prove that they exceed all specified requirements for the particular application.

2.1.4.1.1 General Use

Heavy-duty black neoprene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Heavy-duty chlorosulfonated polyethylene	NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Heavy-duty cross-linked (thermoset) chlorinated polyethylene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639

2.1.4.1.2 Accessible Use Only, 2,000 Volts or Less

Cables installed where they are entirely accessible, such as cable trays and raceways with removable covers, or where they pass through less than 10 feet of exposed conduit only, must have jackets of one of the materials in item "a. General Use" or one of the following:

General-purpose neoprene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Black polyethylene (MDPE)	NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Thermoplastic chlorinated polyethylene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639

2.1.4.2 Jacket Thickness

The minimum thickness of the jackets must be not less than 80 percent of the respective nominal thicknesses specified below.

2.1.4.2.1 Multiple-Conductor Cables

Thickness of the jackets of the individual conductors of multiple-conductor cables must be as required by NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable and must be in addition to the conductor insulation thickness required by the applicable respective NEMA publication for the insulation used. Thickness of the outer jackets and associated coverings of the assembled multiple-conductor cables must be as required by NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable.

2.1.4.2.2 Single-Conductor Cables

Single-conductor cables must have a jacket thickness as specified in NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable.

2.1.5 Multiple-Conductor Cables

Grounding conductor(s) conforming to NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable must be furnished for each multiple-conductor cable. Assembly and cabling must be as specified in paragraph CABLING.

2.2 CABLE IDENTIFICATION

2.2.1 Color-Coding

Insulation of individual conductors of multiple-conductor cables must be color-coded in accordance with ICEA S-58-679, except that colored braids will not be permitted. Only one color-code method must be used for each cable construction type. Control cable color-coding must be in accordance with ICEA S-58-679 as follows: Power cable color-coding must be black for Phase A, red for Phase B, blue for Phase C, white for grounded neutral, and green for an insulated grounding conductor, if included.

2.2.2 Shielded Cables Rated 2,001 Volts and Above

Marking must be in accordance with ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable.

2.2.3 Cabling

Individual conductors of multiple-conductor cables must be assembled with flame-and moisture-resistant fillers, binders, and a lay conforming to NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639. Flat twin cables are prohibited. Fillers must be used in the interstices of multiple-conductor round cables with a common covering where necessary to give the completed cable a substantially circular cross section. Fillers must be non-hygroscopic material, compatible with the cable insulation, jacket, and other components of the cable. The rubber-filled or other approved type of binding tape must consist of a material that is compatible with the other components of the cable and must be lapped at least 10 percent of its width.

2.2.4 Dimensional Tolerance

The outside diameters of single-conductor cables and of multiple-conductor cables must not vary more than 5 percent and 10 percent, respectively, from the manufacturer's published catalog data.

PART 3 EXECUTION

3.1 INSTALLATION INSTRUCTIONS

Submit cable manufacturing data. The following information must be provided by the cable manufacturer for each size, conductor quantity, and type of cable furnished:

a. Minimum bending radius, in inches - For multiple-conductor cables, this information must be provided for both the individual conductors and the multiple-conductor cable.

b. Pulling tension and sidewall pressure limits, in pounds.

c. Instructions for stripping semiconducting insulation shields, if furnished, with minimum effort without damaging the insulation.

d. Upon request, compatibility of cable materials and construction with specific materials and hardware manufactured by others must be stated. Also, if requested, recommendations must be provided for various cable operations, including installing, splicing, terminating, etc.

3.2 TEST REPORT(S), INSPECTION REPORT(S), AND VERIFICATION REPORT(S)

3.2.1 Cable Data

Do not begin any wire and cable fabrication until materials are submitted and approved by the Contracting Officer. Submit cable data for approval including, but not limited to, dimensioned sketches showing cable construction and sufficient additional data to show that wire and cable meet the requirements of this Section.

3.2.2 Inspection and Tests

Inspection and tests of wire and cable furnished under these specifications must be made by and at the plant of the manufacturer and the manufacturer must provide certification and certification reports of completed inspections and completed tests. The Government may require or perform further tests before or after installation. Testing in general must comply with NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable. Specific tests required for particular materials, components, and completed cables must be as specified in the sections of the above standards applicable to those materials, components, and cable types. Tests must also be performed in accordance with the additional requirements specified below. Submit two certified copies of test reports.

3.2.2.1 High-Voltage Test Source

Where the applicable standards allow a choice, high-voltage tests for cables to be used exclusively on dc circuits must be made with dc test voltages. Cables to be used exclusively on ac circuits must be tested with ac test voltages. If both ac and dc will be present, on either the same or separate conductors of the cable, ac test voltages must be used.

3.2.2.2 Shielded Cables Rated 2,001 Volts or Greater

The following test(s) must be performed in addition to those specified above:

a. If high-voltage testing is done with an AC test voltage as specified in paragraph "High-Voltage Test Source," an additional test must be made using a DC test voltage rated at 75 percent of the specified full DC test voltage, for 5 consecutive minutes.

b. If voltage tests after installation are required for 5-65kV shielded

power cables then testing must be done in accordance with NEMA WC 74/ICEA S-93-639, Appendix F.

3.2.2.3 Flame Tests

All cable assemblies must pass either the vertical cable tray flame tests required by ICEA T-30-520 (stated in, but not required by NEMA WC 70), the vertical tray flame propagation test requirements of UL 1685 and IEEE 1202, the wire and cable burning characteristics test of the UL 2556 VW-1 Test, or (for control cables only) the flame test as required by NEMA WC 57. If such tests, however, have previously been made on identical cables, these tests need not be repeated. Instead, certified reports of the original qualifying tests must be submitted. In this case the reports furnished under paragraph "Reports," must include information, identify critical information, and verify that all of each cable's materials, construction, and dimensions are the same as those in the qualifying tests.

3.2.2.4 Independent Tests

The Government may make visual inspections, continuity or resistance checks, insulation resistance readings, power factor tests, or dc high potential tests at field test values. A cable's failure to pass these tests and inspections, or failure to produce readings consistent with acceptable values for the application, will be grounds for rejection of the cable.

3.2.2.5 Reports

Furnish results of tests. No wire or cable must be shipped until authorized. Lot number and reel or coil number of wire and cable tested must be indicated on the test reports.

3.3 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 05 48.00 10

SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT
10/07
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2017) Steel Construction Manual

ASTM INTERNATIONAL (ASTM)

ASTM A780/A780M	***(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings***
ASTM E580/E580M	(2020) Standard Practice for Installation of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Subject to Earthquake Ground Motions

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019) Structural Engineering

UNDERWRITERS LABORATORIES (UL)

UL 1598	(2008; Reprint Oct 2012) Luminaires

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

The requirements for seismic protection measures described in this section shall be applied to the electrical equipment and systems listed below. Structural requirements shall be in accordance with Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT.

1.2.2 Electrical Equipment

Electrical equipment shall include the following items to the extent required on the drawings or in other sections of these specifications:

Control Panels	Air Handling Units
Pumps with Motors	Switchgear

Light Fixtures	Transfer Switches
DC Converters	Transformers
Switchboards (Floor Mounted)	Storage Racks
Generators	

1.2.3 Electrical Systems

The following electrical systems shall be installed as required on the drawings and other sections of these specifications and shall be seismically protected in accordance with this specification: transformers, panelboards, motor starters, and light fixtures

1.2.4 Contractor Designed Bracing

Submit copies of the Design Calculations with the Drawings. Calculations shall be approved, certified, stamped and signed by a Registered Professional Engineer. Calculations shall verify the capability of structural members to which bracing is attached for carrying the load from the brace. Design the bracing in accordance with UFC 3-301-01 and additional data furnished by the Contracting Officer. Resistance to lateral forces induced by earthquakes shall be accomplished without consideration of friction resulting from gravity loads. UFC 3-301-01 uses parameters for the building, not for the equipment in the building; therefore, corresponding adjustments to the formulas shall be required. Loadings determined using UFC 3-301-01 are based on strength design; therefore, AISC 325 shall be used for the design. Develop the bracing for the following electrical equipment and systems: transformers, panelboards, motor starters, and light fixtures.

1.3 EQUIPMENT REQUIREMENTS

Submit detail drawings along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals shall be complete in detail, indicating thickness, type, grade, class of metal, and dimensions; and shall show construction details, reinforcement, anchorage, and installation with relation to the building construction. Submit copies of the design calculations with the detail drawings. Calculations shall be stamped by a registered engineer and shall verify the capability of structural members to which bracing is attached for carrying the load from the brace.

1.3.1 Rigidly Mounted Equipment

The following specific items of equipment: Rigidly mounted equipment to be furnished under this contract shall be constructed and assembled to withstand the seismic forces specified in UFC 3-301-01. Each item of rigid electrical equipment shall be entirely located and rigidly attached on one side only of a building expansion joint. Piping, electrical conduit, etc., which cross the expansion joint shall be provided with flexible joints that are capable of accommodating displacements equal to the full width of the joint in both orthogonal directions.

Engine-Generators
Substations

Transformers
Switch Boards and Switch Gears
Free Standing Electric Motors
Transfer Switches
DC Converters

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Lighting Fixtures in Buildings

Equipment Requirements

SD-03 Product Data

Lighting Fixtures in Buildings; G

Equipment Requirements; G

Contractor Designed Bracing; G

PART 2 PRODUCTS

2.1 LIGHTING FIXTURE SUPPORTS

Lighting fixtures and supports shall conform to UL 1598.

2.2 SWAY BRACING MATERIALS

Sway bracing materials (e.g. rods, plates, rope, angles, etc.) shall be as specified in Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT. ***Materials must be compatible with installation environment. In corrosive environments (ECS C3, C4 or C-5), provide a hot-dip galvanized or stainless steel components.***

PART 3 EXECUTION

3.1 SWAY BRACES FOR CONDUIT

Conduit shall be braced as for an equivalent weight pipe in accordance with Section 23 05 48.19 SEISMIC BRACING FOR HVAC.

3.1.1 Corrosion Protection

Isolate dissimilar metals in close contact, such as aluminum and steel, stainless steel and carbon steel, or zinc-coated steel and uncoated steel, to prevent galvanic corrosion. Interpose a non-absorbing inert gasket or washer between the dissimilar metals. Seal faying edges to preclude the entry of liquids. Repair factory-applied protective coatings damage during field installation. For galvanized surfaces repair using a zinc-rich paint conforming to ASTM A780/A780M.

3.2 LIGHTING FIXTURES IN BUILDINGS

Lighting fixtures and supports shall conform to the following:

3.2.1 Pendant Fixtures

Pendant fixtures shall conform to the requirements of UFC 3-301-01.

3.2.2 Ceiling Attached Fixtures

3.2.2.1 Recessed Fluorescent Fixtures

Recessed fluorescent individual or continuous-row mounted fixtures shall be supported by a seismic-resistant suspended ceiling support system built in accordance with ASTM E580/E580M. Seismic protection for the fixtures shall conform to the requirements of UFC 3-301-01. Recessed lighting fixtures not over 56 pounds in weight may be supported by and attached directly to the ceiling system runners using screws or bolts, number and size as required by the seismic design. Fixture accessories, including louvers, diffusers, and lenses shall have lock or screw attachments.

3.2.2.2 Surface-Mounted Fluorescent Fixtures

Surface-mounted fluorescent individual or continuous-row fixtures shall be attached to a seismic-resistant ceiling support system built in accordance with ASTM E580/E580M. Seismic protection for the fixtures shall conform to the requirements of UFC 3-301-01.

3.2.3 Assembly Mounted on Outlet Box

A supporting assembly, that is intended to be mounted on an outlet box, shall be designed to accommodate mounting features on 4 inch boxes, plaster rings, and fixture studs.

3.2.4 Wall-Mounted Emergency Light Unit

Attachments for wall-mounted emergency light units shall be designed and secured for the worst expected seismic disturbance at the site.

3.2.5 Lateral Force

Structural requirements for light fixture bracing shall be in accordance with Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT.

3.3 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

SECTION 26 05 75

POWER SYSTEM STUDY
03/15
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1015	(2006; Corr 1 2007) Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems - IEEE Blue Book
IEEE 1584	(2002; Amendment 1 2004; INT 1-3 2008; Amendment 2 2011) Guide for Performing Arc-Flash Hazard Calculations
IEEE 242	(2001; Errata 2003) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book
IEEE 399	(1997) Brown Book IEEE Recommended Practice for Power Systems Analysis

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
NFPA 70E	(2021) Standard for Electrical Safety in the Workplace

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Power Study Report; G

Final Power Study Report; G

1.3 SCOPE OF ANALYSIS

Prepare analyses to demonstrate that the equipment selected and system constructed meets the contract requirements for ratings, coordination, and protection. No time extensions or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed will be based on recommendations of this study. The Government will not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study. Provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

Furnish a power system analysis. Studies to be included are:

a. Short Circuit (Fault Current)

b. Protective Device Coordination

c. Load Flow, including voltage drop, demand loading and power factor

d. Arc Flash: Provide the Arc Flash Hazard Study per the requirements NFPA 70E and perform according to the IEEE 1584.

The scope of the studies will include the electrical distribution equipment identified by the Ownerand new distribution equipment supplied by the selected vendor under this contract.

1.4 QUALIFICATIONS

Conduct the power system analysis under the responsible charge and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies. The Registered Professional Electrical Engineer must be an employee of the equipment manufacturer or an approved engineering firm. The Registered Professional Electrical Engineer must have a minimum of five (5) years of experience in performing power system studies. The approved engineering firm must demonstrate experience with Arc Flash Hazard Analysis by submitting names of at least ten actual arc flash hazard analyses it has performed in the past year. The engineering firm must have a minimum of ten (10) years of experience in performing power system studies.

PART 2 PRODUCTS

2.1 STUDIES

Contractor must either obtain an available fault capacity at the power source or provide a fault capacity on which to base the analysis.

Begin the Load Flow Analysis, Fault Current Analysis, and Protective Device Coordination Studies at:

a. The source bus and extend down to system buses where fault availability is 10,000 amperes (symmetrical) for building/facility 600 volt level distribution buses.

Furnish an Arc Flash Hazard Analysis Study per NFPA 70E.

Prepare a single line diagram to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). Provide either a fault-impedance diagram or a computer analysis diagram. Each bus, device or transformation point must have a unique identifier. If a fault-impedance diagram is provided, show impedance data. Show location of switches, breakers, and circuit interrupting devices on the diagram together with available fault data, and the device interrupting rating.

2.1.1 Power Study Report

Submit the studies to the Government prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the study may cause delays in equipment shipments, approval from the Government may be obtained for a preliminary submittal of data to ensure that the selection of device ratings and characteristics is satisfactory to properly select the distribution equipment. Provide the formal study to verify preliminary findings.

Include the following in the Power Study Report:

a. Executive Summary including, but not limited to, Introduction, Scope of Work and Results/Recommendations.

b. Short-Circuit Methodology Analysis Results and Recommendations.

c. Short-Circuit Device Evaluation Table.

d. Protective Device Coordination Methodology Analysis Results and Recommendations.

e. Protective Device Settings Table.

f. Time-Current Coordination Graphs and Recommendations.

g. Load Flow, including KV, KW, KVA, PF, VD, Current, conductor size and impedance.

h. Arc Flash Hazard Methodology Analysis Results and Recommendations including the details of the incident energy and flash protection boundary calculations, along with Arc Flash boundary distances, working distances, Incident Energy levels and Personal Protection Equipment levels.

i. Arc Flash Labeling section showing types of labels to be provided. Provide label type as indicated on the drawings.

j. One-line system diagram generated by software approved for use on the Navy Network as indicated in UFC 3-501-01 ELECTRICAL ENGINEERING, and clearly identifying individual equipment buses, bus numbers used in the analysis, cable and bus connections between the equipment, calculated parameters at each bus location, device numbers used in the design one-line diagrams, and other information pertinent to the computer analysis. Do not use hand calculations or use of other software not approved for the Navy Network.

2.1.2 Final Power Study Report

Summarize the results of the studies in a final report. Submit a minimum of five (5) bound copies of the complete final report. The report must include the section containing the computer printout of the short-circuit input and output data. Provide electronic PDF copies of the report with the electronic file of the one-line diagram created for the power system analysis included.

2.2 DATA

Furnish all data as required for the power system studies. The Engineer performing the short-circuit, protective device coordination, load flow, and arc flash hazard analysis studies must furnish a listing of required data immediately after award of the contract. Expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.

Source combination may include present and future motors and generators. Load data utilized may include existing and proposed loads obtained from Contract Documents.

If applicable, include fault contribution of existing motors in the study. Obtain required existing equipment data, if necessary, to satisfy the study requirements. Gather the relevant data for a minimum 30 day, 24 hour-per-day period.

a. The Government will provide qualified personnel to show the Contractor's field personnel the equipment location and to open all equipment doors, locks, etc. necessary to collect nameplate data.

b. Perform field data collection by a qualified, as defined by NFPA 70E, person to ensure accurate equipment modeling, that has completed an 8-hour instructor-led Electrical Safety Training Course from a training provider acceptable to the Government. The course must include NFPA 70E training which includes the selection and use of personal protective equipment.

c. De-energize all equipment prior to inspection. Safe work permits are required.

d. Begin data collection downstream from the utility service and continue down through the electrical distribution system as defined under scope of work. Do not include in the study any single phase AC circuits or DC distribution systems as these types of circuits and systems are excluded from IEEE 1584 Arc Flash calculation guidelines. Do not include in the study equipment rated 240 volts or less per NFPA 70E, when supplied by a single transformer rated less than 125kVA.

e. Gather all data as required for the power system studies to ensure accurate equipment modeling. Visually inspect all equipment to verify equipment ratings, conductor ratings and over-current device data by removing panels, covers and doors where required to document the necessary data. Source combination may include present motors and generators.

f. Include load data utilizing existing loads obtained from Government. Electronic file copy will be provided if available. Verify data

provided and provide updated one-line and other drawings where discrepancies are found.

g. Obtain from the utility the minimum, normal, and maximum operating service voltage levels, three-phase short circuit MVA and X/R ratio, as well as line-to-ground short circuit MVA and X/R ratio at the point of connection as shown on the drawings.

2.3 SAFETY

Follow NAVFAC ELECTRICAL SAFE Standard Operating Procedure (SOP), available from the Government.

2.4 SHORT-CIRCUIT (FAULT) ANALYSIS

Refer to Section 26 28 01.00 10 COORDINATION POWER SYSTEM PROTECTION for requirement.

Provide the following:

2.5 PROTECTIVE DEVICE TIME-CURRENT COORDINATION ANALYSIS

Perform the analysis with recommended practices and procedures set forth in IEEE 242, IEEE 399, IEEE 1015 and NFPA 70.

2.5.1 Device Coordination Time-Current Curves (TCC)

Refer to Section 26 28 01.00 10 COORDINATION POWER SYSTEM PROTECTION for requirement.

2.5.2 One-Line Diagram

Provide the following:

a. Provide a one-line diagram which clearly identifies individual equipment buses, bus numbers, device identification numbers and the maximum available short-circuit current at each bus when known.

b. Provide a sufficient number of log-log plots to indicate the degree of system protection and coordination by displaying the time-current characteristics of series connected over-current devices and other pertinent system parameters.

c. Computer printouts must accompany the log-log plots containing descriptions for each of the devices shown, settings of the adjustable devices, and device identification numbers to aid in locating the devices on the log-log plots and the system one-line diagram.

d. Include a separate, tabular printout containing the recommended settings of all adjustable over-current protective devices, the equipment designation where the device is located, and the device number corresponding to the device on the system one-line diagram.

e. A discussion section which evaluates the degree of system protection and service continuity with over-current devices, along with recommendations as required for addressing system protection or device coordination deficiencies.

f. Notification to the Government in writing of any significant deficiencies in protection and/or coordination. Provide recommendations for improvements.

2.6 ARC FLASH HAZARD ANALYSIS

Perform the arc flash hazard analysis according to the IEEE 1584 equations that are presented in NFPA 70E. Perform the arc flash hazard analysis in conjunction with requirements in Articles SHORT-CIRCUIT (FAULT) ANALYSIS and PROTECTIVE DEVICE TIME-CURRENT COORDINATION ANALYSIS.

a. Calculate the flash protection boundary and the incident energy at significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway, and splitters) where work could be performed on energized parts.

b. Circuits 240V or less fed by single transformer rated less than 125 kVA may be omitted from the computer model and assumed to have a hazard risk category 0 per NFPA 70E.

c. Base working distances on IEEE 1584 and UFC 3-560-01. Calculate the arc flash protection boundary working distance in feet. For low voltage systems, assume a working distance of 18 inches. For medium voltage systems, assume a minimum working distance of 4 feet. For high voltage systems, assume a minimum working distance of 6 feet.

d. When appropriate, the short circuit calculations and the clearing times of the phase over-current devices should be retrieved from the short circuit and coordination study model. Do not take into consideration ground over-current relays when determining the clearing time when performing incident energy calculations.

e. Compare the short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios. The greatest incident energy must be uniquely reported for each equipment location in a single table. Perform calculations to represent the maximum and minimum contributions of fault current magnitude for normal and emergency operating conditions. The minimum calculation assumes that the utility contribution is at a minimum. Conversely, the maximum calculation assumes a maximum contribution from the utility. Calculations must take into consideration the parallel operation of synchronous generators with the electric utility, where applicable as well as any stand-by generator applications.

f. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors should be decremented as follows:

   (1) Fault contribution from induction motors should not be considered beyond 5 cycles.

g. For each piece of ANSI rated equipment with an enclosed main device, two calculations must be made: (1) For the main cubicle, sides, or rear based on a device located upstream of the equipment to clear the arcing fault; and (2) For the front cubicles based on the equipment's main device to clear the arcing fault. For all other non-ANSI rated

equipment, only one calculation is required based on a device located upstream of the equipment to clear the arcing fault.

h. When performing incident energy calculations on the line side of a main breaker (as required per above), include the line side and load side contributions in the fault calculation.

i. Check miscoordination amongst all devices within the branch containing the immediate protective device upstream of the calculation location and utilize in the calculation the fastest device to compute the incident energy for the corresponding location.

j. Base Arc Flash calculations on actual over-current protective device clearing time. Use a maximum clearing time of 2 seconds based on IEEE 1584. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, utilize a maximum clearing time based on the specific location.

k. Provide the following:

(1) Submit results of the Arc-Flash Hazard Analysis in tabular form, including device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, working distances, personal-protective equipment classes and AFIE (Arc Flash Incident Energy) levels.

(2) Report incident energy values in the Arc-Flash Hazard Analysis based on recommended device settings for equipment within the scope of the study. Provide list of prohibited energized work locations based on arc flash results.

(3) The Arc-Flash Hazard Analysis may include recommendations to reduce AFIE levels and enhance worker safety.

2.7 LOAD FLOW ANALYSIS

Perform the analysis with recommended practices and procedures set forth in IEEE 399 and NFPA 70.

Provide a single-line diagram consisting of a drawing identifying, at a minimum, buses, interconnecting lines, loads, generators, transformers, reactors and capacitors, all shown in their respective places in the system.

Provide an impedance single line diagram.

Data input may either be in per unit or in physical units, depending on program convention. Converting the system data to per unit representation requires the selection of a base kVA and base voltage. Selection of the base kVA and base voltage specifies the base impedance and current. The accepted convention is a base of 100 MVA.

2.7.1 Bus Data

Bus data, describing each bus and the load and shunts connected to that bus, includes the following:

a. Bus number

b. Bus name

c. Bus type (load bus, generator bus, swing bus or disconnected bus)

d. Load

e. Bus base kV (show voltage in kV and current in amperes)

f. Voltage drop in percent

g. Reactive power (kVar) and real power (kW)

2.7.2 Branch Data

Branch refers to all elements that connect two buses including transmission lines, cables, transformers, series reactors and series capacitors. Branch data includes the following:

a. Impedance

b. Line wire size and length

c. Transformer size, kV rating and impedance

d. Shunt capacitance

e. Additional data required for transformers must include tap setting in percent.

PART 3 EXECUTION

3.1 FINAL POWER STUDY REPORT

Submit to the Government in the following format:

3.1.1 Short Circuit (Fault) Study

Refer to Section 26 28.01.00 10 Coordination POWER SYSTEM PROTECTION for requirement.

3.1.2 Coordination Study

Refer to Section 26 28.01.00 10 Coordination POWER SYSTEM PROTECTION for requirement.

3.1.3 Load Flow

a. Tabulations of the data used to model the system components with the corresponding single line diagram.

b. Description of scenarios evaluated, identification of the scenario used and the basis of each.

c. Tabulations of power and current flow vs. equipment rating.

d. Tabulations of voltage drops, system real and reactive power losses.

e. Conclusions and recommendations.

3.1.4 Arc Flash

a. Tabulations of the data used to model the system components with the corresponding single line diagram.

b. Description of scenarios evaluated and identification of the scenarios used to evaluate equipment ratings.

c. Tabulations of equipment incident energies, hazard risk categories, and flash protection boundaries.

d. Conclusions and recommendations.

3.2 APPLICATION

Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Complete protective devices adjustments. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

3.3 ARC FLASH LABELS

Provide a thermal transfer type label of high adhesion polyester for each work location analyzed. ***For labels installed in exterior locations, humid locations, or environments within environmental security classification (ESC) of C3, C4, or C5, provide labels that are UV resistant, weather resistant, and resistant to specific corrosive environments.*** Design the label in accordance with UFC 3-560-01 ELECTRICAL SAFETY, O & M.

Print labels with a thermal transfer type printer, with no field markings. ***Ensure label adhesion is rated for the specific substrate and environmental conditions (temperature, moisture and corrosiveness) at the installation location.*** Provide arc flash labels for equipment as identified in the study and the respective equipment access areas per the following:

a. Floor Standing Equipment - Provide labels on the front of each individual section. Provide labels for equipment requiring rear and/or side access on each individual section access area. Equipment line-ups containing sections with multiple incident energy and flash protection boundaries must be labeled as identified in the Arc Flash Analysis table.

b. Wall Mounted Equipment - Provide labels on the front cover or a nearby adjacent surface, depending upon equipment configuration.

c. Install General Use Safety labels equipment in coordination with the Arc Flash labels, which warn of general electrical hazards associated with shock, arc flash, and explosions, and instruct workers to turn off power prior to work.

3.3.1 Installation

Field install labels. The technician providing the installation must have completed an 8-hour instructor led Electrical Safety Training Course from a training provider acceptable to the Government. The course must include NFPA 70E training which includes the selection and use of personal protective equipment.

3.4 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

SECTION 26 08 00

APPARATUS INSPECTION AND TESTING
08/08
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 1-200-01	***(2022; with Change 4, 2024) DoD Building Code***

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to this section with additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Acceptance tests and inspections; G

SD-07 Certificates

Qualifications of organization, and lead engineering technician; G

Acceptance test and inspections procedure; G

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

Contractor shall engage the services of a qualified testing organization to provide inspection, testing, calibration, and adjustment of the electrical distribution system and generation equipment listed in paragraph entitled "Acceptance Tests and Inspections" herein. Organization shall be independent of the supplier, manufacturer, and

installer of the equipment. The organization shall be a first tier subcontractor. No work required by this section of the specification shall be performed by a second tier subcontractor.

a. Submit name and qualifications of organization. Organization shall have been regularly engaged in the testing of electrical materials, devices, installations, and systems for a minimum of 5 years. The organization shall have a calibration program, and test instruments used shall be calibrated in accordance with NETA ATS.

b. Submit name and qualifications of the lead engineering technician performing the required testing services. Include a list of three comparable jobs performed by the technician with specific names and telephone numbers for reference. Testing, inspection, calibration, and adjustments shall be performed by an engineering technician, certified by NETA or the National Institute for Certification in Engineering Technologies (NICET) with a minimum of 5 years' experience inspecting, testing, and calibrating electrical distribution and generation equipment, systems, and devices.

1.4.2 Acceptance Tests and Inspections Reports

Submit certified copies of inspection reports and test reports. Reports shall include certification of compliance with specified requirements, identify deficiencies, and recommend corrective action when appropriate. Type and neatly bind test reports to form a part of the final record. Submit test reports documenting the results of each test not more than 10 days after test is completed.

1.4.3 Acceptance Test and Inspections Procedure

Submit test procedure reports for each item of equipment to be field tested at least 45 days prior to planned testing date. Do not perform testing until after test procedure has been approved.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 ACCEPTANCE TESTS AND INSPECTIONS

Testing organization shall perform acceptance tests and inspections. Test methods, procedures, and test values shall be performed and evaluated in accordance with NETA ATS, the manufacturer's recommendations, and paragraph entitled "Field Quality Control" of each applicable specification section. Tests identified as optional in NETA ATS are not required unless otherwise specified. Equipment shall be placed in service only after completion of required tests and evaluation of the test results have been completed. Contractor shall supply to the testing organization complete sets of shop drawings, settings of adjustable devices, and other information necessary for an accurate test and inspection of the system prior to the performance of any final testing. Contracting Officer shall be notified at least 14 days in advance of when tests will be conducted by the testing organization. ***Verify equipment, components, and installation hardware comply with the Corrosion Prevention and Control (CPC) requirements of UFC 1-200-01 for the projects Environmental Severity Classification (ESC). In locations designated as ESC C3, C4, or C5***

specifically verify the use of type 316L or duplex stainless steel enclosures and hardware, or the presence of specified corrosion resistant coatings. Specifically, inspect field applied touch up coatings for proper application on coverage. Verify cable terminations and splices involve the use of corrosion-inhibiting compounds were specified or required by the ESC. Perform acceptance tests and inspections on applicable equipment and systems specified in the following sections:

a. Section 26 32 15.00 ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES. Functional engine shutdown tests, vibration base-line test, and load bank test shall not be performed by the testing organization. These tests shall be performed by the start-up engineer.

b. Section 26 12 19.10 THREE-PHASE, LIQUID-FILLED PAD-MOUNTED TRANSFORMERS

c. Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Medium voltage cables and grounding systems only.

c. Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH

d. Section 26 24 13 SWITCHBOARDS

3.2 SYSTEM ACCEPTANCE

Final acceptance of the system is contingent upon satisfactory completion of acceptance tests and inspections.

3.3 PLACING EQUIPMENT IN SERVICE

A representative of the approved testing organization shall be present when equipment tested by the organization is initially energized and placed in service.

3.4 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 08 01.00 50

COMMISSIONING OF ELECTRICAL SYSTEMS
01/18
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 1-200-01	***(2022; with Change 4, 2024) DoD Building Code***

U.S. GREEN BUILDING COUNCIL (USGBC)

LEED	(2002; R 2007) Leadership in Energy and Environmental Design(tm) Green Building Rating System for New Construction (LEED-NC), Version 2009

1.2 SUMMARY

This project will have selected building systems commissioned. The commissioning process, which the Contractor is responsible to execute, is defined in Section 01 91 00.15 22 TOTAL BUILDING COMMISSIONING. A Commissioning Agent (CA) appointed by the Government will direct the commissioning process.

1.2.1 This Section Includes

Requirements for commissioning the Electrical systems, sub-systems and equipment. This Section supplements the general requirements specified in Section01 91 00.15 22 TOTAL BUILDING COMMISSIONING.

1.2.2 Commissioning Activities

a. The commissioning activities have been developed to support the United States Green Building Council (USGBC) LEED™ rating program and to support delivery of project performance in accordance with the Contract Documents.

(1) Commissioning activities and documentation for the LEED™ section on "Energy and Atmosphere" prerequisite of "Fundamental Building Systems Commissioning".
(2) Commissioning activities and documentation for the LEED™ section on "Energy and Atmosphere" requirements for the "Enhanced Building System Commissioning" credit.
(3) Activities and documentation for the LEED™ section on "Measurement and Verification" requirements for the Measurement and Verification credit.

b. The commissioning activities include verification of Corrosion

Prevention and Control (CPC) measures in accordance with the project's Environmental Severity Classification (ESC) and UFC 1-200-01.

1.2.3 Related Sections

Refer to Section 01 91 00.15 22 TOTAL BUILDING COMMISSIONING for more details regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.3 DEFINITIONS

Refer to Section 01 91 00.15 22 TOTAL BUILDING COMMISSIONING for definitions.

1.4 COMMISSIONED SYSTEMS

a. Commissioning of a system or systems specified in this Division 26 is part of the construction process. Documentation and testing of these systems, as well as training of User's Operation and Maintenance personnel, is required in cooperation with and the Commissioning Agent.

b. The following Electrical systems will be commissioned:

(1) Automatic Transfer Switches (Test with associated generator).
(2) Diesel-Generator Sets.
(3) Lighting controls (Control system hardware and software, scene settings, zone settings, occupancy sensor interface, and unoccupied cycle control).
(4) Uninterruptible Power Supply Systems and UPS Power Distribution systems (Battery chargers, static and dynamic power generators - i.e. inverters, MG sets, metering and controls, system power displays, and distribution panel circuit breakers).
5. Solar Photovoltaic System (i.e. solar panels, inverters and control system).
6. Helipad Lighting and Visual Navigation Aids.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

b. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00.15 22 TOTAL BUILDING COMMISSIONING.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 SYSTEMS READINESS CHECKLISTS

The Contractor shall complete Systems Readiness Checklists to verify systems, sub-systems, and equipment installation is complete and systems are ready for Systems Functional Testing. The Commissioning Agent will prepare Systems Readiness Checklists to be used to document equipment installation. The Contractor shall complete the checklists. Completed checklists shall be submitted to the Contracting Officer and to the Commissioning Agent for review. The Commissioning Agent may spot-check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and re-submission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and re-submission. Refer to Section 01 91 00.15 22 TOTAL BUILDING COMMISSIONING for submittal requirements for System Readiness Checklists, Equipment Startup Reports, and other commissioning documents.

3.2 CONTRACTOR'S TESTS

Contractor tests as required by other sections of Division 26 shall be scheduled and documented. The Commissioning Agent will witness selected Contractor tests. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing. Prior to scheduling the System Functional performance test, the Contractor shall complete the field testing of the generators with a reactive load bank.

3.3 SYSTEMS FUNCTIONAL PERFORMANCE TESTING

The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the Contracting Officer. The Contractor shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and test equipment identified in the test procedure to perform the tests. The Commissioning Agent will direct and document the testing. The Contractor shall sign the test reports to verify tests were performed. See Section 01 91 00.15 22 TOTAL BUILDING COMMISSIONING, for additional details.

3.4 TRAINING OF OWNER PERSONNEL

Training of User's operation and maintenance personnel is required in cooperation with the Contracting Officer and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with Contracting Officer after submission and

approval of formal training plans. Refer to Section 01 91 00.15 22 TOTAL BUILDING COMMISSIONING and Division 26 Sections for additional Contractor training requirements.

3.5 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

SECTION 26 12 19.10

THREE-PHASE, LIQUID-FILLED PAD-MOUNTED TRANSFORMERS
05/19
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM D92	(2012a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2017b) Standard Test Method for Pour Point of Petroleum Products
ASTM D877/D877M	(2019) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.47	(2011) Standard for High Voltage Distribution Class Current-Limiting Type Fuses and Fuse Disconnecting Switches
IEEE C57.12.00	(2015) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity

IEEE C57.12.29	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE C57.12.34	(2015) Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 10 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2015; Corr 2017) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 260	(1996; R 2004) Safety Labels for Pad-Mounted Switchgear and Transformers Sited in Public Areas
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 1-200-01	***(2022; with Change 4, 2024) DoD Building Code***

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 712-C-98-075	(1998) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"
EPA 821-R-02-012	(2002) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 431	Energy Efficiency Program for Certain Commercial and Industrial Equipment

UNDERWRITERS LABORATORIES (UL)

UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Pad-mounted Transformer Drawings; G

SD-03 Product Data

Pad-mounted Transformers; G

Submittal shall include manufacturer's information for each component, device, insulating fluid, and accessory provided with the transformer.

SD-06 Test Reports

Acceptance Checks and Tests; G

Submittal shall include acceptance criteria and limits for each test in accordance with NETA ATS "Test Values"

SD-07 Certificates

Transformer Efficiencies; G

Submit certification, including supporting calculations, from the manufacturer indicating conformance with the paragraph entitled "Specified Transformer Efficiencies."

SD-09 Manufacturer's Field Reports

Transformer Test Schedule; G

Pad-mounted Transformer Design Tests; G

Pad-mounted Transformer Routine and Other Tests; G

SD-10 Operation and Maintenance Data

Transformer(s), Data Package 5; G

1.4.1 Reduced Submittal Requirements

Transformers designed and manufactured by ABB in Jefferson City, MO; by Eaton's Cooper Power Series Transformers in Waukesha, WI; by ERMCO in Dyersburg, TN; or by Howard Industries in Laurel, MS need not submit the entire submittal package requirements of this contract. Instead, submit the following items:

a. A certification, signed by the manufacturer, stating that the manufacturer will meet the technical requirements of this specification.

b. An outline drawing of the transformer with devices identified (paragraph PAD-MOUNTED TRANSFORMER DRAWINGS, item a).

c. ANSI nameplate data of the transformer (paragraph PAD-MOUNTED TRANSFORMER DRAWINGS, item b).

d. Manufacturer's published time-current curves in PDF format and in electronic format suitable for import or updating into the SKM PowerTools for Windows computer program of the transformer high side fuses (paragraph PAD-MOUNTED TRANSFORMER DRAWINGS, item e).

e. Provide transformer test schedule and routine and other tests required by submittal item "SD-09 Manufacturer's Field Reports".

f. Provide acceptance test reports required by submittal item "SD-06 Test Reports".

g. Provide operation and maintenance manuals required by submittal item "SD-10 Operation and Maintenance Data".

1.5 QUALITY ASSURANCE

1.5.1 Pad-Mounted Transformer Drawings

Include the following as a minimum:

a. An outline drawing, including front, top, and side views.

b. IEEE nameplate data.

c. Elementary diagrams and wiring diagrams.

d. One-line diagram, including switch(es).

e. Manufacturer's published time-current curves in PDF format and in electronic format suitable for import or updating into the SKM PowerTools for Windows computer program of the transformer high side fuses.

1.5.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, except of NFPA 70 when more stringent requirements are specified or indicated, as though the word "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with NFPA 70 unless more stringent requirements are specified or indicated.

1.5.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship, and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.3.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable.

1.6 MAINTENANCE

1.6.1 Additions to Operation and Maintenance Data

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein. In addition to

requirements of Data Package 5, include the following on the actual transformer(s) provided:

a. An instruction manual with pertinent items and information highlighted

b. An outline drawing, front, top, and side views

c. Prices for spare parts and supply list

d. Routine and field acceptance test reports

e. Fuse curves for primary fuses

f. Actual nameplate diagram

g. Date of purchase

1.7 PROJECT/SITE CONDITIONS

Environmental Severity Classification (ESC) the project location is classified As ESC (C4) in accordance with UFC 1-200-01.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be pad-mounted transformers and related accessories are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.2 THREE-PHASE PAD-MOUNTED TRANSFORMERS

IEEE C57.12.34, IEEE C57.12.28 and as specified herein. Submit manufacturer's information for each component, device, insulating fluid, and accessory provided with the transformer.

2.2.1 Compartments

Provide high- and low-voltage compartments separated by steel isolating barriers extending the full height and depth of the compartments. Compartment doors: hinged lift-off type with stop in open position and three-point latching.

2.2.1.1 High Voltage, Dead-Front

High-voltage compartment contains: the incoming line, insulated high-voltage load-break connectors, bushing well inserts, six high-voltage bushing wells configured for loop feed application, load-break switch handle(s), access to oil-immersed bayonet fuses, dead-front surge arresters, tap changer handle, connector parking stands protective caps, and ground pad.

a. Insulated high-voltage load-break connectors: IEEE 386, rated 15 kV, 95 kV BIL. Current rating: 200 amperes rms continuous. Short time rating: 10,000 amperes rms symmetrical for a time duration of 0.17 seconds. Connector must have a ***stainless*** steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

b. Bushing well inserts: IEEE 386, 200 amperes, 15 kV Class. Provide a bushing well insert for each bushing well unless indicated otherwise.

c. Load-break switch

Loop feed sectionalizer switches: Provide three, two-position, oil-immersed type switches to permit closed transition loop feed and sectionalizing. Each switch must be rated at 15kV, 95kV BIL, with a continuous current rating and load-break rating of 600 amperes, and a make-and-latch rating of 12,000rms amperes symmetrical. Locate the switch handes in the high-voltage compartment.

d. Provide bayonet oil-immersed, expulsion fuses in series with oil-immersed, partial-range, current-limiting fuses. The bayonet fuse links sense both high currents and high oil temperature in order to provide thermal protection to the transformer. Coordinate transformer protection with expulsion fuse clearing low-current faults and current-limiting fuse clearing high-current faults beyond the interrupting rating of the expulsion fuse. Include an oil retention valve inside the bayonet assembly housing, which closes when the fuse holder is removed, and an external drip shield to minimize oil spills. Display a warning label adjacent to the bayonet fuse(s) cautioning against removing or inserting fuses unless the transformer has been de-energized and the tank pressure has been released.

Bayonet fuse assembly: 150 kV BIL.

Oil-immersed current-limiting fuses: IEEE C37.47; 50,000 rms amperes symmetrical interrupting rating at the system voltage specified. Connect current-limiting fuses ahead of the radial-feed load-break switch.

e. Surge arresters: IEEE C62.11, rated 15 kV, fully shielded, dead-front, metal-oxide-varistor, elbow type with resistance-graded gap. Provide three arresters for radial feed circuits.

f. Parking stands: Provide a parking stand near each bushing.

g. Protective caps: IEEE 386, 200 amperes, 15 kV Class. Provide insulated protective caps (not shipping caps) for insulating and sealing out moisture from unused bushings.

2.2.1.2 Low Voltage

Low-voltage compartment contains: low-voltage bushings with NEMA spade terminals, accessories, metering, stainless steel or laser-etched anodized aluminum diagrammatic transformer nameplate, and ground pad.

a. Include the following accessories: drain valve with sampler device, fill plug, pressure relief device, liquid level gage, pressure-vacuum gage, and dial type thermometer with maximum temperature indicator.

b. Metering: Provide as specified in Section 26 27 14.00 20 ELECTRICITY METERING.

2.2.2 Transformer

a. Less-flammable bio-based liquid-insulated, two winding, 60 hertz, 65 degrees C rise above a 30 degrees C average ambient, self-cooled type.

b. Transformer rating: As indicated on Contract Drawings.

c. Transformer voltage ratings: As indicated on Contract Drawings.

d. Tap changer: externally operated, manual type for changing tap setting when the transformer is de-energized. Provide four 2.5 percent full capacity taps, two above and two below rated primary voltage. Indicate which tap setting is in use, clearly visible when the compartment is opened.

e. Minimum tested percent impedance at 85 degrees C:

5.32 for units rated 750kVA and above

f. Comply with the following audible sound level limits:

kVA	DECIBELS (MAX
75	51
112.5	55
150	55
225	55
300	55
500	56
750	57
1000	58
1500	60
2000	61
2500	62

g. Include:

(1) Lifting lugs and provisions for jacking under base, with base construction suitable for using rollers or skidding in any direction.

(2) An insulated low-voltage neutral bushing with NEMA spade terminal, and with removable ground strap.

(3) Provide transformer top with an access handhole.

(4) kVA rating conspicuously displayedusing 3 inch high yellow letters on its enclosure.

2.2.2.1 Specified Transformer Efficiencies

Provide transformer efficiency calculations utilizing the actual no-load and load loss values obtained during the routine tests performed on the actual transformer(s) prepared for this project. Reference no-load losses (NLL) at 20 degrees C. Reference load losses (LL) at 55 degrees C and at 50 percent of the nameplate load. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in the "KVA / Efficiency" table below. The table is based on requirements contained within 10 CFR 431, Subpart K. Submit certification, including supporting calculations, from the manufacturer indicating conformance.

kVA	EFFICIENCY (percent)
15	98.65
30	98.83
45	98.92
75	99.03
112.5	99.11
150	99.16
225	99.23
300	99.27
500	99.35
750	99.40
1000	99.43
1500	99.48
2000	99.51
2500	99.53
above 2500	99.54

2.2.3 Insulating Liquid

a. Less-flammable transformer liquids: NFPA 70 and FM APP GUIDE for less-flammable liquids having a fire point not less than 300 degrees C tested per ASTM D92 and a dielectric strength not less than 33 kV tested per ASTM D877/D877M. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid" on the nameplate.

Provide a fluid that is a biodegradable, electrical insulating, and cooling liquid classified by UL and approved by FM as "less flammable" with the following properties:

(1) Pour point: ASTM D97, less than -15 degree C

(2) Aquatic biodegradation: EPA 712-C-98-075, ultimately biodegradable as designated by EPA.

(3) Trout toxicity: OECD Test 203, zero mortality of EPA 821-R-02-012, pass

2.2.3.1 Liquid-Filled Transformer Nameplates

Provide nameplate information in accordance with IEEE C57.12.00 and as modified or supplemented by this section.

2.2.4 Corrosion Protection

Provide entire transformer assembly, including tank and radiator, base, enclosure, and metering enclosure fabricated of stainless steel conforming to ASTM A240/A240M, Type 304 or 304L. Form enclosure of stainless steel sheets. The optional use of aluminum is permitted for the metering enclosure.

Paint entire transformer assembly Munsell 7GY3.29/1.5 green, with paint coating system complying with IEEE C57.12.28 and IEEE C57.12.29 regardless of base, cabinet, and tank material. The Munsell color notation is specified in ASTM D1535.

2.3 WARNING SIGNS AND LABELS

Provide warning signs for the enclosures of pad-mounted transformers having a nominal rating exceeding 600 volts in accordance with NEMA Z535.4 and NEMA 260.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28, such as for pad-mounted transformers, provide self-adhesive warning labels on the outside of the high voltage compartment door(s)with nominal dimensions of 7 by 10 inches with the legend "WARNING HIGH VOLTAGE" printed in two lines of nominal 2 inch high letters. Include the work "WARNING" in white letters on an orange background and the words "HIGH VOLTAGE" in black letters on a white background.

2.4 ARC FLASH WARNING LABEL

Provide arc flash warning label for the enclosure of pad-mounted transformers. Locate this self-adhesive warning label on the outside of the high voltage compartment door warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.

2.5 GROUNDING AND BONDING

UL 467. Provide grounding and bonding as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.6 CAST-IN-PLACE CONCRETE

Provide concrete associated with electrical work for other than encasement of underground ducts rated for 4000 psi minimum 28-day compressive

strength unless specified otherwise. Conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.7 SOURCE QUALITY CONTROL

2.7.1 Transformer Test Schedule

The Government reserves the right to witness tests. Provide transformer test schedule for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

a. Test Instrument Calibration

(1) Provide a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

(2) Accuracy: Traceable to the National Institute of Standards and Technology.

(3) Instrument calibration frequency schedule: less than or equal to 12 months for both test floor instruments and leased specialty equipment.

(4) Dated calibration labels: visible on all test equipment.

(5) Calibrating standard: higher accuracy than that of the instrument tested.

(6) Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.7.2 Design Tests

IEEE C57.12.00, and IEEE C57.12.90. Section 5.1.2 in IEEE C57.12.80 states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for the specified transformer(s), with design tests performed prior to the award of this contract.

a. Tests: certified and signed by a registered professional engineer.

b. Temperature rise: "Basically the same design" for the temperature rise test means a pad-mounted transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (KNAN), the same temperature rise rating, and the same insulating liquid as the transformer specified.

c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a pad-mounted transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary), and a tap changer, if specified. Design lightning impulse tests includes the primary windings only of that transformer.

(1) IEEE C57.12.90, paragraph 10.3 entitled "Lightning Impulse Test Procedures," and IEEE C57.98.

(2) State test voltage levels.

(3) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

d. Lifting and moving devices: "Basically the same design" requirement for the lifting and moving devices test means a test report confirming that the lifting device being used is capable of handling the weight of the specified transformer in accordance with IEEE C57.12.34.

e. Pressure: "Basically the same design" for the pressure test means a pad-mounted transformer with a tank volume within 30 percent of the tank volume of the transformer specified.

f. Short circuit: "Basically the same design" for the short circuit test means a pad-mounted transformer with the same kVA as the transformer specified.

2.7.3 Routine and Other Tests

IEEE C57.12.00. Routine and other tests: performed in accordance with IEEE C57.12.90 by the manufacturer on the actual transformer(s) prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence as follows:

a. Phase relation

b. Ratio

c. No-load losses (NLL) and excitation current

d. Load losses (LL) and impedance voltage

e. Dielectric

(1) Impulse

(2) Applied voltage

(3) Induced voltage

f. Leak

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to the requirements specified herein.

Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 25 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Pad-Mounted Transformer Grounding

Provide a ground ring around the transformer with 4/0 AWG bare copper. Provide two ground rods in the ground ring at opposite corners. Install the ground rods at least 10 feet apart from each other. Provide separate copper grounding conductors and connect them to the ground loop as indicated. When work in addition to that indicated or specified is required to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect pad-mounted transformers furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.4 FIELD APPLIED PAINTING

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.5 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

Mount transformer on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 8 inches thick, reinforced with a 6 by 6 inches - W2.9 by W2.9 mesh placed uniformly 4 inches from the top of the slab.

b. Place slab on a 6 inch thick, well-compacted gravel base.

c. Install slab such that top of concrete slab is approximately 4 inches above the finished grade with gradual slope for drainage.

d. Provide edges above grade with 1/2 inch chamfer.

e. Provide slab of adequate size to project at least 8 inches beyond the equipment.

Stub up conduits, with bushings, 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.

3.5.1 Cast-In-Place Concrete

Provide cast-in-place concrete work in accordance with the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.5.2 Sealing

When the installation is complete, seal all entries into the equipment enclosure with an approved sealing method. Provide seals of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.6 FIELD QUALITY CONTROL

3.6.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS. Submit reports, including acceptance criteria and limits for each test in accordance with NETA ATS "Test Values".

3.6.1.1 Pad-Mounted Transformers

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.

(3) Inspect anchorage, alignment, and grounding.

(4) Verify the presence of PCB content labeling.

(5) Verify the bushings and transformer interiors are clean.

(6) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(7) Verify correct liquid level in tanks and bushings.

(8) Verify that positive pressure is maintained on gas-blanketed transformers.

(9) Perform specific inspections and mechanical tests as recommended by manufacturer.

(10) Verify de-energized tap changer position is left as specified.

(11) Verify the presence of transformer surge arresters.

b. Electrical tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

(2) Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3.6.1.2 Grounding System

a. Visual and mechanical inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.6.1.3 Surge Arresters, Medium- and High-Voltage

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect anchorage, alignment, grounding, and clearances.

(4) Verify the arresters are clean.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method,

or performing thermographic survey.

(6) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.

b. Electrical tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform an insulation-resistance test on each arrester, phase terminal-to-ground.

(3) Test grounding connection.

3.6.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, notify the Contracting Officer 5 working days in advance of the dates and times of checking and testing.

3.7 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM
08/19
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 90.1 - IP	(2013) Energy Standard for Buildings Except Low-Rise Residential Buildings

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1	(2005) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2015) American National Standard for Electrical Metallic Tubing (EMT)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
NEMA MG 1	(2018) Motors and Generators
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2016) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA VE 1	(2017) Metal Cable Tray Systems
NEMA WD 1	(1999; R 2015) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2016) Wiring Devices Dimensions Specifications
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

NFPA 70E	(2021) Standard for Electrical Safety in the Workplace
NFPA 780	(2017) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-569	(2015d) Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-607	(2015c; Addendum 1 2017) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 431	Energy Efficiency Program for Certain Commercial and Industrial Equipment
29 CFR 1910.147	The Control of Hazardous Energy (Lock Out/Tag Out)
29 CFR 1910.303	Electrical, General

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jan 2020) UL Standard for Safety Flexible Metal Conduit
UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 20	(2010; Reprint Feb 2012) General-Use Snap Switches
UL 44	(2018) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint Oct 2019) UL Standard for Safety Panelboards
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 360	(2013; Reprint Nov 2018) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors

UL 486C	(2019) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint Jan 2020) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017) UL Standard for Safety Specialty Transformers
UL 508	(2018) UL Standard for Safety Industrial Control Equipment
UL 510	(2020) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint Nov 2014) Conduit, Tubing and Cable Fittings
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 651	(2011; Reprint Nov 2018) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 797	(2007; Reprint Mar 2017) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 854	(2020) Standard for Service-Entrance Cables
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 984	(1996; Reprint Sep 2005) Hermetic Refrigerant Motor-Compressors
UL 1063	(2017) UL Standard for Safety Machine-Tool Wires and Cables
UL 1242	(2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 1449	(2021; Reprint Dec 2022) UL Standard for Safety Surge Protective Devices
UL 1660	(2019) Liquid-Tight Flexible Nonmetallic Conduit

UL 1699 (2017) UL Standard for Safety Arc-Fault Circuit-Interrupters

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE 100.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Panelboards; G

Transformers; G

Cable Trays; G

Marking Strips Drawings; G

Installation Drawings; G

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Identify circuit terminals on wiring diagrams and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Indicate on the drawings adequate clearance for operation, maintenance, and replacement of operating equipment devices.

SD-03 Product Data

Receptacles; G

Circuit Breakers; G

Switches; G

Transformers; G

Enclosed Circuit Breakers; G

Motor Controllers; G

Manual Motor Starters; G

Telecommunications Grounding Busbar; G

Surge Protective Devices; G

SD-06 Test Reports

600-volt Wiring Test; G

Grounding System Test; G

Transformer Tests; G

Ground-fault Receptacle Test; G

Arc-fault Receptacle Test; G

Acceptance Test Report; G

SD-07 Certificates

SD-09 Manufacturer's Field Reports

Transformer Factory Tests

SD-10 Operation and Maintenance Data

Electrical Systems, Data Package 5; G

1.4 QUALITY ASSURANCE

1.4.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" or "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with NFPA 70 unless more stringent requirements are specified or indicated.

1.4.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.2.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable.

1.5 MAINTENANCE

1.5.1 Electrical Systems

Submit operation and maintenance data in accordance with Section 01 78 23, OPERATION AND MAINTENANCE DATA and as specified herein. Submit operation and maintenance manuals for electrical systems that provide basic data relating to the design, operation, and maintenance of the electrical distribution system for the building. Include the following:

a. Single line diagram of the "as-built" building electrical system.

b. Schematic diagram of electrical control system (other than HVAC, covered elsewhere).

c. Manufacturers' operating and maintenance manuals on active electrical equipment.

1.6 WARRANTY

Provide equipment items supported by service organizations that are reasonably convenient to the equipment installation drawings in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.7 SEISMIC REQUIREMENTS

Provide seismic details conforming to Section 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

As a minimum, meet requirements of UL, where UL standards are established for those items, and requirements of NFPA 70 for all materials, equipment, and devices.

2.2 CONDUIT AND FITTINGS

Conform to the following:

2.2.1 Rigid Metallic Conduit

2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit

ANSI C80.1, UL 6.

2.2.2 Rigid Nonmetallic Conduit

PVC Type EPC-40, and EPC-80 in accordance with NEMA TC 2,UL 651.

2.2.3 Intermediate Metal Conduit (IMC)

UL 1242, zinc-coated steel only.

2.2.4 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797, ANSI C80.3.

2.2.5 Plastic-Coated Rigid Steel and IMC Conduit

NEMA RN 1, Type 40(40 mils thick).

2.2.6 Flexible Metal Conduit

UL 1.

2.2.6.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360.

2.2.7 Fittings for Metal Conduit, EMT, and Flexible Metal Conduit

UL 514B. Ferrous fittings: cadmium- or zinc-coated in accordance with UL 514B.

2.2.7.1 Fittings for Rigid Metal Conduit and IMC

Threaded-type. Split couplings unacceptable.

2.2.7.2 Fittings for EMT

Steel compression type.

2.2.8 Fittings for Rigid Nonmetallic Conduit

NEMA TC 3 for PVC, and UL 514B.

2.2.9 Liquid-Tight Flexible Nonmetallic Conduit

UL 1660.

2.3 CABLE TRAYS

NEMA VE 1. Provide the following:

a. Cable trays: form a wireway system, with a nominal 4 inch depth as indicated.

b. Cable trays: constructed of steel that has been zinc-coated after fabrication.

c. Cable trays: include splice and end plates, dropouts, and miscellaneous hardware.

d. Edges, fittings, and hardware: finished free from burrs and sharp edges.

e. Fittings: ensure not less than load-carrying ability of straight tray sections and have manufacturer's minimum standard radius.

f. Radius of bends: As recommended by the manufacturer.

2.3.1 Basket-Type Cable Trays

Provide size as indicated with maximum wire mesh spacing of 2 by 4 inch.

2.4 OUTLET BOXES AND COVERS

UL 514A, cadmium- or zinc-coated, if ferrous metal. UL 514C, if nonmetallic.

2.4.1 Floor Outlet Boxes

Provide types as indicated on Drawings.

2.4.2 Outlet Boxes for Telecommunications System

Provide the following:

a. Size as indicated on the Drawings.

b. Depth of boxes: Large enough to allow manufacturers' recommended conductor bend radii.

2.5 CABINETS, JUNCTION BOXES, AND PULL BOXES

UL 50; volume greater than 100 cubic inches, NEMA Type 1 enclosure; sheet steel, hot-dip, zinc-coated. Where exposed to wet, damp, or corrosive environments, NEMA Type as indicated.

2.6 WIRES AND CABLES

Provide wires and cables in accordance applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Do not use wires and cables manufactured more than 12 months prior to date of delivery to site.

2.6.1 Conductors

Provide the following:

a. Conductor sizes and capacities shown are based on copper, unless indicated otherwise.

b. Conductors No. 8 AWG and larger diameter: stranded.

c. Conductors No. 10 AWG and smaller diameter: solid.

d. Conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3: stranded unless specifically indicated otherwise.

2.6.1.1 Minimum Conductor Sizes

Provide minimum conductor size in accordance with the following:

a. Branch circuits: No. 12 AWG.

b. Class 1 remote-control and signal circuits: No. 14 AWG.

c. Class 2 low-energy, remote-control and signal circuits: No. 16 AWG.

d. Class 3 low-energy, remote-control, alarm and signal circuits: No. 22 AWG.

e. Digital low voltage lighting control (DLVLC) system at 24 Volts or less: Category 5 UTP cables in accordance with DLVLC system manufacturer requirements.

2.6.2 Color Coding

Provide color coding for service, feeder, branch, control, and signaling circuit conductors.

2.6.2.1 Ground and Neutral Conductors

Provide color coding of ground and neutral conductors as follows:

a. Grounding conductors: Green.

b. Neutral conductors: White.

c. Exception, where neutrals of more than one system are installed in same raceway or box, other neutrals color coding: white with a different colored (not green) stripe for each.

2.6.2.2 Ungrounded Conductors

Provide color coding of ungrounded conductors in different voltage systems as follows:

a. 208/120 volt, three-phase

(1) Phase A - black

(2) Phase B - red

(3) Phase C - blue

b. 480/277 volt, three-phase

(1) Phase A - brown

(2) Phase B - orange

(3) Phase C - yellow

c. 120/240 volt, single phase: Black and red

2.6.3 Insulation

Unless specified or indicated otherwise or required by NFPA 70, provide power and lighting wires rated for 600-volts, Type THWN/THHN conforming to UL 83; remote-control and signal circuits: Type TW or TF, conforming to UL 83. Where lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.6.4 Bonding Conductors

ASTM B1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

2.6.4.1 Telecommunications Bonding Backbone (TBB)

Provide a copper conductor TBB in accordance with TIA-607 with No. 6 AWG minimum size, and sized at 2 kcmil per linear foot of conductor length up to a maximum size of 3/0 AWG.

2.6.4.2 Bonding Conductor for Telecommunications

Provide a copper conductor Bonding Conductor for Telecommunications between the telecommunications main grounding busbar (TMGB) and the electrical service ground in accordance with TIA-607. Size the bonding conductor for telecommunications the same as the TBB.

2.6.5 Service Entrance Cables

Service Entrance (SE) and Underground Service Entrance (USE) Cables, UL 854.

2.7 SPLICES AND TERMINATION COMPONENTS

UL 486A-486B for wire connectors and UL 510 for insulating tapes. Connectors for No. 10 AWG and smaller diameter wires: insulated, pressure-type in accordance with UL 486A-486B or UL 486C (twist-on splicing connector). Provide solderless terminal lugs on stranded conductors.

2.8 DEVICE PLATES

Provide the following:

a. UL listed, one-piece device plates for outlets to suit the devices installed.

b. For metal outlet boxes, plates on unfinished walls: stainless steel having round or beveled edges.

c. For nonmetallic boxes and fittings, stainless steel.

d. Plates on finished walls: stainless steel.

e. Screws: machine-type with countersunk heads in color to match finish of plate.

f. Sectional type device plates are not be permitted.

g. Plates installed in wet locations: gasketed and UL listed for "wet locations."

2.9 SWITCHES

2.9.1 Toggle Switches

NEMA WD 1, UL 20, single pole, three-way, totally enclosed with bodies of

thermoplastic or thermoset plastic and mounting strap with grounding screw. Include the following:

a. Handles: white thermoplastic.

b. Wiring terminals: screw-type, side-wired.

c. Contacts: silver-cadmium and contact arm - one-piece copper alloy.

d. Switches: rated quiet-type ac only, 120/277 volts, with current rating and number of poles indicated.

2.9.2 Breakers Used as Switches

For 120- and 277-Volt fluorescent fixtures, mark breakers "SWD" in accordance with UL 489.

2.9.3 Disconnect Switches

NEMA KS 1. Provide heavy duty-type switches where indicated, where switches are rated higher than 240 volts, and for double-throw switches. Provide horsepower rated for switches serving as the motor-disconnect means. Provide switches in NEMA enclosure as indicated per NEMA ICS 6 ***4X Type 316 stainless steel***.

2.10 RECEPTACLES

Provide the following:

a. UL 498, general purpose specification grade, grounding-type as indicated on the drawings. Residential grade receptacles are not acceptable.

b. Ratings and configurations: as indicated.

c. Bodies: white as per NEMA WD 1.

d. Face and body: thermoplastic supported on a metal mounting strap.

e. Dimensional requirements: per NEMA WD 6.

f. Screw-type, side-wired wiring terminals or of the solderless pressure type having suitable conductor-release arrangement.

g. Grounding pole connected to mounting strap.

h. The receptacle: containing triple-wipe power contacts and double or triple-wipe ground contacts.

2.10.1 Split Duplex Receptacles

Provide separate terminals for each ungrounded pole. One receptacle must be controlled separately.

2.10.2 Weatherproof Receptacles

Provide receptacles, UL listed for use in "wet locations". Include cast metal box with gasketed, hinged, lockable and weatherproof while-in-use, die-cast metal/aluminum cover plate.

2.10.3 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak when the current to ground is 6 milliamperes or higher, and tripping per requirements of UL 943 for Class A ground-fault circuit interrupter devices. Provide screw-type, side-wired wiring terminals or pre-wired (pigtail) leads.

2.10.4 Special Purpose Receptacles

Select receptacles serving telecommunications racks are special purpose.

2.10.5 Plugs

Provide heavy-duty, rubber-covered three-, four-, or five-wire cord of required size, install plugs thereon, and attach to equipment. Provide UL listed plugs with receptacles, complete with grounding blades. Where equipment is not available, turn over plugs and cord assemblies to the Government.

2.10.6 Tamper-Resistant Receptacles

Provide duplex receptacle with mechanical sliding shutters that prevent the insertion of small objects into its contact slots.

2.11 PANELBOARDS

Provide panelboards in accordance with the following:

a. UL 67 and UL 50 having a short-circuit current rating as indicated.

b. Panelboards: circuit breaker-equipped.

c. Designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL.

d. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings.

e. Use of "Subfeed Breakers" is not acceptable.

f. Main breaker: "separately" mounted "above" or "below" branch breakers.

g. Where "space only" is indicated, make provisions for future installation of breakers.

h. Directories: indicate load served by each circuit in panelboard.

i. Directories: indicate source of service to panelboard (e.g., Panel PA served from Panel MDP).

j. Type directories and mount in holder behind transparent protective covering.

k. Panelboard nameplates: provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

2.11.1 Enclosure

Provide panelboard enclosure in accordance with the following:

a. UL 50.

b. Cabinets mounted outdoors or flush-mounted: hot-dipped galvanized after fabrication.

c. Cabinets: painted in accordance with paragraph PAINTING.

d. Front edges of cabinets: form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front.

e. All cabinets: fabricated such that no part of any surface on the finished cabinet deviates from a true plane by more than 1/8 inch.

f. Holes: provided in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a 1/2 inch clear space between the back of the cabinet and the wall surface.

g. Flush doors: mounted on hinges that expose only the hinge roll to view when the door is closed.

h. Each door: fitted with a combined catch and lock latch.

i. Keys: two provided with each lock, with all locks keyed alike.

j. Finished-head cap screws: provided for mounting the panelboard fronts on the cabinets.

2.11.2 Panelboard Buses

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet. All panelboard buses shall be copper.

2.11.2.1 Panelboard Neutrals for Non-Linear Loads

Provide in accordance with the following:.

a. UL listed, with panelboard type specifically UL heat rise tested for use on non-linear loads.

b. Panelboard: heat rise tested in accordance with UL 67, except with the neutral assembly installed and carrying 200 percent of the phase bus current during testing.

c. Verification of the testing procedure: provided upon request.

d. Two neutral assemblies paralleled together with cable is not acceptable.

e. Nameplates for panelboard rated for use on non-linear loads: marked "SUITABLE FOR NON-LINEAR LOADS" and in accordance with paragraph FIELD FABRICATED NAMEPLATES.

f. Provide a neutral label with instructions for wiring the neutral of panelboards rated for use on non-linear loads.

2.11.3 Circuit Breakers

UL 489, thermal magnetic-type or solid state-type having a minimum short-circuit current rating equal to the short-circuit current rating of the panelboard in which the circuit breaker will be mounted. Breaker terminals: UL listed as suitable for type of conductor provided. Where indicated on the drawings, provide circuit breakers with shunt trip devices. Series rated circuit breakers and plug-in circuit breakers are unacceptable.

2.11.3.1 Multipole Breakers

Provide common trip-type with single operating handle. Design breaker such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

2.11.3.2 Circuit Breaker With Ground-Fault Circuit Interrupter

UL 943 and NFPA 70. Provide with auto-monitoring (self-test) and lockout features, "push-to-test" button, visible indication of tripped condition, and ability to detect and trip when current imbalance is 6 milliamperes or higher per requirements of UL 943 for Class A ground-fault circuit interrupter devices.

2.11.3.3 Electronic Trip Units

Where indicated, equip breakers with a solid-state tripping system consisting of three current sensors and a microprocessor-based trip unit that provides true rms sensing adjustable time-current circuit protection. Include the following:

a. Trip units shall provide local and remote trip indication and reason for trip (e.g. overload, short circuit or ground fault).

b. Trip units shall visually indicate the operating status of the circuit breaker: normal, warnings, alarms, ERMS, through the color changing backlit display.

c. Trip units shall incorporate "True RMS Sensing" through the 40th harmonic and have LED long-time pickup indications.

d. Current sensors ampere rating: the same as the breaker frame rating.

e. Trip unit ampere rating: as indicated

f. Electronic trip units: provide additional features as indicated:

(1) Breakers: include long delay pick-up and time settings and instantaneous settings.

(2) For electronic trip units that are rated for or can be adjusted to

1,200 amperes or higher, provide arc energy reduction capability with an energy-reducing maintenance switch with local status indicator. The maintenance switch is not required where zone selective interlocking is provided.

2.11.3.4 Measurement and Analysis Functions

a. Where indicated, trip units shall have embedded measurement to provide real time power metering for loads as indicated in accordance with ASHRAE 90.1 - IPASHRAE 90.1. Metering accuracy by function shall be within 0.5 percent for current and voltage, and 1 percent for power and energy measurements. Metering accuracies shall be total measurement system, including CT and meter and shall be full scale over the range 10 percent to 120 percent of Ir.

b. Measurements shall be shown on the remote monitoring system via Modbus TCP/IP.

c. Event management shall provide user notification of alarms and traceability. Event history to include: trips, protection setting changes, diagnostics, metering, configuration, and operation.

d. The date and time the entry was made and the user ID associated with the change.

e. User shall be able to activate alarms based on measurement (I, V, F, P, Q, S, THD, CosPhi, PF, I demand, P demand,) or counters.

f. All events shall be available by communication and Modbus TCP/IP.

g. Trip unit shall communicate trip cause information without requiring power to the trip unit. This function shall assist the user to restore power by displaying circuit breaker event information, potential causes, a list of additional investigations needed to determine if power can be restored and recommendations for power restoration.

2.11.3.5 Communications

Circuit breakers shall be provided with a communication interface with two Modbus TCP/IP 10/100 Mbps ports (dual-port, single network) for connection to a Ethernet network for real-time access to the circuit breaker device data and settings. Ethernet network accessible circuit breakers shall provide embedded web page interface using a standard PC and web browser without the need for additional hardware and software. Ethernet communication interfaces shall be compliant to Device Profile Web Service (DPWS) for auto-discovery on the local area network (LAN).

2.11.3.6 Electrical Power Management System

a. The trip units shall provide the necessary communications connectivity and functionality required to support the functionality of an Electrical Power Management System (EPMS). This shall include, but not be limited, to the following:

(1) Communications connectivity using the specified Ethernet network and protocols of the EPMS and related EPMS connected equipment necessary to provide functionality. Equipment shall be connected through a communications gateway as shown or specified; otherwise Ethernet and protocol connectivity shall be provided within the

equipment.

(2) Compliance with Cyber security requirements.

(3) Remote EPMS application functionality for equipment configuration; electrical power monitoring; power quality monitoring, compliance and correction; and alarm monitoring with event log.

(4) Refer to the Electrical Power Management System specification section for additional requirements.

b. Native EPMS software compatibility shall be fully factory-tested and shall include the following characteristics.

(1) Interactive graphical display screens to view and analyze real-time device data.

(2) Pre-mapping of registers to standard measurement names without the need for additional configuration or internal device registers.

(3) Automatic collection and logging of device data by EPMS software without additional configuration.

(4) Refer to the individual circuit breaker device requirements for EPMS monitoring of measured and calculated values, alarms, events, parameters and additional data as available from the device, as specified herein and within the Electrical Power Management System specification.

2.12 ENCLOSED CIRCUIT BREAKERS

UL 489. Individual molded case circuit breakers with voltage and continuous current ratings, number of poles, overload trip setting, and short circuit current interrupting rating as indicated. Enclosure type as indicated.

2.13 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

Motor short-circuit protectors, also called motor circuit protectors (MCPs): UL 508 and UL 489, and provided as shown. Provide MSCPs that consist of an adjustable instantaneous trip circuit breaker used only in conjunction with a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection. Rate MSCPs in accordance with the requirements of NFPA 70.

2.14 TRANSFORMERS

Provide transformers in accordance with the following:

a. NEMA ST 20, general purpose, dry-type, self-cooled, ventilated.

b. Provide transformers in NEMA 1 enclosure.

c. Taps for transformers 15 kVA and larger: Two 2.5 percent taps Full Capacity Above Nominal (FCAN) and two 2.5 percent taps Full Capacity Below Nominal (FCBN).

d. Transformer insulation system:

(1) 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding 115 degrees C under full-rated load in maximum ambient of 40 degrees C.

e. Transformer of 115 degrees C temperature rise: capable of carrying continuously 115 percent of nameplate kVA without exceeding insulation rating.

f. Provide copper windings. Aluminum windings are not allowed.

2.14.1 Specified Transformer Efficiency

Transformers, indicated and specified with: 480V primary, 80 degrees C or 115 degrees C temperature rise, kVA ratings of 37.5 to 100 for single phase or 30 to 500 for three phase, energy efficient type. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in 10 CFR 431, Subpart K.

2.14.2 Transformers With Non-Linear Loads

Provide transformers for non-linear loads in accordance with the following:

a. Transformer insulation: UL recognized 220 degrees C system. Neither the primary nor the secondary temperature is allowed to exceed 220 degrees C at any point in the coils while carrying their full rating of non-sinusoidal load.

b. Harmonic mitigating type as shown on the drawings.

c. K-Factor rated transformers impedance: allowed range of 3 percent to 5 percent, with a minimum reactance of 2 percent to prevent excessive neutral current when supplying loads with large amounts of third harmonic.

2.15 MOTORS

Provide motors in accordance with the following:

a. NEMA MG 1.

b. Hermetic-type sealed motor compressors: Also comply with UL 984.

c. Provide the size in terms of HP, or kVA, or full-load current, or a combination of these characteristics, and other characteristics, of each motor as indicated or specified.

d. Determine specific motor characteristics to ensure provision of correctly sized starters and overload heaters.

e. Rate motors for operation on 208-volt, 3-phase circuits with a terminal voltage rating of 200 volts, and those for operation on 480-volt, 3-phase circuits with a terminal voltage rating of 460 volts.

f. Use motors designed to operate at full capacity with voltage variation of plus or minus 10 percent of motor voltage rating.

g. Unless otherwise indicated, use continuous duty type motors if rated 1 HP and above.

h. Where fuse protection is specifically recommended by the equipment manufacturer, provide fused switches in lieu of non-fused switches indicated.

i. Use motors designed to operate with adjustable speed drive (ASD).

2.15.1 High Efficiency Single-Phase Motors

Single-phase fractional-horsepower alternating-current motors: high efficiency types are not acceptable. In exception, for special purpose motors and motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.15.2 Premium Efficiency Polyphase and Single-Phase Motors

Select polyphase and continuous-duty single phase motors based on high efficiency characteristics relative to typical characteristics and applications as listed in NEMA MG 10 and NEMA MG 11. In addition, continuous rated, polyphase squirrel-cage medium induction motors must meet the requirements for premium efficiency electric motors in accordance with NEMA MG 1, including the NEMA full load efficiency ratings. In exception, for motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.15.3 Motor Sizes

Provide size for duty to be performed, not exceeding the full-load nameplate current rating when driven equipment is operated at specified capacity under most severe conditions likely to be encountered. When motor size provided differs from size indicated or specified, make adjustments to wiring, disconnect devices, and branch circuit protection to accommodate equipment actually provided. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

2.15.4 Wiring and Conduit

Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field-installed equipment using adjustable speed drive (ASD) manufacturer required wiring type and length, and motor control equipment forming part ofor switchgear assemblies, the conduit and wiring connecting such assemblies, or other power sources to equipment as specified herein. Power wiring and conduit: conform to the requirements specified herein. Control wiring: provided under, and conform to, the requirements of the section specifying the associated equipment.

2.16 MOTOR CONTROLLERS

Provide motor controllers in accordance with the following:

a. UL 508, NEMA ICS 1, and NEMA ICS 2.

b. Provide controllers with thermal overload protection in each phase,

and one spare normally open auxiliary contact, and one spare normally closed auxiliary contact.

c. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage.

d. Provide protection for motors from immediate restart by a time adjustable restart relay.

e. When used with pressure, float, or similar automatic-type or maintained-contact switch, provide a hand/off/automatic selector switch with the controller.

f. Connections to selector switch: wired such that only normal automatic regulatory control devices are bypassed when switch is in "hand" position.

g. Safety control devices, such as low and high pressure cutouts, high temperature cutouts, and motor overload protective devices: connected in motor control circuit in "hand" and "automatic" positions.

h. Control circuit connections to hand/off/automatic selector switch or to more than one automatic regulatory control device: made in accordance with indicated or manufacturer's approved wiring diagram.

i. Provide a disconnecting means, capable of being locked in the open position, for the motor that is located in sight from the motor location and the driven machinery location. As an alternative, provide a motor controller disconnect, capable of being locked in the open position, to serve as the disconnecting means for the motor if it is in sight from the motor location and the driven machinery location.

j. Overload protective devices: provide adequate protection to motor windings; be thermal inverse-time-limit type; and include manual reset-type pushbutton on outside of motor controller case.

k. Cover of combination motor controller and manual switch or circuit breaker: interlocked with operating handle of switch or circuit breaker so that cover cannot be opened unless handle of switch or circuit breaker is in "off" position.

l. Minimum short circuit withstand rating of combination motor controller: 10,000 rms symmetrical amperes.

2.16.1 Control Wiring

Provide control wiring in accordance with the following:

a. All control wire: stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44, or Type MTW meeting UL 1063, and passing the VW-1 flame tests included in those standards.

b. Hinge wire: Class K stranding.

c. Current transformer secondary leads: not smaller than No. 10 AWG.

d. Control wire minimum size: No. 14 AWG.

e. Power wiring for 480-volt circuits and below: the same type as control wiring with No. 12 AWG minimum size.

f. Provide wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.16.2 Control Circuit Terminal Blocks

Provide control circuit terminal blocks in accordance with the following:

a. NEMA ICS 4.

b. Control circuit terminal blocks for control wiring: molded or fabricated type with barriers, rated not less than 600 volts.

c. Provide terminals with removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts.

d. Terminals: not less than No. 10 in size with sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal.

e. Terminal arrangement: subject to the approval of the Contracting Officer with not less than four spare terminals or 10 percent, whichever is greater, provided on each block or group of blocks.

f. Modular, pull apart, terminal blocks are acceptable provided they are of the channel or rail-mounted type.

g. Submit data showing that any proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.16.2.1 Types of Terminal Blocks

a. Short-Circuiting Type: Short-circuiting type terminal blocks: furnished for all current transformer secondary leads with provision for shorting together all leads from each current transformer without first opening any circuit. Terminal blocks: comply with the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

b. Load Type: Load terminal blocks rated not less than 600 volts and of adequate capacity: provided for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits, except those for feeder tap units. Provide terminals of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, provide screws with hexagonal heads. Conducting parts between connected terminals must have adequate contact surface and cross-section to operate without overheating. Provide each connected terminal with the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.16.3 Control Circuits

Control circuits: maximum voltage of 120 volts derived from control transformer in same enclosure. Transformers: conform to UL 506, as applicable. Transformers, other than transformers in bridge circuits: provide primaries wound for voltage available and secondaries wound for correct control circuit voltage. Size transformers so that 80 percent of rated capacity equals connected load. Provide disconnect switch on primary side.

2.16.4 Enclosures for Motor Controllers

NEMA ICS 6.

2.16.5 Multiple-Speed Motor Controllers and Reversible Motor Controllers

Across-the-line-type, electrically and mechanically interlocked. Multiple-speed controllers: include compelling relays and multiple-button, station-type with pilot lights for each speed.

2.16.6 Pushbutton Stations

Provide with "start/stop" momentary contacts having one normally open and one normally closed set of contacts, and red lights to indicate when motor is running. Stations: heavy duty, oil-tight design.

2.16.7 Pilot and Indicating Lights

Provide LED cluster lamps.

2.17 MANUAL MOTOR STARTERS (MOTOR RATED SWITCHES)

Single pole designed for surface mounting with overload protection and pilot lights.

2.17.1 Pilot Lights

Provide yoke-mounted, seven element LED cluster light module. Color: red.

2.18 LOCKOUT REQUIREMENTS

Provide circuit breakers, disconnecting means, and other devices that are electrical energy-isolating capable of being locked out for machines and other equipment to prevent unexpected startup or release of stored energy in accordance with 29 CFR 1910.147, NFPA 70E and 29 CFR 1910.303. Comply with requirements of Division 23, "Mechanical" for mechanical isolation of machines and other equipment.

2.19 TELECOMMUNICATIONS SYSTEM

Provide system of telecommunications wire-supporting structures (pathway), including: outlet boxes, conduits with pull wires cable trays, and other accessories for telecommunications outlets and pathway in accordance with TIA-569 and as specified herein. Additional telecommunications requirements are specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.20 COMMUNITY ANTENNA TELEVISION (CATV) SYSTEM

Additional CATV requirements are specified in Section 27 05 13.43 TELEVISION DISTRIBUTION SYSTEM.

2.20.1 CATV Outlets

Provide flush mounted, 75-ohm, F-type connector outlet rated from 5 to 1000 MHz in standard electrical outlet boxes with mounting frame.

2.20.2 CATV Faceplates

Provide modular faceplates for mounting of CATV Outlets. Faceplate: include designation labels and label covers for circuit identification. Faceplate color: match outlet and switch coverplates.

2.20.3 Backboards

Provide void-free, fire rated interior grade plywood, 3/4 inch thick, 4 by 8 feet as indicated. Do not cover the fire stamp on the backboard. Coordinate CATV backboard requirements with telecommunications backboard requirements as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING.

2.21 GROUNDING AND BONDING EQUIPMENT

2.21.1 Ground Rods

UL 467. Ground rods: cone pointed copper-clad steel, with minimum diameter of 3/4 inch and minimum length 10 feet. Sectional ground rods are permitted.

2.21.2 Ground Bus

Copper ground bus: provided in the electrical equipment rooms as indicated.

2.21.3 Telecommunications Grounding Busbar

Provide corrosion-resistant grounding busbar suitable for indoorinstallation in accordance with TIA-607. Busbars: plated for reduced contact resistance. If not plated, clean the busbar prior to fastening the conductors to the busbar and apply an anti-oxidant to the contact area to control corrosion and reduce contact resistance. Provide a telecommunications main grounding busbar (TMGB) in the telecommunications entrance facility and a (TGB) in all other telecommunications rooms and equipment rooms. The telecommunications main grounding busbar (TMGB) and the telecommunications grounding busbar (TGB): sized in accordance with the immediate application requirements and with consideration of future growth. Provide telecommunications grounding busbars with the following:

a. Predrilled copper busbar provided with holes for use with standard sized lugs,

b. Minimum dimensions of 0.25 in thick by 4 in wide for the TMGB and 2 in wide for TGBs with length as indicated;

c. Listed by a nationally recognized testing laboratory.

2.22 MANUFACTURER'S NAMEPLATE

Provide on each item of equipment a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.23 FIELD FABRICATED NAMEPLATES

Provide field fabricated nameplates in accordance with the following:

a. ASTM D709.

b. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings.

c. Each nameplate inscription: identify the function and, when applicable, the position.

d. Nameplates: melamine plastic, 0.125 inch thick, white with black center core.

e. Provide red laminated plastic label with white center core where indicated.

f. Surface: matte finish. Corners: square. Accurately align lettering and engrave into the core.

g. Minimum size of nameplates: one by 2.5 inches.

h. Lettering size and style: a minimum of 0.25 inch high normal block style.

2.24 WARNING SIGNS

Provide warning signs for flash protection in accordance with NFPA 70E and NEMA Z535.4 for switchboards, panelboards, industrial control panels, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized. Provide field installed signs to warn qualified persons of potential electric arc flash hazards when warning signs are not provided by the manufacturer. Provide marking that is clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

2.25 FIRESTOPPING MATERIALS

Provide firestopping around electrical penetrations in accordance with Section 07 84 00 FIRESTOPPING.

2.26 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entrance and panelboards. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. SPD must have the same short-circuit current rating as the protected equipment and shall not be installed at a point of system where the available fault current is in

excess of that rating. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker. Submit performance and characteristic curves.

Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-
Phase to phase (L-L)
Each phase to neutral (L-N)
Neutral to ground (N-G)
Phase to ground (L-G)

SPDs at the service entrance: provide with a minimum surge current rating of 80,000 amperes for L-L mode minimum and 40,000 amperes for other modes (L-N, L-G, and N-G) and downstream SPDs rated 40,000 amperes for L-L mode minimum and 20,000 amperes for other modes (L-N, L-G, and N-G).

2.27 FACTORY APPLIED FINISH

Provide factory-applied finish on electrical equipment in accordance with the following:

a. NEMA 250 corrosion-resistance test and the additional requirements as specified herein.

b. Interior and exterior steel surfaces of equipment enclosures: thoroughly cleaned followed by a rust-inhibitive phosphatizing or equivalent treatment prior to painting.

c. Exterior surfaces: free from holes, seams, dents, weld marks, loose scale or other imperfections.

d. Interior surfaces: receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice.

e. Exterior surfaces: primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish.

f. Equipment located indoors: ANSI Light Gray, and equipment located outdoors: ANSI Light Gray.

g. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

2.28 SOURCE QUALITY CONTROL

2.28.1 Transformer Factory Tests

Submittal: include routine NEMA ST 20 transformer test results on each transformer and also provide the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal to those specified.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations, including weatherproof and hazardous locations

and ducts, plenums and other air-handling spaces: conform to requirements of NFPA 70 and IEEE C2 and to requirements specified herein.

3.1.1 Underground Service

Underground service conductors and associated conduit: continuous from service entrance equipment to outdoor power system connection.

3.1.2 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures: labeled and identified as such.

3.1.2.1 Labels

Wherever work results in service entrance disconnect devices in more than one enclosure, as permitted by NFPA 70, label each enclosure, new and existing, as one of several enclosures containing service entrance disconnect devices. Label, at minimum: indicate number of service disconnect devices housed by enclosure and indicate total number of enclosures that contain service disconnect devices. Provide laminated plastic labels conforming to paragraph FIELD FABRICATED NAMEPLATES. Use lettering of at least 0.25 inch in height, and engrave on black-on-white matte finish. Service entrance disconnect devices in more than one enclosure: provided only as permitted by NFPA 70.

3.1.3 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor: separate from electrical system neutral conductor. Provide insulated green equipment grounding conductor for circuit(s) installed in conduit and raceways. Minimum conduit size: 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings: made with metal conduit in fire-rated shafts, with metal conduit extending through shafts for minimum distance of 6 inches. Firestop conduit which penetrates fire-rated walls, fire-rated partitions, or fire-rated floors in accordance with Section 07 84 00 FIRESTOPPING.

3.1.3.1 Pull Wire

Install pull wires in empty conduits. Pull wire: plastic having minimum 200-pound force tensile strength. Leave minimum 36 inches of slack at each end of pull wire.

3.1.4 Conduit Installation

Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 6 inches away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project.

3.1.4.1 Restrictions Applicable to EMT

a. Do not install underground.

b. Do not encase in concrete, mortar, grout, or other cementitious materials.

c. Do not use in areas subject to physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.

d. Do not use in hazardous areas.

e. Do not use outdoors.

f. Do not use in fire pump rooms.

g. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.2 Restrictions Applicable to Nonmetallic Conduit

a. PVC Schedule 40.

(1) Do not use where subject to physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, fire pump rooms, and where restrictions are applying to both PVC Schedule 40 and PVC Schedule 80.

(2) Do not use above grade, except where allowed in this section for rising through floor slab or indicated otherwise.

b. PVC Schedule 40 and Schedule 80.

(1) Do not use where subject to physical damage, including but not limited to, hospitals, power plant, missile magazines, and other such areas.

(2) Do not use in hazardous (classified) areas.

(3) Do not use in penetrating fire-rated walls or partitions, or fire-rated floors.

-

3.1.4.3 Restrictions Applicable to Flexible Conduit

Use only as specified in paragraph FLEXIBLE CONNECTIONS. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.4 Underground Conduit

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40 Plastic coating: extend minimum 6 inches above floor.

3.1.4.5 Conduit Installed Under Floor Slabs

Conduit run under floor slab: located a minimum of 12 inches below the vapor barrier. Seal around conduits at penetrations thru vapor barrier.

3.1.4.6 Conduit Through Floor Slabs

Where conduits rise through floor slabs, do not allow curved portion of

bends to be visible above finished slab. Where conduit rises through slab-on grade, seal all electrical penetrations to address radon mitigation and prevent infiltration of air, insects, and vermin.

3.1.4.7 Conduit Installed in Concrete Floor Slabs

Do not install conduit in concrete floor slabs.

3.1.4.8 Stub-Ups

Provide conduits stubbed up through concrete floor for connection to free-standing equipment with adjustable top or coupling threaded inside for plugs, set flush with finished floor. Extend conductors to equipment in rigid steel conduit, except that flexible metal conduit may be used 6 inches above floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.

3.1.4.9 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Do not exceed one-fourth proof test load for load applied to fasteners. Provide vibration resistant and shock-resistant fasteners attached to concrete ceiling. Do not cut main reinforcing bars for any holes cut to depth of more than 1 1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete joints. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Conduit and box systems: supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are placed. Do not share supporting means between electrical raceways and mechanical piping or ducts. Coordinate installation with above-ceiling mechanical systems to assure maximum accessibility to all systems. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations. Support exposed risers in wire shafts of multistory buildings by U-clamp hangers at each floor level and at 10 foot maximum intervals. Where conduit crosses building expansion joints, provide suitable watertight expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means. For conduits greater than 2 1/2 inches inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.4.10 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

3.1.4.11 Locknuts and Bushings

Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by NFPA 70, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least minimum single locknut and bushing. Provide locknuts with sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by NFPA 70.

3.1.4.12 Flexible Connections

Provide flexible steel conduit between 3 and 6 feet in length for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size: 1/2 inch diameter. Provide liquid tight flexible conduit in wet and damp locations for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

3.1.5 Boxes, Outlets, and Supports

Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways: cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces, when surface mounted on interior walls exposed up to 7 feet above floors and walkways, and when specifically indicated. Boxes in other locations: sheet steel. Provide each box with volume required by NFPA 70 for number of conductors enclosed in box. Boxes for mounting lighting fixtures: minimum 4 inches square, or octagonal, except that smaller boxes may be installed as required by fixture configurations, as approved. Boxes for use in masonry-block or tile walls: square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers. Provide gaskets for cast-metal boxes installed in wet locations and boxes installed flush with outside of exterior surfaces. Provide separate boxes for flush or recessed fixtures when required by fixture terminal operating temperature; provide readily removable fixtures for access to boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of ceiling supports. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel. In open overhead spaces, cast boxes threaded to raceways need not be separately supported except where used for fixture support; support sheet metal boxes directly from building structure or by bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved-type fastener maximum 24 inches from box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

3.1.5.1 Boxes

Boxes for use with raceway systems: minimum 1 1/2 inches deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets: minimum 4 inches square, except that 4 by 2 inch boxes may be used where only one raceway enters outlet. Telecommunications outlets: a minimum of 4 inches square by 2 1/8 inches deep. Mount outlet boxes flush in finished walls.

3.1.5.2 Pull Boxes

Construct of at least minimum size required by NFPA 70 of code-gauge aluminum or galvanized sheet steel, except where cast-metal boxes are required in locations specified herein. Provide boxes with screw-fastened covers. Where several feeders pass through common pull box, tag feeders to indicate clearly electrical characteristics, circuit number, and panel designation.

3.1.5.3 Extension Rings

Extension rings are not permitted for new construction.

3.1.6 Mounting Heights

Mount panelboards, enclosed circuit breakers, and disconnecting switches so height of operating handle at its highest position is maximum 78 inches above floor. Mount lighting switches 48 inches above finished floor. Mount receptacles and telecommunications outlets 18 inches above finished floor, unless otherwise indicated. Mount other devices as indicated.

3.1.7 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, provide color coding by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, provide color coding by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves. Identify control circuit terminations in accordance with manufacturer's recommendations. Provide telecommunications system conductor identification as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.

3.1.7.1 Marking Strips

Provide marking strips for identification of power distribution, control, data, and communications cables in accordance with the following:

a. Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations.

b. Use permanent ink for the wire numbers

c. Provide reversible marking strips to permit marking both sides, or provide two marking strips with each block.

d. Size marking strips to accommodate the two sets of wire numbers.

e. Assign a device designation in accordance with NEMA ICS 1 to each device to which a connection is made. Mark each device terminal to which a connection is made with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams.

f. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, provide additional wire and cable designations for identification of remote (external) circuits for the Government's wire designations.

g. Prints of the marking strips drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

3.1.8 Splices

Make splices in accessible locations. Make splices in conductors No. 10 AWG and smaller diameter with insulated, pressure-type connector. Make splices in conductors No. 8 AWG and larger diameter with solderless connector, and cover with insulation material equivalent to conductor insulation.

3.1.8.1 Splices of Aluminum Conductors

Make with solderless circumferential compression-type, aluminum-bodied connectors UL listed for AL/CU. Remove surface oxides from aluminum conductors by wire brushing and immediately apply oxide-inhibiting joint compound and insert in connector. After joint is made, wipe away excess joint compound, and insulate splice.

3.1.9 Covers and Device Plates

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Install plates with alignment tolerance of 1/16 inch. Use of sectional-type device plates are not permitted. Provide gasket for plates installed in wet locations.

3.1.10 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.1.11 Grounding and Bonding

Provide in accordance with NFPA 70 and NFPA 780. Ground exposed, non-current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductor in metallic and nonmetallic raceways, telecommunications system grounds, and neutral conductor of wiring systems. Make ground connection at main service equipment, and extend grounding conductor to point of entrance of metallic water service. Make connection to water pipe by suitable ground clamp or lug connection to plugged tee. If flanged pipes are encountered, make connection with lug bolted to street side of flanged connection. Supplement metallic water service grounding system with additional made electrode in compliance with NFPA 70. Interconnect all grounding media in or on the structure to provide a common ground potential. This includes lightning protection, electrical service, telecommunications system grounds, as well as underground metallic piping systems. Make interconnection to the gas line on the customer's side of the meter. Use main size lightning conductors for interconnecting these grounding systems to the lightning protection system. In addition to the requirements specified herein, provide telecommunications grounding in accordance with TIA-607. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

3.1.11.1 Ground Rods

Provide ground rods and measure the resistance to ground using the fall-of-potential method described in IEEE 81. Do not exceed 25 ohms under normally dry conditions for the maximum resistance of a driven ground. If this resistance cannot be obtained with a single rod, provide additional rods, spaced on center. Spacing for additional rods must be a minimum of 10 feet. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer who will decide on the number of ground rods to add.

3.1.11.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, excepting specifically those connections for which access for periodic testing is required, by exothermic weld or high compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make high compression connections using a hydraulic or electric compression tool to provide the correct circumferential pressure. Provide tools and dies as recommended by the manufacturer. Use an embossing die code or other standard method to provide visible indication that a connector has been adequately compressed on the ground wire.

3.1.11.3 Ground Bus

Provide a copper ground bus in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of transformer neutrals and other electrical equipment: effectively grounded by bonding to the ground bus. Bond the ground bus to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately 4 inches above the floor. Make connections and splices of the brazed, welded, bolted, or pressure-connector type, except use pressure connectors or bolted connections for connections to removable equipment.

3.1.11.4 Resistance

Maximum resistance-to-ground of grounding system: do not exceed 5 ohms under dry conditions. Where resistance obtained exceeds 5 ohms, contact Contracting Officer for further instructions.

3.1.12 Equipment Connections

Provide power wiring for the connection of motors and control equipment under this section of the specification. Except as otherwise specifically noted or specified, automatic control wiring, control devices, and protective devices within the control circuitry are not included in this section of the specifications and are provided under the section specifying the associated equipment.

3.1.13 Elevator

Provide circuit to line terminals of elevator controller, and disconnect switch on line side of controller, outlet for control power, outlet receptacle and work light at midheight of elevator shaft, and work light and outlet receptacle in elevator pit.

3.1.14 Government-Furnished Equipment

Contractor shall make connections to Government-furnished equipment to make equipment operate as intended, including providing miscellaneous items such as plugs, receptacles, wire, cable, conduit, flexible conduit, and outlet boxes or fittings.

3.1.15 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible. Maximum allowed lead length is 3 feet avoiding 90 degree bends.

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.4 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting: as specified in Section 09 90 00 PAINTS AND COATINGS.

In spaces indentified on the drawings as requiring corrosion protection and control, paint electrical equipment, boxes, and conduig as required to match finish of adjacent surfaces and to meet the indicated or specified safety criteria. Painting: as specified in Section 09 96 00 HIGH-PERFORMANCE COATINGS.

3.5 FIELD QUALITY CONTROL

Furnish test equipment and personnel and submit written copies of test results. Give Contracting Officer 5 working days notice prior to each test.

3.5.1 Devices Subject to Manual Operation

Operate each device subject to manual operation at least five times, demonstrating satisfactory operation each time.

3.5.2 600-Volt Wiring Test

Test wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of

1,000 volts DC for 600 volt rated wiring and 500 volts DC for 300 volt rated wiring per NETA ATS to provide direct reading of resistance. All existing wiring to be reused shall also be tested.

3.5.3 Transformer Tests

Perform the standard, not optional, tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in NETA ATS. Measure primary and secondary voltages for proper tap settings. Tests need not be performed by a recognized independent testing firm or independent electrical consulting firm.

3.5.4 Ground-Fault Receptacle Test

Test ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed. Press the TEST button and then the RESET button to verify by LED status that the device is a self-test model as specified in UL 943.

3.5.5 Arc-Fault Receptacle Test

Test arc-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed. Press the TEST button and then the RESET button to verify by LED status that the device is a self-test model as specified in UL 1699.

3.5.6 Grounding System Test

Test grounding system to ensure continuity, and that resistance to ground is not excessive. Test each ground rod for resistance to ground before making connections to rod; tie grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Submit written results of each test to Contracting Officer, and indicate location of rods as well as resistance and soil conditions at time measurements were made.

3.5.7 Phase Rotation Test

Perform phase rotation test to ensure proper rotation of service power prior to operation of new or reinstalled equipment using a phase rotation meter. Follow the meter manual directions performing the test.

3.5.8 Power Factor Correction Equipment Acceptance Testing

For the main bus of capacitor equipment, conduct an insulation-resistance test with a 5000-volt insulation test set for units 5 KV and above, 2,500-volt insulation-resistance test set for units 2.4 kV to 5 kV, and 1,000 volts for units 600 volts and below.

Apply tests for not less than 5 minutes and until three equal consecutive readings, 1 minute apart, are obtained. Record readings every 30 seconds during the first 2 minutes and every minute thereafter. Minimum acceptable resistance is 100 megohms.

Upon satisfactory completion of all bus testing, confirm the capacitor's value by performing a capacitance value test. Discharge the capacitor and measure the capacitance per the manufacturer's instructions. Satisfactory measurement is between 100 percent and 110 percent of

nameplate. Values between 90 percent and 100 percent, and 110 percent and 120 percent require investigation. Values outside these limits indicate shorted groups of internal layers and the capacitor is considered defective.

Upon satisfactory completion of the capacitance test, subject the capacitor to a dielectric strength test using a DC voltage of 75 percent of the original factory test voltage. Test voltage should be held for 10 seconds. During application of test voltage listen for any indication of internal arcing. If any arcing is heard the unit is defective.

Upon satisfactory completion of the dielectric test, remeasure the capacitance of the capacitor to insure no damage had occurred during the dielectric test. Results cannot vary more than the manufacturer's IEEE tolerance.

Final acceptance depends upon the satisfactory performance of the PFC equipment under test. Do not energize capacitor equipment until the recorded test data has been approved by the Contracting Officer. Submit acceptance test report to the Contracting Officer containing the results of all acceptance tests.

3.6 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 24 13

SWITCHBOARDS
05/15
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 90.1 - IP	(2013) Energy Standard for Buildings Except Low-Rise Residential Buildings

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.13	(2015) Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures

IEEE C37.90.1	(2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA PB 2.1	(2013) General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 V or Less
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA PB 2	(2011) Deadfront Distribution Switchboards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 891	(2005; Reprint Oct 2012) Switchboards

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE 100.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Switchboard Drawings; G

SD-03 Product Data

Switchboard; G

SD-06 Test Reports

Switchboard Design Tests; G

Switchboard Production Tests; G

Acceptance Checks and Tests; G

SD-10 Operation and Maintenance Data

Switchboard Operation and Maintenance, Data Package 5; G

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals; G

Equipment Test Schedule; G

Service Entrance Available Fault Current Label; G

1.5 QUALITY ASSURANCE

1.5.1 Product Data

Include manufacturer's information on each submittal for each component, device and accessory provided with the switchboard including:

a. Circuit breaker type, interrupting rating, and trip devices, including available settings.

b. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device.

1.5.2 Switchboard Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Identify circuit terminals on wiring diagrams and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Indicate on the drawings adequate clearance for operation, maintenance, and replacement of operating equipment devices. Include the nameplate data, size, and capacity on submittal. Also include applicable federal, military, industry, and technical society publication references on submittals. Include the following:

a. One-line diagram including breakers, current transformers, and meters.

b. Outline drawings including front elevation, section views, footprint, and overall dimensions.

c. Bus configuration including dimensions and ampere ratings of bus bars.

d. Markings and NEMA nameplate data.

e. Circuit breaker type, interrupting rating, and trip devices, including available settings.

f. Wiring diagrams and elementary diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.

g. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device. Use this information (designer of record) to provide breaker settings that ensures protection and coordination are achieved. For Navy installations, provide electronic format curves using SKM's Power Tools for Windows device library electronic format or EasyPower device library format depending on installation modeling software requirements.

1.5.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" or "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.4 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship, and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site are not acceptable.

1.6 MAINTENANCE

1.6.1 Switchboard Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.6.2 Assembled Operation and Maintenance Manuals

Assemble and securely bind manuals in durable, hard covered, water resistant binders. Assemble and index the manuals in the following order with a table of contents:

a. Manufacturer's O&M information required by the paragraph SD-10, OPERATION AND MAINTENANCE DATA.

b. Catalog data required by the paragraph SD-03, PRODUCT DATA.

c. Drawings required by the paragraph SD-02, SHOP DRAWINGS.

d. Prices for spare parts and supply list.

e. Information on metering.

f. Design test reports.

g. Production test reports.

1.7 WARRANTY

Provide equipment items that are supported by service organizations reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be switchboards and related accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.2 SWITCHBOARD

NEMA PB 2 and UL 891.

2.2.1 Ratings

Provide equipment with the following ratings:

a. Voltage rating: 480Y/277 volts AC, three-phase, 4-wire.

b. Continuous current rating of the main bus: 2000 amperes.

c. Short-circuit current rating: 65000 rms symmetrical amperes.

d. UL listed and labeled as service entrance equipment.

2.2.2 Construction

Provide the following:

a. Switchboard: consisting of one or more vertical sections bolted together to form a rigid assembly and front and rear aligned as indicated.

b. All circuit breakers: front accessible.

c. Front and rear aligned switchboards: rear accessible load connections.

d. Where indicated, "space for future" or "space" means to include a vertical bus provided behind a blank front cover. Where indicated, "provision for future" means full hardware provided to mount a breaker suitable for the location.

e. Completely factory engineered and assembled, including protective devices and equipment indicated with necessary interconnections, instrumentation, and control wiring.

2.2.2.1 Enclosure

Provide the following:

a. Enclosure: NEMA ICS 6 Type fabricated entirely of 12 gauge ASTM A240/A240M type 304 or 304L stainless steel.

b. Enclosure: bolted together with removable bolt-on side and rear covers.

c. Front doors: provided with padlockable vault handles with a three point catch.

d. Bases, frames and channels of enclosure: corrosion resistant and fabricated of ASTM A240/A240M type 304 or 304L stainless steel.

e. Base: includes any part of enclosure that is within 3 inches of concrete pad.

f. Paint color: ASTM D1535 light gray No. 61 or No. 49 over rust inhibitor.

2.2.2.2 Bus Bars

Provide the following:

a. Bus bars: copper with silver-plated contact surfaces.

(1) Phase bus bars: uninsulated.

(2) Neutral bus: rated 100 percent of the main bus continuous current rating.

b. Make bus connections and joints with hardened steel bolts.

c. Main-bus (through bus): rated at the full ampacity of the main throughout the switchboard.

d. Minimum one-quarter by 2 inch copper ground bus secured to each vertical section along the entire length of the switchboard.

2.2.2.3 Main Section

Provide the main section consisting of an individually mounted fixed molded-case circuit breaker.

2.2.2.4 Distribution Sections

Provide the distribution sections consisting of molded-case circuit breakers as indicated.

2.2.3 Protective Device

Provide main and branch protective devices as indicated.

2.2.3.1 Power Circuit Breaker

Provide the following:

a. IEEE C37.13. Low-voltage power circuit breaker with a short-circuit current rating as indicated at 600 volts.

b. Breaker frame size: as indicated.

c. Equip electrically operated breakers with motor-charged, stored-energy closing mechanism to permit rapid and safe closing of the breaker against fault currents within the short time rating of the breaker, independent of the operator's strength or effort in closing the handle.

2.2.3.2 Molded-Case Circuit Breaker

Provide the following:

a. UL 489. UL listed and labeled, standard rated branch breakers, manually operated, low voltage molded-case circuit breaker, with a short-circuit current rating as indicated at 600 volts.

b. Breaker frame size: as indicated.

c. Series rated circuit breakers are unacceptable.

2.2.4 Electronic Trip Units

Equip main and distribution breakers with a solid-state tripping system consisting of three current sensors and a microprocessor-based trip unit that provides true rms sensing adjustable time-current circuit protection. Include the following:

a. Trip units shall provide trip indication and reason for trip (e.g. overload, short circuit or ground fault).

b. Current sensors ampere rating: The same as the breaker frame rating.

c. Trip unit ampere rating: As indicated.

d. Ground fault protection: As indicated. Provide modified differential ground fault sensing system for the main-tie-main switchgear.

e. Electronic trip units: Provide additional features as indicated:

(1) Breakers: Include long delay pick-up and time settings, and indication of cause of circuit breaker trip.

(2) Main breakers: Includeshort delay pick-up and time settings and, instantaneous settings and ground fault settings. Ground fault monitoring shall be provided for the essential system switchgear as indicated, ground fault tripping is not allowed for the essential system switchgear.

(3) Distribution breakers: Include short delay pick-up and time settings, instantaneous settings, and ground fault settings. Ground fault protection is not allowed for the essential system switchgear distribution breakers.

(4) Breakers: Include a digital display for phase and ground current.

(5) Breakers: Include a digital display for watts, vars, VA, kWh, kvarh, and kVAh.

(6) Breakers: Include a digital display for phase voltage, and current.

(7) Breakers: Were indicated include communications via a network twisted pair cable for remote monitoring of phase voltage, line to neutral voltage, current, watts, vars, VA, kWh, kvarh, and kVAh.

(8) For electronic trip units that are rated for or can be adjusted to 1,200 amperes or higher, provide arc energy reduction capability with an energy-reducing maintenance switch with local status indicator. Where breakers are provided with zone selective interlocking, the energy reducing maintenance switch is not required.

(9) Provide zone selective interlocking for the circuit breakers as indicated to ensure that the circuit breaker nearest the fault trips for short time and ground fault conditions.

2.2.4.1 Measurement and Analysis Functions

a. Electronic trip units shall have embedded measurement to provide real time metering for loads as indicated in accordance with ASHRAE 90.1 - IP. Metering accuracy by function shall be within 0.5 percent for current and voltage, and 1 percent for power and energy measurements. Metering accuracies shall be total measurement system, including CT and meter and shall be full scale over the range 10 percent to 120 percent of Ir.

b. Metering functions, at the point of measurement, shall calculate and display the imported and exported energy on each phase of the power system network. It shall calculate and display active, reactive and apparent energy per phase, as well as the total active, reactive and

apparent energy.

c. Measurements shall be shown on the breaker display and the remote monitoring system via Modbus TCP/IP.

d. Event management shall provide user notification of alarms and traceability. Event history to include: trips, protection setting changes, diagnostics, metering, configuration, and operation.

e. The date and time the entry was made and the user ID associated with the change.

f. User shall be able to activate alarms based on measurement (I, V, F, P, Q, S, THD, CosPhi, PF, I demand, P demand,) or counters.

g. All events shall be available by communication, and Modbus TCP/IP.

h. Provide circuit breaker internal monitored functions for maintenance purposes: Coils electrical continuity checks, Circuit breaker closing time, Gear motor charging time, Circuit breaker closing and opening counter, Circuit breaker time stamp closing and opening history log.

i. Provide trip unit internal monitored functions for maintenance purposes: Internal Sensors (CTs) continuity, External Sensors disconnection (ENCT, ground fault sensor and I/O modules), Internal failure discrimination (ASIC, sensor plugs, internal battery, trip solenoid), Wireless communication failure (Bluetooth Low Energy BLE and Ethernet).

j. Trip unit shall communicate trip cause information without requiring power to the trip unit. This function shall assist the user to restore power by displaying circuit breaker event information, potential causes, a list of additional investigations needed to determine if power can be restored and recommendations for power restoration.

k. Provide Auto-test function for monitoring and communicating the following functions: trip unit state, battery state, contact state, circuit breaker remaining life estimate (algorithm based), spring charging function, and opening/closing function, indicated by Health State LED, embedded HMI display and smart mobile device app.

2.2.4.2 Communications

a. Trip units shall have a communication/test port for checks on electronic and trip mechanism operation in compliance with market standards (USB and PC) avoiding requiring a specific Manufacturer's hardware tool.

b. Circuit breakers shall be provided with a communication interface with two Modbus TCP/IP 10/100 Mbps ports (dual-port, single network) for connection to a Ethernet network for real-time access to the circuit breaker device data and settings. Ethernet network accessible circuit breakers shall provide embedded web page interface using a standard PC and web browser without the need for additional hardware and software. Ethernet communication interfaces shall be compliant to Device Profile Web Service (DPWS) for auto-discovery on the local area network (LAN).

c. Ethernet interface device used on drawout circuit breakers shall be capable of reporting cradle position, viewable in the embedded Web

page and over a data connection to external monitoring software.

2.2.4.3 Electrical Power Management System

a. The trip units shall provide the necessary communications connectivity and functionality required to support the functionality of an Electrical Power Management System (EPMS), refer to specification section 26 27 14.01 20 ELECTRICITY POWER MANAGEMENT SYSTEM for requirements. This shall include, but not be limited, to the following:

(1) Communications connectivity using the specified Ethernet network and protocols of the EPMS and related EPMS connected equipment necessary to provide functionality. Equipment shall be connected through a communications gateway as shown or specified; otherwise Ethernet and protocol connectivity shall be provided within the equipment.

(2) Compliance with Cybersecurity requirements.

(3) Remote EPMS application functionality for equipment configuration; electrical power monitoring; power quality monitoring, compliance and correction; and alarm monitoring with event log.

(4) Refer to the Electrical Power Management System specification section for additional requirements.

b. Native EPMS software compatibility shall be fully factory-tested and shall include the following characteristics.

(1) Interactive graphical display screens to view and analyze real-time device data.

(2) Pre-mapping of registers to standard measurement names without the need for additional configuration or internal device registers.

(3) Automatic collection and logging of device data by EPMS software without additional configuration.

(4) Refer to the individual circuit breaker device requirements for EPMS monitoring of measured and calculated values, alarms, events, parameters and additional data as available from the device, as specified herein and within the Electrical Power Management System specification.

2.2.5 Metering

2.2.5.1 Digital Meters

IEEE C37.90.1 for surge withstand. Provide true rms, plus/minus one percent accuracy, programmable, microprocessor-based meter enclosed in a sealed case with the following features.

An Advanced Metering Infrastructure (AMI) shall be provided. The AMI shall monitor the total utility usage of electricity, natural gas, and water. Provide coordination with the governments metering staff to ensure the metering requirements of the project are met.

Each AMI meter shall be provided with three Current Transformers (CT's). Each meter shall have connections for a minimum of four pulse meter inputs

and shall have a minimum of two Ethernet outputs. Refer to the drawings for requirements.

Electricity meter readings shall be monitored and recorded as necessary for providing power consumption historical data. Usage readings shall be recorded on a daily, month-to-date basis, and year-to-date basis; they shall be measured at least hourly, in fifteen-minute intervals. The metering shall monitor and record high (peak) and low demand readings. Peak readings shall be recorded on a daily, month-to-date, and year-to-date basis.

Water and natural gas meter readings shall be monitored and recorded as necessary for providing water and natural gas consumption historical data. Usage readings shall be recorded on a daily, month-to-date, and year-to-date basis. The metering shall monitor and record high (peak) and low demand readings. These readings shall be recorded on a daily, month-to-date, and year-to-date basis.

Provide all necessary MDMS communications cabling.

CT's shall be provided integral to the switchgear as indicated. Each meter shall provide the following readings, and shall record and save the minimum, maximum, and average values of all listed readings at any interval since last reset:

a. Display capability:

(1) Multi-Function Meter: Display a selected phase to neutral voltage, phase to phase voltage, percent phase to neutral voltage THD, percent phase to phase voltage THD; a selected phase current, neutral current, percent phase current THD, percent neutral current; selected total PF, kW, KVA, kVAR, FREQ, kVAh, kWh, kVARh. Detected alarm conditions include over/under current, over/under voltage, over/under KVA, over/under frequency, over/under selected PF/kVAR, voltage phase reversal, voltage imbalance, reverse power, over percent THD. Include a Form C KYZ pulse output relay on the meter.

(2) Power Meter: Display Watts, VARs, and selected KVA/PF. Detected alarm conditions include over/under KVA, over/under PF, over/under VARs, over/under reverse power. Accumulated power (real kWh, reactive kVARh, apparent kVAh). Total consumption for up to four pulse meter inputs. Provide inputs for water and natural gas.

(3) Volt Meter: Provide capability to be selectable between display of the three phases of phase to neutral voltages and simultaneous display of the three phases of the phase to phase voltages. Detected alarm conditions include over/under voltage, over/under voltage imbalance, over percent THD.

(4) Ammeter: Display phase A, B, and C currents. Display three phase average current and neutral current. Detected alarm conditions include over/under current, over percent THD.

(5) Digital Watthour Meter: Provide a single selectable display for watts, total kilowatt hours (kWh) and watt demand (Wd). Include a Form C KYZ pulse output relay on the meter.

b. Meters shall accept input from standard 5A secondary instrument

transformers direct voltage monitoring range to 600 volts, phase to phase.

c. Provide programming via a front panel display and a communication interface accessible by a computer.

d. Provide password secured programming stored in non-volatile EEPROM memory.

e. Provide digital communications in a Modbus protocol via a RS485 serial port and dual Ethernet ports.

f. Provide meter that calculates and stores average max/min demand values with time and date for all readings based on a user selectable sliding window averaging period.

g. Provide meter with programmable hi/low set limits with two Form C dry contact relays when exceeding alarm conditions.

h. Provide meter with a display of Total Harmonic Distortion (THD) measurement to a minimum of the thirty-first order.

i. Include historical trend logging capability with the ability to store up to 100,000 data points with intervals of 1 second to 180 minutes. Provide a unit that can store and time stamp up to 1000 programmable triggered conditions.

j. Provide event waveform recording triggered by the rms of 2 cycles of voltage or current exceeding programmable set points. Store waveforms for all 6 channels of voltage and current for a minimum of 10 cycles prior to the event and 50 cycles past the event.

2.2.5.2 Submetering

ASHRAE 90.1 - IP. Provide submetering for the following loads as indicated on the drawings:

a. HVAC Systems that are dictated by ASHRAE 90.1 Metering requirements.

b. Interior Lighting

c. Exterior Lighting

d. Receptacle Circuits

2.2.6 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Provide short-circuiting type terminal boards associated with current transformer. Terminate conductors for current transformers with ring-tongue lugs. Provide terminal board identification that is identical in similar units. Provide color coded external wiring that is color coded consistently for similar terminal boards.

2.2.7 Wire Marking

Mark control and metering conductors at each end. Provide factory installed, white, plastic tubing, heat stamped with black block type

letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Provide a single letter or number on each sleeve, elliptically shaped to securely grip the wire, and keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Indicate on each wire marker the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.3 MANUFACTURER'S NAMEPLATE

Provide a nameplate on each item of equipment bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent is not acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

2.4 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each switchboard, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Identify on each nameplate inscription the function and, when applicable, the position. Provide nameplates of melamine plastic, 0.125 inch thick, white with black center core. Provide matte finish surface. Provide square corners. Accurately align lettering and engrave into the core. Provide nameplates with minimum size of one by 2.5 inches. Provide lttering that is a minimum of 0.25 inch high normal block style.

2.5 SOURCE QUALITY CONTROL

2.5.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

Provide the following as part of test equipment calibration:

a. Provide a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

b. Accuracy: Traceable to the National Institute of Standards and Technology.

c. Instrument calibration frequency schedule: less than or equal to 12 months for both test floor instruments and leased specialty equipment.

d. Dated calibration labels: visible on all test equipment.

e. Calibrating standard: higher accuracy than that of the instrument tested.

f. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration,

include the following:

(1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(2) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.5.2 Switchboard Design Tests

NEMA PB 2 and UL 891.

2.5.2.1 Design Tests

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification.

a. Short-circuit current test.

b. Enclosure tests.

c. Dielectric test.

2.5.3 Switchboard Production Tests

NEMA PB 2 and UL 891. Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:

a. 60-hertz dielectric tests.

b. Mechanical operation tests.

c. Electrical operation and control wiring tests.

d. Ground fault sensing equipment test.

2.6 ARC FLASH WARNING LABEL

Provide warning label for switchboards. Locate this self-adhesive warning label on the outside of the enclosure warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.

2.7 SERVICE ENTRANCE AVAILABLE FAULT CURRENT LABEL

Provide label on exterior of switchboards used as service equipment listing the maximum available fault current at that location. Include on the label the date that the fault calculation was performed and the contact information for the organization that completed the calculation. Locate this self-adhesive warning label on the outside of the switchboard. Provide label format as indicated.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified

otherwise.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounds and grounding systems with a resistance to solid earth ground not exceeding 25 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than 24 inches below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Switchboard

ANSI/NEMA PB 2.1.

3.3.2 Meters and Instrument Transformers

ANSI C12.1.

3.3.3 Field Applied Painting

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.4 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A780/A780M, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.3.5 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Exterior Location

Mount switchboard on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 8 inches thick, reinforced with a 6 by 6 inch No. 6 mesh placed uniformly 4 inches from the top of the slab.

b. Place slab on a 6 inch thick, well-compacted gravel base.

c. Install slab such that the top of the concrete slab is approximately 4 inches above the finished grade.

d. Provide edges above grade 1/2 inch chamfer.

e. Provide slab of adequate size to project at least 8 inches beyond the equipment.

f. Provide conduit turnups and cable entrance space required by the equipment to be mounted.

g. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.

h. Cut off and bush conduits 3 inches above slab surface.

i. Provide concrete work as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.4.2 Interior Location

Mount switchboard on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 4 inches thick.

b. Install slab such that the top of the concrete slab is approximately 4 inches above the finished grade.

c. Provide edges above grade 1/2 inch chamfer.

d. Provide slab of adequate size to project at least 8 inches beyond the equipment.

e. Provide conduit turnups and cable entrance space required by the equipment to be mounted.

f. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.

g. Cut off and bush conduits 3 inches above slab surface.

h. Provide concrete work as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.5 FIELD APPLIED PAINTING

In spaces indentified on the drawings as requiring corrosion protection and control, paint electrical equipment, boxes, and conduit as required to match finish of adjacent surfaces and to meet the indicated or specified safety criteria. Painting: as specified in Section 09 96 00 HIGH-PERFORMANCE COATINGS.

3.6 FIELD QUALITY CONTROL

Submit request for settings of breakers to the Contracting Officer after approval of switchboard and at least 30 days in advance of their requirement.

3.6.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.6.1.1 Switchboard Assemblies

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical, electrical, and mechanical condition.

(3) Verify appropriate anchorage, required area clearances, and correct alignment.

(4) Clean switchboard and verify shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.

(5) Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

(6) Verify that circuit breaker sizes and types correspond to approved shop drawings as well as to the circuit breaker’s address for microprocessor-communication packages.

(7) Verify that current transformer ratios correspond to approved shop drawings.

(8) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(9) Confirm correct operation and sequencing of electrical and mechanical interlock systems.

(10) Confirm correct application of manufacturer's recommended

lubricants.

(11) Inspect insulators for evidence of physical damage or contaminated surfaces.

(12) Verify correct barrier installation.

(13) Exercise all active components.

(14) Inspect all mechanical indicating devices for correct operation.

(15) Verify that filters are in place and vents are clear.

(16) Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.

(17) Inspect control power transformers.

b. Electrical Tests

(1) Perform insulation-resistance tests on each bus section.

(2) Perform dielectric withstand voltage tests.

(3) Perform insulation-resistance test on control wiring; Do not perform this test on wiring connected to solid-state components.

(4) Perform control wiring performance test.

(5) Perform primary current injection tests on the entire current circuit in each section of assembly.

3.6.1.2 Circuit Breakers - Low Voltage - Power

a. Visual and Mechanical Inspection

(1) Compare nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect anchorage, alignment, and grounding.

(4) Verify that all maintenance devices are available for servicing and operating the breaker.

(5) Inspect arc chutes.

(6) Inspect moving and stationary contacts for condition, wear, and alignment.

(7) Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

(8) Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.

(9) Inspect all bolted electrical connections for high resistance

using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(10) Verify cell fit and element alignment.

(11) Verify racking mechanism.

(12) Confirm correct application of manufacturer's recommended lubricants.

b. Electrical Tests

(1) Perform contact-resistance tests on each breaker.

(2) Perform insulation-resistance tests.

(3) Adjust Breaker(s) for final settings in accordance with Government provided settings.

(4) Determine long-time minimum pickup current by primary current injection.

(5) Determine long-time delay by primary current injection.

(6) Determine short-time pickup and delay by primary current injection.

(7) Determine ground-fault pickup and delay by primary current injection.

(8) Determine instantaneous pickup value by primary current injection.

(9) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

(10) Verify operation of charging mechanism.

3.6.1.3 Circuit Breakers

Low Voltage Molded Case with Solid State Trips

a. Visual and Mechanical Inspection

(1) Compare nameplate data with specifications and approved shop drawings.

(2) Inspect circuit breaker for correct mounting.

(3) Operate circuit breaker to ensure smooth operation.

(4) Inspect case for cracks or other defects.

(5) Inspect all bolted electrical connections for high resistance using low resistance ohmmeter, verifying tightness of accessible bolted connections and/or cable connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

(1) Perform contact-resistance tests.

(2) Perform insulation-resistance tests.

(3) Perform Breaker adjustments for final settings in accordance with Government provided settings.

(4) Perform long-time delay time-current characteristic tests

(5) Determine short-time pickup and delay by primary current injection.

(6) Determine ground-fault pickup and time delay by primary current injection.

(7) Determine instantaneous pickup current by primary injection.

(8) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.

3.6.1.4 Current Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform insulation-resistance tests.

(3) Perform polarity tests.

(4) Perform ratio-verification tests.

3.6.1.5 Metering and Instrumentation

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

(2) Calibrate watthour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.

(4) Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.6.1.6 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

(1) IEEE 81. Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.6.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Trip circuit

breakers by operation of each protective device. Test each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, provide the Contracting Officer 5 working days advance notice of the dates and times for checks, settings, and tests.

3.7 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

****
This specification section contains proprietary products.
****

SECTION 26 27 14.00 20

ELECTRICITY METERING
NAVFAC NW Version 1.0; issued 06/30/2020
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.90.1	(2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.13	(2016) Requirements for Instrument Transformers
IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation;

submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings; G

SD-03 Product Data

Electricity Meters; G

Current Transformer; GSD-06 Test Reports

Acceptance Checks And Tests; G

SD-11 Closeout Submittals

System Functional Verification Report; G

1.4 QUALITY ASSURANCE

1.4.1 Installation Drawings

Provide drawings in hard-copy and PDF electronic format, drawings must include following:

a. Wiring diagrams with terminals identified of advanced meter, current transformers, communications interfaces, Ethernet connections. For each typical meter installation, provide a diagram.

1.4.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for 1 year prior to bid opening. The 1-year period must include applications of equipment and materials under similar circumstances and of similar size. The product, or an earlier release of the product, must have been on sale on the commercial market through advertisements, manufacturers catalogs, or brochures during the prior 1-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.3 Material and Equipment Manufacturing Data

Products manufactured more than 1 year prior to date of delivery to site must not be used, unless specified otherwise.

1.5 PROJECT SEQUENCING

THE PROJECT SEQUENCING TABLE specifies the sequencing of submittals as specified in paragraph SUBMITTALS (denoted by an 'S' in the 'TYPE' column) and activities as specified in PART 3: EXECUTION (denoted by an 'E' in the 'TYPE' column).

a. Sequencing for submittals: The sequencing specified for submittals is the deadline by which the submittal must be initially submitted to the Government. Following submission there will be a Government review period as specified in Section 01 33 00 SUBMITTAL PROCEDURES. If the submittal is not accepted by the Government, revise the submittal and resubmit it to the Government within 14 working days of notification that the submittal has been rejected. Upon re-submittal there will be an additional Government review period. If the submittal is not accepted, the process repeats until the submittal is accepted by the Government.

b. Sequencing for Activities: The sequencing specified for activities indicates the earliest the activity may begin.

c. Abbreviations: AAO is used for 'after approval of' and 'ACO' is used for 'after completion of'.

d. The Network UMCS Hardware and Software Inventory form will be provided by NAVFAC NW CIO and is similar to that found here: http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-11.

TABLE I. AMI METER PROJECT SEQUENCING

ITEM	TYPE	DESCRIPTION	SEQUENCING
1		Notice to proceed	
2	S	Submit Installation Drawings and Product Data Sheets for approval	30 days ACO No. 1
3	E	Verify AMI meter has appropriate NAVFAC framework installed (Typically installed at factory)	AAO No. 2
4	E	Install AMI meter	ACO No. 3

TABLE I. AMI METER PROJECT SEQUENCING

ITEM	TYPE	DESCRIPTION	SEQUENCING
5	E	Obtain current transformer ratios for electrical meter and confirm ratio has been labeled on meter face	ACO No. 4
6	S	Perform acceptance checks and tests and submit test report.	ACO No. 5
7	E	Verify meter is connected to UMCS network.	ACO No. 6
8	E	Notify NAVFAC NW AMI Manager, AMI meter is installed and ready for programming.	ACO No. 7
9	E	Government personnel will configure meter and program AMI software for remote monitoring.	14 days ACO No. 8
10	S	Perform system functional verifciation and submit test report	ACO No. 9

TABLE II. UMCS NETWORK PROJECT SEQUENCING

ITEM	TYPE	DESCRIPTION	SEQUENCING
1		Notice to proceed.	
2	S	Submit Installation Drawings and Product Data Sheets for approval.	30 days ACO No. 1
3	S	Complete Network Hardware and Software Inventory form and deliver form and managed network switch to be installed to NAVFAC NW CIO for configuration.	AAO No. 2
4	E	Contractor picks up programmed AMI managed network switch from CIO.	ACO No. 3
5	E	Request physical UMCS network connection.	ACO No. 4
6	E	Government authorized personnel will make physical connection.	14 days ACO No. 5
7	E	Verify meter is communicating to UMCS network.	ACO No. 6

1.6 SYSTEM DESCRIPTION

1.6.1 System Requirements

Electricity metering, consisting of meters and associated equipment, will be used to record the electricity consumption and other values as described in the requirements that follow and as shown on the drawings.

PART 2 PRODUCTS

2.1 ELECTRICITY METERS AND ACCESSORIES

2.1.1 Physical and Common Requirements

a. Provide meter and base form 9S for typical three phase secondary wye connected system configuration.

b. Meter must have NEMA 3R stainless steel enclosure for surface mounting

with bottom or rear penetrations.

c. Surge withstand capability must conform to IEEE C37.90.1.

d. Use No. 12 SIS (XHHW, or equivalent) wiring with ring lugs for all meter connections. Color code and mark the conductors as follows:

(1) Red - Phase A CT - C1
(2) Orange - Phase B CT - C2
(3) Brown - Phase C CT - C3
(4) Gray with white stripe - neutral current return - C0
(5) Black - Phase A voltage - V1
(6) Yellow - Phase B voltage - V2
(7) Blue - Phase C voltage - V3
(8) White - Neutral voltage

2.1.2 Potential Transformer Requirements

a. Meter must be capable of connection to the service voltage phases and magnitude being monitored. If the meter is not rated for the service voltage, provide suitable potential transformers to send an acceptable voltage to the meter.

b. Voltage input must be optically isolated to 2500 volts DC from signal and communications outputs. Components must meet or exceed IEEE C37.90.1.

c. Provide a pull-out type fuse block containing one fuse per phase, Class RK type, to protect the voltage input to the meter. Size fuses as recommended by the meter manufacturer. Fusing must either be inside the secondary compartment of the transformer or inside the same enclosure as the CT shorting device.

d. Potential transformers will be used to convert 480 volt inputs to 120 volts for the locations shown on the metering schedule. Potential transformers must be rated indoor or outdoor, as required for the specific application. Voltage rating must provide 120 volts, wye-connected, 3 phase, 4 wire, 60 Hz, insulation class, 600 volts. Potential transformers BIL must be 10 kV and must have an accuracy class of 0.3 at burdens w, x, and y. Thermal rating must be 500 VA.

e. The Contractor shall be responsible for determining the actual voltage ratio of each potential transformer for medium voltage applications. Transformer must conform to IEEE C57.13 and the following requirements.

(1) Type: Dry type, of two-winding construction.

(2) Weather: Outdoor or indoor rated for the application.

(3) Frequency: Nominal 60 Hz.

(4) Accuracy: Plus or minus 0.3 percent at 60 Hz.

f. Potential transformers installed inside switchgear and panels must be rated for interior use. Voltage rating must provide 120 volts, wye-connected, 3 phase, 4 wire, 60 Hz, insulation class, 600 volts. Potential transformers BIL must be a minimum of 10 kV, and have an insulation class and BIL rating that equals or exceeds the ratings of the associated switchgear. Potential transformers must have an

accuracy class of 0.3 at burdens w, x, and y. Thermal rating must be 500 VA. Potential transformers must be accessed from the front and mounted in a metering section.

2.1.3 Current Transformer Requirements

a. Current transformer must be installed with a rating as shown in the schedule.

b. Current transformers must have an Accuracy Class of 0.3 (with a maximum error of plus or minus 0.3 percent at 5.0 amperes) when operating within the specified rating factor.

c. Current transformers must be solid-core, bracket-mounted for new installations using ring-tongue lugs for electrical connections. Current transformers must be accessible and the associated wiring must be installed in an organized and neat workmanship arrangement. Current transformers that are retrofitted onto existing switchgear busbar can be a busbar split-core design.

d. Current transformers must have:

(1) Insulation Class: All 600 volt and below current transformers must be rated 10 KV BIL.

(2) Frequency: Nominal 60 Hz.

(3) Burden: Burden class must be selected for the load.

(4) Phase Angle Range: 0 to 60 degrees.

e. Meter must accept current input from standard instrument transformers (5A secondary current transformers).

f. Current inputs must have a continuous rating in accordance with IEEE C57.13.

g. Provide one single-ratio current transformer for each phase per power transformer with characteristics listed in the following table.

Single-Ratio Current Transformer Characteristics				
kVA	Sec. Volt	CT Ratio	RF	Meter Acc. Class
1000	480Y/277	800:5	1.33	0.3 thru B0.05

2.1.4 Meter Requirements

Notwithstanding any other provision of this contract, socket-mounted meters must be Schneider Electric PowerLogic ION8650C meter with 32 MB Memory, 3 digital inputs and 2 pulse, 4 form C relay outputs, Ethernet communication. Panel mount meters must be compatible with the existing government software.

Electricity meters must include the following features:

a. Provide socket-mounted and panel mounted meters as indicated on the drawings.

b. Provide blank tag fixed to the meter faceplate for the addition of the meter multiplier, which will be the product of the current transformer and potential transformer ratio and will be filled in by base personnel on the job site. The meter's nameplate must include:

(1) Meter ID number.
(2) Rated voltage.
(3) Current class.
(4) Metering form.
(5) Test amperes.
(6) Frequency.
(7) Catalog number.
(8) Manufacturing date.

c. On switchboard style installations, provide switchboard case with disconnect means for meter removal incorporating short-circuiting of current transformer circuits.

2.1.5 Disconnect Method

a. Provide a 10-pole safety disconnect complete with isolation devices for the voltage and current transformer inputs, including a shorting means for the current transformers.

b. Disconnecting wiring blocks must be provided between the current transformer and the meter. A shorting mechanism must be built into the wiring block to allow the current transformer wiring to be changed without removing power to the transformer. The wiring blocks must be located where they are accessible without the necessity of disconnecting power to the transformer.

c. Voltage monitoring circuits must be equipped with disconnect switches to isolate the meter base or socket from the voltage source.

2.1.6 Installation Methods

a. Stand Mounted Adjacent to Transformer. Meter base must be mounted on a structural steel pole approximately 4 feet from the transformer pad. This can be used for multiple meters associated with a single transformers.

b. Panel Mounted. Meter must be mounted where directed.

2.2 COMMUNICATIONS INTERFACES

Provide meter with Ethernet (10/100BASE-T copper cable, RJ-45 connector) Interface. Provide communications cabling to an approved Managed Ethernet Switch with fiber optic link to the Utility Monitoring and Control System (UMCS) point of connection shown on the drawings. .

Refer to Section 25 05 11.06 CYBERSECURITY FOR LIGHTING CONTROL SYSTEM for the Managed Ethernet Switch requirements for these meters.

2.2.1 MANAGED AMI ETHERNET SWITCH

a. Notwithstanding any other provision of this contract, Managed AMI Ethernet Switch must be compatible with the existing base wide system.

b. Provide in lockable, enclosure. Enclosures located outdoors or in wet ambient conditions must be mounted in rainproof NEMA 3R or NEMA 3 enclosures. Device enclosures located outdoors in ***ESC C3, C4, or C5 environments or within*** wet ambient conditions AND within 100 feet of waterfront must be mounted in rain-tight corrosion-resistant NEMA 4X enclosures. Device enclosures used in conditioned space may be mounted in a NEMA 1 or NEMA 12 enclosure. Passive enclosure venting must provide adequate cooling to maintain the manufacturer's maximum thermal limitations for all installed equipment in the enclosure based on calculated total wattages and adequate convective cooling. Top mounted louvers without allowing for a bottom ventilation air circulation path are not allowed.

c. Ports must be non-blocking, store and forward switching, with long haul optics to allow Gigabit distance up to 70km and multiple connector types. Gigabit fiber ports must be configured for small form-factor pluggable (SFP). Provide an SFP transceiver for each SFP port

d. Managed AMI Ethernet switch must be protected against or withstand power-line surges. Protection must meet the requirements of IEEE C62.41. Fuses must not be used for surge protection.

e. Fiber ports for all planned connections can be in a fixed configuration.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations must conform to IEEE C2, NFPA 70 (National Electrical Code), and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.1.1 Scheduling of Work and Outages

The Contract Clauses must govern regarding permission for power outages, scheduling of work, coordination with Government personnel, and special working conditions.

3.1.2 UMCS Network

3.1.2.1 Switch Configuration by NAVFAC NW CIO

Deliver managed AMI network switch to NAVFAC NW CIO. NAVFAC NW CIO will configure all switches prior to field deployment. See Part 1 Project Sequence for more information.

3.1.2.2 UMCS Network Connection

Provide all equipment and materials needed to complete the connection to the existing NAVFAC UMCS IP network. Only Government authorized personnel are allowed to complete the actual physical connection between the

Contractor's installation and the Government Control Systems network. Provide two weeks' notice to the Contracting Officer when scheduling this connection and include it in the project's schedule.

Coordinate the connection location and available port characteristics with the Contracting Officer.

3.2 FIELD QUALITY CONTROL

Perform the following acceptance checks and tests on all installed meters.

3.2.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

a. Meter Assembly

(1) Visual, mechanical and electrical inspection.

(a) Compare equipment nameplate data with specifications and approved shop drawings.

(b) Inspect physical and mechanical condition. Confirm the meter is firmly seated in the socket, the socket is not abnormally heated, the display is visible, and the ring and seal on the cover are intact.

(c) Inspect all electrical connections to ensure they are tight. For Class 200 services, verify tightness of the service conductor terminations for high resistance using low-resistance ohmmeter, or by verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method.

(d) Record model number, serial number, firmware revision, software revision, and rated control voltage.

(e) Verify operation of display and indicating devices.

(f) Verify grounding of metering enclosure.

(g) Confirm that CT ration and PT ratio is recorded on the meter face or on the meter.

(h) Apply voltage or current as appropriate to each analog input and verify correct measurement and indication.

(i) Confirm correct operation and setting of each auxiliary input/output feature including mechanical relay, digital, and analog.

(j) Make note of, and report, any "Error-Code" or "Caution-Code" on the meter's display.

b. Current Transformers

(1) Visual and mechanical inspection.

(a) Compare equipment nameplate data with specification and approved shop drawings.

(b) Inspect physical and mechanical condition.

(c) Verify correct connection, including polarity.

(d) Inspect all electrical connections to ensure they are tight.

(e) Verify that required grounding and shorting connections provide good contact.

c. Potential Transformers

(1) Visual and mechanical inspection.

(a) Verify potential transformers are rigidly mounted.

(b) Verify potential transformers are the correct voltage.

(c) Verify that adequate clearances exist between the primary and secondary circuit.

d. Provide acceptance checks and tests report for each installed meter.

3.2.2 System Functional Verification Report

Verify that the installed meters are working correctly.:

a. All voltage phases are present.

b. Phase rotation is correct.

c. Phase angles are correct.

d. The new meter accurately measures power magnitude and direction, and can communicate as required by paragraph entitled "Communications Interfaces".

e. Confirm measurements and indications are consistent with loads present.

f. Provide system functional verification report for each installed meter.

3.3 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 28 01.00 10

COORDINATED POWER SYSTEM PROTECTION
10/07
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 242	(2001; Errata 2003) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book
IEEE 399	(1997) Brown Book IEEE Recommended Practice for Power Systems Analysis
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 486E	(2015; Reprint Apr 2019) UL Standard for Safety Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 1203	(2013; Reprint Jan 2020) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations

1.2 SYSTEM DESCRIPTION

The power system covered by this specification consists of: Service entrance panelboard and down stream branch panelboards with 480V-208Y/120V, 3PH, 4W dry type transformers.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation;

submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fault Current Analysis
Protective Device Coordination Study
Equipment
System Coordinator
Installation

SD-06 Test Reports

Field Testing

SD-07 Certificates

Devices and Equipment

1.4 QUALITY ASSURANCE

1.4.1 System Coordinator

System coordination, recommended ratings and settings of protective devices, and design analysis shall be accomplished by a registered professional electrical power engineer with a minimum of 3 years of current experience in the coordination of electrical power systems. Submit verification of experience and license number, of a registered Professional Engineer as specified above. Experience data shall include at least five references for work of a magnitude comparable to this contract, including points of contact, addresses and telephone numbers.

1.4.2 System Installer

Calibration, testing, adjustment, and placing into service of the protective devices shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of two years of current product experience in protective devices.

1.5 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected when received and prior to acceptance from conveyance. Protect stored items from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced.

PART 2 PRODUCTS

2.1 STANDARD PRODUCT

Provide protective devices and equipment which are the standard product of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory utility type use for at least two years prior to bid opening. Submit data consisting of manufacturer's time-current characteristic curves for individual protective devices, recommended settings of adjustable

protective devices, and recommended ratings of non-adjustable protective devices.

2.2 NAMEPLATES

Provide nameplates to identify all protective devices and equipment. Nameplate information shall be in accordance with UL 489.

2.3 CORROSION PROTECTION

Provide corrosion protection for all metallic materials and hardware for ESC C1 and C2:

a. Provide zinc-plated or chrome plated ferrous metal hardware.

For ESC C3, C4, and C5:

Provide type 304 or 316 stainless steel hardware. Do not use zinc-plated or chrome-plated ferrous metal. Provide corrosion resistant coatings or materials for equipment enclosures And mounting supports compatible with the specific corrosive environments.

2.4 MOLDED-CASE CIRCUIT BREAKERS

2.4.1 General

Molded-case circuit breakers shall conform to UL 489 and UL 489. Circuit breakers may be installed in panelboards, switchboards, enclosures, motor control centers, or combination motor controllers. Circuit breakers and circuit breaker enclosures located in hazardous (classified) areas shall conform to UL 1203.

2.4.2 Construction

Molded-case circuit breakers shall be assembled as an integral unit in a supporting and enclosing housing of glass reinforced insulating material providing high dielectric strength. Circuit breakers shall be suitable for mounting and operating in any position. Lugs shall be listed for copper conductors only in accordance with UL 486E. Single-pole circuit breakers shall be full module size with not more than one pole per module. Multi-pole circuit breakers shall be of the common-trip type having a single operating handle such that an overload or short circuit on any one pole will result in all poles opening simultaneously. Sizes of 100 amperes or less may consist of single-pole breakers permanently factory assembled into a multi-pole unit having an internal, mechanical, nontamperable common-trip mechanism and external handle ties. All circuit breakers shall have a quick-make, quick-break overcenter toggle-type mechanism, and the handle mechanism shall be trip-free to prevent holding the contacts closed against a short-circuit or sustained overload. All circuit breaker handles shall assume a position between "ON" and "OFF" when tripped automatically. All ratings shall be clearly visible.

2.4.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. The interrupting rating of the circuit breakers shall be at least equal to

the available short-circuit current at the line terminals of the circuit breaker and correspond to the UL listed integrated short-circuit current rating specified for the panelboards and switchboards. Molded-case circuit breakers shall have nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings in accordance with UL 489. Ratings shall be coordinated with system X/R ratio.

2.4.4 Thermal-Magnetic Trip Elements

Thermal magnetic circuit breakers shall be provided as shown. Automatic operation shall be obtained by means of thermal-magnetic tripping devices located in each pole providing inverse time delay and instantaneous circuit protection. The instantaneous magnetic trip shall be adjustable and accessible from the front of all circuit breakers on frame sizes above 150 amperes.

2.4.5 Solid-State Trip Elements

Solid-state circuit breakers shall be provided as shown. All electronics shall be self-contained and require no external relaying, power supply, or accessories. Printed circuit cards shall be treated to resist moisture absorption, fungus growth, and signal leakage. All electronics shall be housed in an enclosure which provides protection against arcs, magnetic interference, dust, and other contaminants. Solid-state sensing shall measure true RMS current with error less than one percent on systems with distortions through the 13th harmonic. Peak or average actuating devices are not acceptable. Current sensors shall be toroidal construction, encased in a plastic housing filled with epoxy to protect against damage and moisture and shall be integrally mounted on the breaker. Where indicated on the drawings, circuit breaker frames shall be rated for 100 percent continuous duty. Circuit breakers shall have tripping features as shown on the drawings and as described below:

a. Long-time current pick-up, adjustable from 50 percent to 100 percent of continuous current rating.

b. Adjustable long-time delay.

c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

d. Adjustable short-time delay.

e. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

2.4.6 Current-Limiting Circuit Breakers

Current-limiting circuit breakers shall be provided as shown. Current-limiting circuit breakers shall limit the let-through I square times t to a value less than the I square times t of one-half cycle of the symmetrical short-circuit current waveform. On fault currents below the threshold of limitation, breakers shall provide conventional overload and short-circuit protection. Integrally-fused circuit breakers shall not be used.

2.4.7 Motor Circuit Protectors (MCP)

Motor circuit protectors shall conform to UL 489 and UL 489 and shall be provided as shown. MCPs shall consist of an adjustable instantaneous trip circuit breaker in conjunction with a combination motor controller which provides coordinated motor circuit overload and short-circuit protection. Motor Circuit Protectors shall be rated in accordance with NFPA 70.

2.5 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for ratings, coordination, and protection. They shall include a load flow analysis, a fault current analysis, and a protective device coordination study. Submit the study along with protective device equipment submittals. No time extensions or similar contact modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed will be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last 3 years. Provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

2.5.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at: the source bus and extend down to the downstream devices at the load end.

2.5.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. Coordinate with the commercial power company for fault current availability at the site.

2.5.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Location of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

2.5.4 Fault Current Analysis

2.5.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE 242, and IEEE 399.

2.5.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedance shall be those proposed. Data shall be documented in the report.

2.5.4.3 Fault Current Availability

Balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

2.5.5 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. A written narrative shall be provided describing: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost damages (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.5.6 Study report

a. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.

c. The report shall document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device numbers and settings; and existing power system data including time-current characteristic curves and protective device ratings and settings.

d. The report shall contain fully coordinated composite time-current characteristics curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.

e. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

Submit procedures including diagrams, instructions, and precautions required to properly install, adjust, calibrate, and test the circuit breakers. Install protective devices in accordance with the manufacturer's published instructions and in accordance with the requirements of NFPA 70 and IEEE C2.

3.3 FIELD TESTING

Prior to field tests, submit the proposed test plan consisting of complete field test procedure, tests to be performed, test equipment required, and tolerance limits, and complete testing and verification of the ground fault protection equipment, where used. Submit performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.

3.3.1 General

Perform field testing in the presence of the Contracting Officer. Notify the Contracting Officer 5 days prior to conducting tests. Furnish all materials, labor, and equipment necessary to conduct field tests. Perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. Maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results.

3.3.2 Safety

Provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. Replace any devices or equipment which are damaged due to improper test procedures or handling.

3.3.3 Molded-Case Circuit Breakers

Circuit breakers shall be visually inspected, operated manually, and connections checked for tightness. Current ratings shall be verified and adjustable settings incorporated in accordance with the coordination study.

3.3.4 Power Circuit Breakers

3.3.4.1 General

Visually inspect the circuit breaker and operate the circuit breaker manually; adjust and clean primary contacts in accordance with manufacturer's published instructions; check tolerances and clearances; check for proper lubrication; and ensure that all connections are tight. For electrically operated circuit breakers, verify operating voltages on

closing and tripping coils. Verify fuse ratings in control circuits; electrically operate the breaker, where applicable; and implement settings in accordance with the coordination study.

3.4 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

SECTION 26 29 23

ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS

02/20

AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

EUROPEAN COMMITTEE FOR STANDARDIZATION (CEN/CENELEC)

EN 61800-3	(2017) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 519	(2014) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 3.1	(2019) Guide for the Application, Handling, Storage, Installation and Maintenance of Medium-Voltage AC Contactors, Controllers and Control Centers
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA ICS 7	(2014) Adjustable-Speed Drives
NEMA ICS 7.2	(2015) Application Guide for AC Adjustable Speed Drive Systems
NEMA MG 1	(2018) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508C	(2002; Reprint Nov 2010) Power Conversion Equipment

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to this section with additions and modifications specified herein.

1.3 SYSTEM DESCRIPTION

1.3.1 Performance Requirements

1.3.1.1 Electromagnetic Interference Suppression

Computing devices, as defined by 47 CFR 15 and EN 61800-3 rules and regulations, must be certified to comply with the requirements for class A computing devices and labeled.

1.3.1.2 Electromechanical and Electrical Components

Ensure electrical and electromechanical components of the Adjustable Speed Drive (ASD) do not cause electromagnetic interference to adjacent electrical or electromechanical equipment while in operation.

1.3.2 Electrical Requirements

1.3.2.1 Power Line Surge Protection

IEEE C62.41.1 and IEEE C62.41.2, IEEE 519 Control panel must have surge protection, included within the panel to protect the unit from damaging transient voltage surges. Surge protective device must be mounted near the incoming power source and properly wired to all three phases and ground. Fuses must not be used for surge protection.

1.3.2.2 Sensor and Control Wiring Surge Protection

I/O functions as specified must be protected against surges induced on control and sensor wiring installed outdoors and as shown. Test the inputs and outputs in both normal mode and common mode using the following two waveforms:

a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Schematic Diagrams; G

Interconnecting Diagrams; G

Installation Drawings; G

As-Built Drawings; G

Harmonic Analysis Study; showing compliance with IEEE 519; G

Submit drawings and harmonic analysis for government approval prior to equipment construction or integration. Modifications to original drawings made during installation shall be immediately recorded for inclusion into the as-built drawings. The harmonic analysis shall take into consideration any centralized power correction system equipment.

SD-03 Product Data

Adjustable Speed Drives; G

Wires and Cables

Equipment Schedule

SD-06 Test Reports

ASD Test

Performance Verification Tests

Endurance Test

SD-08 Manufacturer's Instructions

Installation instructions

SD-09 Manufacturer's Field Reports

ASD Test Plan; G

Standard Products

SD-10 Operation and Maintenance Data

Adjustable Speed Drives, Data Package 4

1.5 QUALITY ASSURANCE

1.5.1 Schematic Diagrams

Submit diagrams showing circuits and device elements for each replaceable module. Schematic diagrams of printed circuit boards are permitted to group functional assemblies as devices, provided that sufficient information is provided for government maintenance personnel to verify proper operation of the functional assemblies.

1.5.2 Interconnecting Diagrams

Show interconnections between equipment assemblies, and external interfaces, including power and signal conductors. Include for enclosures and external devices.

1.5.3 Installation Drawings

Show floor plan of each site, with ASD's and motors indicated. Indicate ventilation requirements, adequate clearances, and cable routes. Submit drawings for government approval prior to equipment construction or integration. Immediately record modifications to original drawings made during installation for inclusion into the as-built drawings.

1.5.4 Equipment Schedule

Provide schedule of equipment supplied. Schedule must provide a cross reference between manufacturer data and identifiers indicated in shop drawings. Schedule must include the total quantity of each item of equipment supplied and data indicating compatibility with motors being driven. For complete assemblies, such as ASD's, provide the serial numbers of each assembly, and a sub-schedule of components within the assembly. Provide recommended spare parts listing for each assembly or component.

1.5.5 Installation Instructions

Provide installation instructions issued by the manufacturer of the equipment, including notes and recommendations, prior to shipment to the site. Provide operation instructions prior to acceptance testing.

1.5.6 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component

parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6 DELIVERY AND STORAGE

Store delivered equipment to protect from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.7 WARRANTY

The complete system must be warranted by the manufacturer for a period of one year. Repair or replace any component failing to perform its function as specified and documented at no additional cost to the Government. Items repaired or replaced must be warranted for an additional period of at least one year from the date that it becomes functional again, as specified in FAR 52.246-21 Warranty of Construction.

1.8 MAINTENANCE

1.8.1 Spare Parts

Manufacturers provide spare parts in accordance with recommended spare parts list.

1.8.2 Operation and Maintenance Data

Provide in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Provide service and maintenance information including preventive maintenance, assembly, and disassembly procedures. Include electrical drawings from electrical general sections. Provide additional information necessary to provide complete operation, repair, and maintenance information, detailed to the smallest replaceable unit. Include copies of as-built submittals. Provide routine preventative maintenance instructions, and equipment required. Provide instructions on how to modify program settings, and modify the control program. Provide instructions on drive adjustment, trouble-shooting, and configuration. Provide instructions on process tuning and system calibration.

1.8.3 Maintenance Support

During the warranty period, provide on-site, on-call maintenance services by drive manufacturer's personnel on the following basis: The service must be on a per-call basis with 36 hour response. Contractor is responsible for the maintenance of all hardware and software of the system during the warranty period. Various personnel of different expertise must be sent on-site depending on the nature of the maintenance service required. Costs must include travel, local transportation, living expenses, and labor rates of the service personnel while responding to the service request. The provisions of this Section are not in lieu of, nor relieve the Contractor of, warranty responsibilities covered in this specification. Should the result of the service request be the uncovering of a system defect covered under the warranty provisions, all costs for the call, including the labor necessary to identify the defect, must be borne by the Contractor.

1.8.4 Technical Support

Provide the ASDs with manufacturer's technical telephone support in English, readily available during normal working hours.

PART 2 PRODUCTS

2.1 ADJUSTABLE SPEED DRIVES (ASD)

Provide adjustable speed drive to control the speed of induction motor(s). The ASD must include the following minimum functions, features and ratings.

a. Input circuit breaker per UL 489 with a minimum of 10,000 amps symmetrical interrupting capacity and door interlocked external operator.

b. A converter stage per UL 508C must change fixed voltage, fixed frequency, ac line power to a fixed dc voltage. The converter must utilize a full wave bridge design incorporating diode rectifiers. Silicon Controlled Rectifiers (SCR) are not acceptable. The converter must be insensitive to three phase rotation of the ac line and must not cause displacement power factor of less than .95 lagging under any speed and load condition.

c. An inverter stage must change fixed dc voltage to variable frequency, variable ac voltage for application to a standard NEMA MG 1 Part 30 motor designed for use with adjustable frequency power supplies. Switch the inverter to produce a sine coded pulse width modulated (PWM) output waveform.

d. The ASD shall be capable of supplying 120 percent of rated full load current for one minute at maximum ambient temperature.

e. The ASD must be designed to operate from a 480 volt, plus or minus 10 percent, three phase, 60 Hz supply, and control motors with a corresponding voltage rating.

f. Acceleration and deceleration time must be independently adjustable from one second to 60 seconds.

Required deceleration time may be achieved using not only dynamic braking resistor but with other methods described in NEMA ICS 7.2-2015 paragraph 5.2.5.

g. Adjustable full-time current limiting must limit the current to a preset value which must not exceed 110 percent of the controller rated current. The current limiting action must maintain the V/Hz ratio constant so that variable torque can be maintained. Short time starting override must allow starting current to reach 175 percent of controller rated current to maximum starting torque.

h. The controllers must be capable of producing an output frequency over the range of 3 Hz to 60 Hz (20 to one speed range), without low speed cogging. Over frequency protection must be included such that a failure in the controller electronic circuitry must not cause frequency to exceed 110 percent of the maximum controller output frequency selected.

i. Minimum and maximum output frequency must be adjustable over the following ranges: 1) Minimum frequency 3 Hz to 50 percent of maximum selected frequency; 2) Maximum frequency 40 Hz to 60 Hz.

j. The controller efficiency at any speed must not be less than 96 percent.

k. The controllers must be capable of being restarted into a motor coasting in the forward direction without tripping.

l. Protection of power semiconductor components must be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controllers to any of the following conditions must not result in component failure or the need for fuse replacement:

(1) Short circuit at controller output

(2) Ground fault at controller output

(3) Open circuit at controller output

(4) Input undervoltage

(5) Input overvoltage

(6) Loss of input phase

(7) AC line switching transients

(8) Instantaneous overload

(9) Sustained overload exceeding 115 percent of controller rated current

(10) Over temperature

(11) Phase reversal

m. Solid state motor overload protection must be included such that current exceeding an adjustable threshold must activate a 60 second timing circuit. Should current remain above the threshold continuously for the timing period, the controller will automatically shut down.

n. Include slip compensation circuit that will sense changing motor load conditions and adjust output frequency to provide speed regulation of NEMA MG 1 Part 30 designed for use with adjustable frequency power supplies motors to within plus or minus 0.5 percent of maximum speed without the necessity of a tachometer generator.

o. The ASD must be factory set for manual restart after the first protective circuit trip for malfunction (overcurrent, undervoltage, overvoltage or overtemperature) or an interruption of power. The ASD must be capable of being set for automatic restart after a selected time delay. If the drive faults again within a specified time period (adjustable 0-60 seconds), a manual restart will be required.

p. The ASD must include external fault reset capability. All the necessary logic to accept an external fault reset contact must be included.

q. Provide critical speed lockout circuitry to prevent operating at frequencies with critical harmonics that cause resonant vibrations.

The ASD must have a minimum of three user selectable bandwidths.

r. Provide properly sized NEMA rated by-pass and isolation contactors to enable operation of motor in the event of ASD failure. Install mechanical and electrical interlocks between the by-pass and isolation contactors. Provide a selector switch and transfer delay timer. Motor overload and short circuit protective features must remain in use during the bypass mode.

s. Each individual ASD must meet the following Total Harmonic Distortion (THD) requirements at the input terminals to the factory assembly of the ASD or at the load disconnecting means serving the ASD and filter assembly. These measurements should be taken with the drive set at 90 percent frequency (rpms) and the motor under a minimum of 50 percent demand.

(1) The Voltage THD should not exceed 3 percent THD.

(2) The Current THD should not exceed 5 percent THD.

(3) If the standard factory ASD does not meet or exceed these requirements the factory must install appropriate equipment (Harmonic Traps, Filters, different Drive technology, etc.) to mitigate the distortion to assure performance of the VFD is within the limits.

(4) These tests should be performed at the Manufacturers Laboratory facilities and submitted as part of the Product Data Submittals, in order to prevent the necessity of adding mitigation equipment in the field. If the requirements listed above are met, IEEE 519 will also be met.

2.1.1 Harmonic Analysis Study

Submit drawings and harmonic analysis study for government approval prior to equipment construction or integration. Modifications to original drawings made during installation shall be immediately recorded for inclusion into the as-built drawings. The harmonic analysis shall take into consideration any centralized power correction system equipment.

2.1.2 ASD for HVAC Application

ASDs must have the following features:

a. A local operator control providing the following functions:

(1) Remote/Local operator selection with password access.

(2) Run/Stop and manual speed commands.

(3) All programming functions.

(4) Scrolling through all display functions.

b. A local operator control panel with the following data displayed:

(1) ASD status.

(2) Frequency.

(3) Motor RPM.

(4) Phase current.

(5) Scrolling through all display functions.

(6) Fault diagnostics in descriptive text.

(7) All programmed parameters.

c. Standard PI loop controller with input terminal for controlled variable and parameter settings.

d. User interface terminals for remote control of ASD speed, speed feedback, and an isolated form C SPDT relay, which energizes on a drive fault condition.

e. An isolated form C SPDT auxiliary relay which energizes on a run command.

f. An adjustable carrier frequency with 16 KHz minimum upper limit.

g. A built-in or external line reactor with 3 percent minimum impedance to protect the DC bus capacitors and rectifier section diodes.

h. Historical logging information and displays:

(1) Total run time.

i. ASDs must include the following operator programmable parameters:

(1) Upper and lower limit frequency.

(2) Acceleration and deceleration rate.

(3) Variable torque volts per Hertz curve.

(4) Starting voltage level.

(5) Starting frequency level.

(6) Display speed scaling.

(7) Enable/disable soft stall feature.

(8) Motor overload level.

(9) Motor stall level.

(10) Jump frequency and hysteresis band.

(11) PWM carrier frequency.

j. ASD must have the following protective features:

(1) An electronic adjustable inverse time current limit with consideration for additional heating of the motor at frequencies below 45Hz, for the protection of the motor.

(2) An electronic adjustable soft stall feature, allowing the ASD to lower the frequency to a point where the motor will not exceed the full-load amperage when an overload ASD will automatically return to the requested frequency when load conditions permit.

(3) A separate electronic stall at 110 percent ASD rated current, and a separate hardware trip at 190 percent current.

(4) The ability to shut down if inadvertently started into a rotating load without damaging the ASD or the motor.

(5) The ability to keep a log of a minimum of four previous fault conditions, indicating the fault type and time of occurrence in descriptive text.

(6) The ability to sustain 110 percent rated current for 60 seconds.

(7) The ability to shutdown safely or protect against and record the following fault conditions:

(a) Over current (and an indication if the over current was during acceleration, deceleration, or running).

(b) Over current internal to the drive.

(c) Motor overload at start-up.

(d) Over voltage from utility power.

(e) Motor running overload.

(f) Over voltage during deceleration.

(g) ASD over heat.

(h) Load and ground fault.

(h) Abnormal parameters or data in ASD EEPROM.

2.2 ENCLOSURES

Provide equipment enclosures conforming to NEMA 250, NEMA ICS 7, and NEMA ICS 6, ***Provide strip heaters with thermostat control for enclosures located outdoors or in unconditioned spaces to prevent condensation. Corrosion prone locations (Environmental Severity Classification C3, C4, or C5) or were indicated provide NEMA type 4X enclosures manufactured from stainless steel.***.

2.3 WIRES AND CABLES

All wires and cables must conform to NEMA 250, NEMA ICS 7, NFPA 70. ***Provide cable connectors and glands listed for the environmental application and corrosion prone locations provide water tight corrosion resistance stainless steel or plastic coated cable glands.***

2.4 NAMEPLATES

Nameplates external to NEMA enclosures must conform with the requirements

of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide manufacturer's standard, permanent nameplates for internal areas of enclosures.

2.5 SOURCE QUALITY CONTROL

2.5.1 ASD Test Plan

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test plans.

2.5.2 ASD Test Report

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test reports.

2.6 HARDWARE AND COMPONENT MATERIALS

Provide hardware fasteners and securement system made of stainless steel. Do not use various metal for securement systems or finishing strips. Ensure all aluminum components are coated with an industrial protective coating or heavy-duty anodized coating.

PART 3 EXECUTION

3.1 INSTALLATION

Per NEMA ICS 3.1, install equipment in accordance with the approved manufacturer's printed installation drawings, instructions, wiring diagrams, and as indicated on project drawings and the approved shop drawings. A field representative of the drive manufacturer must supervise the installation of all equipment, and wiring.

3.2 GROUNDING

Per NEMA ICS 7.2, ASD must be solidly grounded to the main distribution.

3.3 FIELD APPLIED PAINTING

In spaces indentified on the drawings as requiring corrosion protection and control, paint electrical equipment, boxes, and conduig as required to match finish of adjacent surfaces and to meet the indicated or specified safety criteria. Painting: as specified in Section 09 96 00 HIGH-PERFORMANCE COATINGS.

3.4 FIELD QUALITY CONTROL

Specified products must be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. Conduct performance verification tests in the presence of Government representative, observing and documenting complete compliance of the system to the specifications. Submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.4.1 ASD Test

A proposed test plan must be submitted to the contracting officer at least 28 calendar days prior to proposed testing for approval. The tests must

conform to NEMA ICS 1, NEMA ICS 7, and all manufacturer's safety regulations. The Government reserves the right to witness all tests and review any documentation. Inform the Government at least 14 working days prior to the dates of testing. Perform the ASD test with the assistance of a factory-authorized service representative.

3.4.2 Performance Verification Tests

"Performance Verification Test" plan must provide the step by step procedure required to establish formal verification of the performance of the ASD. Compliance with the specification requirements must be verified by inspections, review of critical data, demonstrations, and tests. The Government reserves the right to witness all tests, review data, and request other such additional inspections and repeat tests as necessary to ensure that the system and provided services conform to the stated requirements. Inform the Government 14 calendar days prior to the date the test is to be conducted.

3.4.3 Endurance Test

Immediately upon completion of the performance verification test, the endurance test must commence. The system must be operated at varying rates for not less than 192 consecutive hours, at an average effectiveness level of 0.9998, to demonstrate proper functioning of the complete PCS. Continue the test on a day-to-day basis until performance standard is met. The contractor is not allowed in the building during the endurance test. The system must respond as designed.

3.5 DEMONSTRATION

3.5.1 Training

Coordinate training requirements with the Contracting Officer. Provide video tapes, if available, of all training provided to the Government for subsequent use in training new personnel. Provide all training aids, texts, and expendable support material for a self-sufficient presentation shall be provided, the amount of which to be determined by the contracting officer.

3.5.1.1 Instructions to Government Personnel

Provide the services of competent instructors with minimum two-year field experience with the operation and maintenance of similar ASDs who will give full instruction to designated personnel in operation, maintenance, calibration, configuration, and programming of the complete control system. Orient the training specifically to the system installed. Instructors must be thoroughly familiar with the subject matter they are to teach. The number of training days of instruction furnished must be as specified. A training day is defined as eight hours of instruction, including two 15-minute breaks and excluding lunch time; Monday through Friday. Provide a training manual for each student at each training phase which describes in detail the material included in each training program. Provide one additional copy for archiving. Provide equipment and materials required for classroom training. Provide a list of additional related courses, and offers, noting any courses recommended. List each training course individually by name, including duration, approximate cost per person, and location of course. Unused copies of training manuals must be turned over to the Government at the end of last training session.

3.5.1.2 Operating Personnel Training Program

Provide one 2-hour training session at the site at a time and place mutually agreeable between the Contractor and the Government. Provide session to train 4 operation personnel in the functional operations of the system and the procedures that personnel will follow in system operation. This training shall include:

a. System overview

b. General theory of operation

c. System operation

d. Alarm formats

e. Failure recovery procedures

f. Troubleshooting

3.5.1.3 Engineering/Maintenance Personnel Training

Accomplish the training program as specified. Training must be conducted on site at a location designated by the Government. Provide a one-day training session to train four engineering personnel in the functional operations of the system. This training must include:

a. System overview

b. General theory of operation

c. System operation

d. System configuration

e. Alarm formats

f. Failure recovery procedures

g. Troubleshooting and repair

h. Maintenance and calibration

i. System programming and configuration

3.6 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 31 00

FACILITY-SCALE SOLAR PHOTOVOLTAIC (PV) SYSTEMS
11/21
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16	(2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020) Structural Welding Code - Steel
AWS D1.2/D1.2M	(2014; Errata 1 2014; Errata 2 2020) Structural Welding Code - Aluminum

ASTM INTERNATIONAL (ASTM)

ASTM A780/A780M	***(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings***
ASTM D149	(2020) Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D257	(2014) Standard Test Methods for D-C Resistance or Conductance of Insulating Materials
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D882	(2012) Tensile Properties of Thin Plastic Sheeting
ASTM D903	(1998; R 2017) Standard Test Method for Peel or Stripping Strength of Adhesive Bonds
ASTM D1876	(2008; R 2023) Standard Test Method for

	Peel Resistance of Adhesives (T-Peel Test)
ASTM D2244	(2016) Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
ASTM D2765	(2016) Standard Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics
ASTM D5870	(2016) Standard Practice for Calculating Property Retention Index of Plastics
ASTM D7567	(2009) Standard Test Method for Determining Gel Content in Crosslinked Ethylene Plastics Using Pressurized Liquid Extraction
ASTM E308	(2022) Standard Practice for Computing the Colors of Objects by Using the CIE System
ASTM E424	(1971; R 2023) Standard Test Methods for Solar Energy Transmittance and Reflectance (Terrestrial) of Sheet Materials
ASTM E772	(2015; R 2021) Standard Terminology of Solar Energy Conversion
ASTM E1171	(2015; R 2025) Standard Test Methods for Photovoltaic Modules in Cyclic Temperature and Humidity Environments
ASTM F1249	(2020) Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor
ASTM G155	(2021) Standard Practice for Operating Xenon Arc Lamp Apparatus for Exposure of Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1547	(2018) Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2018) International Building Code

ICC IgCC	(2018) International Green Construction Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

ANSI IEC 60529	(2020) Degrees of Protection Provided by Enclosures
IEC 61215	(2005; ED 2.0) Crystalline Silicon Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval
IEC 61730-1	(2023) Photovoltaic (PV) Module Safety Qualification – Part 1: Requirements for Construction
IEC 61853-1	(2011; ED 1.0) Photovoltaic (Pv) Module Performance Testing and Energy Rating – Part 1: Irradiance and Temperature Performance Measurements and Power Rating
IEC 62446	(2018) Photovoltaic (PV) Systems - Requirements for Testing, Documentation, and Maintenance - Part 1: Grid Connected Systems - Documentation, Commissioning Tests and Inspection

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 9001	(2015) Quality Management Systems-Requirements

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA IEC 60529	(2004) Degrees of Protection Provided by Enclosures (IP Code)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 1	(2024) Fire Code
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
NFPA 70E	(2021) Standard for Electrical Safety in the Workplace
NFPA 780	(2017) Standard for the Installation of Lightning Protection Systems

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 1-200-01	***(2022; with Change 4, 2024) DoD Building Code***

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards

UL SOLUTIONS (UL)

UL 969	(2017; Reprint Mar 2018) UL Standard for Safety Marking and Labeling Systems
UL 1449	(2021; Reprint Dec 2022) UL Standard for Safety Surge Protective Devices
UL 1703	(2002; Reprint Jun 2016) UL Standard for Safety Flat-Plate Photovoltaic Modules and Panels
UL 1741	(2010; Reprint Jan 2015) UL Standard for Safety Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources
UL 2703	(2015; Reprint Jul 2023) UL Standard for Safety Mounting Systems, Mounting Devices, Clamping/Retention Devices, And Ground Lugs For Use With Flat-Plate Photovoltaic Modules And Panels
UL 6703	(2014, Reprint Jun 2024) Standard for Connectors for Use in Photovoltaic Systems
UL Electrical Construction	(2012) Electrical Construction Equipment Directory

1.2 RELATED REQUIREMENTS

Sections 26 20 00 INTERIOR DISTRIBUTION SYSTEM, 26 08 00 APPARATUS INSPECTION AND TESTING and 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION apply to this section with additions and modifications specified herein.

1.2.1 Environmental Severity Classification (ESC)

The Environmental Severity Classification (ESC) uses for this project is C4 coordinate material section coatings and corrosion protection measures with the requirements for the specific ESC zone in accordance with one UFC 1-200-01 prior to ordering materials.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in the IEEE Stds Dictionary.

b. Unless otherwise specified or indicated, solar energy conversion terms

used in these specifications, and on the drawings, are as defined in ASTM E772.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Commissioning Plan; G

Commissioning Schedule; G

SD-02 Shop Drawings

Schematic Diagrams; G

Interconnection Diagrams; G

Installation Drawings; G

Site Plan Drawings; G

Riser Diagram and General Notes; G

Installation and Assembly Details; G

Shop Drawings; G

Complete Solar PV System Components and Interconnection Wiring Diagrams; G

SD-03 Product Data

Combiner and Recombiner Boxes; G

Inverters; G; S

String Inverter Efficiency; G; S

Photovoltaic Module Backsheet; G

Photovoltaic Module Encapsulent; G

Photovoltaic Modules; G; S

Photovoltaic Wire; G

System Monitoring; G

System Wiring; G

SD-05 Design Data

System Operation; G

Calculations; G; S

System Performance Calculations; G; S

SD-06 Test Reports

NABCEP Acceptance Checks and Tests; G

NETA Acceptance Checks and Tests; G

Inverter Startup Tests; G

Functional Performance Testing; G

SD-07 Certificates

Installer; G

Materials; G

Warranty; G

Cybersecurity Equipment Certification; G

Commissioning Agent Qualification; G

Seismic Certification; G

Wind Certification; G

SD-08 Manufacturer's Instructions

Manufacturer's Installation Instructions; G

SD-10 Operation and Maintenance Data

Electrical Systems, Data Package 5; G

Training Course; G

SD-11 Closeout Submittals

Solar Posted Operating Instructions; G

Solar Training Documentation; G

Final Commissioning Report; G

Warranty; G

As-Built Drawings; G

1.5 MAINTENANCE MATERIAL SUBMITTALS

Comply with requirements specified in Section 01 78 00 CLOSEOUT SUBMITTALS.

1.6 QUALITY ASSURANCE

1.6.1 Regulatory Requirements

Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officers. Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.2 Installation Drawings

Submit a minimum of three hard copies of drawings for government approval prior to manufacturing and equipment construction or integration. Submit site plan drawings and riser diagram and general notes at a minimum of 24 by 36 inches. Submit installation and assembly details at a minimum of 24 by 36 inches. Submit at minimum scale of 1/2 inch per foot for overview and 2 inches per foot for detail.

In addition to requirements in Section 01 33 00 SUBMITTAL PROCEDURES, include the following:

a. All details legible and all text no smaller than 0.1 inches in height on any drawing. As needed, provide enlargements to ensure clarity of intent.

b. Submit shop drawings at a minimum of 11 by 17 inches in size using a minimum scale of 1/4 inch per foot, for the exception of drawings not required scale. Shop drawings must include three-wire diagrams and installation details of photovoltaic (PV) system equipment indicating location as proposed in design drawings, layout and arrangement of PV modules, support and mounting mechanism, inverters, combiner boxes, AC and DC disconnects, equipment enclosures, conduits, monitors, meters, security systems, and all other accessories associated with the installation of the PV system. Wiring diagrams must identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each equipment item.

c. Shop drawings may include legible copies of manufacturer's product literature, with selected items and specifications highlighted thereon.

d. Modifications to original drawings made during installation must be immediately recorded for inclusion into the as-built drawings. When items have changed relative to the approved design, the designer must provide certification indicating that the changes will not negatively affect the system's operation or the structure supporting the system.

1.6.2.1 Installation and Assembly Drawings and Details

Submit site plan drawings, components and interconnection wiring and general notes, and installation and assembly details drawings prior to start of construction. Drawings must include sufficient detail for all parts of the work to enable the Government to check conformity with the requirements of the contract documents. Include in the site plan drawings: topographic and utility survey; bore logs; soils report; site plan(s); site construction details; structural drawings; structural construction details; site electrical plan; and site electrical construction details. Include in the installation and assembly drawings and details: parts lists; assembly drawings; interconnection wiring

diagrams; wire and cable schedules; wire and cable termination schedules; instrument plan; instrument and control wire, conduit and cable schedules; instrument wire and cable termination schedule; control diagrams; control sequence of operation; seismic restraint details; and wind restraint details.

1.6.2.2 "As-Built" and Record Drawings

After completion of construction, submit As-built drawings prepared and certified by the construction contractor, showing in red ink, on-site changes to the original construction details and all underground utilities measured from field benchmarks, accurate to within 1" of centerline of the utility. Immediately record for inclusion into the as-built drawings all modifications to original drawings made during installation. Indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

After submittal and approval of "As-built" drawings, submit Record Drawings, prepared and by the project engineer(s) and architect(s), of the original design drawings reflecting all design changes and contractor noted changes in the "As-built" drawings.

1.6.3 System Operation

Provide a complete description of the function of each component including PV modules, DC wiring, combiner boxes, inverters, AC wiring, AC and DC disconnect switches, and monitoring system. Provide a discussion of the overall system operation.

1.6.4 Installer

Submit NABCEP (North American Board of Certified Energy Practitioners) PV Installation Professional certification, and a resume with references that details least four successful projects that, in aggregate, equal or exceed the size of the proposed project. Provide references for each of these referenced projects.

1.6.5 Standard Materials and Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products with satisfactory commercial or industrial use for 2 years prior to bid opening, and past performance documentation with consistent design and bill of materials. Include applications of equipment and materials under similar circumstances and of similar size. Where two or more items of the same class of equipment are required, products will be from a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in the technical section. Submit proof of compliance with requirements of UL, where material or equipment is specified to comply. The label of or listing in UL Electrical Construction Directory will be acceptable evidence. In lieu of the label or listing, a written certificate from an approved nationally recognized testing laboratory (NRTL) equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of Underwriters Laboratories may be submitted.

1.6.5.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if the manufacturer has been regularly engaged in the design and production of solar photovoltaic products for a minimum of 5-years. Similar photovoltaic products must have been in satisfactory commercial or industrial use for 5-years prior to bid opening and must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 5-year period.

1.6.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site must not be used, unless specified otherwise.

1.6.6 Cybersecurity Equipment Certification

Furnish a certification that control systems are designed and tested in accordance with DoD Instruction 8500.01, DoD Instruction 8510.01, and as required by individual Service Implementation Policy.

1.6.7 Operation and Maintenance Data

Submit Solar Photovoltaic Systems data package for the following items in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

a. Troubleshooting guide.

b. Warranty.

c. Operation instructions.

d. Preventive maintenance and inspection data, including a schedule for system operators.

1.6.7.1 Electrical Systems

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. In addition to requirements of Data Package 5, include the following for the actual solar photovoltaic (PV) system provided:

a. Service and maintenance information including preventive maintenance, assembly, and disassembly procedures.

b. Complete operation, repair, and maintenance information, detailed to the smallest replaceable unit.

c. Adjustment, trouble-shooting, configuration, tuning, and system calibration instructions.

d. Programming information for the communications and monitoring interface.

e. An instruction manual with pertinent items and information highlighted.

f. A layout drawing showing locations as well as views of equipment; front, top, and side views.

g. A one-line drawing showing all components and interfaces to the electrical system.

h. Prices for spare parts and supply list including spare modules and inverters.

i. Inverter efficiency report and field acceptance test reports.

j. Actual nameplate diagram.

k. Date of purchase.

1.6.7.2 Training Course

Provide training by a factory trained instructor to provide full instructions to designated Government personnel in the operation, maintenance and programming of the specified systems and equipment. Include safety training for first responders including fire department representatives. The proposed Training Course Curriculum (including topics and dates of discussion) indicating that all of the items contained in the operating and maintenance instructions, as well as demonstrations of safety and routine maintenance operations, including testing procedures included in the maintenance instructions, are to be covered. The proposed Training Course must be video-recorded and provided with any PowerPoint slides as part of the final documentation for those that cannot attend. Submit training documentation along with the proposed training dates, at least 14 days prior to dates of proposed training course. Provide training session for six personnel specifically oriented to installed equipment, system layout, and user operations.

1.6.8 Bill of Materials

Submit a Bill of Materials listing each product being incorporated into the system. Bill of Materials includes a general description of the product, quantity, and exact manufacturer's model number. Where the manufacturer's model number does not fully identify the product, list options, accessories, or custom features by additional descriptions.

1.6.9 Qualified Testing Organization

Comply with requirements specified in Section 26 08 00 APPARATUS INSPECTION AND TESTING. Engage the services of a qualified testing organization, NABCEP-certified professional, or licensed electrician to provide inspection, testing, calibration, and adjustment of the solar photovoltaic electrical distribution system and equipment listed herein. Organization must be independent of the supplier, manufacturer, and installer of the equipment. The organization must be a first tier contractor.

Submit name and qualifications of organization. Organization must have been regularly engaged in the testing of electrical materials, devices, installations, and regularly engaged in solar PV systems for a minimum of five years.

Organization calibration program requirements:

a. Provide a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

b. Accuracy: Traceable to the National Institute of Standards and Technology.

c. Instrument calibration frequency schedule: Less than or equal to 12 months for both test floor instruments and leased specialty equipment.

d. Dated calibration tables: Visible on all test equipment.

e. Calibrating standard: Higher accuracy than that of the instrument tested.

f. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(2) Identify the third party laboratory calibrated instrument to verify that calibrating standard is met.

1.6.10 Commissioning Agents

Commissioning Agents Qualifications: Engage commissioning service personnel, that specialize in the types of inspections and tests to be performed.

1.6.11 System Performance Calculations

Submit system performance calculations to show that the components provided will produce the minimum required production of power in accordance with PERFORMANCE REQUIREMENTS paragraph.

1.7 DELIVERY, STORAGE, AND HANDLING

a. Store solar PV modules in their original packaging according to the manufacturer's guidance, and do not remove from packaging until day of installation.

b. If a solar PV module is removed from its packaging, store it according to the manufacturer's guidance.

c. Do not store solar PV modules on-site for more than 12 months.

1.8 WARRANTY

Provide a list of all applicable warranties for all equipment and components. Include warranty information, names, addresses, telephone numbers, and procedures for filing a claim and obtaining warranty services. The equipment items must be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

Warrant the overall system for both parts and labor for a minimum period of 5 years. Provide specific warranties for solar photovoltaic modules, inverters, combiner boxes, recombiner boxes, and mounting system.

1.8.1 Solar Photovoltaic Modules

Furnish the solar photovoltaic module manufacturer's written warranty. The warranty must be a 25-year linear 80 percent (minimum) power warranty (at the end of the 25th year after purchase an actual minimum power output of 80 percent based on the nameplate rating must be achieved) and not less than 10-years for workmanship material and manufacturing defects from the date of manufacture.

The warranty must state that the malfunctioning solar photovoltaic module must be exchanged by the manufacturer and promptly shipped to the using Government facility. The replacement solar module must be identical to, or an improvement upon, the original design of the malfunctioning solar module.

1.8.2 Inverters

Furnish the inverter manufacturer's warranty. Inverter to be free from defects in material and workmanship for a minimum of 20 years from the date of manufacture. Inverter device installation, transportation, and on-site storage must not exceed 12 months, thereby permitting 19 years of the 20 year warranty to be in service and energized.

The warranty must state that the malfunctioning inverter must be exchanged by the manufacturer and promptly shipped to the using Government facility, and arrive in no more than ten days. The replacement inverter must be identical to, or an improvement upon, the original design of the malfunctioning inverter.

1.8.2.1 Inverter Software Updates Title

Provide, at no cost or charge, any inverter software upgrades that become available during the warranty period.

1.8.3 Combiner Boxes

Combiner boxes to be free from defects in material and workmanship for a period of 5 years.

1.8.4 Mounting System

Provide PV mounting system warranty of minimum 15 years.

1.8.5 Warranty Exclusion

The warranty must cover all system malfunctions and failures except those resulting from misuse, abuse, neglect, fire, vandalism, acts of nature, or other causes beyond the control of the Contractor or manufacturer.

1.9 CALCULATIONS

If construction deviates from design, provide relevant calculations to demonstrate that new design is satisfactory and approved by a licensed professional engineer.

1.10 CERTIFICATIONS

Provide seismic certification and wind certification, prepared by a licensed professional engineer or National Recognized Testing Laboratory,

(NRTL) for all components and assembled systems in accordance with ICC IBC, ASCE 7-16 state and local building codes. Seismic and wind certifications must demonstrate system must withstand wind and seismic requirements as installed and remain online and functional after a seismic or wind event.

1.11 HEALTH AND SAFETY RECOMMENDATIONS

Section 01 35 26 GOVERNMENTAL SAFETY REQUIREMENTS, applies to this section with additions and modifications specified herein.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

a. The PV system described in this document is a facility-scale less than 1 megawatt with system voltage not exceeding 1,000 VDC, single PV systems with a single service, and is of the grid-connected type which provides a direct interconnection of PV system and grid power service supplying building. The PV system does not include battery/backup storage or secondary electrical generation devices. PV system feeds AC power into the local services when solar energy is available and immediately disconnects from the grid upon loss of grid power to the service in accordance with IEEE 1547and local utility regulations.

b. PV system must comply with these specifications, all applicable construction document drawings, all applicable codes, and all local authorities having jurisdiction. System must comply with all policies and standards required by the electrical utility having jurisdiction and all applicable incentive program guidelines. PV system equipment includes, but is not limited to, PV modules and electrical insulating components such as encapsulants and backsheets, raceways, inverters, combiner boxes, disconnect switches, wire, conduit, junction boxes, mounting hardware, mounting structure for modules (racking), monitoring and communication equipment.

c. Provide surge protective device (SPD) complying with NFPA 780 requirements and listed to UL 1449.

2.1.1 System Requirements

Conform electrical installations to IEEE C2, NFPA 70, and requirements specified herein.

a. Solar photovoltaic system characteristics provided includes:

(1) 250kW minimum rated kW DC output

(2) 215kW minimum rated kW AC output

(3) 600 VDC nominal, not to exceed 1000 VDC maximum. system voltage

(4) Canopy mounted.

b. All equipment must be listed and labeled in accordance with NFPA 70 and OSHA-listed nationally recognized testing laboratories (NRTL) and installed in accordance with the listing requirements and the manufacturer's instructions.

c. Provide all accessories needed for a complete, secure, operational

grid-tied PV system.

d. Wiring and connections of inverters, PV source circuits, AC branch circuits, and all interconnections must be rated at a minimum for IP65 in accordance with NEMA IEC 60529.

2.1.1.1 System Wiring

System wiring must conform to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and must be in accordance with Section 690 of NFPA 70. Cabling exposed to sunlight must be UV resistant.

Provide conduits in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Use galvanized rigid steel conduit above grade and mount on UV resistant high-density polyethylene (HDPE) supports.

2.1.1.2 Site Design

Provide adequate space for personnel, vehicles and equipment throughout the PV array to facilitate installation, inspection and maintenance access to all modules.

2.1.2 Performance Requirements

System components provided must be selected to achieve a minimum calculated energy production as required by ICC IgCC.

2.2 PHOTOVOLTAIC MODULES

a. PV modules must be IEC 61215 compliant and IEC 61730-1 compliant listed to UL 1703, and manufactured in an ISO 9001 certified facility.

b. PV modules must be of monocrystalline technology and

(1) for rack-mounting.

c. PV module efficiency must be greater than 15 percent for crystalline technology.

d. PV modules must be of the same manufacturer and model number and consistent sub-components.

e. Submit on cutsheets PV module performance data from the manufacturer that must include a flash test data in accordance with IEC 61853-1, and temperature coefficients at: STC, nominal operating cell temperature (NOCT), low irradiance conditions (LIC), high temperature conditions (HTC), and low temperature conditions (LTC).

f. PV module bypass diodes must be inside the solar PV module's single conductor cable junction box.

g. Photovoltaic wire, wiring methods, and utilization of locking-type connectors must comply with the requirements of NFPA 70 and UL 6703. Provide USE-2 or RHH or RHW-2 wire, and sunlight-resistant wire when exposed to sunlight.

2.2.1 Crystalline Photovoltaic Module Backsheet

a. Backsheet component must consist of a tri-layer construction (minimum

thickness of 9.8 mils) with outer layers of polyvinyl fluoride (PVF) and an inner layer of polyester for crystalline-silicon modules with a maximum system voltage of 1000 VDC.

b. Alternate polymeric backsheets consisting of different chemical composition, thickness, or construction must fulfill the safety and performance specifications and acceptance criteria in Table 1. The required component properties in Table 1 must be verified by a test report provided by an OSHA-listed nationally recognized testing laboratory (NRTL) and a cutsheet submitted.

TABLE 1 - PV MODULE BACKSHEET COMPONENT SAFETY AND PERFORMANCE		
Items	Test Methods	Specification
Tensile Strength (MPa)	ASTM D882	>=100 (TD) >=100 (MD)
Elongation at Break (percent)	ASTM D882	>=80 (TD) >=100 (MD)
Dimensional Stability (percent, 150 degrees C, 0.5 h)	ASTM D882	<=1.0 (TD) <=1.0 (MD)
Breakdown Voltage (kV)	ASTM D149	>=18
WVTR (g/m^2 day, 37.8 degrees C, 100 percent RH)	ASTM F1249	<=2.5
Interlayer Peeling Strength (N/cm)	ASTM D1876	>=4
Peeling Strength with EVA (N/cm)	ASTM D903	>=40
Damp Heat (85 degrees C, 85 percent RH, 1000 hrs) -Color Change delta b -Elongation Retention (percent) -Appearance	ASTM E1171 ASTM E308/ASTM D2244 ASTM D882/ASTM D5870	<=2.5 >=70 No cracking or delamination.
UV Exposure Irradiance of 0.55 W/m^2 at 340 nm (61 W/m^2) using a xenon lamp with a daylight filter (outer layer). Exposure is 4200 hours (260 kWh/m^2 total UV (300-400 nm)) -Color Change delta b -Elongation Retention (percent) -Tensile Retention (percent) -Appearance	ASTM G155 ASTM E308/ASTM D2244 ASTM D882/ASTM D5870 ASTM D882/ASTM D5870	<=2.0 >=70 >=70 No cracking or delamination.

2.2.2 Crystalline Photovoltaic Module Encapsulent

a. Encapsulant component must consist of ethyl vinyl acetate (EVA) with a total nominal (prelamination) thickness of 35 mils or greater in the completed module. The EVA must have a minimum of 28 percent VA content. Through statistical process control, the module manufacturer must ensure that the cured EVA has a minimum of 70 percent gel content

per ASTM D7567 or ASTM D2765. The EVA must have a UV cutoff wavelength of 360 nm as measured according to ASTM E424. The EVA must have a minimum volume resistivity of 1X10^15 ohm-cm per ASTM D257.

b. Thermoplastic encapsulants consisting of different chemical composition, thickness, or construction must fulfill the safety and performance specifications and acceptance criteria described in Table 2. The required component properties described in Table 2 must be verified by a test report provided by an OSHA-listed nationally recognized testing laboratory (NRTL) and a cutsheet submitted.

TABLE 2 - PV MODULE ENCAPSULANT COMPONENT PROPERTIES

Items	Test Methods	Specification
Appearance	Visual Examination	No bubble, crack, or delamination.
Gel Content (percent)	ASTM D7567/ASTM D2765	>=70
UV Cutoff Wavelength (nm)	ASTM E424	>=360
Volume Resistivity (ohm-cm)	ASTM D257	>=1X10^15

2.2.3 Electrical Characteristics

Provide high-power type PV module(s), with typical peak power of not less than 580 watts, plus or minus 3 percent power tolerance, under Standard Test Conditions (STC). The AC output must not be less than 80 percent of the DC kWp rating. The individual current harmonics and TRD shall not exceed the limits specified in IEEE 1547.

The operating voltage corresponding to the power output mentioned above must be at least 37 volts. The open circuit voltage of the PV modules under STC should be at least 37 volts. Operate PV module at an ambient temperature range of minus 40 degrees F to plus 185 degrees F with 100 percent relative humidity.

2.2.4 Terminal Box

Include a terminal box on the module having a provision for opening for replacing the cable, if required.

2.2.5 Nameplate

Include the following on the module nameplate so as to be clearly visible:

a. Name of the Manufacturer or distinctive logo;

b. Model or Type Number;

c. Serial Number;

d. Year of make;

e. Peak wattage rating;

f. Peak voltage; and

g. Peak current.

2.3 INVERTERS

a. Array-to-inverter kW ratio must not exceed manufacturer recommendations. Inverter must be IEEE 1547 compliant, listed to UL 1741, comply with the latest applicable ANSI and FCC standards and addenda, and inspected before commissioning, testing, and operation of the system. Submit documentation validating system performance requirements.

b. Inverter must be approved by FCC Part 15, Class A as an unintentional radiator.

c. All same-sized inverters supplied must be of the same manufacturer and model number.

d. Provide inverter utilizing a floor-mount system.

e. Provide inverter utilizing a NEMA 1 indoor enclosure in accordance with NEMA 250. Provide enclosure made of steel.

f. Provide inverter with anti-islanding protection to prevent back-feeding inverter generated power to the grid in the event of a utility outage. Anti-islanding protection must be listed to UL 1741 and IEEE 1547.

g. Overcurrent protection, ground fault protection, arc fault circuit interrupter (AFCI), and rapid shutdown must comply with the requirements of NFPA 70.

h. Provide inverter with self-diagnostics routines, and remote and local display of operating status and remote monitoring capabilities. Provide inverter compatible with monitoring system and metering system. If capability for remote monitoring and control does not exist, then it must be added.

i. Provide inverter with integrated monitoring system. Data monitoring equipment must be able to sustain an overload across its output terminals up the 150 percent load, while supplying any load within its rating and without reducing its output voltage. Fuse power semiconductors in the inverter with fast acting fuses to prevent cascading failures. Provide each fuse with a blown fuse excluding String and Micro inverters and alarm indicating diodes on the control panel.

j. Match inverter DC input to the design of the PV module array outputs and account for the following:

   (1) The inverter low voltage is 50 percent of the maximum system voltage, to account for 25 year degradation.

   (2) Voltage decrease due to high temperatures at project site. Operate inverter at an ambient temperature range of minus 4 degrees F to plus 122 degrees F with 95 percent humidity (non-condensing).

k. Provide isolation transformer via built into inverter to provide safe galvanic separation between the AC side of the inverter and the grid.

l. Inverter must include AC and DC disconnecting means. DC and AC disconnecting means must be listed with ratings suitable for the intended use and purpose. System disconnecting means must meet the requirements of NFPA 70.

2.3.1 String Inverters

a. Submit String Inverter Efficiency of having a weighted average inverter power conversion efficiency of 93 percent with external isolation transformer or greater.

b. Allow the use of DC optimizers provided that a design which coordinates the DC optimizers and the inverter(s) is approved by the Contracting Officer.

c. Inverter must feature maximum power point tracking (MPPT).

2.4 COMBINER AND RECOMBINER BOXES

a. All combiner and recombiner boxes must be listed to UL 1741, and inspected before commissioning, testing, and operation of the system.

b. Provide combiner boxes support structure mountNEMA 4/4X outdoor steel enclosures in accordance with NEMA 250.

c. Supply combiner and recombiner boxes designed for use with the inverter provided, and coordinated to the specific PV source circuit design.

d. Include in the combiner and recombiner boxes fuses and a bus to combine the outputs of the strings. Each combiner box must be UL 1741 listed and operate at an ambient temperature range of minus 13 degrees F to plus 135 degrees F.

e. Provide combiner box output terminals for paralleling two conductors for the PV positive and negative, as well as the equipment ground conductors. Run set of wires from the combiner box to the inverter. Provide overcurrent protection and output disconnecting means listed for intended use and purpose that comply with the requirements of NFPA 70.

2.5 SOLAR CANOPY SUPPORT STRUCTURE

a. The solar canopy shall be a complete, factory-engineered structural system designed to support the PV array as indicated on the drawings. The PV module mounting components shall be an integral part of the canopy structure and the entire assembly shall be compliant with UL 2703.

b. The canopy structure, including modules, hardware, foundations, and all attachments, must be designed to withstand all applicable environmental loads, including wind and seismic loads, as required by ASCE 7-16 and ICC IBC.

c. The canopy structure must be suitable for Seismic Design Category D as defined by ASCE 7-16 and ICC IBC.

d. Submit complete structural design calculations for the canopy system and its foundations, prepared and stamped by a licensed professional structural engineer registered in the state of the project. The calculations must show compliance with all applicable seismic and wind requirements.

e. The canopy must include an integrated gutter and downspout system.

f. Provide a solar snow management system composed of:

(1) Pad-style snow guard installed in the horizontal joints of the panels.

(2) Array-mounted fence-style snow guard, 2" inches high, installed at the lowest edge of the array.

g. All structural and mounting components shall be fabricated from corrosion-resistant materials suitable for the site environment and a minimum 25-year design life, such as hot-dip galvanized steel, stainless steel, or aluminum. All fasteners, bolts, nuts, and washers shall be 18-8 stainless steel. Note: All shop and field welding shall be performed in accordance with the applicable American Welding Society (AWS) standard (e.g., AWS D1.1/D1.1M for steel, AWS D1.2/D1.2M for aluminum).

h. The structural design and foundations for the solar canopy shall be specified in and coordinated with Division 05 - Metals and Division 31 - Earthwork.

2.6 PV SYSTEM MONITORING

a. Provide a complete PV system monitoring system that collects data from the inverter and the grid interface meter and makes it available to authorized users via a secure, cloud-based web portal provided by the inverter manufacturer. The system shall provide real-time dashboards, historical data charting, and automatic email fault alerts. Additionally provide a PV system monitoring panel mounted as indicated.

b. The following quantities must be viewable from a localscreen display mounted at location as indicated:

(1) DC Input Voltage from PV array

(2) DC Input Power from PV array

(3) DC Input Current from PV array

(4) AC Phase Current from inverter

(5) AC Voltage from inverter

(6) AC Real Power from inverter

(7) Daily, Weekly, Monthly, Yearly, and Cumulative Energy Production

(8) Inverter Fault and Status Reports, including DC Ground Fault and Arc Fault alerts

(9) DC Ground Current Report

(10) AC Neutral Current from inverter

(11) AC Reactive Power from inverter

(12) AC Apparent Power from inverter

(13) AC Power Factor

(14) AC Phase Current from inverter (A, B, C)

(15) AC Voltage from inverter (A, B, C)

(16) Information from the meter:

(a) AC Real Power Imported from the Utility (kW)

(b) AC Real Power Exported to the Utility (kW)

(c) Cumulative Energy Imported from the Utility (kWh)

(d) Total Calculated Facility Power Consumption (kW)

(e) Total Calculated PV Self-Consumption (kW)

c. Provide additional data acquisition sensors to measure irradiance ambient temperature PV module temperature. Any additional data acquisition sensors require a conduit separate from the current conductor conduit.

2.7 PV SYSTEM METERING

a. Comply with metering requirements in Section 26 27 14.00 20 ELECTRICITY METERING.

b. Provide a revenue-grade Interval Data Recording (IDR) meter that shall function as the primary sensor for the Zero-Export control system. The meter shall be installed to measure all power flowing through the main service conductors at the main switchboard. A revenue-grade meter is required for the high accuracy and fast response time necessary for a stable control loop, not for billing purposes.

c. Connect to a monitoring/data collection recording solar production through time increments applicable to installation and utility standards, with a minimum of 15-minute intervals and 30-day memory.

d. UL listed and conform to ANSI C12.1.

e. Measure kWh, demand, instantaneous power, volts, amps, and watts.

f. Provide UL listed communication and annunciator panel.

2.8 POSTED OPERATING INSTRUCTIONS

Provide for each system and principal item of equipment as specified in the technical sections for use by the operation and maintenance personnel. The operating instructions include the following:

a. Wiring diagrams, schematic diagrams, interconnection diagrams, control

diagrams, and control sequence for each principal system and item of equipment.

b. Array layout showing the locations of all DC and AC disconnects.

c. Start up, proper adjustment, operating, and shutdown procedures.

d. Safety precautions.

e. The procedure in the event of equipment failure.

f. Other items of instruction as recommended by the manufacturer of each system or item of equipment.

Print operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions do not fade when exposed to sunlight and secure to prevent easy removal or peeling.

2.9 MANUFACTURER'S NAMEPLATE

Each item of equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. For PV modules, a label on the back of the module is acceptable.

2.10 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified. Each nameplate inscription identifies the function and, when applicable, the position. Nameplates are of melamine plastic, 0.125 inch thick, white with black center core. Surface is of matte finish. Square corners. Accurately align lettering and engrave into the core. Minimum size of nameplates is 1 inch by 2.5 inches. Lettering is a minimum of 0.25 inch high normal block style.

2.11 PV EQUIPMENT MARKING AND WARNING LABELS

Provide PV equipment listed or be evaluated for the application and have a field label applied in compliance with NFPA 70.

Provide warning signs for the enclosures of electrical equipment having a nominal rating exceeding 600 volts.

a. Provide PV equipment with UL 969 weather-resistant marking and warning labels in compliance with NFPA 1 and NFPA 70.

b. Provide warning signs for arc flash protection in accordance with NFPA 70E as indicated for all electrical equipment and components that are requiring examination, adjustment, servicing, or maintenance while energized. Provide field installed signs to warn qualified persons of potential electrical arc flash hazards when warning signs are not provided by the manufacturer. Provide marking that is clearly visible and readable from each accessible side to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

2.12 CABLE TAGS IN MANHOLES, HANDHOLES, AND VAULTS

Provide tags for each power cable or wire located in manholes, handholes, and vaults. The tags must be polyethylene. Do not provide handwritten letters.

2.13 GROUNDING AND BONDING

a. Provide properly sized equipment grounding conductors. Equipment grounding conductors must be insulated stranded copper, except that sizes 10 AWG and smaller must be solid copper. Insulation color must be continuous green for all equipment grounding conductors, except that wire sizes 4 AWG and larger shall be identified per NFPA 70.

b. Provide grounding lugs for aluminum PV solar module frames of either stainless steel or tin-coated copper.

c. Bonding conductors must be bare stranded copper, except that sizes 10 AWG and smaller must be bare solid copper. Bonding conductors must be stranded for final connection to motors, transformers, and vibrating equipment.

d. Provide bonding fittings on concentric/eccentric knockouts with metal conduits for circuits over 250 volts in accordance with NFPA 70.

e. Provide bonding fittings for ferrous metal conduits enclosing grounding electrode conductors in accordance with NFPA 70.

2.14 PV LIGHTNING PROTECTION SYSTEM

Provide PV Lightning Protection for electrical and mechanical systems in accordance with Section 26 41 00 LIGHTING PROTECTION SYSTEM and NFPA 780.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTALLATION INSTRUCTIONS AND INSTALLATION DRAWINGS

a. Complete all electrical work in accordance with NFPA 70.

b. Provide all permanent and temporary shoring, anchoring, and bracing required by the nature of this work in order to make all parts absolutely stable and rigid, even when such shoring, anchoring, and bracing are not explicitly called for.

c. Install the solar PV system in accordance with this section, installation drawings, and the printed installation instructions of the manufacturer.

d. Follow the manufacturer's installation recommendations to ensure no electricity is being fed to the grid and that all available disconnects are in the open position and fuses are not installed during wiring operations. Utilize on-site measurements in conjunction with engineering designs to accurately cut wires and layout before making permanent connections. Locate wires out of the way of windows, doors, openings, and other hazards. Ensure wires are free of snags and sharp edges that have the potential to compromise the wire insulation. If the system is roof-mounted, it must have direct current ground fault protection in accordance with NFPA 70. Ensure breakers in combiner box are in the off position (or fuses removed)

during combiner box wiring. Ensure wires and conduit are not installed as a trip hazard.

e. Attach solar PV modules to the mounting structure according to the manufacturer's instructions and approved plans.

f. Install instrumentation according to the manufacturer's instructions, with control panels located as indicated.

3.1.1 Wiring Methods

Furnish and install conductors required to connect incoming and outgoing circuits. Install conductors with conduits, boxes, and terminal cabinets in a totally enclosed installation. Install wiring in accordance with NFPA 70 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.2 Electrical Connections

a. Use twist on wire connectors listed for the environment (i.e. wet, damp, direct burial) and installed per manufacturer's instructions.

b. Use listed power distribution blocks.

c. Use terminals containing more than one conductor listed for multiple conductors.

d. Use connectors and terminals used for fine strand conductors that are listed for use with such conductors.

e. Utilize appropriate tools for connector type as recommended by the manufacturer.

f. Tighten and secure module connectors.

g. Provide corrosion protection in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and by adding a stainless steel isolating washer between components of incompatible metals on the racking structure.

h. Rate all enclosures for electrical connections and interconnections for NEMA 6 in accordance with NEMA 250 or IP67 in accordance with ANSI IEC 60529.

3.1.3 Disconnects

Provide disconnecting means in accordance with NFPA 70 requirements.

a. Install disconnects for all current carrying conductors of the PV source.

b. Install disconnects for the PV equipment. For inverters and other equipment that are energized from more than one source, group and identify the disconnecting means. Equipment disconnecting means or its remote operating device or the enclosure providing access to the disconnecting means must be capable of being locked in the open position when not within sight or not within 10 ft of the equipment.

c. Install disconnects and overcurrent protection for all ungrounded conductors in ungrounded (transformerless) PV power systems.

d. Install disconnecting means with a rapid shutdown function using the rapid shutdown initiation devices as specified in NFPA 70. Each device's "off" position must indicate that the rapid shutdown function has been initiated for all PV systems connected to that rapid shutdown initiation device.

e. Disconnecting means equipment that performs the rapid shutdown function, other than initiating devices, must be listed for providing rapid shutdown protection.

f. Buildings with rapid shutdown disconnecting means must have a permanent label as specified in NFPA 70.

3.1.4 Overcurrent and Overvoltage Protection

a. Install the PV interconnect overcurrent protective device as indicated in accordance with NFPA 70. Overcurrent devices used in PV system dc circuits must be listed for use in PV systems.

b. Install overvoltage surge protective device (SPD) as indicated and in accordance with NFPA 780 and NFPA 70. PV surge protective devices must be listed for use in PV system and marked "DC" or "PV SPD." If the system inverter is more than 100 ft from the closest combiner or recombiner box, provide additional PV SPDs at the PV output circuit adjacent to the inverter.

3.1.5 Fire Safety

Firestop conduit that penetrates fire-rated walls, fire-rated partitions, or fire-rated floors in accordance with Section 07 84 00 FIRESTOPPING. For all buildings other than one and two-family dwellings and townhouses provide access to roof mounted PV systems by providing a minimum 6 ft wide clear perimeter around the edges of the roof. Follow OSA safety requirements for roof mounted PV system equipment that requires access for periodic maintenance.

3.2 GROUNDING

3.2.1 PV System Grounding

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 25 ohms. Ground according to racking manufacturer's recommendations.

Install grounding lugs in locations on the solar PV module as designated by the module manufacturer, using stainless steel machine screws of the thread size provided in the pre-tapped holes, along with a stainless steel star washer placed between the grounding lug and the solar module frame.

3.2.2 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

Provide ground ring electrode in accordance with NFPA 780 encompassing the perimeter of each ground-mounted PV array. Interconnect all building

grounding electrode systems, including lighting protection.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

3.3.1 Ground Mounted Structures

3.3.1.1 Installation

In order to maximize potential energy output from each PV system, the system must be sited to maximize the amount of sunlight it receives daily, without shading from adjacent structures or trees. Existing and proposed land uses adjacent to the PV system must not be taller than the PV location.

a. Site Preparation:

b. Prepare the site for system installation by removing vegetation, grading for adequate drainage and avoid standing water on site, and excavating and compacting foundations for individual module installation. Provide access roads, pathways, fencing and other improvements as necessary for site access and security. Provide vegetation barrier to keep surrounding area free from array-shading vegetation as required.

c. Airspace Coordination:

d. When PV system to be sited near an airfield or related facilities and equipment used to sustain flight operations submit plans to the airfield manager and safety officer (among other stakeholders) for approval. Contact the DoD Siting Clearinghouse and provide applicable data items required for the DoD Siting coordination. Avoid glare from solar panels following FAA interim policy. Provide Glare and Glint calculation using Sandia Labs software which is maintained by ForgeSolar now. Use link https:/share-ng.sandia.gov/glare-tools.

3.4 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting must be as specified in Section 09 90 00 PAINTS AND COATINGS. ***Repair damage to galvanized surfaces in accordance with ASTM A780/A780M using a zinc rich paint as specified in Section 09 96 00 HIGH-PERFORMANCE COATINGS.***

3.5 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.6 WARNING SIGN MOUNTING

a. Display calculated maximum and minimum voltages and their respective amperages on engraved warning labels.

b. Display information on the arc flash warning labels in accordance with NFPA 70E.

c. Provide the number of signs required to be clearly visible and readable from each accessible side. Space the signs in accordance

with NFPA 70E.

3.7 CABLE TAG INSTALLATION

Install cable tags in each manhole, handhole, and vault as specified, including each splice. Install cable tags over the fireproofing, if any, and locate the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes, handholes, and vaults.

3.8 FIELD QUALITY CONTROL

Perform in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.8.1 Performance of NABCEP Acceptance Checks and Tests

Perform all inspections using a NABCEP-certified professional and in accordance with NABCEP inspection procedures, and in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests.

3.8.1.1 PV Modules

a. Visual and Mechanical Inspection

(1) Solar PV module manufacturer, model, and number of modules must match the approved plans.

(2) Solar PV modules must be in good conditions (including but not limited to no broken glass or cells, no discoloration, frames not damaged).

b. Electrical Tests

(1) Verify output of PV modules according to manufacturer's recommendations and NABCEP practices.

3.8.1.2 Inverters

a. Visual and Mechanical Inspection

(1) Inverter manufacturer, model, and number of inverters must match the approved plans.

(2) Inverters must be in good condition.

b. Electrical Tests

(1) Verify output of inverters according to manufacturer's recommendations and NABCEP practices.

3.8.2 Performance of NETA Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.8.2.1 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod, perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e. pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.8.3 Functional Acceptance Tests

a. Provide final and complete commissioning of the solar PV system in accordance with IEEE 1547.

b. Verify that all electrical components are installed and connected according to the requirements of the PV electrical drawings, specifications, and manufacturer's written instructions.

c. Before starting or operating the system, check continuity of all conductors and grounding conductors to verify that there are no faults and that all equipment has been properly installed according to the manufacturer's recommendations. Check factory instructions to see that installations have been made accordingly. Check equipment for any damage that may have occurred during shipment, after delivery, or during installation. Replace damaged equipment.

d. Before starting or operating the system, obtain a final inspection approval and final inspection from the Contracting Officer. Be present on site for both of these inspections.

e. Make final adjustments to all inverters and monitoring equipment so that they will be placed in an acceptable operating condition. Adjustable parameters must be set so that the PV system will produce the maximum possible amount of energy on an annual basis.

3.9 COMMISSIONING

Conduct Commissioning, after the system is installed and is ready for operation, in accordance with Section 01 91 00.15 22 BUILDING COMMISSIONING, item (6) renewable energy generation, to verify that the completed and installed system meets the requirements of IEEE 1547.

Tailor for non-building systems.

3.9.1 Commissioning Agent Qualification

Individual qualified in testing protective equipment (e.g., professional engineer, factory-certified technician, licensed electrician with experience in testing protective equipment) must perform or directly supervise commissioning tests.

3.9.2 Commissioning Plan and Schedule

Develop and implement a commissioning plan and commissioning schedule in accordance with Section 01 91 00.15 22 BUILDING COMMISSIONING.

3.9.3 Start-up Pre-functional Checklists

Carry out a checklist of startup requirements and conduct a series of safety tests to ensure proper installation, safe operation, and performance conforming to specification.

3.9.4 Functional Performance Testing

Prepare test procedures and conduct functional performance testing of the installed system. Include the following test requirements:

a. All inverter startup tests as specified by the inverter manufacturer in the inverter operation manual;

b. Actual power;

c. Loss of grid;

d. Grid resume;

e. Data monitoring check out;

f. V_{oc} measurement of every source circuit and log it;

g. Verify tightness of all wiring terminations;

h. Verify proper markings and labeling of all wire terminations and enclosures;

i. Verify startup/shut down procedures;

j. Verify system 5 minutes delay upon restart;

k. Verify PV array quick connectors are fully mated and wires are neatly secured;

l. Verify no debris on the modules, no damaged or broken modules;

m. Verification and inspections (see IEEE 1547.1 7.2)

n. Field-conducted type and production tests (see IEEE 1547 7.3)

o. Unintentional islanding functionality test (see IEEE 1547.1)

p. Cease-to-energize functionality test (see IEEE 1547.1)

q. Unintentional islanding functionality test (see IEEE 1547.1)

r. Cease-to-energize functionality test (see IEEE 1547.1 7.5)

s. Revised settings (see IEEE 1547.1 7.6)

3.9.5 Functional Performance Testing Results

Coordinate, observe and record the results of the functional performance testing. Coordinate retesting as necessary until satisfactory performance is verified. Verify the intended operation of individual components and system interactions under various conditions and modes of operation.

Document items of non-compliance in materials, installation or operation. Immediately address observed non-conformance and deficiencies in terms of notification to responsible parties, and provide recommended actions to correct deficiencies.

3.9.6 Final Commissioning Report

Prepare and submit final commissioning report. Summarize all tasks, findings, conclusions, and recommendations of the commissioning process in accordance with IEC 62446. Include the results of all tests and a listing of the final settings.

3.10 FINAL ACCEPTANCE

The acceptance of the solar PV system occurs only after all deficiencies identified by the functional acceptance tests and commissioning report are corrected, and the system operates successfully during a 30 day initial testing period.

The Contracting Officer must sign appropriate certificates, if equipment and systems are operating satisfactorily in accordance with the specifications, stating the system's operation has been tested and accepted at the end of the final start-up and testing.

3.11 CLOSEOUT ACTIVITIES

3.11.1 Demonstration

Upon completion of the work and at a time approved by the Contracting Officer, provide instructions by a qualified instructor to the Government personnel in the proper adjustment, system operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Government personnel must receive training comparable to the equipment manufacturer's factory training. Instructor must provide a separate training course for the monitoring system.

3.11.2 Instructor's Qualification Resume

Instructor(s) must be employee(s) of certified solar photovoltaic system training program. Instructors must be thoroughly familiar with all parts of the installation and trained in operating theory as well as practical operation and maintenance work. Submit the name(s) and qualification resume(s) of instructor(s) to the Contracting Officer for approval.

3.11.3 Training

Furnish training service by a factory-trained representative. Document that each qualified employee has received the required training in accordance with 29 CFR 1910. Maintain all training documentation in a central location for the entire employee's employment duration. Minimum documentation data includes employee's name, training name, and date(s) of training.

The training period must consist of a total of 2 hours of normal working time and begin after the system is functionally completed but prior to final acceptance tests. Submit the training course curriculum for approval, along with the proposed training date, at least 14 days prior to the date of proposed conduction of the training course. Instruction must be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. Provide any PowerPoint slides as part of the final documentation for those that cannot attend. Extend safety training to fire department representatives. Coordinate with Contracting Officer for Fire Department first responder training.

-- End of Section --

SECTION 26 32 15.00

ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES
05/20
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2016) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2017) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B31.3	(2016) Process Piping
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A126	(2004; R 2019) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A181/A181M	(2014) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

ASTM D975	(2019c) Standard Specification for Diesel Fuel Oils

ELECTRICAL GENERATING SYSTEMS ASSOCIATION (EGSA)

EGSA 101P	(1995) Performance Standard for Engine Driven Generator Sets

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE 115	(2009) Guide for Test Procedures for Synchronous Machines: Part I Acceptance and Performance Testing; Part II Test Procedures and Parameter Determination for Dynamic Analysis
IEEE 519	(2014) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C50.12	(2005; R 2010) Standard for Salient Pole 50 HZ and 60 Hz Synchronous Generators and Generation/Motors for Hydraulic Turbine Applications Rated 5 MVA and above
IEEE C57.13	(2016) Requirements for Instrument Transformers
IEEE C57.13.1	(2006; R 2012) Guide for Field Testing of Relaying Current Transformers

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2018) International Building Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 3046	(2002, 2006, 2009, 2001) Reciprocating Internal Combustion Engines - Performance--Part 1, 3, 4, 5, 6
ISO 8528	(1993; R 2018) Reciprocating Internal Combustion Engine Driven Alternating Current Generator Sets--Part 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2018) Motors and Generators
NEMA PB 1	(2011) Panelboards
NEMA PB 2	(2011) Deadfront Distribution Switchboards
NEMA/ANSI C12.11	(2007) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2021; TIA 20-1; TIA 20-2) Flammable and Combustible Liquids Code
NFPA 37	(2018) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 54	(2018) National Fuel Gas Code
NFPA 58	(2020) Liquefied Petroleum Gas Code
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
NFPA 99	(2021; TIA 20-1) Health Care Facilities Code

NFPA 110	(2016) Standard for Emergency and Standby Power Systems

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE ARP892	(1965; R 1994) DC Starter-Generator, Engine
SAE J537	(2016) Storage Batteries

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-461	(2015; Rev G) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 60	Standards of Performance for New Stationary Sources

UNDERWRITERS LABORATORIES (UL)

UL 142	(2006; Reprint Jul 2013) Steel Aboveground Tanks for Flammable and Combustible Liquids
UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 1236	(2015; Reprint Mar 2016) UL Standard for Safety Battery Chargers for Charging Engine-Starter Batteries
UL 1437	(2006) Electrical Analog Instruments - Panel Board Types

1.2 RELATED MATERIALS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and Section 26 08 00 APPARATUS INSPECTION AND TESTING apply to this section, except as modified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Engine-Generator Set and Auxiliary Equipment; G

Auxiliary Systems; G

Detailed Drawings; G

Acceptance; G

SD-03 Product Data

Harmonic Requirements; G

Engine-Generator Set Efficiencies; G

Emissions; G

filters; G

special tools; G

Engine-Generator Parameter Schedule

Onsite Training

Vibration-Isolation

Posted Data and Instructions; G

Instructions; G

Experience

Field Engineer

SD-05 Design Data

Performance Criteria

Sound Limitations; G

Time-Delay on Alarms

Cooling System

Vibration Isolation

Battery Charger

Capacity Calculations for Engine-Generator Set; G

Brake Mean Effective Pressure (BMEP) Calculations; G

Torsional Vibration Stress Analysis Computations; G

Capacity Calculations for Batteries; G

Turbocharger Load Calculations; G

SD-06 Test Reports

Factory Inspection and Tests

Onsite Inspection and Tests; G

Acceptance Checks and Tests; G

Functional Acceptance Tests; G

Maintenance Procedures; G

Operation and Maintenance Manuals; G

Functional Acceptance Test Procedure; G

SD-07 Certificates

Vibration Isolation

Prototype Test

Reliability and Durability

Start-Up Engineer; G

Instructor's Qualification Resume; G

Engine Emission Limits; G

Sound Limitations

Factory Inspection and Tests

SD-09 Manufacturer's Field Reports

Assembled Engine-Generator Set Tests; G

SD-10 Operation and Maintenance Data

Preliminary Assembled Operation and Maintenance Manuals; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and the paragraph ASSEMBLED OPERATION AND MAINTENANCE MANUALS.

SD-11 Closeout Submittals

Posted Data and Instructions; G

Training Plan; G

1.4 QUALITY ASSURANCE

1.4.1 Conformance to Codes and Standards

Where equipment is specified to conform to requirements of any code or standard such as UL, NEMA, etc., the design, fabrication and installation must also conform to the code.

1.4.2 Vibration Limitation

Limit the maximum engine-generator set vibration in the horizontal,

vertical, and axial directions to 6 mils (peak-peak RMS), with an overall velocity limit of 0.95 inches/second RMS, at rated speed for all loads through 110 percent of rated speed. The engine-generator set must be provided with vibration isolation in accordance with the manufacturer's standard recommendation. Where the vibration isolation system does not secure the base to the structure floor or unit foundation, provide seismic restraints in accordance with the seismic parameters specified.

1.4.3 Torsional Analysis

Submit torsional analysis including prototype testing or calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, plus/minus 10 percent.

1.4.4 Performance Data

Submit vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor. Also submit a description of seismic qualification of the engine-generator mounting, base, and vibration isolation.

1.4.5 Experience

Each component manufacturer must have a minimum of 3 years' experience in the manufacture, assembly and sale of components used with stationary engine-generator sets for commercial and industrial use. The engine-generator set manufacturer/assembler must have a minimum of 3 years' experience in the manufacture, assembly and sale of stationary engine-generator sets for commercial and industrial use. Submit a statement showing and verifying these requirements.

1.4.6 Field Engineer

The engine-generator set manufacturer or assembler must furnish a qualified field engineer to supervise the complete installation of the engine-generator set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment. The field engineer must have attended the engine generator manufacturer's training courses on installation and operation and maintenance of engine generator sets. Submit a letter listing the qualifications, schools, formal training, and experience of the field engineer.

1.4.7 Detailed Drawings

Submit detailed drawings showing the following:

a. Base-mounted equipment, complete with base and attachments, including anchor bolt template and recommended clearances for maintenance and operation.

b. Starting system.

c. Fuel system.

d. Cooling system.

e. Exhaust system.

f. Electric wiring of relays, breakers, programmable controllers, and switches including single line and wiring diagrams.

g. Lubrication system, including piping, pumps, strainers, filters, electric heater, controls and wiring.

h. Location, type, and description of vibration isolation devices for all applications.

i. The safety system, including wiring schematics.

j. One-line schematic and wiring diagrams of the generator, exciter, regulator, governor, and instrumentation.

k. Panel layouts.

l. Mounting and support for each panel and major piece of electrical equipment.

m. Engine-generator set rigging points and lifting instructions.

1.4.8 Auxiliary Systems Engine-Generator Set and Auxiliary Equipment Drawing Requirements

Submit drawings pertaining to the engine-generator set and auxiliary equipment, including but not limited to the following:

a. Certified outline, general arrangement (setting plan), and anchor bolt details. Show total weight and center of gravity of assembled equipment on the steel sub-base.

b. Detailed elementary, schematic wiring, and interconnection diagrams of the engine starting system, jacket coolant heating system, engine protective devices, engine alarm devices, engine speed governor system, generator and excitation system, and other integral devices.

c. Detailed elementary, schematic wiring; and interconnection diagrams of the fuel system, starting battery system, engine-generator control panel, generator circuit breaker, and remote alarm annunciator.

d. Dimensional drawings or catalog cuts of exhaust silencers, radiator, fuel day tanks, fuel oil cooler, valves and pumps, intake filters, vibration isolators, and other auxiliary equipment not integral with the engine-generator set.

1.4.9 Auxiliary Systems Drawing Requirements

Submit drawings showing floor plan arrangement of exhaust, air intake, fuel oil cooler, and jacket coolant water systems including arrangement of piping and pipe sizes.

1.4.10 Vibration Isolation System Certification

Submit certification from the manufacturer that the vibration isolation system will reduce the vibration to the limits specified in the paragraph VIBRATION ISOLATION.

1.4.11 Cybersecurity

The Risk Management Framework (RMF) is the process by which information systems are accredited for operation by a designated official from the Using Military Department. It is the standard process under which all DoD information systems must achieve and maintain their Authority To Operate. Refer to Section 25 05 11.06 CYBERSECURITY FOR LIGHTING CONTROL SYSTEM for cybersecutity requirements related to the generator monitoring and control system.

1.5 DELIVERY, STORAGE, AND HANDLING

Properly protect materials and equipment, in accordance with the manufacturers recommended storage procedures,before, during, and after installation. Protect stored items from the weather and contamination. During installation, cap piping and similar openings to keep out dirt and other foreign matter.

Deliver equipment on pallets or blocking wrapped in heavy-duty plastic, sealed to protect parts and assemblies from moisture and dirt. Protect and prepare batteries for shipment as recommended by the battery manufacturer. Store auxiliary equipment at the site in covered enclosures, protected from atmospheric moisture, dirt, and ground water.

1.6 EXTRA MATERIALS

Provide two sets of special tools and two sets of filters required for maintenance. Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. One handset must be provided for each electronic governor when required to indicate and/or change governor response settings. Furnish 4 liters one gallon of identical paint used on engine-generator set in manufacturer's sealed container with each engine-generator set.

Wrenches and tools specifically designed and required to work on the new equipment, which are not commercially available as standard mechanic's tools, must be furnished to the Contracting Officer.

Provide proposed operating instructions for the engine-generator set and auxiliary equipment laminated between matte-surface thermoplastic sheets and suitable for placement adjacent to corresponding equipment. After approval, install operating instructions where directed.

1.7 MAINTENANCE SERVICES

Submit the operation and maintenance manuals and have them approved prior to commencing onsite tests.

1.7.1 Operation Manual

Provide three copies of the operation manual in 8-1/2 by 11 inch three-ring binders. Sections must be separated by heavy plastic dividers with tabs which identify the material in the section. Fold drawings with the title block visible, and placed in 8-1/2 by 11 inch plastic pockets with reinforced holes. The manual must include:

a. Step-by-step procedures for system startup, operation, and shutdown;

b. Drawings, diagrams, and single-line schematics to illustrate and

define the electrical, mechanical, and hydraulic systems with their controls, alarms, and safety systems;

c. Procedures for interface and interaction with related systems to include automatic transfer switches, fire alarm/suppression systems, and load shedding systems.

1.7.2 Maintenance Manual

Provide three copies of the maintenance manual containing the information described below in 8-1/2 x 11 inch three-ring binders. Separate each section by a heavy plastic divider with tabs. Fold drawings with the title block visible, and placed in plastic pockets with reinforced holes. The manual must include:

a. Procedures for each routine maintenance item. Procedures for troubleshooting. Factory-service, take-down overhaul, and repair service manuals, with parts lists.

b. The manufacturer's recommended maintenance schedule.

c. A component list which includes the manufacturer's name, address, type or style, model or serial number, rating, and catalog number for the major components.

d. A list of spare parts for each piece of equipment and a complete list of materials and supplies needed for operation.

1.7.3 Assembled Operation and Maintenance Manuals

The contents of the assembled operation and maintenance manuals must include the manufacturer's O&M information required by the paragraph SD-10, OPERATION AND MAINTENANCE DATA and the manufacturer's O&M information specified in Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH.

a. Manuals must be in separate books or volumes, assembled and bound securely in durable, hard covered, water resistant binder, and indexed by major assembly and components in sequential order.

b. A table of contents (index) must be made part of the assembled O&M. The manual must be assembled in the order noted in table of contents.

c. The cover sheet or binder on each volume of the manuals must be identified and marked with the words, "Operation and Maintenance Manual."

1.8 SITE CONDITIONS

Protect the components of the engine-generator set, including cooling system components, pumps, fans, and similar auxiliaries when not operating and provide components capable of the specified outputs in the following environment:

a. Site Location: MCAS Beaufort, SC. USA

b. Site Elevation: 37 feet above mean sea level.

c. Ambient Temperatures:

(1) Maximum 93 degrees F dry bulb, 78 degrees F wet bulb.

(2) Minimum 32 degrees F dry bulb.

d. Design Wind Velocity: 72 mph.

e. Prevailing Wind Direction: West

f. Seismic Zone: Zone as defined by ICC IBC.

PART 2 PRODUCTS

2.1 SYSTEM REQUIREMENTS

a. Provide and install each engine-generator set complete and totally functional, with all necessary ancillary equipment to include: air filtration; starting system; generator controls, protection, and isolation; instrumentation; lubrication; fuel system; cooling system; and engine exhaust system. Each engine-generator set must satisfy the requirements specified in the Engine-Generator Parameter Schedule. Submit certification that the engine-generator set and cooling system function properly in the ambient temperatures specified.

b. Provide each engine-generator set consisting of one engine, one generator, and one exciter mounted, assembled, and aligned on one base; and all other necessary ancillary equipment which may be mounted separately. Assemble sets having a capacity of 750 kW or smaller and attach to the base prior to shipping. Provide set components that are environmentally suitable for the locations shown and that are the manufacturer's standard product offered in catalogs for commercial or industrial use. Provide a generator strip heater for moisture control when the generator is not operating. Identify any nonstandard products or components and the reason for their use.

2.1.1 Engine-Generator Parameter Schedule

Engine-Generator Set and Auxiliary Equipment Capacity Calculations for Engine-Generator Set

ENGINE-GENERATOR PARAMETER SCHEDULE	
Identification	Make/Model
Electrical Characteristics	
Power Rating	Emergency Standby Gross bhp rating / Net brake power rating 400KW at 0.8 power factor

ENGINE-GENERATOR PARAMETER SCHEDULE	
Governor Type	Type Make / Model Isochronous
Overload Capacity	None
Service Load	261 kVA (maximum)
Motor Starting kVA (Max.)	118 kVA
Power Factor	0.90 lagging
Engine-Generator Applications	stand-alone
Voltage Regulation (No Load to Full Load)(Stand-alone applications)	plus or minus 2 percent (maximum)
Voltage Bandwidth (steady state)	plus or minus 0.5 percent
Frequency	60 Hz
Voltage	480 volts
Phases	3 Phase, Wye
Nonlinear Loads	13.2 kVA
Max Step Load Increase	100 percent of Service Load at .85 PF
Time with Step Load Increase (Frequency)	
Maximum Voltage Deviation with Step Load Increase	20 percent of rated voltage

ENGINE-GENERATOR PARAMETER SCHEDULE	
Maximum Frequency Deviation with Step Load Increase	5 percent of rated frequency
Max Step Load Decrease (without shutdown)	100 percent of Service Load at 0.85 PF
Frequency Bandwidth (steady state)	plus or minus 0.25 percent
Frequency Regulation (droop) (No Load to Full Load)	3 percent (maximum)
Reactances	Synchronous reactance, Xd Transient reactance, X'd Sub-transient reactance, X"d Negative sequence reactance, X2 Zero sequence reactance, Xo
Capacity Calculations	
Calculations must verify that the engine-generator set power rating is adequate for the following load conditions:	
Lighting	13.3 kVA
Uninterruptible Power Supplies (UPS)	22 kVA, 6 pulse
Other Load	kW at 0.8 power factor

ENGINE-GENERATOR PARAMETER SCHEDULE	
Capacity Calculations for Batteries	
Calculation must verify that the engine starting battery capacity exceeds dc power requirements.	
Mechanical Characteristics	
Engine Description	Strokes/cycle Number of cylinders Bore and Stroke, inches
Engine Speed	1800 rpm
Piston Speed	1770 fpm
Heat Exchanger Type	fin-tube (radiator)
Engine Cooling Type	water/ethylene glycol
Intercooler Type	Air-to-Air / Jacket Water
Induction Method	Naturally Aspirated / Turbocharged
Turbocharger	Make / Model
Max Time to Start and be Ready to Assume Load	10 seconds
Max Summer Outdoor Temp (Ambient)	100 degrees F
Min Winter Outdoor Temp (Ambient)	48 degrees F
Installation Elevation	520 feet above sea level
Engine-Generator Set Efficiencies	

ENGINE-GENERATOR PARAMETER SCHEDULE	
Fuel Consumption	At 0.8 power factor, Gallons / hour for: 1 / 2 load 3 / 4 load Full Load
Generator Efficiency	At 0.8 power factor,(per cent) for: 1 / 2 load 3 / 4 load Full Load
Radiator Capacity	Coolant Type gpm coolant cfm air through radiator Btu per hr of heat exchange based on optimum coolant temperature to and from engine
Engine-Generator Set Emissions Data	
Exhaust Temperature	Degrees F at full load
Weight of Exhaust Gas	lb per hr at full load
Weight of Intake Air	lb per hr at full load
Total Heat Rejected	Btu per hr, at full load to: Jacket Coolant System Fuel Oil Cooling System
Emissions	lb per hr, at full load Total Suspended Particulate Particulate Matter with an average aerodynamic diameter of 10 microns Sulfur Dioxides Nitrogen Oxides (as NO2) Carbon Monoxide Volatile Organic Compounds
Visible Emissions	Percent opacity at full load
Brake Mean Effective Pressure (BMEP) Calculations	

ENGINE-GENERATOR PARAMETER SCHEDULE

Calculation must verify that the engine meets the specified maximum BMEP, as follows:

$$\text{BMEP psi} = \frac{(120{,}000 \times \text{bkW}) \times (792{,}000 \times \text{bhp})}{(\text{rpm} \times \text{cu. in.})}$$

Where:

bkW bhp = bkW' + bkW" bhp' + bhp"
bkW" bhp" is the Brake kW horsepower required by engine driven fan for cooling radiator or motor driven fan for cooling radiator.
bkW' bhp' = kW/GEN.EFF. kW/(GEN.EFF. times 0.746)
GEN.EFF. = Generator efficiency
cu. in. = Total engine piston displacement in cubic inches
rpm = Engine revolutions per minute
kW = Minimum power rating

Torsional Vibration Stress Analysis Computations

Torsional vibrational stresses in the crankshaft and generator shaft of assembled engine and driven generator must not exceed 5000 psi when engine is driving generator at rated speed while assembled unit is loaded to rated engine-generator set power. Computations must be based on a mathematical model of the assembled generator set provided or based on calculations using measured values from tests on a unit identical to the one provided. Calculations based on models of, or measured data from, the unassembled engine and generator will not be acceptable. Calculations must include:

a. A description of the system relating information pertinent to analysis such as operating speed range and identification plate data.

b. A mass elastic assembly drawing, showing the arrangement of the units in the generator set and dimensions of shafting, including minimum diameters (or section moduli) of shafting in the system.

c. A labeled line diagram of the mass elastic system indicating values of masses, stiffness, equivalent lengths, and equivalent diameters including basic assumptions and definition of terms.

d. Sample computations showing procedures used to obtain resulting stress values.

e. Computations indicating assembled engine-generator speed of 1800 rpm with assembly loaded to rated generator power and the resulting computed critical torsional stress values in the assembled engine crankshaft and generator shaft.

Turbocharger Load Calculations

ENGINE-GENERATOR PARAMETER SCHEDULE
NOTE: When the engine-generator set installation includes field installed exhaust system (i.e., the engine-generator set is installed internal to a building in lieu of in a self-contained outdoor enclosure), include the following paragraph. When the proposed exhaust system layout is different from that shown on the contract drawings, submit calculations showing that the external loads from the exhaust system such as weight and thermal expansion do not exceed the engine manufacturer's maximum allowed forces and moments on the turbocharger.

2.1.2 Rated Output Capacity

Provide each engine-generator-set with power equal to the sum of service load plus the machine's efficiency loss and associated ancillary equipment loads. Rated output capacity must also consider engine and/or generator oversizing required to meet requirements in paragraph Engine-Generator Parameter Schedule.

The engine must meet the specified maximum BMEP requirements at rated speed as calculated in accordance with the calculations in the engine-generator parameter schedule. The engine capacity must be based on the following:

a. Engine burning diesel fuel conforming to ASTM D975, Grade 2-D, at an ambient temperature of 85 degrees F. For stationary engines operated in the United States, diesel fuel requirements are found in 40 CFR 60 Subpart IIII.

b. Engine cooled by a radiator fan mechanically driven by the engine.

c. Engine cooled by coolant mixture of water and ethylene glycol, 50 percent by volume of each.

2.1.2.1 Engine Emission Limits

Engine must be certified by the manufacturer to meet applicable EPA emission standards found in 40 CFR 60 Subpart IIII. In addition, engine must meet any applicable state or local emission requirements (ex: California SCAQMD).

2.1.2.2 Performance Class

The voltage and frequency behavior of the generator set must be in accordance with ISO 8528 operating limit values for performance Class G3.

2.1.3 Power Ratings

Power ratings must be in accordance with EGSA 101P.

2.1.4 Transient Response

The engine-generator set governor and voltage regulator must cause the engine-generator set to respond to the maximum step load changes such that output voltage and frequency recover to and stabilize within the operational bandwidth within the transient recovery time. The engine-generator set must respond to maximum step load changes such that the maximum voltage and frequency deviations from bandwidth are not exceeded.

2.1.5 Reliability and Durability

Each standby engine-generator set must have both an engine and a generator capable of delivering the specified power on a standby basis with an anticipated mean time between overhauls of no less than 5,000 hours operating with a load factor of 70 percent. Cite two like engines and two like generators that have performed satisfactorily in a stationary power plant, independent and separate from the physical location of the manufacturer's and assembler's facilities, for standby without any failure to start, including all periodic exercise. Provide like engines and generators that have had no failures resulting in downtime for repairs in excess of 72 hours during two consecutive years of service. Provide engines that are the same model, speed, bore, stroke, number and configuration of cylinders, and rated output capacity. Provide generators that are the same model, speed, pitch, cooling, exciter, voltage regulator and rated output capacity.

Submit a reliability and durability certification letter from the manufacturer and assembler to prove that existing facilities are and have been successfully utilizing the same components proposed to meet this specification, in similar service. Certification may be based on components, i.e. engines used with different models of generators and generators used with different engines, and does not exclude annual technological improvements made by a manufacturer in the basic standard-model component on which experience was obtained, provided parts interchangeability has not been substantially affected and the current standard model meets the performance requirements specified. Provide a list with the name of the installations, completion dates, and name and telephone number of a point of contact.

2.1.6 Engine-Generator Set Enclosure

Provide engine-generator set enclosures that are corrosion resistant and fully weather resistant. The enclosure must contain all set components and provide ventilation to permit operation at Service Load under secured conditions. Provide access doors to controls and equipment requiring periodic maintenance or adjustment. Provide removable panels for access to components requiring periodic replacement. The enclosure must be capable of being removed without disassembly of the engine-generator set or removal of components other than the exhaust system. The enclosure

must reduce the noise of the generator set to within the limits specified in the paragraph SOUND LIMITATIONS. Rigidity wind test equal to 180MPH, roof load equal to 50 pounds per square foot and rain test equal to 4 inches per hour. ***For projects located in an environmental severity classification (ESC) C3, C4, or C5, provided enclosure fabricated from type 304 or 316 stainless steel NEMA 4X.***

2.1.7 Vibration Isolation

Provide an engine-generator set with a vibration isolation system in accordance with the manufacturer's standard recommendation. Submit vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor plus description of seismic qualification of the engine-generator mounting, base, and vibration isolation. Submit torsional analysis including prototype testing or and calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, plus 10 percent. Design and qualify vibration isolation systems as an integral part of the base and mounting system in accordance with the seismic parameters specified. Where the vibration isolation system does not secure the base to the structure floor or unit foundation, provide seismic restraints in accordance with the seismic parameters specified.

2.1.8 Harmonic Requirements

Non-linear loads to be served by each engine-generator set are as indicated. The maximum linear load demand (kVA at PF) when non-linear loads will also be in use is as indicated.

2.1.9 Starting Time Requirements

Upon receipt of a signal to start, each engine generator set will start, reach rated frequency and voltage and be ready to assume load within the time specified. For standby sets used in emergency power applications, each engine generator set will start, reach rated frequency and voltage, and power will be supplied to the load terminals of the automatic transfer switch within the starting time specified.

2.2 NAMEPLATES

Provide the manufacturer's name, type or style, model or serial number and rating on a plate secured to the equipment for each major component of this specification. Provide plates and tags sized so that inscription is readily legible to operating or maintenance personnel and securely mounted to or attached in proximity of their identified controls or equipment. Lettering must be normal block lettering, a minimum of 0.25 inch high. As a minimum, provide nameplates for:

Engines	Relays
Generators	Transformers (CT & PT)
Regulators	

Generator Breaker

Where the following equipment is not provided as a standard component by the engine generator set manufacturer, the nameplate information may be provided in the maintenance manual in lieu of nameplates.

Battery charger	Heaters
Switchboards	Exhaust mufflers
Battery	Exciters

2.2.1 Materials

Construct ID plates and tags of 16 gage minimum thickness bronze or stainless steel sheet metal engraved or stamped with inscription. Construct plates and tags not exposed to the weather or high operational temperature of the engine of laminated plastic, 0.125 inch thick, matte white finish with black center core, with lettering accurately aligned and engraved into the core.

2.2.2 Control Devices and Operation Indicators

Provide ID plates or tags for control devices and operation indicators, including valves, off-on switches, visual alarm annunciators, gages and thermometers, that are required for operation and maintenance of provided mechanical systems. Plates or tags must be minimum of 0.5 inch high and 2 inches long and must indicate component system and component function.

2.2.3 Equipment

Provide ID plates of a minimum size of high and 5 inches long on provided equipment indicating the following information:

a. Manufacturer's name, address, type and model number, serial number, and certificate of compliance with applicable EPA mission standards;

b. Contract number and accepted date;

c. Capacity or size;

d. System in which installed; and

e. System which it controls.

2.3 SAFETY DEVICES

Exposed moving parts, parts that produce high operating temperatures, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices such that proper operation of the equipment is not impaired.

2.4 MATERIALS AND EQUIPMENT

Submit certification stating that where materials or equipment are

specified to comply with requirements of UL, written proof of such compliance has been obtained. The label or listing of the specified agency, or a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency are acceptable as proof.

2.4.1 Circuit Breakers, Low Voltage

UL 489.

2.4.2 Filter Elements

Provide the manufacturer's standard fuel-oil, lubricating-oil, and combustion-air filter elements.

2.4.3 Instrument Transformers

NEMA/ANSI C12.11.

2.4.4 Revenue Metering

IEEE C57.13.

2.4.5 Pipe (Fuel/Lube-Oil, Compressed Air, Coolant, and Exhaust)

ASTM A53/A53M, or ASTM A106/A106M steel pipe. Pipe smaller than 2 inches must be Schedule 80. Pipe 2 inches and larger must be Schedule 40.

2.4.5.1 Flanges and Flanged Fittings

ASTM A181/A181M, Class 60, or ASME B16.5, Grade 1, Class 150.

2.4.5.2 Pipe Welding Fittings

ASTM A234/A234M, Grade WPB or WPC, Class 150 or ASME B16.11, 3000 lb.

2.4.5.3 Threaded Fittings

ASME B16.3, Class 150.

2.4.5.4 Valves

MSS SP-80, Class 150.

2.4.5.5 Gaskets

Manufacturer's standard.

2.4.6 Pipe Hangers

MSS SP-58.

2.4.7 Electrical Enclosures

NEMA ICS 6. ***For outdoor equipment located in an environmental severity classification (ESC) C3, C4, or C5, provide NEMA 4X stainless steel enclosures.***

2.4.7.1 Switchboards

NEMA PB 2.

2.4.7.2 Panelboards

NEMA PB 1.

2.4.8 Electric Motors

Provide electric motors that conform to the requirements of NEMA MG 1. Motors must have sealed ball bearings and a maximum speed of 1800 rpm. Motors used indoors must have drip-proof frames; enclose those that are used outside. Alternating current motors larger than 1/2 Hp must be of the squirrel-cage induction type for operation on 208 volts or higher, 60 Hz, and three-phase power. Alternating current motors 1/2 Hp or smaller, must be suitable for operation on 120 volts, 60 Hz, and single-phase power. Direct current motors must be suitable for operation on 125 volts.

2.4.9 Motor Controllers

Provide motor controllers and starters that conform to the requirements of NFPA 70 and NEMA ICS 2.

2.5 ENGINE

Each engine must operate on No. 2-D dieselfuel must be designed for stationary applications and must be complete with ancillaries. The engine must be a standard production model shown in the manufacturer's catalog describing and depicting each engine-generator set and all ancillary equipment in sufficient detail to demonstrate complete specification compliance. The engine must be naturally aspirated, supercharged, or turbocharged. The engine must be 4-stroke-cycle and compression-ignition type. The engine must be vertical in-line, V- or opposed-piston type, with a solid cast block or individually cast cylinders. The engine must have a minimum of two cylinders. Opposed-piston type engines must have more than four cylinders. Each block must have a coolant drain port. Equip each engine with an over-speed sensor.

ISO 3046. Diesel engines must be four-cycle naturally aspirated, or turbocharged, or turbocharged and intercooled; vertical in-line or vertical Vee type; designed for stationary service. Engines must be capable of immediate acceleration from rest to normal speed without intermediate idle/warm up period or pre-lubrication to provide essential electrical power. Two-cycle engines are not acceptable.

2.5.1 Sub-base Mounting

Mount each engine-generator set on a structural steel sub-base sized to support the engine, generator, and necessary accessories, auxiliaries and control equipment to produce a complete self-contained unit as standard with the manufacturer. Design the structural sub-base to properly support the equipment and maintain proper alignment of the engine-generator set in the specified seismic zone. In addition, provide sub-base with both lifting rings and jacking pads properly located to facilitate shipping and installation of the unit. Factory align engine and generator on the sub-base and securely bolt into place in accordance with the manufacturer's standard practice. Crankshaft must have rigid coupling for connection to the generator.

2.5.2 Assembly

Completely shop assemble each engine-generator set on its structural steel sub-base. Paint entire unit with manufacturer's standard paints and colors. After factory tests and before shipping, thoroughly clean and retouch painting as necessary to provide complete protection.

2.5.3 Turbocharger

If required by the manufacturer to meet the engine-generator set rating, provide turbine type driven by exhaust gas from engine cylinders, and direct connected to the blower supplying air to the engine intake manifold.

2.5.4 Intercooler

Provide manufacturer's standard intercooler for engine size specified.

2.5.5 Crankcase Protection

2.5.6 Miscellaneous Engine Accessories

Provide the following engine accessories where the manufacturer's standard design permits:

a. Piping on engine to inlet and outlet connections, including nonstandard companion flanges.

b. Structural steel sub-base and vibration isolators, foundation bolts, nuts, and pipe sleeves.

c. Level jack screws or shims, as required.

d. Rails, chocks, and shims for installation of sub-base on the foundation.

e. Removable guard, around fan. Support guard, on engine sub-base, to suit manufacturer's standard.

2.5.7 Intercooler

Provide manufacturer's standard intercooler for engine size specified.

2.6 FUEL SYSTEM

Provide fuel system conforming to the requirements of NFPA 30 and NFPA 37 and containing the following elements.

2.6.1 Pumps

Fuel transfer pumps may be mounted on the base tank. Pump must be horizontal, positive displacement. Direct-connect pump to motor through a flexible coupling. Equip each pump with a bypass relief valve, if not provided with an internal relief valve.

2.6.1.1 Main Pump

Provide engines with an engine driven pump. The pump must supply fuel at a minimum rate sufficient to provide the amount of fuel required to meet

the performance indicated within the parameter schedule. Base the fuel flow rate on meeting the load requirements and all necessary recirculation.

2.6.1.2 Auxiliary Fuel Pump

Provide auxiliary fuel pumps to maintain the required engine fuel pressure, if either required by the installation or indicated on the drawings. The auxiliary pump must be driven by a dc electric motor powered by the starting/station batteries. Automatically actuate the auxiliary pump by a pressure-detecting device.

2.6.2 Fuel Filter

Provide a minimum of one full-flow fuel filter for each engine. The filter must be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. Mark the inlet and outlet connections of the filter.

Provide intake filter assemblies for each engine of the oil bath or dry type, as standard with the manufacturer. Filters must be capable of removing a minimum of 92 percent of dirt and abrasive 3 microns and larger from intake air. Size filters to suit engine requirements at 100 percent of rated full load. Design unit for field access for maintenance purposes.

2.6.3 Relief/Bypass Valve

Provide a relief/bypass valve to regulate pressure in the fuel supply line, return excess fuel to a return line and prevent the build-up of excessive pressure in the fuel system.

2.6.4 Integral Main Fuel Storage Tank

Provide engine with an integral main fuel tank. Ttank must be factory installed and provided as an integral part of the generator manufacturer's product. Provide each tank with connections for fuel supply line, fuel return line, local fuel fill port, gauge, vent line, and float switch assembly. Provide a fuel return line cooler as recommended by the manufacturer and assembler. The temperature of the fuel returning to the tank must be below the flash point of the fuel. Mount the tank within the enclosure for each engine-generator set provided with weatherproof enclosures. The fuel fill line must be accessible without opening the enclosure.

a. Tanks: UL 142. Provide in skid double wall (110 percent containment) fuel tanks with a minimum capacity of 48 hours of engine-generator set operation at full-rated load. Epoxy coat day tanks inside and prime and paint outside. Construct tanks of not less than 3/16 inch steel plate with welded joints and necessary stiffeners on exterior of tank. Provide a braced structural steel framework support. Weld tank top tight. Provide 4 1/2 inch square inspection port with a 2 inch NPT fill connection and spill box. Provide proper normal and emergency venting for the primary tank and emergency venting only for the secondary tank / containment basin in accordance with UL 142 requirements.

b. Leak Detector Switch: Actuates when fuel is detected in containment basin, stops fuel transfer pump, and closes the fuel oil solenoid valve.

c. Tank Gages: Provide buoyant force type gages for fuel tanks with dial indicator not less than 4 inches in size and arranged for top mounting. Calibrate each reading dial or scale for its specific tank to read from empty to full, with intermediate points of 1/4, 1/2, and 3/4.

d. Integral Base Tanks Used as Primary Tank: Provide a 2 inch opening at the tank fill port, fitted an overfill prevention valve (OPV). Additionally, the fill opening must be perpendicular to the tank in order to allow operation of the OPV. Integral base tank must be sized and configured such that the filling and venting nozzles are outside the generator cabinet for ease of accessibility, inspection, and maintenance. Level gage must be in the line of sight from the fill port.

2.6.4.1 Capacity

Each tank must have capacity to supply fuel to the engine for an uninterrupted 48-hour period at 100 percent rated load without being refilled.

2.6.4.2 Local Fuel Fill

Each local fuel fill port on the base tank must have a screw-on cap.

2.6.4.3 Fuel Level Controls

Provide tanks with a float-switch assembly to perform the following functions:

a. Activate the "Low Fuel Level" alarm at 70 percent of the rated tank capacity.

b. Activate the "Overfill Fuel Level" alarm at 95 percent of the rated tank capacity.

2.6.4.4 Arrangement

Integral tanks may allow gravity flow into the engine. Gravity flow tanks and any tank that allows a fuel level above the fuel injectors must have an internal or external factory installed valve located as near as possible to the shell of the tank. The valve must close when the engine is not operating. Provide integral day tanks with any necessary pumps to supply fuel to the engine as recommended by the generator set manufacturer. The fuel supply line from the tank to the manufacturer's standard engine connection must be welded pipe.

2.7 LUBRICATION

Provide engine with a separate lube-oil system conforming to NFPA 30 and NFPA 37. Pressurize each system by engine-driven pumps. Regulate system pressure as recommended by the engine manufacturer. Provide a pressure relief valve on the crankcase for closed systems. Vent the crankcase in accordance with the manufacturer's recommendation. Do not vent the crankcase to the engine exhaust system. Crankcase breathers, if provided on engines installed in buildings or enclosures, must be piped to vent to the outside. The system must be readily accessible for service such as draining, refilling, etc. Each system must permit addition of oil and have oil-level indication with the set operating. The system must utilize

an oil cooler as recommended by the engine manufacturer.

2.7.1 Lube-Oil Filter

Provide one full-flow filter for each pump. The filter must be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. Mark inlet and outlet connections.

2.7.2 Lube-Oil Sensors

Equip each engine with lube-oil pressure sensors located downstream of the filters and provide signals for required indication and alarms. Submit two complete sets of filters, required for maintenance, supplied in a suitable storage box. Provide these filters in addition to filters replaced after testing.

2.7.3 Precirculation Pump

Provide a motor-driven precirculation pump powered by the station battery, complete with motor starter, if recommended by the engine manufacturer.

2.8 COOLING SYSTEM

Provide each engine with its own cooling system to operate automatically while its engine is running. The cooling system coolant must use a combination of water and ethylene-glycol sufficient for freeze protection at the minimum winter outdoor temperature specified. The maximum temperature rise of the coolant across each engine must not exceed that recommended below. Submit a letter which certifies that the engine-generator set and cooling system function properly in the ambient temperature specified, stating the following values:

a. The maximum allowable inlet temperature of the cooling air.

b. The minimum allowable inlet temperature of the cooling air across the engine.

c. The maximum allowable temperature rise in the cooling air across the engine.

d. The minimum allowable inlet fuel temperature.

2.8.1 Coolant Pumps

Provide centrifugal coolant pumps. Each engine must have an engine-driven primary pump. Provide secondary pumps that are electric motor driven and have automatic controllers. Control raw-water circulating pump by manual-off-automatic controllers and must be electric motor driven.

2.8.2 Heat Exchanger

Provide heat exchanger with the size and capacity to limit the maximum allowable temperature rise in the coolant across the engine to that recommended and submitted for the maximum summer outdoor design temperature and site elevation. Submit manufacturer's data to quantify heat rejected to the space with the engine generator set at rated capacity. Provide heat exchangers that are corrosion resistant, suitable for service in ambient conditions of application.

2.8.2.1 Fin-Tube-Type Heat Exchanger (Radiator)

Heat exchanger may be factory coated with corrosion resistant film, provided that corrective measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via over sizing, or other compensating methods. Provide internal surfaces that are compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Provide heat exchangers that are pressure type incorporating a pressure valve, vacuum valve and a cap. Design caps for pressure relief prior to removal. Provide heat exchanger and cooling system that is capable of withstanding a minimum pressure of 7 psi and protect with a strong grille or screen guard. Provide heat exchanger with at least two tapped holes; equip one tapped hole with a drain cock, and plug the rest.

Provide for each engine-generator set, as standard with the manufacturer.

a. Design Conditions: Each radiator unit must have ample capacity to remove not less than the total Btu per hour of heat rejected by its respective engine at 100 percent full-rated load to the jacket water, fuel oil, and lubricating oil system, and intercooler. Radiator capacity must be rated at optimum temperature of coolant leaving the engine and intercooler as recommended by the engine manufacturer with an ambient dry bulb air temperature outside the enclosure of 76 degrees F maximum, and 48 degrees F minimum at the site elevation specified in the paragraph SITE CONDITIONS, and with the coolant mixture specified in the paragraph ENGINE CAPACITY. Pressure drop through the radiator must not exceed 6 psi when circulating the maximum required coolant flow. Radiator air velocity must be a maximum of 1500 feet per minute.

b. Engine Mounted Radiator Construction: Radiator fan must direct airflow from the engine outward through the radiator. Fan must be V-belt driven directly from the engine crankshaft. Radiator fan must have sufficient capacity to meet design conditions against a static restriction of 0.5 inch of water. Fan static capacity must be adjusted to suit the ductwork furnished. Cooling section must have a tube and fin-type core consisting of copper or copper base alloy tubes with nonferrous fins. Select engine-driven fans for quiet vibration-free operation. Make provision for coolant expansion either by self-contained expansion tanks or separately mounted expansion tanks, as standard with the manufacturer. Provide suitable guards for each fan and drive.

c. Coolant solution must be a mixture of clean water and ethylene glycol, 50 percent by volume each. Provide an anti-freeze solution tester suitable for the mixture.

Field installed jacket coolant water piping must conform to the following:

a. Piping: Provide seamless steel pipe, Schedule 40, conforming to ASTM A53/A53M, Grade A.

b. Fittings and Flanges: Fittings, 1 1/2 inches or smaller, must be malleable iron conforming to ASME B16.3 for Class 300 threaded type. Fittings, 2 inches and larger, must be steel butt welding conforming to ASME B16.9. Utilize either ASME B16.1 or Class A of ASTM A126 for Class 125 cast-iron flanged fittings. Flanges must be Class 150 slip-on forged steel welding flanges in accordance with ASME B16.5,

with material in accordance with ASTM A181/A181M, Grade I. Provide flat face flanges for connecting to Class 125 standard cast-iron valves, fittings, and equipment connections.

c. Valves

(1) Gate Valves: For valves, 1 1/2 inches and smaller, provide double disk, rising stem, inside screw, union bonnet type, Class 125 bronze material conforming to MSS SP-80. For valves, 2 inches and larger, provide double-disk, parallel seat type, hydraulic-rated, Class 125, outside screw and yoke type with flanged ends and bronze trim conforming to MSS SP-70. Provide stem packing of material compatible with the system coolant.

(2) Globe Valves: For valves, 1 1/2 inches and smaller, provide rising stem, inside screw, union bonnet type, Class 125 bronze valves conforming to MSS SP-80. For valves, 2 inches and larger, provide Class 125 cast iron, flanged ends, bronze trim globe valves conforming to MSS SP-85. Valves must have renewable composition or cast iron discs compatible with the system coolant.

(3) Check Valves: MSS SP-71 or MSS SP-80, swing check type.

d. Hangers and Supports: MSS SP-58.

e. Piping Sleeves: Provide where piping passes through masonry or concrete walls, floors, roofs, and partitions. Place sleeves during construction. Unless indicated otherwise, pipe sleeves must comply with following requirements: Sleeves in outside walls below and above grade, in floor, or in roof slabs, must be standard weight zinc coated steel pipe. Sleeves in partitions must be zinc coated sheet steel having a nominal weight of not less than 0.90 pound per square foot. Space between piping insulation and the sleeve must be not less than 0.25 inch. Sleeves must be held securely in proper position and location during construction. Sleeves must be of sufficient length to pass through entire thickness of walls, partitions, or slabs. Sleeves in floor slabs must extend 2 inches above the finished floor. Space between the pipe and the sleeve must be firmly packed with insulation and caulked at both ends of the sleeve with plastic waterproof cement.

2.8.3 Expansion Tank

The cooling system must include an air expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting the pressure increase at all components in the system to the maximum allowable pressure at those components. The tank must be suitable for operating temperature of 250 degrees F and a working pressure of 125 psi. Provide welded steel tank , tested and stamped in accordance with ASME BPVC SEC VIII D1 for the stated working pressure. Do not use a bladder type tank. Support the tank by steel legs or bases for vertical or steel saddles for horizontal installation.

2.8.4 Thermostatic Control Valve

Provide a modulating type, thermostatic control valve in the coolant system to maintain the coolant temperature range submitted in paragraph SUBMITTALS.

2.8.5 Temperature Sensors

Equip each engine with coolant temperature sensors. Provide temperature sensors with signals for pre-high and high indication and alarms.

2.9 SOUND LIMITATIONS

Submit sound power level data for the packaged unit operating at 100 percent load in a free field environment. The data should demonstrate compliance with the sound limitation requirements of this specification. Submit certification from the manufacturer stating that the sound emissions meet the specification. Do not exceed the following sound pressure levels in any of the indicated frequencies when measured in a free field at a radial distance of 22.9 feet 7 meters at 45 degrees apart in all directions when operating at 100 percent load.2.10 EXHAUST SYSTEM

Provide a separate and complete system for each engine. Support piping to minimize vibration. Where a V-type engine is provided, use a V-type connector, with necessary flexible sections and hardware, to connect the engine exhaust outlets.

2.10.1 Flexible Sections and Expansion Joints

Provide a flexible section at each engine and an expansion joint at each muffler. Provide flexible sections and expansion joints that have flanged connections. Provide flexible sections made of convoluted seamless tube without joints or packing. Provide bellows type expansion joints. Provide stainless steel expansion and flexible elements suitable for engine exhaust gas at the maximum exhaust temperature that is specified by the engine manufacturer. Provide expansion and flexible elements that are capable of absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.10.2 Exhaust Muffler

Provide a chamber type exhaust muffler. Provide welded steel muffler designed for outside mounting. Provide eyebolts, lugs, flanges, or other items as necessary for support in the location and position indicated. Do not exceed the engine manufacturer's recommended pressure drop. Outside mufflers must be zinc coated or painted with high temperature 400 degrees F resisting paint. The muffler and exhaust piping together must reduce the noise level to less than the maximum acceptable level listed for sound limitations in paragraph SOUND LIMITATIONS. Provide muffler with a drain valve, nipple, and cap at the low-point of the muffler.

A critical class silencer must be provided for each engine which will reduce the exhaust sound spectrum by the following listed values at a 75 foot radius from the outlet, with generator set loaded to rated capacity and clear weather. Inlet and outlet connections must be flanged.

Octave Band Center Frequency (Hertz)								
Minimum Silencer Attenuation Decibels	63	125	250	500	1000	2000	4000	8000
Critical Class	15	32	37	36	30	36	37	37

2.11 PYROMETER

Provide a pyrometer, and thermocouple with calibrated leads to show the temperature in each engine cylinder and the combined exhaust of the combined exhaust. For a supercharged engine, provide additional points, thermocouples and leads to show the temperature in the turbocharger exhaust gas outlet and combustion air discharge passages. Graduated scale length less than 6 inches is not acceptable. Provide double pole selector switch with an "off" position, one set of points for each thermocouple, and suitable indicating dial. Calibrate the pyrometer, thermocouples, leads and compensating devices to show true exhaust temperature within plus or minus 1 percent above the highest temperature encountered at 110 percent load conditions.

2.12 EMISSIONS

The finished installation must comply with Federal, state, and local regulations and restrictions regarding the limits of emissions. Submit certification from the engine manufacturer stating that the engine exhaust emissions meet the federal, state, and local regulations and restrictions specified. At a minimum this certification must include emission factors for criteria pollutants including nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, non-methane hydrocarbon, and for hazardous air pollutants (HAPs).

2.13 STARTING SYSTEM

Provide starting system for standby engine generator sets used in emergency applications in accordance with NFPA 110 and as follows.

2.13.1 Controls

Provide an engine control switch with functions including: run/start (manual), off/reset, and, automatic mode. Provide start-stop logic for adjustable cycle cranking and cool-down operation. Arrange the logic for manual starting and fully automatic starting in accordance with paragraph AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION. Provide electrical starting systems with an adjustable cranking limit device to limit cranking periods from 1 second up to the maximum duration.

2.13.2 Capacity

Provide starting system with sufficient capacity, at the maximum outdoor summer temperature specified to crank the engine without damage or overheating. The system must provide a minimum of three cranking periods with 15 second intervals between cranks. Each cranking period must have a maximum duration of 15 seconds. Starting must be accomplished using an adequately sized dc starter system with a positive shift solenoid to engage the starter motor and to crank the engine continuously for 60 seconds without overheating.

2.13.3 Electrical Starting

Manufacturers recommended dc system, utilizing a negative circuit ground. Starting motors must be in accordance with SAE ARP892.

2.13.3.1 Battery

Provide a starting battery system including the battery, battery rack,

intercell connectors, spacers, automatic battery charger with overcurrent protection, metering and relaying. Provide battery in accordance with SAE J537. Size critical system components (rack, protection, etc.) to withstand the seismic acceleration forces specified. Provide nickel-cadmium battery with sufficient capacity, at the minimum outdoor and maximum outdoor temperature specified, to provide the specified cranking periods. Valve-regulated lead-acid batteries are not acceptable.

2.13.3.2 Battery Charger

Provide a current-limiting battery charger, conforming to UL 1236, that automatically recharges the batteries. Submit battery charger sizing calculations. The charger must be capable of an equalize charging rate which is manually adjustable in a continuous range and a floating charge rate for maintaining the batteries at fully charged condition. Provide an ammeter to indicate charging rate. Provide a voltmeter to indicate charging voltage. Provide a timer for the equalize charging-rate setting. A battery is considered to be fully depleted when the output voltage falls to a value which will not operate the engine generator set and its components. 120 volts AC operation.

a. DC ammeter

b. DC voltmeter

c. Equalize light

d. AC on light

e. Low voltage light

f. High voltage light

g. Equalize test button/switch

h. AC circuit breaker

i. Low dc voltage alarm relay

j. High dc voltage alarm relay

k. Current failure relay

l. AC power failure relay

2.13.4 Starting Aids

Provide one or more of other following methods to assist engine starting.

2.13.4.1 Jacket-Coolant Heaters

Mount a thermostatically controlled electric heater in the engine coolant jacketing to automatically maintain the coolant within plus or minus 3 degrees F of the control temperature. The heater must operate independently of engine operation so that starting times are minimized. Power for the heaters must be 120 volts ac. Include necessary equipment, piping, controls, wiring, and accessories. Provide relay to disconnect the heater when the generator is running.

2.13.4.1.1 Standby Rated Sets

The control temperature must be the temperature recommended by the engine manufacturer to meet the starting time specified at the minimum winter outdoor temperature.

2.13.4.2 Lubricating-Oil Heaters

Mount a thermostatically controlled electric heater in the engine lubricating-oil system to automatically maintain the oil temperature within plus or minus 3 degrees F of the control temperature. The heater must operate independently of engine operation so that starting times are minimized. Power for the heaters must be 120 volts ac.

2.13.5 Exerciser

Provide exerciser in accordance with Section 26 36 23 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.14 GOVERNOR

Provide a forward acting type engine speed governor system. Steady-state frequency band and frequency regulation (droop) must be in accordance with the operating limit values of the performance class specified in the paragraph PERFORMANCE CLASS.

Provide engine with a governor which maintains the frequency within a bandwidth of the rated frequency, over a steady-state load range of zero to 100 percent of rated output capacity. Configure the governor for safe manual adjustment of the speed/frequency during operation of the engine-generator set, without special tools, from 90 to 110 percent of the rated speed/frequency, over a steady state load range of 0 to 100 percent or rated capacity. Submit two complete sets of special tools required for maintenance (except for electronic governor handset). Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. Provide a suitable tool box for tools. Provide one handset for each electronic governor when required to indicate and/or change governor response settings. Maintain the midpoint of the frequency bandwidth at the same value for steady-state loads over the range of zero to 100 percent of rated output capacity for isochronous governors.

2.15 GENERATOR

Provide synchronous type, one or two bearing, generator conforming to the performance criteria in NEMA MG 1, equipped with winding terminal housings in accordance with NEMA MG 1, equipped with an amortisseur winding, and directly connected to the engine. Submit calculations of the engine and generator output power capability, including efficiency and parasitic load data. Provide Class H insulation.

a. Select NEMA MG 1, Part 16, standby duty, and temperature rise of 130 degrees C for engine-generator sets which are expected to operate for less than 300 hours per year. Select NEMA MG 1, Part 22, continuous duty, and temperature rise of 105 degrees C for engine-generator sets expected to operate 300 hours or greater per year or rated 300 kW and above.

b. Select 2/3 pitch design option for engine-generator sets rated 100 kW

and above.

c. Provide salient-pole type, ac, brushless-excited, revolving field, air-cooled, self-ventilated, drip-proof guarded, coupled type, synchronous generator conforming to NEMA MG 1, Part 22, and IEEE C50.12. Generator must be rated for standby duty at 100 percent of the power rating of the engine-generator set as specified in paragraph ENGINE-GENERATOR SET RATINGS AND PERFORMANCE. Temperature rise of each of the various parts of the generator must not exceed 105 degrees C as measured by resistance, based on a maximum ambient temperature of 40 degrees C. Winding insulation must be Class H.

d. Stator: Stator windings must be 2/3 pitch design, 10-12 lead re-connectable with VPI insulated coils.

e. Rotor: The rotor must have connected amortisseur windings.

f. Generator Space Heater: Provide 120 volt ac heaters. Heater capacity must be as recommended by the generator manufacturer to aid in keeping the generator insulation dry.

g. Grounding: Provide non-corrosive steel grounding pads located at two opposite mounting legs.

h. Filters: Provide manufacturer's standard generator cooling air filter assembly.

i. Design generator to protect against mechanical, electrical and thermal damage due to vibration, 25 percent overspeeds, or voltages and temperatures at a rated output capacity of 110 percent for prime applications and 100 percent for standby applications.

j. Provide generator ancillary equipment meeting the short circuit requirements of NEMA MG 1. Select drip-proof guarded option for generators without weatherproof enclosures.

k. Submit manufacturer's standard data for each generator (prototype data at the specified rating or above is acceptable), listing the following information:

(1) Direct-Axis sub-transient reactance (per unit).

(2) The generator kW rating and short circuit current capacity (both symmetric and asymmetric).

2.15.1 Current Balance

At 100 percent rated output capacity, and load impedance equal for each of the 3 phases, the permissible current difference between any 2 phases must not exceed 2 percent of the largest current on either of the 2 phases. Submit certification stating that the flywheel has been statically and dynamically balanced and is capable of being rotated at 125 percent of rated speed without vibration or damage.

2.15.2 Voltage Balance

At any balanced load between 75 and 100 percent of rated output capacity, the difference in line-to-neutral voltage among the 3 phases must not exceed 1 percent of the average line-to-neutral voltage. For a single

phase load condition, consisting of 25 percent load at unity power factor placed between any phase and neutral with no load on the other 2 phases, the maximum simultaneous difference in line-to-neutral voltage between the phases must not exceed 3 percent of rated line to neutral voltage. The single-phase load requirement must be valid utilizing normal exciter and regulator control. The interpretation of the 25 percent load for single phase load conditions means 25 percent of rated current at rated phase voltage and unity power factor.

2.15.3 Waveform

The deviation factor of the line-to-line voltage at zero load and at balanced rated output capacity must not exceed 10 percent. The RMS of all harmonics must be less than 5.0 percent and that of any one harmonic less than 3.0 percent of the fundamental at rated output capacity. Design and configure engine-generator to meet the total harmonic distortion limits of IEEE 519.

2.16 EXCITER

Provide brushless generator exciter. Provide semiconductor rectifiers that have a minimum safety factor of 300 percent for peak inverse voltage and forward current ratings for all operating conditions, including 110 percent generator output at 104 degrees F ambient. The exciter and regulator in combination must maintain generator-output voltage within the limits specified.

Provide a brushless excitation system consisting of an exciter and rotating rectifier assembly, and permanent magnet generator integral with the generator and a voltage regulator. Insulation class for parts integral with the generator must be as specified in paragraph GENERATOR. System must provide a minimum short circuit of 300 percent rated engine-generator set current for at least 10 seconds. Steady state voltage regulation must be in accordance with the operating limit values of the performance class specified in the paragraph PERFORMANCE CLASS.

a. Exciter and Rotating Rectifier Assembly: Rectifiers must be provided with surge voltage protection.

b. Permanent Magnet Generator: Provide a voltage spike suppression device for permanent magnet generator (PMG) excitation systems.

c. Voltage Regulator: Voltage regulator must be solid state or digital, automatic, three-phase sensing, volts per hertz type regulator. Regulator must receive its input power from a PMG. Voltage variation for any 40 degree C change over the operating temperature range must be less than plus or minus 1.0 percent. Operating temperature must be minus 40 degree C to plus 70 degree C. Voltage adjust range must be plus to minus 5.0 percent of nominal. Inherent regulator features must include over excitation shutdown.

2.16.1 Electromagnetic Interference (EMI) Suppression

Provide as an integral part of the generator and excitation system, EMI suppression complying with MIL-STD-461.

2.17 VOLTAGE REGULATOR

Provide a solid-state voltage regulator, separate from the exciter, for

each generator. Maintain the voltage within a bandwidth of the rated voltage, over a steady-state load range of zero to 100 percent of rated output capacity. Configure regulator for safe manual adjustment of the engine-generator voltage output without special tools, during operation, from 90 to 110 percent of the rated voltage over the steady state load range of 0 to 100 percent of rated output capacity. Regulation drift exceeding plus or minus 0.5 percent for an ambient temperature change of 68 degrees F is not acceptable. Reactive droop compensation or reactive differential compensation must load share the reactive load proportionally between sets during parallel operation. Provide voltage regulator with a maximum droop of 2 percent of rated voltage over a load range from 0 to 100 percent of rated output capacity and automatically maintain the generator output voltage within the specified operational bandwidth.

2.18 GENERATOR ISOLATION AND PROTECTION

Provide necessary devices for electrical protection and isolation of each engine-generator set and its ancillary equipment. The generator circuit breaker (IEEE Device 52) ratings must be consistent with the generator rated voltage and frequency, with continuous, short circuit withstand, and interrupting current ratings to match the generator capacity. Provide manually operated generator circuit breaker. Mount a set of surge capacitors at the generator terminals. Provide monitoring and control devices as specified in paragraph GENERATOR PANEL.

The generator circuit breaker must comply with UL 489 requirements for molded case, adjustable thermal magnetic trip type circuit breaker. The circuit breaker continuous current rating must be adequate for the power rating of the engine-generator set and the circuit breaker must be rated to withstand the short circuit current provided by the generator set. Provide circuit breaker in a NEMA ICS 6, Type 3R enclosure mounted on the engine-generator set.

2.18.1 Devices

Provide switches, circuit breakers, switchgear, fuses, relays, and other protective devices as specified in Section 26 05 75 POWER SYSTEM STUDY.

Furnish with respective pieces of equipment. Motors, controllers, contactors, and disconnects must conform to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical connections under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide controllers and contactors with maximum of 120-volt control circuits, and auxiliary contacts for use with controls furnished. When motors and equipment furnished are larger than size indicated, the cost of providing additional electrical service and related work must be included under this section.

2.19 SAFETY SYSTEM

Provide and install devices, wiring, remote panels, and local panels, etc., as a complete system to automatically activate the appropriate signals and initiate the appropriate actions. Provide a safety system with a self-test method to verify its operability. Provide alarm signals that have manual acknowledgment and reset devices. The alarm signal systems must reactivate for new signals after acknowledgment is given to any signal. Configure the systems so that loss of any monitoring device will be dealt with as an alarm on that system element.

2.19.1 Audible Signal

Provide audible alarm signal sound at a frequency of 70 Hz at a volume of 75 dB at 10 feet. The sound must be continuously activated upon alarm and silenced upon acknowledgment. Locate signal devices as shown.

2.19.2 Visual Signal

The visual alarm signal must be a panel light. The light must be normally off, activated to be blinking upon alarm. The light must change to continuously lit upon acknowledgement. If automatic shutdown occurs, the display must maintain activated status to indicate the cause of failure and must not be reset until cause of alarm has been cleared and/or restored to normal condition. Shutdown alarms must be red; all other alarms must be amber.

2.19.3 Alarms and Action Logic

2.19.3.1 Shutdown

Accomplish simultaneous activation of the audible signal, activation of the visual signal, stopping the engine, and opening the generator main circuit breakers.

2.19.3.2 Problem

Accomplish activation of the visual signal.

2.19.4 Safety Indications and Shutdowns
Provide a local alarm panel with the following shutdown and alarm functions in accordance with NFPA 99 mounted either on or adjacent to the engine generator set.

A remote alarm panel is required for audible alarms, e.g., in the control room. The alarm panel shall be recessed in the wall.

Indicator Function (at battery voltage)	NFPA 99 Level 1 CV S RA
Overcrank	X X X
Low water temperature	X NA X
High engine temperature pre-alarm	X NA X
High engine temperature	X X X
Low lube oil pressure pre-alarm	X NA X
Low lube oil pressure	X X X
Overspeed	X X X

Indicator Function (at battery voltage)	NFPA 99 Level 1 CV S RA
Low fuel main tank	X NA X
Low coolant level	X O X
EPS supplying load	X NA NA
Control switch not in automatic position	X NA X
High battery voltage	X NA NA
Low cranking voltage	X NA X
Low voltage in battery	X NA NA
Battery charger ac failure	X NA NA
Lamp test	X NA NA
Contacts for local and remote common alarm	X NA X
Audible alarm silencing switch	NA NA X
Low starting air pressure	X NA NA
Low starting hydraulic pressure	X NA NA
Air shutdown damper when used	X X X
Remote emergency stop	NA X NA

Symbology:
CV: Control panel-mounted visual.
S: Shutdown of EPS indication.
RA: Remote audible.
Symbology:
CV: Control panel-mounted visual.
S: Shutdown of EPS indication.
RA: Remote audible.
X: Required.
O: Optional.
NA: Not applicable.

2.19.5 Time-Delay on Alarms

For startup of the engine-generator set, install time-delay devices bypassing the low lubricating oil pressure alarm during cranking, and the coolant-fluid outlet temperature alarm. Submit the magnitude of monitored values which define alarm or action set points, and the tolerance (plus and/or minus) at which the devices activate the alarm or action for items contained within the alarm panels. The lube-oil time-delay device must return its alarm to normal status after the engine starts. The coolant time-delay device must return its alarm to normal status 5 minutes after the engine starts.

2.20 PANELS

Each panel must be of the type and kind necessary to provide specified functions. Mount panels on the engine-generator set base by vibration/shock absorbing type mountings. Mount instruments flush or semiflush. Provide convenient access to the back of panels to facilitate maintenance. Calibrate instruments using recognized industry calibration standards. Provide a panel identification plate identifying the panel function. Provide a plate identifying the device and its function for each instrument and device on the panel. Provide switch plates identifying the switch-position function.

2.20.1 Enclosures

Design enclosures for the application and environment, conforming to NEMA ICS 6. Locking mechanisms must be keyed alike.

Provide for each engine-generator set and fabricate from zinc coated or phosphatized and shop primed 16 gage minimum sheet steel in accordance with the manufacturer's standard design. Provide a complete, weatherproof enclosure for the engine, generator, and auxiliary systems and equipment. Support exhaust piping and silencer so that the turbocharger is not subjected to exhaust system weight or lateral forces generated in connecting piping that exceed the engine manufacturer's maximum allowed forces and moments. The housing must have sufficient louvered openings to allow entrance of outside air for engine and generator cooling at full load. Design louvered openings to exclude driving rain and snow. Provide properly arranged and sized, hinged panels in the enclosure to allow convenient access to the engine, generator, and control equipment for maintenance and operational procedures. Provide hinged panels with spring type latches which must hold the panels closed securely and will not allow them to vibrate. Brace the housing internally to prevent excessive vibration when the set is in operation. Provide a platform with staircase at all access points to the enclosure to allow safe access for maintenance personnel.

2.20.2 Analog

Provide analog electrical indicating instruments in accordance with UL 1437 with semi-flush mounting. Switchboard, switchgear, and control-room panel-mounted instruments must have 250 degree scales with an accuracy of not less than 99 percent. Unit-mounted instruments must be the manufacturer's standard with an accuracy of not less than 98 percent. The instrument's operating temperature range must be minus 4 to plus 158 degrees F. Distorted generator output voltage waveform of a crest factor less than 5 must not affect metering accuracy for phase voltages, hertz and amps.

2.20.3 Electronic

Electronic indicating instruments must be true RMS indicating instruments, 100 percent solid state, state-of-the-art, microprocessor controlled to provide specified functions. Provide control, logic, and function devices that are compatible as a system, sealed, dust and water tight, and that utilize modular components with metal housings and digital instrumentation. Provide an interface module to decode serial link data from the electronic panel and translate alarm, fault and status conditions to set of relay contacts. Instrument accuracy less than 98 percent for unit mounted devices and 99 percent for control room, panel mounted devices, throughout a temperature range of minus 4 to 158 degrees F is not acceptable. Provide LED or back lit LCD data display. Additionally, the display must provide indication of cycle programming and diagnostic codes for troubleshooting. Numeral height must be 0.5 inch.

2.20.4 Parameter Display

Provide indication or readouts of the tachometer, lubricating-oil pressure, ac voltmeter, ac ammeter, frequency meter, and safety system parameters. Specify a momentary switch for other panels.

2.21 SURGE PROTECTION

Electrical and electronic components must be protected from, or designed to withstand the effects of surges from switching and lightning.

2.22 AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION

Provide fully automatic operation for the following operations: engine-generator set starting and load transfer upon loss of normal source; retransfer upon restoration of the normal source; and stopping of each engine-generator set after cool-down. Devices must automatically reset after termination of their function.

2.22.1 Automatic Transfer Switch

Provide automatic transfer switches in accordance with Section 26 36 23 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.22.2 Monitoring and Transfer

Provide devices to monitor voltage and frequency for the normal power source and each engine-generator set, and control transfer from the normal source and retransfer upon restoration of the normal source. Describe functions, actuation, and time delays as described in Section 26 36 23 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.23 MANUAL ENGINE-GENERATOR-SET SYSTEM OPERATION

Provide complete facilities for manual starting and testing of each set without load, loading and unloading of each set, and synchronization of each set with an energized bus.

2.24 BASE

Provide a steel base. Design the base to rigidly support the engine-generator set, ensure permanent alignment of rotating parts, be

arranged to provide easy access to allow changing of lube-oil, and ensure that alignment is maintained during shipping and normal operation. The base must permit skidding in any direction during installation and must withstand and mitigate the affects of synchronous vibration of the engine and generator. Provide base with suitable holes for anchor bolts and jacking screws for leveling.

2.25 PAINTING AND FINISHING

Clean, prime and paintthe engine-generator set in accordance with the manufacturer's standard color and practice.

2.26 FACTORY INSPECTION AND TESTS

Submit one complete reproducible copies of the factory inspection result on the checklist format specified below. Perform the factory tests on each engine-generator set. The component manufacturer's production line test is acceptable as noted. Run each engine-generator set for at least 1 hour at rated output capacity prior to inspections. Complete inspections and make all necessary repairs prior to testing. Use engine generator controls and protective devices that are provided by the generator set manufacturer as part of the standard package for factory tests. When controls and switchgear are not provided as part of the generator set manufacturer's standard package, the actual controls and protective devices provided for the project are not required to be used during the factory test. The Contracting Officer may provide one or more representatives to witness inspections and tests.

2.26.1 Factory Inspection

Perform inspections prior to beginning and after completion of testing of the assembled engine-generator set. Look for leaks, looseness, defects in components, proper assembly, etc. and note any item found to be in need of correction as a necessary repair. Use the following checklist for the inspection:

INSPECTION ITEM	GOOD	BAD	NOTES
Drive belts			
Governor and adjustments			
Engine timing mark			
Starting motor			
Starting aids			
Coolant type and concentration			
Radiator drains			
Block coolant drains			
Coolant fill level			

INSPECTION ITEM	GOOD	BAD	NOTES
All coolant line connections			
All coolant hoses			
Combustion air filter			
Combustion air silencer			
Lube oil type			
Lube oil sump drain			
Lube-oil filter			
Lube-oil-level indicator			
Lube-oil-fill level			
All lube-oil line connections			
All lube-oil lines			
Fuel type and amount			
All fuel-line connections			
All fuel lines			
Fuel filter			
Coupling and shaft alignment			
Voltage regulators			
Battery-charger connections			
All wiring connections			
Instrumentation			
Hazards to personnel			
Base			
Nameplates			
Paint			
Exhaust-heat recovery unit			
Switchboard			

INSPECTION ITEM	GOOD	BAD	NOTES
Switchgear			

2.26.2 Factory Tests

Submit the following tests made on prototype machines that are physically and electrically identical to the engine-generator set specified.

a. Phase Balance Voltage Test, to the performance criteria specified in paragraph GENERATOR. This test can be performed with any prime mover. Generator manufacturer's production line test results are acceptable.

(1) Start and operate the generator at no load.

(2) Adjust a regulated phase voltage (line-to-neutral) to rated voltage.

(3) Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(4) Apply 75 percent rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(5) Apply rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(6) Calculate average line-neutral voltage and percent deviation of individual line-neutral voltages from average for each load condition.

b. Current Balance on Stator Winding Test, by measuring the current on each phase of the winding with the generator operating at 100 percent of Rated Output Capacity, with the load impedance equal for each of the three phases: to the performance criteria specified in paragraph GENERATOR.

c. Voltage Waveform Deviation and Distortion Test in accordance with IEEE 115 to the performance criteria specified in paragraph GENERATOR. Use high-speed recording instruments capable of recording voltage waveform deviation and all distortion, including harmonic distortion. Include appropriate scales to provide a means to measure and interpret results.

d. Voltage and Frequency Droop Test. Verify that the output voltage and frequency are within the specified parameters as follows:

(1) With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency. Record the generator output frequency and line-line and line-neutral voltages.

(2) Increase load to Rated Output Capacity. Record the generator

output frequency and line-line and line-neutral voltages.

(3) Calculate the percent droop for voltage and frequency with the following equations:

$$\text{Voltage droop percent} = \frac{\text{(No-Load Volts) - (Rated Capacity Volts)}}{\text{(Service-Load Volts)}} \times 100$$

$$\text{Frequency droop percent} = \frac{\text{(No-Load Hertz) - (Rated Capacity Hertz)}}{\text{(Service-Load Hertz)}} \times 100$$

(4) Repeat steps 1 through 3 two additional times without making any adjustments.

e. Frequency and Voltage Stability and Transient Response. Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer. Include the following tabular data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Frequency (before and after load changes).

(5) Generator output power (before and after load changes).

(6) Graphic representations must include the actual instrument trace of voltage and frequency showing: charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

(a) Perform and record engine manufacturer's recommended pre-starting checks and inspections.

(b) Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

(c) With the unit at no load, apply the Maximum Step Load Increase.

(d) Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

(e) Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100 percent of Service Load.

(f) Apply the Maximum Step Load Increase.

(g) Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

(h) Repeat steps (c) through (g).

f. Test Voltage Unbalance with Unbalanced Load (Line-to-Neutral) to the performance criteria specified in paragraph GENERATOR. Prototype test data is acceptable in lieu of the actual test. Submit manufacturer's standard certification that prototype tests were performed for the generator model proposed. This test may be performed using any prime mover.

(1) Start and operate the generator set at rate voltage, no load, rated frequency, and under control of the voltage regulator. Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(2) Apply the specified load between terminals L_1-L_2, L_2-L_0, and L_3-L_0 in turn. Record all instrument readings at each line-neutral condition.

(3) Express the greatest difference between any two of the line-to-line voltages and any two of the line-to-neutral voltages as a percent of rated voltage.

(4) Compare the largest differences expressed in percent with the maximum allowable difference specified.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the job, perform a Site Visit to verify the information shown on the drawings, before performing any work. Submit a letter stating the date the site was visited and listing discrepancies found. Notify the Contracting Officer in writing of any discrepancies.

3.2 GENERAL INSTALLATION

Provide clear space for operation and maintenance in accordance with NFPA 70 and IEEE C2. Submit a copy of the manufacturer's installation procedures and a detailed description of the manufacturer's recommended break-in procedure. Install pipe, duct, conduit, and ancillary equipment to facilitate easy removal and replacement of major components and parts of the engine-generator set.

3.3 PIPING INSTALLATION

Weld piping. Provide flanged valve connections. Provide flanged connections at equipment. Provide threaded connections to the engine if the manufacturers standard connection is threaded. Except where otherwise specified, use welded flanged fittings to allow for complete dismantling and removal of each piping system from the facility without disconnecting or removing any portion of any other system's equipment or piping. Make connections to equipment with vibration isolation-type flexible connectors. Support and align piping and tubing to prevent stressing of flexible hoses and connectors. Flash pipes extending through the roof. Install piping clear of windows, doors and openings, to permit thermal expansion and contraction without damage to joints or hangers, and install a 1/2 inch drain valve with cap at each low point.

The installation of gas engines must conform to the requirements of NFPA 37 and its references therein, including NFPA 54, NFPA 58, and ASME B31.3.

3.3.1 Flanged Joints

Provide flanges that are Class 125 type, drilled, and of the proper size and configuration to match the equipment and engine connections. Provide gasketed flanged joints that are square and tight.

3.3.2 Cleaning

After fabrication and before assembly, piping interiors must be manually wiped clean of debris.

3.3.3 Pipe Sleeves

Fit pipes passing through construction such as ceilings, floors, or walls with sleeves. Extend each sleeve through and fasten in its respective structure and cut flush with each surface. Build the structure tightly to the sleeve. The inside diameter of each sleeve must be minimum 1/2 inch, and where pipes pass through combustible materials 1 inch larger than the outside diameter of the passing pipe or pipe insulation/covering.

3.4 ELECTRICAL INSTALLATION

Perform electrical installation in compliance with NFPA 70, IEEE C2, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. For vibration isolation, provide flexible fittings for conduit, cable trays, and raceways attached to engine-generator sets; provide flexible stranded conductor for metallic conductor cables installed on the engine generator set and from the engine generator set to equipment not mounted on the engine generator set; and provide crimp-type terminals or lugs for terminations of conductors on the engine generator set.

3.5 FIELD PAINTING

Perform field painting as specified in Section 09 90 00 PAINTS AND COATINGS. ***For projects located in an environmental severity classification (ESC) C3, C4, or C5, treat field welds, scratches, and damaged coatings to provide corrosive protection equivalent to the factory finish as specified in Section 09 96 00 HIGH-PERFORMANCE COATINGS.***

3.6 ONSITE INSPECTION AND TESTS

3.6.1 Construction Tests

3.6.1.1 Electrical Equipment Tests

a. Each cable failing this test must be repaired or replaced. The repair cable must be retested until failures have been eliminated.

3.6.2 Assembled Engine-Generator Set Tests

Submit the following tests made on prototype machines that are physically and electrically identical to the engine-generator set specified.

3.6.2.1 Initial Stabilization Readings

Operate the engine-generator set and allow the set to stabilize at rated kW at rated power factor, rated voltage, and rated frequency. During this period record instrument readings for output power (kW), terminal voltage, line current, power factor, frequency (rpm) generator (exciter) field voltage and current, lubricating oil pressure, jacket water temperature, and ambient temperature at minimum intervals of 15 minutes. Adjust the load, voltage, and frequency to maintain rated load at rated voltage and frequency. Adjustments to load, voltage, or frequency controls must be recorded on the data sheet at the time of adjustment. Stabilization must be considered to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage, or frequency has been made.

3.6.2.2 Regulator Range Test

Remove load and record instrument readings (after transients have subsided). Adjust voltage to the maximum attainable value or to a value just prior to actuation of the overvoltage protection device. Apply rated load and adjust voltage to the minimum attainable value or a value just prior to activation of the under-voltage protection device. The data sheets must indicate the voltage regulation as a percent of rated voltage and the maximum and minimum voltages attainable. Voltage regulation must be defined as follows:

$$\text{Percent Regulation} = \frac{((\text{No-Load Voltage}) - (\text{Rated-Load Voltage})) \times 100}{(\text{Rated-Load Voltage})}$$

3.6.2.3 Frequency Range Test

Adjust the engine-generator set frequency for the maximum attainable frequency at rated load. Record instrument readings. Adjust the engine-generator set frequency for the specified minimum attainable frequency at rated load. Record instrument readings. Reduce the load to zero and adjust the engine-generator set frequency for the maximum attainable frequency. Record instrument readings. Adjust the engine-generator set frequency for the minimum attainable frequency. Record instrument readings. The data sheet must show the maximum and minimum frequencies attained at rated load, and at no load.

3.6.2.4 Transient Response Test

Drop the load to no load and re-apply rated load three times to ensure that the no load and rated load voltage and frequency values are repeatable and that the frequency and voltage regulation is within the limits specified. Record generator terminal voltage and frequency using a high speed strip chart recorder. The data sheet must show the following results:

a. Frequency

(1) Stability bandwidth or deviation in percent of rated frequency.

(2) Recovery time.

(3) Overshoot and undershoot.

b. Voltage

(1) Stability bandwidth or deviation in percent of rated voltage.

(2) Recovery time.

(3) Overshoot and undershoot.

3.6.3 Pre-operational Tests

3.6.3.1 Protective Relays

Visually and mechanically inspect, adjust, test, and calibrate protective relays in accordance with the manufacturer's published instructions. Include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Implement relay settings in accordance with the installation coordination study. Manually or electrically operate relay contacts to verify that the proper breakers and alarms initiate. Field test relaying current transformers in accordance with IEEE C57.13.1.

3.6.4 Automatic Operation Tests for Stand-Alone Operation

Test the automatic loading system to demonstrate automatic starting, and loading and unloading of each engine-generator set. Utilize the actual loads to be served for this test, and the loading sequence is the indicated sequence. Perform this test for a minimum of two successive, successful tests. Include the following data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Generator output frequency (before and after load changes).

a. Initiate loss of the primary power source and verify automatic sequence of operation.

b. Restore the primary power source and verify sequence of operation.

c. Verify resetting of controls to normal.

3.7 GROUNDING

NFPA 70 and IEEE C2, except that grounding systems must have a resistance to solid earth ground not exceeding 5 ohms.

3.7.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.7.2 Engine-Generator Set Grounding

Provide separate copper grounding conductors and connect them to the ground system as indicated. When work in addition to that indicated or specified is required to obtain the specified ground resistance, the provision of the contract covering "Changes" must apply.

3.7.3 Connections

Make joints in grounding conductors by exothermic weld or compression connector. Exothermic welds and compression connectors must be installed as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION paragraph regarding GROUNDING.

3.7.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.8 START-UP ENGINEER

Provide the services of a qualified factory trained start-up engineer, regularly employed by the engine-generator set manufacturer. The start-up services must include conducting preliminary operations and functional acceptance tests. The start-up engineer must be present at the engine generator set installation-site, full-time, while preliminary operations and functional acceptance tests are being conducted.

3.9 PREREQUISITES FOR FUNCTIONAL ACCEPTANCE TESTING

Completion of the following requirements is mandatory prior to scheduling functional acceptance tests for the engine-generator set and auxiliary equipment.

3.9.1 Performance of Acceptance Checks and Tests

The acceptance checks and tests must be accomplished by the testing organization as described in Section 26 08 00 APPARATUS INSPECTION AND TESTING.

3.9.2 Generator Sets

Complete as specified in the paragraph ACCEPTANCE CHECKS AND TESTS.

3.9.2.1 Automatic Transfer Switches

Complete acceptance checks and tests as specified in Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH.

3.9.3 Preliminary Operations

The start-up engineer must conduct manufacturer recommended start-up procedures and tests to verify that the engine-generator set and auxiliary equipment are ready for functional acceptance tests. Give the Contracting Officer 15 days' advance notice that preliminary operations will be conducted. After preliminary operation has been successfully conducted, the start-up engineer will notify the Contracting Officer in writing stating the engine-generator set and auxiliary equipment are ready for functional acceptance tests.

3.9.4 Preliminary Assembled Operation and Maintenance Manuals

Preliminary assembled operation and maintenance manuals must have been submitted to and approved by the Contracting Officer. Manuals must be prepared as specified in the paragraph ASSEMBLED OPERATION AND MAINTENANCE MANUALS.

3.9.5 Functional Acceptance Test Procedure

Test procedure must be prepared by the start-up engineer specifically for the engine-generator set and auxiliary equipment. The test agenda must cover the requirements specified in the paragraph FUNCTIONAL ACCEPTANCE TESTS. The test procedure must indicate in detail how tests are to be conducted. A statement of the tests that are to be performed without indicating how the tests are to be performed is not acceptable. Indicate what work is planned on each workday and identify the calendar dates of the planned workdays. Specify what additional technical support personnel is needed such as factory representatives for major equipment. Specify on which testing workday each technical support personnel is needed. Data recording forms to be used to document test results are to be submitted with the proposed test procedure. A list of test equipment and instruments must also be included in the test procedure.

3.9.6 Test Equipment

Test equipment and instruments must be on hand prior to scheduling field tests or, subject to Contracting Officer approval, evidence must be provided to show that arrangements have been made to have the necessary equipment and instruments on-site prior to field testing.

3.10 FIELD QUALITY CONTROL

Give Contracting Officer 30 days' notice of dates and times scheduled for tests which require the presence of the Contracting Officer. The Contracting Officer will coordinate with the using activity and schedule a time that will eliminate or minimize interruptions and interference with the activity operations. The Contractor must be responsible for costs associated with conducting tests outside of normal working hours and with incorporating special arrangements and procedures, including temporary power conditions. The Contractor must provide labor, equipment, fuel, test load, and consumables required for the specified tests. The test load must be a cataloged product. Calibration of measuring devices and indicating devices must be certified. Refer to Section 26 20 00 INTERIOR

DISTRIBUTION SYSTEM, for requirements for a cataloged product. Perform the following field tests.

3.10.1 Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.10.1.1 Circuit Breakers - Low Voltage Insulated Case/Molded Case

a. Visual and Mechanical Inspection

(1) Compare nameplate data with specifications and approved shop drawings.

(2) Inspect circuit breaker for correct mounting.

(3) Operate circuit breaker to ensure smooth operation.

(4) Inspect case for cracks or other defects.

(5) Verify tightness of accessible bolted connections and cable connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

(6) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

(1) Perform contact-resistance tests.

(2) Perform insulation-resistance tests.

(3) Adjust breaker(s) for final settings in accordance with engine-generator set manufacturer's requirements.

3.10.1.2 Current Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit.

(5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

(6) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform polarity tests.

(3) Perform ratio-verification tests.

3.10.1.3 Metering and Instrumentation

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

(2) Calibrate watt-hour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.

(4) Electrically confirm that current transformer secondary circuits are intact.

3.10.1.4 Battery Systems

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

(4) Measure electrolyte specific gravity and temperature and visually check fill level.

(5) Verify adequacy of battery support racks, mounting, anchorage, and clearances.

b. Electrical Tests

(1) Set charger float and equalizing voltage levels.

(2) Verify all charger functions and alarms.

(3) Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.

(4) Perform a capacity load test.

3.10.1.5 Engine-Generator Set

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect for correct anchorage and grounding.

b. Electrical and Mechanical Tests

(1) Perform an insulation-resistance test on generator winding with respect to ground. Calculate polarization index.

(2) Perform phase rotation test to determine compatibility with load requirements.

3.10.1.6 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method defined in IEEE 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. Take measurements in normally dry weather, not less than 48 hours after rainfall. Provide site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance.

3.10.2 Functional Acceptance Tests

The tests must be performed by the start-up engineer. Upon successful test completion, the start-up engineer must provide the Contracting Officer with a written test report within 15 calendar days showing the tests performed and the results of each test. The report must include the completed approved test data forms and certification from the start-up engineer that the test results fall within the manufacturer's recommended limits and meet the specified requirements performance. The report must be dated and signed by the start-up engineer, and submitted for approval by the Contracting Officer. The Contracting Officer will witness final acceptance tests. Testing must include, but not be limited to, the following:

a. Verify proper functioning of each engine protective shutdown device and pre-shutdown alarm device. Testing of the devices must be accomplished by simulating device actuation and observing proper alarm and engine shutdown operation.

b. Verify proper functioning of the engine over-speed trip device. Testing of the over-speed trip device must be accomplished by raising

the speed of the engine-generator set until an over-speed trip is experienced.

c. Verify proper functioning of the crank cycle/terminate relay. Testing of the relay must be accomplished by engaging the starter motor with the engine being prevented from running. Observe the complete crank/rest cycle as described in the paragraph STARTING SYSTEM.

d. Verify proper functioning of the following automatic and manual operations. Testing must include, but not be limited to, the following:

(1) Loss of Utility: Initiate a normal power failure with connected test load of rated kW at 1.0 power factor. Record time delay on start, cranking time until engine starts and runs, time to come up to operating speed, voltage and frequency overshoot, and time to achieve steady state conditions with all switches transferred to emergency position.

(2) Return of Utility: Return normal power and record time delay on retransfer for each automatic transfer switch, and time delay on engine cool-down and shutdown.

(3) Manual starting.

(4) Emergency stop.

e. Operate the engine-generator set at rated current (amperes) until the jacket water temperature stabilizes. Stabilization will be considered to have occurred when three consecutive temperature readings remain unchanged. Continue to operate the generator set for an additional 2 hours. Record instrument readings for terminal voltage, line current, frequency (Hz), engine speed rpm, lubricating oil pressure, jacket water temperature, and ambient temperature at 5 minute intervals for first 15 minutes and at 15 minute intervals thereafter.

f. Emissions Tests. Provide on-site testing by a certified testing organization of each engine-generator set. Testing must be in accordance with an EPA approved method, 40 CFR 60, (Appendix, Method 7, 7A, 7B, 7C, 7D or 7E). Emissions at rated full load must be within the limits specified in the paragraph ENGINE EMISSIONS LIMITS.

3.11 DEMONSTRATION

Upon completion of the work and at a time approved by the Contracting Officer, the Contractor must provide instructions by a qualified instructor to the Government personnel in the proper operation and maintenance of the equipment. Government personnel must receive training comparable to the equipment manufacturer's factory training. The duration of instruction must be for not less than one 8 hour working day for instruction of operating personnel and not less than one 8 hour working day for instruction of maintenance personnel.

3.11.1 Instructor's Qualification Resume

Instructors must be regular employees of the engine-generator set manufacturer. The instruction personnel provided to satisfy the requirements above must be factory certified by the related equipment manufacturer to provide instruction services. Submit the name and

qualification resume of instructor to the Contracting Officer for approval.

3.11.2 Training Plan

Submit training plan 30 calendar days prior to training sessions. Training plan must include scheduling, content, outline, and training material (handouts). Content must include, but not be limited to, the following:

3.11.2.1 Operating Personnel Training

This instruction includes operating the engine-generator set, auxiliary equipment including automatic transfer switches in all modes, and the use of all functions and features specified.

3.11.2.2 Maintenance Personnel Training

Training must include mechanical, hydraulic, electrical, and electronic instructions for the engine-generator set and auxiliary equipment including automatic transfer switches.

a. Mechanical Training: Must include at least the following:

(1) A review of mechanical diagrams and drawings.

(2) Component location and functions.

(3) Troubleshooting procedures and techniques.

(4) Repair procedures.

(5) Assembly/disassembly procedures.

(6) Adjustments (how, when, and where).

(7) Preventive maintenance procedures.

(8) Review of flow diagram.

(9) Valve locations and function.

(10) Valve and hydraulic equipment adjustment and maintenance procedures.

(11) Hydraulic system maintenance and servicing.

(12) Lubrication points, type, and recommended procedures and frequency.

b. Electrical and Electronic Maintenance Training: Must include at least the following:

(1) A review of electrical and electronic systems including wiring diagrams and drawings.

(2) Troubleshooting procedures for the machine and control systems.

(3) Electrical and electronic equipment servicing and care.

(4) Use of diagnostics to locate the causes of malfunction.

(5) Procedures for adjustments (locating components, adjustments to be made, values to be measured, and equipment required for making adjustments).

(6) Maintenance and troubleshooting procedures for microprocessor or minicomputer where applicable.

(7) Circuit board repair procedures where applicable (with schematics provided).

(8) Use of diagnostic tapes.

(9) Recommended maintenance servicing and repair for motors, switches, relays, solenoids, and other auxiliary equipment and devices.

3.12 ONSITE TRAINING

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period must consist of a total 4 hours of normal working time and must start after the system is functionally completed but prior to final acceptance.

a. Submit a letter giving the date proposed for conducting the onsite training course, the agenda of instruction, a description of the digital video recording to be provided. The course instructions must cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as major elements of the operation and maintenance manuals. Additionally, the course instructions must demonstrate routine maintenance procedures as described in the operation and maintenance manuals.

b. Submit a digital video recording of the manufacturers operating and maintenance training course.

c. One full size reproducible Mylar ach drawing must accompany the booklets. Mylars must be rolled and placed in a heavy cardboard tube with threaded caps on each end. The manual must include step-by-step procedures for system startup, operation, and shutdown; drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems together with their controls, alarms, and safety systems; the manufacturer's name, model number, and a description of equipment in the system. The instructions must include procedures for interface and interaction with related systems to include automatic transfer switches. Each booklet must include a CD containing an ASCII file of the procedures.

d. Provide approved operation and maintenance manuals for the training course. Post approved instructions prior to the beginning date of the training course. Coordinate the training course schedule with the using service's work schedule, and submit for approval 14 days prior to beginning date of proposed beginning date of training.

3.13 INSTALLATION

Installation must conform to the applicable requirements of IEEE C2, NFPA 30, NFPA 37, and NFPA 70.

3.14 FINAL TESTING AND INSPECTION

a. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

b. Increase the load in steps no greater than the Maximum Step Load Increase to 100 percent of Service Load, and operate the engine-generator set for at least 30 minutes. Measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the same range as previous measurements and is within the required range.

c. Remove load and shut down the engine-generator set after the recommended cool down period.

d. Remove the lube oil filter and have the oil and filter examined by the engine manufacturer for excessive metal, abrasive foreign particles, etc. Verify any corrective action for effectiveness by running the engine for 8 hours at Service Load, then re-examine the oil and filter.

e. Remove the fuel filter and examine the filter for trash, abrasive foreign particles, etc.

f. Visually inspect and check engine and generator mounting bolts for tightness and visible damage.

g. Replace air, oil, and fuel filters with new filters.

3.15 MANUFACTURER'S FIELD SERVICE

The engine generator-set manufacturer must furnish a qualified representative to supervise the installation of the engine generator-set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment.

3.16 POSTED DATA AND INSTRUCTIONS

Post Data and Instructions prior to field acceptance testing of the engine generator set. Provide two sets of instructions/data, typed and framed under weatherproof laminated plastic, and post side-by-side where directed. Include a one-line diagram, wiring and control diagrams and a complete layout of the system in the first set. Include the condensed operating instructions describing manufacturer's pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions in the second set. Submit posted data including wiring and control diagrams showing the key mechanical and electrical control elements, and a complete layout of the entire system.

a. Include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches). Provide two sets of typed instructions/data in 8-1/2 x 11 inch format, laminated in weatherproof plastic, and placed in three-ring vinyl binders. Place the binders as directed by the Contracting Officer. Provide the instructions prior to acceptance of

the engine generator set installation.

b. Include a one-line diagram, wiring and control diagrams and a complete layout of the system in the first set. Include the condensed operating instructions describing manufacturer's pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions in the second set. Include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches).

c. Submit instructions including: the manufacturers pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches). Provide weatherproof instructions, laminated in plastic, and post where directed.

3.17 ACCEPTANCE

Submit drawings which accurately depict the as-built configuration of the installation, upon acceptance of the engine-generator set installation. Revise layout drawings to reflect the as-built conditions and submit them with the as-built drawings. Final acceptance of the engine-generator set will not be given until the Contractor has successfully completed all tests and all defects in installation material or operation have been corrected.

3.18 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 35 43

400-HERTZ (HZ) SOLID STATE FREQUENCY CONVERTER

08/21

AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 519	(2014) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE 1159	(2019) Recommended Practice on Monitoring Electric Power Quality
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60947-4-1	(2018; INT 1 2020; Corr 2 2021) Low-voltage Switchgear and Controlgear, Part 4-1: Contactors and Motor Starters - Electromechanical Contactor and Motor Starters

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
NFPA 70E	(2021) Standard for Electrical Safety in the Workplace

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AS5756/6	(2013; Rev A; Stabilized (S) 2013) Cable, 3-Phase Power, Electric, Portable, Multiconductor, 90 Degree C, 600V, Ozone Resistant, Split Phase
SAE AS7974	(2010; Rev A) Cable Assemblies and Attachable Plugs, External Electrical Power, Aircraft

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-DTL-32180	(2004) Cable Assembly, Aircraft Electrical Service
MIL-STD-704	(2016; Rev F; Change 1) Aircraft Electric Power Characteristics

UNDERWRITERS LABORATORIES (UL)

UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 506	(2017) UL Standard for Safety Specialty Transformers
UL 1012	(2010; Reprint Apr 2016; Rev Mar 2021) UL Standard for Safety Power Units Other than Class 2
UL 1449	(2021; Reprint Dec 2022) UL Standard for Safety Surge Protective Devices

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein. Section 26 35 44 270 VDC SOLID STATE CONVERTER applies to this section where combination 400 HZ/270VDC units are used.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, must be as defined in IEEE 100.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Converter Drawings; G

SD-03 Product Data

Converter; G

Aircraft Power Cable Assembly; G

SD-06 Test Reports

Work Plan; G

Routine Factory Test Plan; G

Special Factory Test Plan; G

Factory Test Schedule; G

Routine Factory Tests Certification; G

Special Factory Tests Certification; G

SD-07 Certificates

Qualifications of Manufacturer; G

Nationally Recognized Testing Laboratory (NRTL) Listing; G

SD-09 Manufacturer's Field Reports

Field Test Plan; G

Field Test Schedule; G

Field Test Certification; G

Training Syllabus; G

SD-10 Operation and Maintenance Data

Converter O&MM, Data Package 5; G

Preliminary Converter O&MM, Data Package 5; G

1.4.1 Government Submittal Review

NAWCAD Air Vehicle Electrical Power Systems Group (AB43), (301) 342-4161 and Code CI44, NAVFAC LANT, Naval Facilities Engineering Command will provide surveillance. If they have comments or concerns, they will contact and coordinate resolution of their comments with the appropriate approving agent.

1.5 QUALITY ASSURANCE

1.5.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for 5 years prior to bid opening. The 5-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 5-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.2.1 Alternative Qualifications

Products having less than a 5-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.2.2 Material and Equipment Manufacturing Date

Products manufactured more than one year prior to date of delivery to site must not be used, unless specified otherwise.

1.5.3 Converter Drawings

Furnish scaled drawings of enclosure outline including front, top, side

views, and overall dimensions. Include "maintenance envelope" dimensions confirming space limitations identified on the drawings, and surface mounting flush against the wall. Rear access for maintenance and repair purposes is prohibited. The "maintenance envelope" drawings must also indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Provide external power and control wiring, cabling, connector, and backplane interconnect drawings. Provide single line, schematic, and wiring diagrams. Drawings must include details of input and output circuit breakers, contactors, rectifiers, surge protectors, control devices and conduit entry and exit locations. If parallel operation is included, provide an interconnection diagram. Submittals must include the nameplate data, size, and capacity.

1.5.4 Qualifications of Manufacturer

Submit a certification stating that the manufacturer has a minimum of five years' experience in the design, manufacturing, and testing of 400 Hz solid state frequency converters at the equivalent or greater kW and voltage ratings for direct connection to aircraft electrical loads. When specifications require multiple converters operating in parallel, the manufacturer must provide specific experience with equal or greater kW rated converters.

Experience in manufacturing motor generator sets does not qualify as equivalent. Experience in manufacturing portable engine-driven 400-hertz power units does not qualify as equivalent. The manufacturer must be experienced in producing units for installation in permanent buildings in environmentally closed spaces or in weatherproof enclosures as applicable. The manufacturer must also document that converters are designed for connection to non-linear loads typically encountered in the aircraft and shipbuilding industries. The manufacturer must furnish documented experience with converters in various environmental conditions including exterior flight line, hangar, and environmentally enclosed spaces within buildings.

1.5.5 Work Plan

Submit a written work plan with the initial shop drawing submittal, which consists of a schedule of dates of the routine and special factory tests, installation of equipment, field tests, and operator training for the system. Furnish a list of the test instrumentation equipment complete with the documented calibration program, for the factory and the field tests.

1.5.6 Routine Factory Test Plan

Submit test plan and procedures at least 21 calendar days prior to the tests being conducted. Provide detailed description of test procedures, including test equipment and setups complete with their current calibration dates, to be used to ensure the converter meets this specification and explain the test methods used. As a minimum, include the tests required under the paragraph ROUTINE FACTORY TESTS.

1.5.7 Special Factory Test Plan

Submit the Special Factory Test Plan and procedures with the Routine Factory Test Plan. Provide detailed description of test procedures, including test equipment and setups complete with their calibration dates, used to ensure the converter meets this specification and explain the test

methods used. As a minimum, include the tests required under the paragraph SPECIAL FACTORY TESTS.

1.5.8 Field Test Plan

Submit test plan and procedures at least 30 calendar days prior to the start of field tests. Provide detailed description and dates and times scheduled for performance of tests, and detailed description of test procedures, including test equipment and setups of the tests to be conducted to ensure the system meets this specification. List make, model, and current calibration dates, and provide functional description of the test instruments and accessories. Explain the test methods to be used. As a minimum, include the tests required under the paragraph FIELD QUALITY CONTROL. Test reports must include power quality measurement data collected in accordance with IEEE 1159.

1.5.9 Nationally Recognized Testing Laboratory (NRTL) Listing

Frequency converters must be identified with a nationally recognized testing laboratory (NRTL) label or UL label prior to shipping.

1.5.9.1 Currently Listed Products

Submit NRTL or UL certification or UL file number for the actual frequency converter to be shipped with the initial submittal to verify compliance of equipment.

1.5.9.2 Proposed Listed Products

Submit NRTL or UL certification or UL file number for same or similar rating or product size range of like design unit with the initial submittal to verify compliance of equipment.

1.5.10 Routine Factory Tests Certification

Submit within 45 calendar days after completion of tests. Receive approval of test prior to shipping unit. Certify tests were conducted on each converter in accordance with the requirements set forth in paragraph ROUTINE FACTORY TESTS and certify converter satisfactorily operated within specified limits. Include copies of the test procedures,test configuration diagrams and schematics, test data, and results.

1.5.11 Special Factory Tests Certification

Certify tests were conducted on a converter of the same design, construction, kW rating, and voltage rating to be provided. Tests must be in accordance with the requirements set forth in paragraph SPECIAL FACTORY TEST and certify converter operated without malfunctioning within specified limits. Include copies of the test procedures, test configuration diagrams and schematics, test data, and results.

1.5.12 Field Test Certification

Submit report of test results as specified by paragraph FIELD QUALITY CONTROL within 15 calendar days after completion of tests. Certify tests were conducted on each converter in accordance with the paragraph FIELD QUALITY CONTROL and certify converter satisfactorily operated within specified limits. Include copies of the test procedures, test configuration diagrams and schematics, test data, and results.

1.6 OPERATION AND MAINTENANCE MANUALS

Submit frequency converter Operation and Maintenance Manuals (O&MM) in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.6.1 Additions to Converter O&MM

In addition to requirements of Data Package 5, include the following on the actual converter provided:

a. A "one-line diagram" from the building service entrance panel to the converter and out to the end utilization point(s).

b. A concise, duplicatable, single page data sheet with operating instructions for each unit including startup and shutdown procedures.

c. Routine and field test reports.

d. NRTL or UL certification or UL file number.

e. A list of all code required identification and warning signage and labels that have been provided on the converter.

1.6.2 Preliminary Converter O&MM

Prior to scheduling Field Tests, 2 bound copies of a Preliminary O&MM must be submitted to and approved by the Contracting Officer.

1.6.3 Spare Parts Information

Furnish recommended manufacturer's spare parts list, quantities, lead time to receive after ordering, and a schedule of prices,(guaranteed for one year after warranty expires), for each type of converter and other equipment specified in this section. Include the following:

a. Fuses

b. Human Machine Interface (HMI)

c. Indicator lamp/LED

d. Output switching modules

e. Plug-in logic cards

f. Power filter capacitors

g. Power semi-conductors

h. Ventilation system filters

i. 400 Hz Aircraft Power Cable Assembly

1.7 WARRANTY

The equipment items must be supported by service organizations which are most convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis

during the warranty period of the contract in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

PART 2 PRODUCTS

2.1 FREQUENCY CONVERTER

Provide frequency converter consisting of modular construction solid-state components for 60 Hz to 400 Hz conversion, input/output devices, and ancillary control devices. Converter must be a standard product of the manufacturer and the manufacturer's latest design that complies with the specification requirements. The converters provided under this contract must be products of the same manufacturer. Each unit must have a calculated Mean Time Between Failures (MTBF) exceeding 24,000 hours as calculated when the converter is provided with yearly servicing and maintenance. Provide converter with NRTL or UL listing complying with UL 1012. The converter must have minimum 12 pulse, active input rectification circuit or a demonstrated design achieving equal or better performance characteristics. Circuit breakers operating at 400 Hz must be designed and UL tested for 60 Hz operation and derated for 400 Hz operation. Provide startup and shutdown instructions posted on the front of the unit using engraved plastic or aluminum plate. Provide a plastic encapsulated schematic diagram attached to the inside of the unit in clear view of maintenance personnel.

2.1.1 Electrical Characteristics

2.1.1.1 Input Voltage

480 V, three phase, three wire, grounded, 60 Hz. Converter must provide rated output voltage when input voltage is varied plus or minus 10 percent. A voltage changing transformer is not permitted at the input of the converter unit

2.1.1.2 Input Power Factor

Between 0.8 lagging and unity, under all conditions of steady state line and load variations specified herein.

2.1.1.3 Surge Protection

Provide converter capable of sustaining an input surge described in and tested in accordance with UL 1449, and IEEE C62.41.1 and IEEE C62.41.2, Location Category B, and continue to operate with no alarms within the specified tolerance.

2.1.1.4 Inrush Current

The inrush current must not exceed 100 percent of the rated full load input current.

2.1.1.5 Input Current Distortion

Input current Total Harmonic Distortion (THD) must not exceed 12 percent of the fundamental frequency with nominal input voltage at full load. Individual harmonic content must not exceed 8 percent of the fundamental frequency.

2.1.1.6 Output Voltage

Provide a frequency converter with a 200Y/115 V, three phase, 400 Hz, grounded system, adjustable to plus or minus 10 percent of the rated voltage.

a. The power characteristics must be within the requirements of MIL-STD-704 with the following clarifications:

(1) The voltage and frequency must be in accordance with the envelope of normal operating range of Figures 3 and 5, not just the limits of Figures 4 and 6.

(2) The steady state voltage must additionally be in accordance with the external power requirements as defined in the MIL-STD-704 Section 4.3, "External Power Source Requirement".

c. The phase rotation of the output voltage must be A-B-C (per Figure 2 in MIL-STD-704, spinning in a counterclockwise direction).

2.1.1.7 Power Output

Provide a frequency converter rated at 90 kW at unity power factor.

2.1.1.8 Load Range

Converter must operate into a linear load with a power factor between 0.5 lagging and 0.7 leading and into a non-linear load with not less than 15 percent current THD, composed of not less than 6 percent of the 3rd harmonic and not less than 7 percent of the 5th harmonic.

2.1.1.9 Efficiency

Provide 90 kW units with a minimum efficiency of 87 percent at 50 percent load and 91 percent at 100 percent load.

2.1.1.10 No Load Input Losses

Provide frequency converter with no-load input losses no greater than 7 percent of the output kW rating.

2.1.1.11 Overload

Satisfactory overload operating time is based on no more than one overload of the same or longer conditions, within the following specified time between overloads.

Percent of Full Load	Satisfactory Operating Time	Time Between Overloads
110 percent	60 minutes	4 hours Note: Unit must still be capable of withstanding any of the other conditions for their respective operating times. e.g. Unit can still do 125 percent for less than 5 minutes, before tripping, etc.
125 percent	5 minutes	10 minutes
150 percent	2 minutes	10 minutes
200 percent	20 seconds	5 minutes
300 percent	4 seconds	5 minutes

After minimum operating time is achieved, unit must interrupt output power. Unit must be capable of sustaining the overload without damage until the protective device interrupts the overload.

2.1.1.12 Short Circuit

When a bolted line-to-line fault or a bolted three phase fault is applied to the unit, unit must be capable of sustaining the short circuit current without damage until the protective device interrupts the fault.

2.1.1.13 Crest Factor

The voltage crest factor must be between 1.31 and 1.51 over the entire load range in accordance with MIL-STD-704. The crest factor is the ratio of the peak value to the root mean square (RMS) value for each half cycle of the voltage waveform measured over a one second period under steady state conditions. Provide the crest factor for each condition in the paragraph LOAD RANGE.

2.1.1.14 Output Voltage THD

a. Balanced load:

(1) Output voltage THD: Not to exceed 3 percent line-to-line and line-to-neutral for linear loads as specified in the paragraph LOAD RANGE.

(2) Output voltage THD: Not to exceed 5 percent line-to-line and line-to-neutral for non-linear loads as specified in the paragraph LOAD RANGE.

(3) Maximum single harmonic distortion: Not to exceed 2 percent of the fundamental at the nominal voltage for linear loads as specified in the paragraph LOAD RANGE.

(4) Maximum single harmonic distortion: Not to exceed 3 percent of

the fundamental at the nominal voltage for non-linear loads as specified in the paragraph LOAD RANGE.

b. Unbalanced load: Output voltage THD not to exceed 4 percent, line-to-neutral with 15 percent unbalanced linear load.

2.1.1.15 Output Voltage Amplitude Modulation

Provide output voltage amplitude modulation not exceeding 1/2 percent of nominal voltage at no load to full load.

2.1.1.16 Frequency Stability

Control output frequency of the 400 Hz converter within plus or minus 0.5 percent for all operating conditions, including maximum and minimum specified input voltages, ambient temperature and relative humidity. The frequency regulation must operate independent of supply frequency and load changes.

2.1.1.17 Phase Angle Regulation

Displacement angle between adjacent voltage phases must be 120 degrees plus or minus 2 degrees with balanced load and plus or minus 4 degrees with three phase 15 percent unbalanced load. A 15 percent unbalanced load is defined as any combination of phasing where:

a. Phase A at full rated single phase load.

b. Phase B at 85 percent of Phase A.

c. Phase C at 85 percent of Phase A.

2.1.1.18 Transient Output Voltage Recovery

In accordance with MIL-STD-704. Monitor and record output voltage at the load end of the cable.

2.1.2 Environmental Rating

The converter must be rated for continuous operation from no load to rated full load under the following conditions:

a. Ambient temperatures ranging from -4 to 130 degrees F.

b. Relative humidity from 0 to 95 percent noncondensing.

c. Ambient pressures from sea level to 3,000 feet.

2.1.3 Monitoring and Control Panel

Provide converter with a control panel that is equipped with the following controls, indicators, instrumentation, data logging, diagnostics, and alarm functions.

2.1.3.1 Controls

Controls must be mounted on the front of the control panel, accessible without opening any doors or covers. Specific sequencing, or the requirement for simultaneous pushbutton operation, is not acceptable for

any input or output control.

a. Start/stop pushbutton for input device control (circuit breaker or contactor).

b. Lamp/light emitting diode (LED) test - A push-to-test button or switch to test indicator lamps/LEDs. If panel lights all blink as part of the startup Built-in-Test (BIT) sequence, then a separate push to test button is not required.

c. Emergency power off - A separate pushbutton for emergency power off.

d. Output device ON/OFF.

e. Alarm silence and "silence" indicator - A switch that must disable the audible alarm without clearing the alarm codes.

f. Additional individual controls for the following functions (Note - these may be included as part of the Human-Machine Interface (HMI) as described in paragraph HUMAN MACHINE INTERFACE REQUIREMENTS):

- Output voltage adjust

- Alarm reset - resets and clears the silenced audible alarm.

2.1.3.2 Indicators

a. The following are mandatory indicators. They must be included on the control panel on the exterior of the unit in addition to any that are included in the HMI:

- Input power available - Lamp/LED to indicate that the supply voltage is available.

- Output power On/Off - Lamp/LED to indicate that the converter output voltage is available.

- Output device "ON".

- Audible alarm.

- Aircraft interlock bypass - Lamp/LED to indicate that the Aircraft Interlock has been bypassed.

b. In addition, include the following additional indicators, if they are not included in the HMI:

- System alarm - Lamp/LED to indicate that a fault has been detected. This indicator must be latched in the "ON" position whenever an alarm condition described in paragraph ALARM ANNUNCIATOR, is detected and must remain "ON" until the alarm reset pushbutton is pressed.

- Indicating lamp/LED to indicate that the alarm silence switch is in the disable position.

- Elapsed time meter in hours; (may be internal or visible externally).

2.1.3.3 Human Machine Interface (HMI) Requirements

Provide an HMI with a minimum of four by twenty (4 x 20) character backlit LED display for presenting the digital instrumentation, diagnostic system, and fault indicating system data. The HMI must be rated for harsh environments.

a. Digital Instrumentation. Provide true RMS, plus/minus one percent accuracy, microprocessor-based readings that include the following functions:

(1) Output phase-to-phase voltage.

(2) Output phase-to-neutral voltage.

(3) Output phase current.

(4) Output frequency.

(5) Inverter temperature. This function is desired for field diagnostics, but is not mandatory.

b. Alarm Annunciator. The unit must be capable of detecting and displaying the following abnormal conditions:

(1) Input overvoltage.

(2) Input undervoltage.

(3) Output undervoltage.

(4) Output overvoltage.

(5) Output overload.

(6) System alarm.

(7) Control logic failure.

(8) Over-temperature.

(9) Logic power supply failure.

2.1.4 Input/Output Devices

Provide fully-rated, three-pole, UL approved devices for control of 60 Hz input and 400 Hz output from the converter. Derate devices and cables operating at 400 Hz in accordance with IEEE 519.

2.1.4.1 Input Device

Provide converter with a UL listed input device (circuit breaker conforming to requirements of UL 489 or contactor) as an integral part of the converter. Device must be operable from the front of the converter. Device must have a short-circuit current rating of 65,000 amperes symmetrical minimum.

2.1.4.2 Output Contactor

Provide converter output with an automatic magnetically-held contactor with interlock circuit. Output contactor must have sufficient capacity to handle rated load, overload, and available short circuit current. Contactor must open when any circuit identified in the paragraph SAFETY FUNCTIONS causes the system to shut down. Electrically interlock contactor with ON/OFF circuitry so that when the frequency converter is shut down, the contactor opens immediately and remains open. Conform to the requirements of IEC 60947-4-1.

2.1.4.3 Aircraft Interlock Circuit

Provide a Split F Type safety insertion interlock system (with the contacts integral to the cable head) in accordance with MIL-DTL-32180.

Utilize a control signal established by the converter to determine whether the servicing cable connector is installed to the aircraft or not. The converter control system must prevent the output control device from closing if the 28 VDC signal is not present. If the converter output control device is closed when the 28 VDC signal is lost, the converter control system must remove the 400 Hz power from the output servicing cable connector within 100 milliseconds. This 28 VDC control signal must not be referenced to the aircraft and cannot affect components on the aircraft.

2.1.5 Safety Functions

2.1.5.1 400 Hz Power Source

The 400 Hz power source internal buss must automatically discharge to below 30 VAC within 5 seconds after the following:

a. 400 Hz power source has been turned off.

b. Whenever any access panel is opened on the equipment. Under this condition, the interlock circuitry must open the input device and the 400 Hz output device, and not allow the input or output device to close. For maintenance purposes, provide an internal bypass switch to defeat the interlock circuitry.

c. Detection of system fault that results in a converter shut down condition, including the following:

(1) Input undervoltage.

(2) Input overvoltage.

(3) Loss of phase (input or output).

(4) Loss of input power.

2.1.5.2 400 Hz Output Cable

The 400 Hz power must be removed from the output cable within 100 milliseconds after one of the following occurs:

a. Receiving a stop command.

b. Loss of 28 VDC control signal.

c. Detection of a fault that results in an output shut down, including the following:

(1) Output overvoltage - Protect by tripping output devices for instantaneous overvoltage of 30 percent or more and for 10 to 30 percent overvoltage lasting more than 0.25 seconds.

(2) Output undervoltage - Protect by preventing the closing of the output disconnect until the output voltage is 95 percent of the rated output. If, after closing, the voltage decreases to below 90 percent for longer than 5 seconds, provide relaying to trip output devices utilizing a field-adjustable time-delayed circuit with a range of 4 to 10 seconds.

(3) Output frequency - Protect by tripping output devices for frequency change in excess of plus or minus 5 percent of the rated output frequency (400 Hz).

(4) Output overload.

(5) Converter overtemperature protection.

2.1.6 Automatic Line Drop Compensation

Provide automatic line drop compensation from zero to ten percent; adjustable internally.

2.1.7 Auto Restart

After a total input power outage the unit must be capable of automatically restarting and re-energizing loads upon restoration of normal power. Provide units with a manual/auto restart switch and with backup battery power supply if it is needed to meet the auto restart requirement. When interlock circuit has been interrupted or when interlock is in the maintenance position (manual restart), the system should not restart.

2.1.8 Magnetic Components

Provide Class 180 power magnetic transformer and inductors in accordance with NEMA ST 20 and UL 506. The limits of Class 180 must not be exceeded at the maximum specified ambient temperature and at 100 percent load.

2.1.9 Acoustical Noise

Provide unit with a maximum continuous acoustical noise level less than 72 dBa (A weighted scale).

2.1.10 Assembly Construction

Provide enclosures suitable for indoor environments in accordance with NEMA 250, Type l. Arrange to provide required louvers, cooling air, entry and exit provisions for equipment within enclosures. ***Provide hardware and fasteners made of stainless steel do not use ferrous metal as finishing strips or as components of other securement systems even if a protective coating is provided.***

a. Units must be mounted flush against the wall, must not require back

access for maintenance, and must comply with the "Maintenance Envelopes" identified on the drawings.

b. Construct unit(s) so that components, with the exception of control and monitoring components, are totally enclosed within the enclosure. Electronic circuits including power circuits must be modular construction readily accessible for maintenance, repair and module replacement from the front of the enclosure.

c. Provide permanent identification tags for wiring. Uniquely identify each wire. Use the same identification system in the wiring diagrams in the Operation and Maintenance Manual. Enclosures must be painted in accordance with paragraph FACTORY APPLIED FINISH and as specified herein. Provide each enclosure with a finish coat over a rust inhibiting substrate or a substrate that has been provided with a rust inhibiting treatment.

d. Provide units with a Mean Time To Repair (MTTR) of 30 minutes from the time of the diagnosed failure based on documented manufacturer's historical data for the average time of repair for their top ten faults. Provide the supporting data with the equipment submittal.

2.1.11 Dual Output Converters

Where indicated, provide selectable dual output converters with a single 480 Volt, 3 phase, 3 wire input and dual selectable outputs. Both outputs cannot be used at the same time. The outputs consist of a 90KW, 270VDC converter and a 72KW, 200Y/115V, 3 phase, 4 wire, 400 Hertz converter. Provide a selector switch to toggle between the two outputs. The selector switch must be located at the remote control panel. Refer to section 26 35 44 270 VDC SOLID STATE CONVERTER for the 270VDC converter requirements.

2.2 AIRCRAFT POWER CABLE ASSEMBLY

Comply with SAE AS7974. For 400 Hz wiring at 200Y/115 volts, provide 7-conductor type cable configured as 6 phase conductors (2xA, 2xB, 2xC) tightly wound around the center located neutral, twisted and single jacketed in accordance with SAE AS5756/6. Rate cable for 260 amperes. Cable length must be 105 feet. Provide control cabling included within the jacket for interlock circuit. Terminate control wiring on accessible terminal blocks in unit. Provide cable assembly with integrally molded 400 Hertz connector capable of connecting to the aircraft 6 pole receptacle. Provide cable/connector assembly suitable for severe duty, with crimped contact terminations. Banded cables are not permitted.2.3 MANUFACTURER'S NAMEPLATE

Each frequency converter, each major component within the frequency converter, and each item of other equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.4 FACTORY APPLIED FINISH

Electrical equipment must have factory-applied painting systems which must, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test and the additional requirements as specified herein. Interior and exterior steel surfaces of equipment enclosures must be thoroughly cleaned

and then receive a rust-inhibitive phosphatizing treatment, a primer powder coat, or equivalent treatment prior to painting. Exterior surfaces must be free from holes, seams, dents, weld marks, loose scale or other imperfections. Interior surfaces must receive not less than one coat of corrosion-resisting paint or powder coating process in accordance with the manufacturer's standard practice. When enclosure is aluminum, interior may optionally be coated with rust inhibiting treated film. Exterior surfaces must be primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish, or finished with a powder coating process. Color must be the manufacturer's standard color. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

2.5 SOURCE QUALITY CONTROL

2.5.1 Factory Test Schedule

The Government reserves the right to witness tests and reserves the right to request the raw data from the tests whether witnessed or not. Provide the frequency converter test schedule for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

Test Instrument Calibration.

a. The manufacturer must have a documented calibration program which assures that all applicable test instruments are maintained within rated accuracy.

b. The accuracy must be directly traceable to the National Institute of Standards and Technology.

c. Instrument calibration frequency schedule must not exceed 12 months for both test floor instruments and leased specialty equipment.

d. Provide dated calibration labels, that are visible on all test equipment.

e. Calibrating standard must be of higher accuracy than that of the instrument tested.

f. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

    (1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

    (2) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.5.2 Routine Factory Tests

Perform routine tests by the manufacturer at the factory, on each of the actual frequency converter(s) prepared for this project to ensure that the design performance is maintained in production. As an exception, test

automatic line drop compensation on only one unit on multiple unit orders of the same kW rating. If there are multiple units with different kW ratings, then testing one of each of the kW ratings is acceptable. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Include a list of the current test equipment calibration dates. Required tests, test conditions, and testing sequence is as follows:

a. For tests which require full load, use 1.0 power factor unless otherwise noted.

b. All measurements must be true RMS measurements. Obtain measurements in accordance with IEEE 1159. Monitor and record all data at the load end of the cable.

c. Connect loads to the converter with the specified aircraft power cable assembly.

d. No adjustments to the frequency converter are allowed between load tests.

2.5.2.1 Test Conditions

Tests must include the following conditions:

a. Initial Safety Verification: Perform tests and checks to validate the safe and timely shutdown for each condition (for the power source and the output cable) identified in paragraph SAFETY FUNCTIONS.

b. Input current and power factor: Operate converter at low, nominal and high input voltage at full load. Measure and record input voltage, input power factor and input current in each phase.

c. Output voltage, output voltage THD, output current, output power factor, and voltage regulation. Operate converter at nominal input voltage unless otherwise specified.

(1) 50 percent of rated capacity with 0.8 lagging power factor linear load.

(2) 100 percent of rated capacity with 0.5 lagging power factor, 0.8 lagging power factor, 1.0 power factor, and 0.7 leading power factor linear loads.

(3) 50 percent of rated capacity with the non-linear load as specified in the paragraph LOAD RANGE.

(4) 100 percent of rated capacity at low and high input voltage.

(5) 100 percent of rated capacity with the non-linear load as specified in the paragraph LOAD RANGE.

(6) Note - Operate for not less than 10 minutes at each test condition in (1), (2), (3) and (4) above, and for not less than 30 minutes at test condition in (5) above.

(7) Note - Monitor and record each of the following at the beginning and end of each test condition: output voltage, output voltage waveform, output voltage THD, output voltage distortion spectrum,

output voltage crest factor, output current, output current waveform, output current distortion spectrum, output power factor and frequency. Verify output remains within specified regulation limits.

d. Efficiency: Operate at nominal input voltage at half load and full load at 1.0 power factor. Measure and record input voltage, input current, input power factor, output voltage, output current, and output power factor. Calculate the unit efficiency.

e. No load losses: Operate at no load and nominal input voltage. Measure and record input voltage, input current, input power, input power factor, and output voltage. Calculate the no load losses.

f. Overload: Operate at nominal input voltage and output voltage with loads and in sequence listed below:

Percent of Full Load	Time	Time Between Overloads	Iterations
300 percent	4 seconds	5 minutes	3
200 percent	20 seconds	5 minutes	1
150 percent	2 minutes	10 minutes	1
125 percent	5 minutes	10 minutes	1
110 percent	60 minutes	4 hours	1

Monitor output to confirm there is no 400 Hz power interruption. After minimum operating time is achieved, unit must interrupt output power. Provide voltage and current waveforms documenting the unit's response for each test.

g. Burn-in Test: Before delivery, burn-in all units under full load conditions at 1.0 power factor for at least 24 hours by cycling units 6 hours "ON" under full load conditions and 3 hours "OFF" at no load conditions for at least 4 complete "ON" cycles. Perform burn-in test with the converter enclosure doors closed, load connected directly to the output terminals, and all ventilation in the final operating condition. The specified aircraft cable is not required to be used for this test.

h. Include harmonic frequency spectrum analysis depicting harmonic order across the range of individual harmonic occurrence, and harmonic magnitude. Conduct tests at the unit's input terminals (to the 37th harmonic), and at the units output terminals (to the 37th harmonic) per IEEE standards.

i. Automatic line drop compensation: Operate converter at nominal voltage and verify specified performance of the line drop compensation at the following loads.

(1) No-load.

(2) 50 percent of rated capacity with a 0.8 lagging power factor linear load.

(3) 50 percent of rated capacity with the specified non-linear load.

(4) 100 percent of rated capacity with a 0.8 lagging power factor linear load.

(5) 100 percent of rated capacity with the specified non-linear load.

j. Post Routine Test Safety Verification: Repeat tests conducted under item a. Initial Safety Validation to confirm safety features were not affected by previous tests.

2.5.3 Special Factory Tests (Design Tests)

Submit special factory test (design test) reports (complete with test data, explanations, formulas, results, setup and cable information, and the list of the calibration dates of the test equipment used), in the same submittal package as the catalog data and drawings for the specified frequency converter(s). Tests must be certified and signed by a registered professional engineer or by a "company certified professional designee" within the manufacturers' organization. Submit designee's credentials with the initial design test report for approval. Tests must be on file based on a production model of converters of the same design, construction and kW rating provided.

For all tests which require full load, use 1.0 power factor unless otherwise noted. For all tests that are "not already on file", connect loads to the converter with an aircraft power cable assembly, 105 feet long, similar to the specified project aircraft power cable assembly. Monitor and record all data at the load end of the cable, unless otherwise noted. The tests conducted on the unit must include the following:

a. Initial Safety Verification: Perform tests and checks to validate the safe and timely shutdown for each condition (for the power source and the output cable) identified in paragraph SAFETY FUNCTIONS.

b. Surge protection: Apply input surges in accordance with IEEE C62.41.1 and IEEE C62.41.2, Location Category B and monitor output. Conduct a minimum of three consecutive successful tests on each unit listed. Confirm there is no interruption to 400 Hz output power and voltage stays within specified regulation tolerances. Surge protection tests must be applicable on all frequency converter units utilizing same surge protection device by manufacturer and part number regardless of frequency converter kW size.

c. Input current: Perform the following tests at nominal input voltage. Conduct each test a minimum of three times. Monitor the input and output power to demonstrate the duration of the transients until the converter reaches steady state. Provide copies of waveforms and analysis in test report.

(1) Measure inrush current when initially turning on machine with no load.

(2) After applying power and unit is at steady state, conduct load application test, going from 0 to full load to measure affect on input.

d. Input current distortion: Operate at nominal input voltage at 0, 25, 50, 75, and 100 percent of rated full load. Measure and record the input current THD for the current in each phase.

e. Overload: Operate at nominal input voltage and output voltage with loads as listed below:

Percent of Full Load	Satisfactory Operating Time	Time Between Overloads	Iterations
110 percent	60 minutes	4 hours	3
125 percent	5 minutes	10 minutes	3
150 percent	2 minutes	10 minutes	3
200 percent	20 seconds	5 minutes	3
300 percent	4 seconds	5 minutes	5

Monitor output to confirm there is no 400 Hz power interruption. After minimum operating time is achieved, unit must interrupt output power. Provide voltage and current waveforms documenting the unit's response for each test.

f. Short-circuit: Apply a bolted line-to-line fault and a bolted three phase fault directly to the output terminals of the unit. Conduct a minimum of three consecutive successful tests on each unit. Provide unit capable of carrying the fault current until the integral system protective devices interrupts the fault with no damage to the unit. Provide waveforms of short circuit current during short circuit tests.

g. Output voltage THD: Operate at nominal input voltage at full load with balanced and 15 percent unbalanced load. A 15 percent unbalanced load is defined as follows:

(1) Phase A at full rated single phase load.

(2) Phase B at 85 percent of Phase A

(3) Phase C at 85 percent of Phase A

Measure and record the output voltage THD for the line-to-neutral voltage of each phase.

h. Phase angle regulation: Operate at full load with balanced and 15 percent unbalanced loads. Measure and record output voltage and current, and identify RMS phase voltages and displacement angles between adjacent output voltage phases. A 15 percent unbalanced load is defined as follows:

(1) Phase A at full rated single phase load.

(2) Phase B at 85 percent of Phase A.

(3) Phase C at 85 percent of Phase A.

i. Transient recovery: Operate at the following load steps: 0 to 100 percent, 0 to 50 percent, 100 to 0 percent and 50 to 0 percent. Measure and record recovery time and output voltage deviation limits. Provide recordings or display of output voltage during transient recovery test.

l. Post Special Test Safety Verification: Repeat tests conducted under item a. Initial Safety Verification to confirm safety features were not affected by previous tests.

2.6 ARC FLASH WARNING LABEL

Provide arc flash warning labels for arc flash protection in accordance with NFPA 70E and NEMA Z535.4 for the enclosures of electrical equipment that are likely to require examination, adjustment, servicing, or maintenance while energized. Locate this self-adhesive warning label on the outside of the equipment compartment doors warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated. The marking must be clearly visible to everyone, including qualified persons, before examination, adjustment, servicing, or maintenance of the equipment.

2.7 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription must identify the function and, when applicable, the position. Nameplates must be melamine plastic, 0.125 inch thick, white with black center core. Surface must be matte finish. Corners must be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be 1 by 2.5 inches. Lettering must be a minimum of 0.25 inch high normal block style.

2.8 GROUNDING AND BONDING

UL 467. Provide grounding and bonding as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.9 REMOTE MONITORING AND CONTROL PANEL

Provide remote monitoring and control panel and circuitry. Connect to clearly and permanently labeled terminal blocks located inside the converter's enclosure. Provide the circuitry such that indicator lamp/LED information and control function(s) can be extended from the terminals to a remote location. The future panel shall duplicate the functions of the unit mounted controls.

PART 3 EXECUTION

3.1 INSTALLATION

Install products to operate at 400 Hz in the same manner as specified in other sections of this specification for products operating at 60 Hz, unless indicated or specified otherwise. Conform to the requirements of NFPA 70 and IEEE C2 and to manufacturer's instructions and recommendations.

3.2 EQUIPMENT

3.2.1 Maintenance Platform Mounted

Install as required for floor-mounted units.

3.2.2 Grounding and Bonding

In accordance with NFPA 70 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.2.3 Grounding and Bonding - Exterior Equipment

3.2.3.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.3.2 Connections

Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors. Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4 Wiring and Conduit

Provide wiring and conduit as specified in Section 26 20 00, INTERIOR DISTRIBUTION SYSTEM. Use copper conductors type XHHW, 7-conductor, 6 around 1, twisted for 400 Hz systems. Use aluminum conduit for exposed 400 Hz feeders. Do not install aluminum conduit underground or encased in concrete. Use aluminum fittings and boxes with aluminum conduit. Use PVC conduit and fittings for underground or concrete encased 400 Hz feeders.

3.2.5 Manufacturer's Representative

The manufacturer's representative must place the system in operation and make necessary adjustments to ensure optimum operation of the equipment. The manufacturer's representative must have at least 2 years of practical experience in the installation and testing of 400 Hz solid state frequency converters.

3.3 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.5 FIELD APPLIED PAINTING

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance to manufacturer's instructions ***as specified in Section 09 96 00 HIGH-PERFORMANCE COATINGS.***.

3.6 FIELD QUALITY CONTROL

3.6.1 Field Test Schedule

Give Contracting Officer 30 days notice of dates, times and scheduled tests which require the presence of the Contracting Officer. The Contracting Officer will coordinate with the using activity and schedule a

time that will eliminate or minimize interruptions and interference with the activity operations.

3.6.2 Instruments

Provide test instruments capable of measuring and recording or displaying test data at a higher resolution and greater accuracy than specified for the converter's performance. The test instruments used in the field tests must have current valid calibration stickers issued by an approved calibration laboratory. Verify calibration and adjustments of converter instruments provided prior to field tests. Calibrate instruments for 400 Hz operation when measuring 400 Hz signals.

3.6.3 Initial Inspection and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests. In addition, coordinate with the NETA ATS representative to witness, document, and validate the converter Field Quality Control.

a. Compare equipment nameplate information with specifications and approved shop drawings.

b. Inspect physical and mechanical condition. Inspect cables and wiring harnesses for damage and strain relief.

c. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey. Perform thermographic survey while the unit is at full load during the loadbank test.

d. Perform specific inspections and mechanical tests as recommended by manufacturer.

e. Verify correct equipment grounding.

3.6.4 Field Performance Checks and Tests

Conduct converter field checks and tests under the supervision of the manufacturer's representative. Provide labor, equipment, test instruments, and incidentals required for the tests including resistive load banks, except the Government will furnish the electricity. For all electrical load tests, use 1.0 power factor unless otherwise noted.

All tests must be performed with the load connected to the load end of the specified aircraft cable assembly. The cable must be laid out / uncoiled to provide heat dissipation. No adjustment to the converter is allowed between tests. Successfully complete the safety verification, preliminary operation, and the control and protective devices check prior to performing load and transient tests. Load tests must be performed with the converter doors closed. If the converter fails to operate within the specified limits during any of the tests, discontinue the test, make necessary repairs to correct the failure, and restart testing of the converter. Repeat all previously completed tests and document the respective failed test data and new data.

3.6.4.1 Initial Safety Verification

Perform tests and checks to validate the safe and timely shutdown for each condition (for the power source and the output cable) identified in paragraph SAFETY FUNCTIONS. As an exception, a representative fault test will be sufficient at this time.

3.6.4.2 Preliminary Operation

Inspect the converter and make adjustments necessary to assure proper operation in accordance with the manufacturer's instructions. Operate converter at 0, 25, 50, 75, and 100 percent of rated full load. On both the input and the output, measure and record the voltage, current, frequency, and THDs (voltage and current) at each load. Calculate output voltage regulation. Verify converter is operating within specified limits at each load level.

Test data must include voltage and current harmonic distortion amplitudes of all individual harmonics presented in a spectrum analysis format up to the 15th order at the 50 percent and 100 percent load points.

3.6.4.3 Control and Protective Device Checks

Operate each control, switch, input/output device that is capable of being operated manually a minimum of three times, demonstrating satisfactory operation each time. Perform operation test on each protective device to ensure that devices function properly. After each operation measure and record the converter output frequency, voltage and current. Verify converter is operating within specified limits.

3.6.4.4 Load (Burn-in) Test

Operate each unit continuously a minimum of 1 hour at 100 percent rated full load. Measure and record the converter output frequency, voltage and current at beginning, 30 minutes, and 1 hour. Verify converter is operating within specified limits. Load test must be performed with the converter doors closed and the test load connected to the converter at the cable head with specified aircraft cable assembly.

3.6.4.5 Post Load Test Verification

Repeat tests identified in paragraph PRELIMINARY OPERATION, to validate converter was not affected by the Load test. However apply loads in the reverse order (e.g. 100, 75, 50, 25, and 0 percent of the rated full load).

Conduct tests on each converter with the load connected to the load end of the specified aircraft power cable assembly. No adjustment to the converter is allowed between load tests. Monitor and record output voltage at the load end of the cable. Verify specified performance of the converter including the line drop compensation.

3.6.4.6 Final Safety Verification

Repeat tests conducted under paragraph INITIAL SAFETY VERIFICATION to confirm safety features were not affected by previous tests.

3.6.5 Grounding System

Inspect grounding system for compliance with contract plans and

specifications.

3.7 DEMONSTRATION

3.7.1 Instructing Government Personnel

Provide field training to Government personnel on the operation and maintenance of the converter provided at the same time as the Field Acceptance Testing. Include up to a maximum of 2 hours of instruction on operation and up to a maximum of 4 hours of repair and maintenance of the converters. The instructor must be approved by the manufacturer of the unit provided. Submit training syllabus including each topic of training and a brief outline of each topic to the Contracting Officer at least 4 weeks prior to training for approval.

Training must be approved by the Contracting Officer at least 2 weeks in advance. The Government may record, video and audio, the training sessions and use these recordings to train personnel on the operation and maintenance of the converter system. Provide two copies of video or audio DVDs, and of any supplemental information and examples covered in the training sessions, to the Contracting Officer.

3.8 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

SECTION 26 35 44

270 VDC SOLID STATE CONVERTER
08/21
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 519	(2014) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE 1159	(2019) Recommended Practice on Monitoring Electric Power Quality
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60947-4-1	(2018; INT 1 2020; Corr 2 2021) Low-voltage Switchgear and Controlgear, Part 4-1: Contactors and Motor Starters - Electromechanical Contactor and Motor Starters

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
NFPA 70E	(2021) Standard for Electrical Safety in the Workplace

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AS7974	(2010; Rev A) Cable Assemblies and Attachable Plugs, External Electrical Power, Aircraft
SAE AS7974/5	(2017; Rev A) Cable Assembly, External Electrical Power, Aircraft, Single-Jacketed 270 VDC, 90 KW

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-704	(2016; Rev F; Change 1) Aircraft Electric Power Characteristics

UNDERWRITERS LABORATORIES (UL)

UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 506	(2017) UL Standard for Safety Specialty Transformers
UL 1012	(2010; Reprint Apr 2016; Rev Mar 2021) UL Standard for Safety Power Units Other than Class 2
UL 1449	(2021; Reprint Dec 2022) UL Standard for Safety Surge Protective Devices

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, must be as defined in IEEE 100.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Converter Drawings; G

SD-03 Product Data

Converter; G

270 VDC Aircraft Power Cable Assembly; G

28 VDC Interlock; G

Remote Monitoring and Control Panel; G

SD-06 Test Reports

Work Plan; G

Routine Factory Test Plan; G

Special Factory Test Plan; G

Factory Test Schedule; G

Routine Factory Tests Certification; G

Special Factory Tests Certification; G

SD-07 Certificates

Qualifications of Manufacturer; G

Nationally Recognized Testing Laboratory (NRTL) Listing; G

SD-09 Manufacturer's Field Reports

Field Test Plan; G

Field Test Schedule; G

Field Test Certification; G

Training Syllabus; G

SD-10 Operation and Maintenance Data

Converter O&MM, Data Package 5; G

Preliminary Converter O&MM, Data Package 5; G

Remote Monitoring and Control Panel, Data Package 5; G

1.4.1 Government Submittal Review

NAWCAD Air Vehicle Electrical Power Systems Group (AB43), (301) 342-4161 and Code DC 44, NAVFAC LANT, Naval Facilities Engineering Command will provide surveillance. If they have comments or concerns, they will contact and coordinate resolution of their comments with the appropriate approving agent.

1.5 QUALITY ASSURANCE

1.5.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for 5 years prior to bid opening. The 5-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 5-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.2.1 Alternative Qualifications

Products having less than a 5-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site must not be used, unless specified otherwise.

1.5.3 Converter Drawings

Furnish scaled drawings of enclosure outline including front, top, side views, and overall dimensions. Include "maintenance envelope" dimensions confirming space limitations identified on the drawings, and surface

mounting flush against the wall. Rear access for maintenance and repair purposes is prohibited. The "maintenance envelope" drawings must also indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Provide external power and control wiring, cabling, connector, and backplane interconnect drawings. Provide single line, schematic, and wiring diagrams. Drawings must include details of input and output circuit breakers, contactors, rectifiers, surge protectors, control devices and conduit entry and exit locations. If parallel operation is included, provide an interconnection diagram. Submittals must include the nameplate data, size, and capacity.

1.5.4 Qualifications of Manufacturer

Submit a certification stating that the manufacturer has a minimum of five years' experience in the design, manufacturing, and testing of a 270 VDC solid state converter at the equivalent or greater kW and voltage ratings for direct connection to aircraft electrical loads. When specifications require multiple converters operating in parallel, the manufacturer must provide specific experience with equal or greater kW rated converters.

Experience in manufacturing motor generator sets does not qualify as equivalent. Experience in manufacturing portable engine-driven 28 VDC power units does not qualify as equivalent. The manufacturer must be experienced in producing units for installation in permanent buildings, in environmentally closed spaces, or in weatherproof enclosures as applicable. The manufacturer must furnish documented experience with converters in various environmental conditions including exterior flight line, hangar, and environmentally enclosed spaces within buildings.

1.5.5 Work Plan

Submit a written work plan with the initial shop drawing submittal, which consists of a schedule of dates of the routine and special factory tests, installation of equipment, field tests, and operator training for the system. Furnish a list of the test instrumentation equipment complete with the documented calibration program, for the factory and the field tests.

1.5.6 Routine Factory Test Plan

Submit test plan and procedures at least 21 calendar days prior to the tests being conducted. Provide detailed description of test procedures, including test equipment and setups complete with their current calibration dates, to be used to ensure the converter meets this specification and explain the test methods used. As a minimum, include the tests required under the paragraph ROUTINE FACTORY TESTS.

1.5.7 Special Factory Test Plan

Submit the Special Factory Test Plan and procedures with the Routine Factory Test Plan. Provide detailed description of test procedures, including test equipment and setups complete with their calibration dates, used to ensure the converter meets this specification and explain the test methods used. As a minimum, include the tests required under the paragraph SPECIAL FACTORY TESTS.

1.5.8 Field Test Plan

Submit test plan and procedures at least 30 calendar days prior to the

start of field tests. Provide detailed description and dates and times scheduled for performance of tests, and detailed description of test procedures, including test equipment and setups of the tests to be conducted to ensure the system meets this specification. List make, model, and current calibration dates, and provide functional description of the test instruments and accessories. Explain the test methods to be used. As a minimum, include the tests required under the paragraph FIELD QUALITY CONTROL. Test reports must include power quality measurement data collected in accordance with IEEE 1159.

1.5.9 Nationally Recognized Testing Laboratory (NRTL) Listing

270 VDC converters must be identified with a nationally recognized testing laboratory (NRTL) label or UL label prior to shipping.

1.5.9.1 Currently Listed Products

Submit NRTL or UL certification or UL file number for the actual converter to be shipped with the initial submittal to verify compliance of equipment.

1.5.9.2 Proposed Listed Products

Submit NRTL or UL certification or UL file number for same or similar rating or product size range of like design unit with the initial submittal to verify compliance of equipment.

1.5.10 Routine Factory Tests Certification

Submit within 45 calendar days after completion of tests. Receive approval of test prior to shipping unit. Certify tests were conducted on each converter in accordance with the requirements set forth in paragraph ROUTINE FACTORY TESTS and certify converter satisfactorily operated within specified limits. Include copies of the test procedures, test configuration diagrams and schematics, test data, and results.

1.5.11 Special Factory Tests Certification

Certify tests were conducted on a converter of the same design, construction, kW rating, and voltage rating to be provided. Tests must be in accordance with the requirements set forth in paragraph SPECIAL FACTORY TEST and certify converter operated without malfunctioning within specified limits. Include copies of the test procedures, test configuration diagrams and schematics, test data, and results.

1.5.12 Field Test Certification

Submit report of test results as specified by paragraph FIELD QUALITY CONTROL within 15 calendar days after completion of tests. Certify tests were conducted on each converter in accordance with the paragraph FIELD QUALITY CONTROL and certify converter satisfactorily operated within specified limits. Include copies of the test procedures, test configuration diagrams and schematics, test data, and results.

1.6 OPERATION AND MAINTENANCE MANUALS

Submit converter Operation and Maintenance Manuals (O&MM) in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.6.1 Additions to Converter O&MM

In addition to requirements of Data Package 5, include the following on the actual converter provided:

a. A "one-line diagram" from the building service entrance panel to the converter and out to the end utilization point(s).

b. A concise, duplicatable, single page data sheet with operating instructions for each unit including startup and shutdown procedures.

c. Routine and field test reports.

d. NRTL or UL certification or UL file number.

e. A list of all code required identification and warning signage and labels that have been provided on the converter.

1.6.2 Preliminary Converter O&MM

Prior to scheduling Field Tests, two bound copies of a Preliminary O&MM must be submitted to and approved by the Contracting Officer.

1.6.3 Spare Parts Information

Furnish recommended manufacturer's spare parts list, quantities, lead time to receive after ordering, and a schedule of prices,(guaranteed for one year after warranty expires), for each type of converter and other equipment specified in this section. Include the following:

a. Fuses

b. Human Machine Interface (HMI)

c. Indicator lamp/LED

d. Output switching modules

e. Plug-in logic cards

f. Power filter capacitors

g. Power semi-conductors

h. Ventilation system filters

i. 270 VDC Aircraft Power Cable Assembly

j. 28 VDC Aircraft Power Cable Assembly

1.7 WARRANTY

The equipment items must be supported by service organizations which are most convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

PART 2 PRODUCTS

2.1 270 VDC CONVERTER

Provide converter consisting of modular construction solid-state components for 60 Hz to 270 VDC conversion, input/output devices, and ancillary control devices. Converter must be a standard product of the manufacturer and the manufacturer's latest design that complies with the specification requirements. The converters provided under this contract must be products of the same manufacturer. Each unit must have a calculated Mean Time Between Failures (MTBF) exceeding 24,000 hours as calculated when the converter is provided with yearly servicing and maintenance. Provide converter with NRTL or UL listing complying with UL 1012. The converter must have minimum 12 pulse, active input rectification circuit or a demonstrated design achieving equal or better performance characteristics. Circuit breakers operating at 270 VDC and 28 VDC must be designed and UL tested for 60 Hz operation for the applicable VDC operation, as appropriate. Provide startup and shutdown instructions posted on the front of the unit using engraved plastic or aluminum plate. Provide a plastic encapsulated schematic diagram attached to the inside of the unit in clear view of maintenance personnel.

2.1.1 Electrical Characteristics

The 270 VDC output and the associated 28 VDC Interlock voltage, measured at the aircraft end of the servicing cable, must be in accordance with MIL-STD-704, must be controlled to the voltage regulation requirements within this document throughout all loadings defined, and must comply with the additional modifications identified herein.

2.1.1.1 Input Voltage

480 V, three phase, three wire, grounded, 60 Hz. Converter must provide rated output voltage when input voltage is varied plus or minus 10 percent. A voltage changing transformer is not permitted at the input of the converter unit.

2.1.1.2 Input Power Factor

Between 0.8 lagging and unity, under all conditions of steady state line and load variations specified herein.

2.1.1.3 Surge Protection

Provide converter capable of sustaining an input surge described in and tested in accordance with UL 1449, and IEEE C62.41.1 and IEEE C62.41.2, Location Category Category C for outdoor units, and continue to operate with no alarms within the specified tolerance.

2.1.1.4 Inrush Current

The inrush current must not exceed 100 percent of the rated full load input current.

2.1.1.5 Input Current Distortion

Input current Total Harmonic Distortion (THD) must not exceed 12 percent of the fundamental frequency with nominal input voltage at full load. Individual harmonic content must not exceed 8 percent of the fundamental

frequency.

2.1.1.6 Output Voltage

As an exception to the requirements of MIL-STD-704, the 270 VDC converter must simultaneously provide and regulate (when measured at the cable head) to the following steady state voltage limits:

a. 270 VDC (plus or minus 3 VDC).

b. 28 VDC (plus 1 VDC or minus 2 VDC).

2.1.1.7 Power Output

The 270 VDC converter must have a power output rating of:

a. 270 VDC: 267 amperes (72 kW) with overload / transient capability as defined herein.

b. 28 VDC: 15 amperes (0.42 kW) with overload / transient capability as defined herein.

2.1.1.8 Load Range

The 270 VDC converter must be capable of meeting the following load ranges:

a. 270 VDC: 0 to 72 kW of any combination of resistive and constant power loads with overload / transient capability as defined herein, in parallel with up to 2,500 microfarads of capacitance, with a minimum current demand rate of 200 Amperes per millisecond.

b. 28 VDC: 0 to 0.42 kW of any combination of resistive and constant power loads with overload / transient capability as defined herein, in parallel with up to 100 microfarads of capacitance, with a minimum current demand rate of 60 Amperes per millisecond.

2.1.1.9 Efficiency

Provide 72 kW units with a minimum efficiency of 89 percent at 50 percent load and 92 percent at 100 percent load.

2.1.1.10 No Load Input Losses

Provide converter with no-load input losses no greater than 7 percent of the output kW rating.

2.1.1.11 Overload

The converter outputs, both 270 VDC and 28 VDC, must have overload capabilities in accordance with the following table. The satisfactory overload operating time is based on no more than one overload of the same or longer conditions, within the following specified time between overloads.

Percent of Full Load (Rated Output)	Satisfactory Operating Time	Time Between Overloads
110 percent	30 minutes	2 hours Note: Unit must still be capable of withstanding any of the other conditions for their respective operating times. e.g. Unit can still do 150 percent for less than 10 seconds, before tripping, etc.
125 percent	5 minutes	10 minutes
150 percent	10 seconds	10 minutes
200 percent	2 seconds	5 minutes
250 percent	100 milliseconds	5 minutes

After minimum operating time is achieved, unit must interrupt output power. Unit must be capable of sustaining the overload without damage until the protective device interrupts the overload.

2.1.1.12 Short Circuit

When a bolted positive to negative fault is applied to the unit, unit must be capable of sustaining the short circuit current without damage until the protective device interrupts the fault. The output transient voltage recovery time and thresholds are more stringent than those required by MIL-STD-704, and must comply with the following:

a. During a bolted fault the current output must be regulated between 485 and 550 Amps for 5 seconds. If the fault condition clears in less than 5 seconds, the power source must recover to the voltage range of 250 to 280 volts within 40 milliseconds, and then settling out to the regulated voltage levels of 270 VDC (plus or minus 3 VDC) within 10 milliseconds, as shown in Figure 263544-1: Transient Voltage Recovery Limits for 270 VDC.

b. During this 270 VDC bolted fault condition, as well as for any high di/dt load or overload condition (e.g. over voltage, over current, under voltage, ripple), the 28 VDC interlock power output must not be disrupted and power quality must remain as defined in Figure 263544-2: Transient Voltage Recovery Limits for 28 VDC, throughout the fault isolation event.

2.1.1.13 Ripple Amplitude

Ripple amplitude is the maximum absolute value of the difference between the steady state and the instantaneous DC voltage. The maximum allowable ripple amplitude for the 270 VDC output is more stringent than what is required by MIL-STD-704. The maximum allowable ripple amplitude for the 28 VDC output must be in accordance with MIL-STD-704 These must comply with the following:

a. 270 VDC output: 1.5V (peak to mean).

b. 28 VDC output: 1.5V (peak to mean).

2.1.1.14 Distortion Spectrum

The converter output distortion spectrum must meet the following requirements:

a. 270 VDC: MIL-STD-704 Figure 18, inclusive of the fundamental voltage ripple component.

b. 28 VDC: MIL-STD-704 Figure 15.

2.1.1.15 Distortion Factor

The DC distortion factor is the ratio of the DC distortion to the DC steady state voltage. The maximum allowable distortion factor for the 270 VDC converter must be as follows per Table IV of MIL-STD-704:

a. 270 VDC output: 0.015.

b. 28 VDC output: 0.035.

2.1.1.16 Transient Output Voltage Recovery

The transient output voltage recovery time and thresholds are more stringent than those required by MIL-STD-704. Monitor and record output voltage at the load end of the cable. Comply with the following:

a. The 270 VDC output must remain within the range of 220 to 330 VDC for any step load change as defined in paragraph LOAD RANGE herein.

b. The 270 VDC output must begin recovery from the worst case transient excursion within 10 milliseconds and must be recovered to within the steady-state operating range specified in paragraph OUTPUT VOLTAGE within 40 milliseconds per Figure 263544-1: Transient Voltage Recovery Limits for 270 VDC.

c. The 28 VDC output must remain within a range of 26 to 40 VDC for any step load change as defined in paragraph LOAD RANGE herein. The voltage must not drop below 26 VDC for more than 50 microseconds.

d. The 28 VDC output must begin recovery from the worst case transient excursion within 15 milliseconds and must be recovered to within the steady-state operating range specified in paragraph OUTPUT VOLTAGE within 100 milliseconds per Figure 263544-2: Transient Voltage Recovery Limits for 28 VDC.

2.1.2 Environmental Rating

The converter must be rated for continuous operation from no load to rated full load under the following conditions:

a. Ambient temperatures ranging from -4 to 130 degrees F.

b. Relative humidity from 0 to 100 percent noncondensing.

c. Ambient pressures from sea level to 3,000 feet.

2.1.3 Monitoring and Control Panel

Provide converter with a control panel that is equipped with the following controls, indicators, instrumentation, data logging, diagnostics, and alarm functions.

2.1.3.1 Controls

Controls must be mounted on the front of the control panel. Specific sequencing, or the requirement for simultaneous pushbutton operation, is not acceptable for any input or output control.

a. Start/stop pushbutton for input device control (circuit breaker or contactor).

b. Lamp/light emitting diode (LED) test - A push-to-test button or switch to test indicator lamps/LEDs. If panel lights all blink as part of the startup Built-in-Test (BIT) sequence, then a separate push to test button is not required.

c. Emergency power off - A separate pushbutton for emergency power off.

d. Output device ON/OFF.

e. Alarm silence and "silence" indicator - A switch that must disable the audible alarm without clearing the alarm codes.

f. Additional individual controls for the following functions (Note - these may be included as part of the Human-Machine Interface (HMI) as described in paragraph HUMAN MACHINE INTERFACE REQUIREMENTS):

- Output voltage adjust

- Alarm reset - resets and clears the silenced audible alarm.

2.1.3.2 Indicators

a. The following are mandatory indicators. They must be included on the control panel on the exterior of the unit, and on the exterior of the remote control panel in addition to any that are included in the HMI:

- Input power available - Lamp/LED to indicate that the supply voltage is available.

- Output power On/Off - Lamp/LED to indicate that the converter output voltage is available.

- Output device "ON".

- Audible alarm.

- Aircraft interlock bypass - Lamp/LED to indicate that the Aircraft Interlock has been bypassed.

b. In addition, include the following additional indicators, if they are not included in the HMI:

- System alarm - Lamp/LED to indicate that a fault has been detected. This indicator must be latched in the "ON" position whenever an alarm condition described in paragraph ALARM ANNUNCIATOR, is detected and must remain "ON" until the alarm reset pushbutton is pressed.

- Indicating lamp/LED to indicate that the alarm silence switch is in the disable position.

- Elapsed time meter in hours; (may be internal or visible externally).

2.1.3.3 Human Machine Interface (HMI) Requirements

Provide an HMI with a minimum of four by twenty (4 x 20) character backlit LED display for presenting the digital instrumentation, diagnostic system, and fault indicating system data. The HMI display must be viewable in direct sunlight and the HMI must be rated for harsh environments.

a. Digital Instrumentation. Provide true RMS, plus/minus one percent accuracy, microprocessor-based readings that include the following functions:

(1) Output voltage.

(2) Output current.

(3) Inverter temperature. This function is desired for field diagnostics, but is not mandatory.

b. Alarm Annunciator. The unit must be capable of detecting and displaying the following abnormal conditions:

(1) Input overvoltage.

(2) Input undervoltage.

(3) Output undervoltage.

(4) Output overvoltage.

(5) Output overload.

(6) System alarm.

(7) Control logic failure.

(8) Over-temperature.

(9) Logic power supply failure.

2.1.4 Input/Output Devices

Provide fully-rated, UL approved devices for control of 60 Hz input and for control of DC outputs from the converter. Derate devices and cables operating at 270 VDC in accordance with IEEE 519.

2.1.4.1 Input Device

Provide converter with a UL listed input device (circuit breaker conforming to requirements of UL 489 or contactor) as an integral part of

the converter. Device must be operable from the front of the converter. Device must have a short-circuit current rating of 65,000 amperes symmetrical minimum. Input circuit breaker shall be an electric trip type with adjustable long time and instantaneous settings and a 150A trip rating.

2.1.4.2 Output Contactor

Provide converter output with an automatic magnetically-held contactor with interlock circuit. Output contactor must have sufficient capacity to handle rated load, overload, and available short circuit current. Contactor must additionally be rated for make / break operation into a 2,500 microfarads capacitance without damage to the converter.

Contactor must open when any circuit identified in the paragraph SAFETY FUNCTIONS causes the system to shut down. Electrically interlock contactor with ON/OFF circuitry so that when the converter is shut down, the contactor opens immediately and remains open. Conform to the requirements of IEC 60947-4-1.

2.1.4.3 Aircraft Interlock Circuit

The 270 VDC output power contactors must be interlocked with the unit's fault indicators, alarms, and the 28 VDC interlock power circuit. When the 28 VDC interlock power source is "broken" (e.g. when the power cord is removed from the aircraft receptacle), the 270 VDC output power source must be disabled.

2.1.5 Safety Functions

2.1.5.1 270 VDC Power Source

The 270 VDC power source internal 270 VDC buss must automatically discharge to below 12 VDC within 2 seconds after the following:

a. 270 VDC power source has been turned off.

b. Whenever any access panel is opened on the equipment. Under this condition, the interlock circuitry must open the input device and the 270 VDC output device, and not allow the input or output device to close. For maintenance purposes, provide an internal bypass switch to defeat the interlock circuitry.

c. Detection of system fault that results in a converter shut down condition, including the following:

(1) Input undervoltage.

(2) Input overvoltage.

(3) Loss of input phase.

(4) Loss of input power.

2.1.5.2 270 VDC Output Cable

The 270 VDC power must be removed from the output cable within 100 milliseconds after one of the following occurs:

a. Receiving a stop command.

b. Loss of 28 VDC interlock power.

c. Detection of a fault that results in an output shut down, including the following:

(1) Output overvoltage - Protect by tripping output devices for instantaneous overvoltage of 30 percent or more and for 10 to 30 percent overvoltage lasting more than 0.25 seconds.

(2) Output undervoltage - Protect by preventing the closing of the output disconnect until the output voltage is 95 percent of the rated output. If, after closing, the voltage decreases to below 90 percent for longer than 5 seconds, provide relaying to trip output devices utilizing a field-adjustable time-delayed circuit with a range of 4 to 10 seconds.

(3) Output overload.

(4) Converter overtemperature protection.

2.1.6 Automatic Line Drop Compensation

Provide automatic line drop compensation (ALDC) from zero to ten percent adjustable internally. Separate ALDC functions are required for the 270 VDC power source and for the 28 VDC interlock power source.

2.1.7 Magnetic Components

Provide Class 180 power magnetic transformer and inductors in accordance with NEMA ST 20 and UL 506. The limits of Class 180 must not be exceeded at the maximum specified ambient temperature and at 100 percent load.

2.1.8 Acoustical Noise

Provide unit with a maximum continuous acoustical noise level less than 72 dBa (A weighted scale).

2.1.9 Assembly Construction

Provide enclosures suitable for the environment which they are located in accordance with NEMA 250, NEMA 4X stainless steel for outdoor units. Arrange to provide required louvers, cooling air, entry and exit provisions for equipment within enclosures. ***Do not use ferrous metal for fasteners, finishing strips, or components of other securement systems. Provide stainless steel.***

a. Units must be mounted flush against the wall, must not require back access for maintenance.

b. Construct unit(s) so that components, with the exception of control and monitoring components, are totally enclosed within the enclosure. Electronic circuits including power circuits must be modular construction readily accessible for maintenance, repair and module replacement from the front of the enclosure. For units installed outdoors or in corrosive environments, provide a conformal (rust-inhibiting) coating for the printed circuit boards enclose electronic circuits in a sealed electronics compartment that is not

provided with direct cooling ventilation or forced air cooling.

c. Provide permanent identification tags for wiring. Uniquely identify each wire. Use the same identification system in the wiring diagrams in the Operation and Maintenance Manual. Enclosures must be painted in accordance with paragraph FACTORY APPLIED FINISH and as specified herein. Provide each enclosure with a finish coat over a rust inhibiting substrate or a substrate that has been provided with a rust inhibiting treatment. For outdoor enclosures, if the unit is not painted using the powder coating process, provide two finish coats on the unit.

d. Provide units with a Mean Time To Repair (MTTR) of 30 minutes from the time of the diagnosed failure based on documented manufacturer's historical data for the average time of repair for their top ten faults. Provide the supporting data with the equipment submittal.

2.2 AIRCRAFT POWER CABLE ASSEMBLY

Provide a single-jacketed 270 VDC aircraft power cable assembly in compliance with SAE AS7974 and SAE AS7974/5. The 270 VDC output cable assembly must be constructed and tested to meet the power requirements of this specification, to minimize cross coupling, to meet current demand rates and to ensure power regulation, ripple, distortion, and transient voltage recovery, as defined herein, is not exceeded.

Rate cable for 333 amperes. Cable length must be 83feet. Provide control cabling included within the jacket for interlock circuit. Terminate control wiring on accessible terminal blocks in unit. Provide cable assembly with integrally molded 270 VDC connector capable of connecting to the aircraft receptacle. Provide cable/connector assembly suitable for severe duty, with crimped contact terminations. Banded cables are not permitted. In addition, the assembly must comply with the following:

a. The 270 VDC and 28 VDC returns must be tied together only on the aircraft side of the on-aircraft external power receptacle.

b. The 28 VDC interlock output positive will be on pin "1" and output negative voltage will be on pin "2".

c. Pins "3" and "4" must be internally connected within the cable connector end to provide a "jumper" for interlock control (less than 0.1 ohms).

d. The contact section of the molded aircraft servicing connector must be capable of being repaired in the field. The contact section must be a one-piece, molded, replacement section or have individually replaceable pins and a molded one-piece cover. Installation of the replacement contact section must restore watertight integrity to the molded aircraft servicing connector. Repair must not include replacement of the entire aircraft servicing connector.

2.2.1 28 VDC Interlock

The 28 VDC interlock power must be within MIL-STD-704 "Normal Operating Limits", be available on power initiation, and must remain present throughout the duration of connection of power to the aircraft.

a. The 28 VDC interlock power must provide at least 15 amps of power

capacity for aircraft equipment use.

b. The 270 VDC output must only be enabled when the 28 VDC interlock is present.

c Power must only be available when the plug is fully seated in the aircraft receptacle.

d. The sensing back of the 28 VDC interlock from the aircraft must indicate a proper connection of the receptacle.

2.3 REMOTE MONITORING AND CONTROL PANEL

Provide remote monitoring and control panel and circuitry only for the interior units that are mounted at 9 feet AFF. Connect to clearly and permanently labeled terminal blocks located inside the converter's enclosure. Provide the circuitry such that indicator lamp/LED information and control function(s) can be extended from the terminals to a remote location in the future. The remote panel shall duplicate the functions of the unit mounted controls.

a. Pushbutton or switch for de-energizing the output terminals.

b. Indicator lamp/LED showing the unit status (energized or not energized).

c. Indicator lamp/LED showing the output control device position (open or closed).

d. System alarm.

2.4 MANUFACTURER'S NAMEPLATE

Each frequency converter, each major component within the frequency converter, and each item of other equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.5 FACTORY APPLIED FINISH

Electrical equipment must have factory-applied painting systems which must, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test and the additional requirements as specified herein. Interior and exterior steel surfaces of equipment enclosures must be thoroughly cleaned and then receive a rust-inhibitive phosphatizing treatment, a primer powder coat, or equivalent treatment prior to painting. Exterior surfaces must be free from holes, seams, dents, weld marks, loose scale or other imperfections. Interior surfaces must receive not less than one coat of corrosion-resisting paint or powder coating process in accordance with the manufacturer's standard practice. When enclosure is aluminum, interior may optionally be coated with rust inhibiting treated film. Exterior surfaces must be primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish, or finished with a powder coating process. Color must be the manufacturer's standard color. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

2.6 SOURCE QUALITY CONTROL

2.6.1 Factory Test Schedule

The Government reserves the right to witness tests and reserves the right to request the raw data from the tests whether witnessed or not. Provide the converter test schedule for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

Test Instrument Calibration.

a. The manufacturer must have a documented calibration program which assures that all applicable test instruments are maintained within rated accuracy.

b. The accuracy must be directly traceable to the National Institute of Standards and Technology.

c. Instrument calibration frequency schedule must not exceed 12 months for both test floor instruments and leased specialty equipment.

d. Provide dated calibration labels, that are visible on all test equipment.

e. Calibrating standard must be of higher accuracy than that of the instrument tested.

f. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

   (1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

   (2) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.6.2 Routine Factory Tests

Perform routine tests by the manufacturer at the factory, on each of the actual converter(s) prepared for this project to ensure that the design performance is maintained in production. As an exception, test automatic line drop compensation on only one unit on multiple unit orders of the same kW rating. If there are multiple units with different kW ratings, then testing one of each of the kW ratings is acceptable. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Include a list of the current test equipment calibration dates. Required tests, test conditions, and testing sequence is as follows:

a. For tests which require full load, use the nameplate full load kW of the unit being tested unless otherwise noted.

b. All measurements must be true RMS measurements. Obtain measurements in accordance with IEEE 1159. Monitor and record all data at the load

end of the cable.

c. Connect loads to the converter with the specified aircraft power cable assembly.

d. No adjustments to the frequency converter are allowed between load tests.

2.6.2.1 Test Conditions

Tests must include the following conditions:

a. Initial Safety Verification: Perform tests and checks to validate the safe and timely shutdown for each condition (for the power source and the output cable) identified in paragraph SAFETY FUNCTIONS.

b. Input current and power factor: Operate converter at low, nominal and high input voltage at full load. Measure and record input voltage, input power factor and input current in each phase.

c. Output voltage, output current, and voltage regulation. Operate converter at nominal input voltage unless otherwise specified.

(1) 50 percent of rated capacity.

(2) 100 percent of rated capacity.

(3) 50 percent of rated capacity with the loads as specified in the paragraph LOAD RANGE.

(4) 100 percent of rated capacity at low and high input voltage.

(5) 100 percent of rated capacity with the loads as specified in the paragraph LOAD RANGE.

(6) Note - Operate for not less than 10 minutes at each test condition in (1), (2), (3) and (4) above, and for not less than 30 minutes at test condition in (5) above.

(7) Note - Monitor and record each of the following at the beginning and end of each test condition: output voltage, output voltage waveform, output voltage ripple (peak-to-peak, distortion factor and distortion spectrum), output current, output current waveform, output current ripple (peak-to-peak, distortion factor and distortion spectrum). Verify output remains within specified regulation limits at each load level by overlaying the graphs of Figure 263544 - 1 with the 270 VDC test data, and Figure 263544 - 2 with the 28 VDC test data.

d. Efficiency: Operate at nominal input voltage at half load and full load. Measure and record input voltage, input current, output voltage, and output current. Calculate the unit efficiency.

e. No load losses: Operate at no load and nominal input voltage. Measure and record input voltage, input current, input power, input power factor, and output voltage. Calculate the no load losses.

f. Overload: Operate at nominal input voltage and output voltage with loads and in sequence listed below:

Percent of Full Load	Time	Time Between Overloads	Iterations
250 percent	50 milliseconds	5 minutes	3
200 percent	2 seconds	5 minutes	1
150 percent	10 seconds	10 minutes	1
125 percent	5 minutes	10 minutes	1
110 percent	30 minutes	2 hours	1

(1) Monitor output to confirm there is no 270 VDC power interruption.

(2) Provide graph showing current magnitude over time for each condition above.

(3) Provide graph showing Output Voltage Response is in accordance with paragraph TRANSIENT OUTPUT VOLTAGE RECOVERY time and thresholds.

(4) After minimum operating time is achieved, unit must interrupt output power.

g. Burn-in Test: Before delivery, burn-in all units under full load conditions for at least 24 hours by cycling units 6 hours "ON" under full load conditions and 3 hours "OFF" at no load conditions for at least 4 complete "ON" cycles. Perform burn-in test with the converter enclosure doors closed, load connected directly to the output terminals, and all ventilation in the final operating condition. The specified aircraft cable is not required to be used for this test.

h. Include harmonic frequency spectrum analysis depicting harmonic order across the range of individual harmonic occurrence, and harmonic magnitude for each load condition in the test reports. Conduct tests at the unit's input terminals (to the 37th harmonic) per IEEE standards. Output voltage distortion spectrum analysis must be measured out to 16,000 Hz.

i. Automatic line drop compensation: Operate converter at nominal voltage and verify specified performance of the line drop compensation at the following loads.

(1) No-load.

(2) 50 percent of rated capacity.

(3) 100 percent of rated capacity.

j. 28 VDC Interlock. Perform each of the above tests (a through h) at 50 percent and 100 percent of full 28 VDC load. Verify operation within specified limits. However, the burn-in test (item g) must be performed only at full load, and not at 50 percent load of 28 VDC.

k. Post Routine Test Safety Verification: Repeat tests conducted under item a. Initial Safety Validation to confirm safety features were not affected by previous tests.

2.6.3 Special Factory Tests (Design Tests)

Submit special factory test (design test) reports (complete with test data, explanations, formulas, results, setup and cable information, and the list of the calibration dates of the test equipment used), in the same submittal package as the catalog data and drawings for the specified converter(s). Tests must be certified and signed by a registered professional engineer or by a "company certified professional designee" within the manufacturers' organization. Submit designee's credentials with the initial design test report for approval. Tests must be on file based on a production model of converters of the same design, construction and kW rating provided.

For all tests which require full load, use the nameplate full load kW of the unit being tested, unless otherwise noted. For all tests that are "not already on file", connect loads to the converter with an aircraft power cable assembly, 140 feet long, similar to the specified project aircraft power cable assembly. Monitor and record all data at the load end of the cable, unless otherwise noted. The tests conducted on the unit must include the following:

a. Initial Safety Verification: Perform tests and checks to validate the safe and timely shutdown for each condition (for the power source and the output cable) identified in paragraph SAFETY FUNCTIONS.

b. Surge protection: Apply input surges in accordance with IEEE C62.41.1 and IEEE C62.41.2, Location Category B for indoor units and category C for outdoor units and monitor output. Conduct a minimum of three consecutive successful tests on each unit listed. Confirm there is no interruption to 270 VDC output power and voltage stays within specified regulation tolerances. Surge protection tests must be applicable on all converter units utilizing same surge protection device by manufacturer and part number regardless of converter kW size.

c. Input current: Perform the following tests at nominal input voltage. Conduct each test a minimum of three times. Monitor the input and output power to demonstrate the duration of the transients until the converter reaches steady state. Provide copies of waveforms and analysis in test report.

   (1) Measure inrush current when initially turning on machine with no load.

   (2) After applying power and unit is at steady state, conduct load application test, going from 0 to full load to measure affect on input.

d. Input current distortion: Operate at nominal input voltage at 0, 25, 50, 75, and 100 percent of rated full load. Measure and record the input current THD for the current in each phase.

e. Input current and power factor: Operate converter at low, nominal and high input voltage at full load. Measure and record input voltage, input power factor and input current in each phase and neutral if the neutral conductor is connected to the converter input.

f. Output voltage, output current, and voltage regulation. Operate converter at nominal input voltage unless otherwise specified.

(1) 50 percent of rated capacity.

(2) 100 percent of rated capacity.

(3) 50 percent of rated capacity with the loads as specified in the paragraph LOAD RANGE.

(4) 100 percent of rated capacity at low and high input voltage.

(5) 100 percent of rated capacity with the loads as specified in the paragraph LOAD RANGE.

(6) Note - Operate for not less than 10 minutes at each test condition in (1), (2), (3) and (4) above, and for not less than 30 minutes at test condition in (5) above.

(7) Note - Monitor and record each of the following at the beginning and end of each test condition: output voltage, output voltage waveform, output voltage ripple (peak-to-peak, distortion factor and distortion spectrum), output current, output current waveform, output current ripple (peak-to-peak, distortion factor and distortion spectrum). Verify converter is operating within specified regulation limits at each load level by overlaying the graph of Figure 263544 - 1 with the 270 VDC test data, and Figure 263544 - 2 with the 28 VDC test data.

g. Include harmonic frequency spectrum analysis depicting harmonic order across the range of individual harmonic occurrence, and harmonic magnitude for each load condition in the test reports. Conduct tests at the unit's input terminals (to the 37th harmonic) per IEEE standards. Output voltage distortion spectrum analysis must be measured out to 500,000 Hz per MIL-STD-704.

h. Overload: Operate at nominal input voltage and output voltage with loads as listed below:

Percent of Full Load	Satisfactory Operating Time	Time Between Overloads	Iterations
110 percent	30 minutes	2 hours	3
125 percent	5 minutes	10 minutes	3
150 percent	10 seconds	10 minutes	3
200 percent	2 seconds	5 minutes	3
250 percent	50 milliseconds	5 minutes	3

Monitor output to confirm there is no 270 VDC power interruption. After minimum operating time is achieved, unit must interrupt output power. Provide voltage and current waveforms documenting the unit's response for each test.

i. Short-circuit: Apply a bolted positive to negative fault directly to the output terminals of the unit. Conduct a minimum of three consecutive successful tests on each unit. Provide unit capable of carrying the fault current until the integral system protective devices interrupts the fault with no damage to the unit. Provide waveforms of short circuit current during short circuit tests.

j. Transient Output Voltage Recovery: Operate at the following load steps: 0 to 100 percent, 0 to 50 percent, 100 to 0 percent and 50 to 0 percent. Measure and record recovery time and output voltage deviation limits. Provide recordings or display of output voltage during transient recovery test. Verify converter is operating within specified regulation limits at each load level by overlaying the graph of Figure 263544 - 1 with the 270 VDC test data, and Figure 263544 - 2 with the 28 VDC test data.

l. Post Special Test Safety Verification: Repeat tests conducted under item a. Initial Safety Verification, to confirm safety features were not affected by previous tests.

2.7 ARC FLASH WARNING LABEL

Provide arc flash warning labels for arc flash protection in accordance with NFPA 70E and NEMA Z535.4 for the enclosures of electrical equipment that are likely to require examination, adjustment, servicing, or maintenance while energized. Locate this self-adhesive warning label on the outside of the equipment compartment doors warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated. The marking must be clearly visible to everyone, including qualified persons, before examination, adjustment, servicing, or maintenance of the equipment.

2.8 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription must identify the function and, when applicable, the position. Nameplates must be melamine plastic, 0.125 inch thick, white with black center core. Surface must be matte finish. Corners must be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be 1 by 2.5 inches. Lettering must be a minimum of 0.25 inch high normal block style.

2.9 GROUNDING AND BONDING

UL 467. Provide grounding and bonding as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and for exterior work, in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.10 CAST-IN-PLACE CONCRETE

Provide concrete associated with electrical work for other than encasement of underground ducts rated for 4000 psi minimum 28-day compressive strength unless specified otherwise. Conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

PART 3 EXECUTION

3.1 INSTALLATION

Install products to operate at 270 VDC in the same manner as specified in other sections of this specification for products operating at 60 Hz, unless indicated or specified otherwise. Conform to the requirements of NFPA 70 and IEEE C2 and to manufacturer's instructions and recommendations.

3.2 EQUIPMENT

3.2.1 Floor Mounted

Provide proper floor mounting channels and install in accordance with the manufacturer's drawings and instructions and as indicated. Align, level, and bolt units to channels to allow easy withdrawal or insertion of removable components and to permit proper operation and maintenance of equipment. When in a Class 1, Division 2 area, mount units at least 18 inches above finished floor.

3.2.2 Maintenance Platform Mounted

Install as required for floor-mounted units.

3.2.3 Grounding and Bonding

In accordance with NFPA 70 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.2.4 Grounding and Bonding - Exterior Equipment

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 25 ohms.

3.2.4.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4.2 Connections

Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors. Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.5 Foundation for Equipment and Assemblies

Mount equipment on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 8 inches thick, reinforced with a 6 by 6 inches - W2.9 by W2.9 mesh placed uniformly 4 inches from the top of the slab.

b. Place slab on a 6 inch thick, well-compacted gravel base.

c. Install slab such that top of concrete slab is approximately 4 inches above the finished grade with gradual slope for drainage.

d. Provide edges above grade with 1/2 inch chamfer.

e. Provide slab of adequate size to project at least 8 inches beyond the equipment.

Stub up conduits, with bushings, 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with equipment cable training

areas.

3.2.6 Wiring and Conduit

Provide wiring and conduit as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Use copper conductors for DC systems.

3.2.7 Manufacturer's Representative

The manufacturer's representative must place the system in operation and make necessary adjustments to ensure optimum operation of the equipment. The manufacturer's representative must have at least 2 years of practical experience in the installation and testing of 270 VDC solid state converters.

3.3 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.5 FIELD APPLIED PAINTING

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance to manufacturer's instructions ***as specified in Section 09 96 00 HIGH-PERFORMANCE COATINGS.***.

3.6 FIELD QUALITY CONTROL

3.6.1 Field Test Schedule

Give Contracting Officer 30 days notice of dates, times and scheduled tests which require the presence of the Contracting Officer. The Contracting Officer will coordinate with the using activity and schedule a time that will eliminate or minimize interruptions and interference with the activity operations.

3.6.2 Instruments

Provide test instruments capable of measuring and recording or displaying test data at a higher resolution and greater accuracy than specified for the converter's performance. The test instruments used in the field tests must have current valid calibration stickers issued by an approved calibration laboratory. Verify calibration and adjustments of converter instruments provided prior to field tests. Calibrate instruments for 270 VDC operation when measuring 270 VDC signals.

3.6.3 Initial Inspection and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests. In addition, coordinate with the NETA ATS representative to witness, document, and validate the converter Field Quality Control.

a. Compare equipment nameplate information with specifications and approved shop drawings.

b. Inspect physical and mechanical condition. Inspect cables and wiring harnesses for damage and strain relief.

c. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey. Perform thermographic survey while the unit is at full load during the loadbank test.

d. Perform specific inspections and mechanical tests as recommended by manufacturer.

e. Verify correct equipment grounding.

3.6.4 Field Performance Checks and Tests

Conduct converter field checks and tests under the supervision of the manufacturer's representative. Provide labor, equipment, test instruments, and incidentals required for the tests including load banks, except the Government will furnish the electricity.

All tests must be performed with the load connected to the load end of the specified aircraft cable assembly. The cable must be laid out / uncoiled to provide heat dissipation. No adjustment to the converter is allowed between tests. Successfully complete the safety verification, preliminary operation, and the control and protective devices check prior to performing load and transient tests. Load tests must be performed with the converter doors closed and the 28 VDC at full load. If the converter fails to operate within the specified limits during any of the tests, discontinue the test, make necessary repairs to correct the failure, and restart testing of the converter. Repeat all previously completed tests and document the respective failed test data and new data.

3.6.4.1 Initial Safety Verification

Perform tests and checks to validate the safe and timely shutdown for each condition (for the power source and the output cable) identified in paragraph SAFETY FUNCTIONS. As an exception, a representative fault test will be sufficient at this time.

3.6.4.2 Preliminary Operation

Inspect the converter and make adjustments necessary to assure proper operation in accordance with the manufacturer's instructions. Operate converter at 0, 25, 50, 75, and 100 percent of rated full load. On the input measure and record the voltage, current, frequency, and THDs (voltage and current) at each load. On both the 270 VDC and the 28 VDC outputs, measure and record the voltage, current, DC ripple, distortion spectrum, and distortion factor at each load. Verify converter is operating within specified regulation limits at each load level by overlaying the graph of Figure 263544 - 1 with the 270 VDC test data, and Figure 263544 - 2 with the 28 VDC test data. Verify the operation of the 28 VDC Interlock Power.

Test data must include input voltage and current harmonic distortion

amplitudes of all individual harmonics presented in a spectrum analysis format up to the 15th order at the 50 percent and 100 percent load points. Output voltage distortion spectrum analysis must be measured out to 6,000 Hz.

3.6.4.3 Control and Protective Device Checks

Operate each control, switch, input/output device that is capable of being operated manually a minimum of three times, demonstrating satisfactory operation each time. Perform operation test on each protective device to ensure that devices function properly. After each operation measure and record the converter output voltage and current. Verify converter is operating within specified limits.

3.6.4.4 Load (Burn-in) Test

Operate each unit continuously a minimum of 1 hour at 100 percent rated full load. Perform a concurrent load (burn in) test for the 270 VDC and the 28 VDC loads. Measure and record the converter output voltage and current (both 270 VDC and the 28 VDC Interlock Power), at beginning, 30 minutes, and 1 hour. Verify converter is operating within specified limits. Load test must be performed with the converter doors closed and the test load connected to the converter at the cable head with specified aircraft cable assembly.

3.6.4.5 Post Load Test Verification

Repeat tests identified in paragraph PRELIMINARY OPERATION, to validate converter was not affected by the Load test. However apply loads in the reverse order (e.g. 100, 75, 50, 25, and 0 percent of the rated full load).

Conduct tests on each converter with the load connected to the load end of the specified aircraft power cable assembly. No adjustment to the converter is allowed between load tests. Monitor and record output voltage at the load end of the cable. Verify converter is operating within specified regulation limits at each load level by overlaying the graph of Figure 263544 - 1 with the 270 VDC test data, and Figure 263544 - 2 with the 28 VDC test data. In addition, verify specified performance of the line drop compensation.

3.6.4.6 Final Safety Verification

Repeat tests conducted under paragraph INITIAL SAFETY VERIFICATION to confirm safety features were not affected by previous tests.

3.6.5 Grounding System

Inspect grounding system for compliance with contract plans and specifications.

3.7 DEMONSTRATION

3.7.1 Instructing Government Personnel

Provide field training to Government personnel on the operation and maintenance of the converter provided at the same time as the Field Acceptance Testing. For Navy projects contact NAWCAD Air Vehicle Electrical Power Systems Group (AB43) at (301) 342-4161 to obtain the name and e-mail of the NAVAIR point-of-contact so they can attend the

training. Coordinate with the Activity to establish availability and non-availability to train on actual aircraft. Include up to a maximum of 2 hours of instruction on operation and up to a maximum of 4 hours of repair and maintenance of the converters. The instructor must be approved by the manufacturer of the unit provided. Submit training syllabus including each topic of training and a brief outline of each topic to the Contracting Officer at least 4 weeks prior to training for approval.

Training must be approved by the Contracting Officer at least 2 weeks in advance. The Government may record, video and audio, the training sessions and use these recordings to train personnel on the operation and maintenance of the converter system. Provide two copies of video or audio DVDs, and of any supplemental information and examples covered in the training sessions, to the Contracting Officer.

3.8 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

SECTION 26 36 23

AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH
05/20
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 602	(2007) Recommended Practice for Electric Systems in Health Care Facilities - White Book

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
NFPA 99	(2021; TIA 20-1) Health Care Facilities

	Code
NFPA 110	(2016) Standard for Emergency and Standby Power Systems

UNDERWRITERS LABORATORIES (UL)

UL 508	(2018) UL Standard for Safety Industrial Control Equipment
UL 1008	(2014) Transfer Switch Equipment
UL 1066	(2012; Reprint Mar 2017) UL Standard for Safety Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and Section 26 08 00 APPARATUS INSPECTION AND TESTING, applies to this section, with the additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Automatic Transfer Switch Drawings; G

SD-03 Product Data

Automatic Transfer Switches; G

BY-PASS/ISOLATION SWITCH (BP/IS); G

SD-06 Test Reports

Acceptance Checks and Tests; G

Functional Acceptance Tests; G

Factory Testing; G

Factory Test Reports; G

Factory Testing - Medical Facilities; G

SD-07 Certificates

Proof of Listing; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Manual, Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA, Data Package 5; G

1.4 OPERATION AND MAINTENANCE MANUAL

Assemble and bind manuals in durable, hard-covered, water resistant binders. Assemble and index the manuals per the following table of contents:

a. Manufacturer's O&M per "SD-10 Operation and Maintenance Data".

b. Catalog data required by "SD-03 Product Data"

c. Drawings required by "SD-02 Shop Drawings".

1.4.1 Additions to Operation and Maintenance Manuals

In addition to requirements of SD-10 Data Package 5, include the followings on the actual equipment provided:

a. An outline drawing, front, top, and side views.

b. Prices for spare parts and supply list.

c. Date of Purchase.

d. Corrective maintenance procedures.

e. Operating manual outlining step-by-step procedures for system startup, operation, and shutdown.

f. Include simplified wiring and control diagrams in the manual for system as installed.

g. Provide typical contact voltage drop readings under specified conditions for use during periodic maintenance. Provide instructions for determination of contact integrity.

1.5 QUALITY ASSURANCE

1.5.1 Proof of Listing

Submit proof of listing by UL 1008.

1.5.2 Automatic Transfer Switch Drawings

Include the following as a minimum:

a. An outline drawing, including front, top, and side views.

b. Provide a nameplate of corrosion-resistant material with not less than 1/8 inch tall characters showing manufacturer's name and equipment ratings. Mount nameplate to front of enclosure and meet the nameplate requirements of NEMA ICS 2.

c. Provide detail drawings that include manufacturer's name and catalog number, electrical ratings, total system transfer statement, reduced normal supply voltage at which transfer to the alternate supply is initiated, transfer delay times, short-circuit current rating, wiring

diagram, description of interconnections, testing instructions, acceptable conductor type for terminals, tightening torque for each wire connector, and other required UL 1008 markings.

d. Submit interface equipment connection diagram showing conduit and wiring between ATS and related equipment. Provide diagrams showing interlocking provisions and cautionary notes, if any.

e. Drawings are to indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

1.5.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated

1.5.4 Standard Product

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship, and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.4.1 Alternative Qualifications

Products having less than a 2-year field service record are acceptable if the manufacturer has been regularly engaged in the design and production of automatic transfer switches and if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 years prior to date of delivery to site are not acceptable.

1.5.5 Cybersecurity

The Risk Management Framework (RMF) is the process by which information systems are accredited for operation by a designated official from the Using Military Department. It is the standard process under which all DoD information systems must achieve and maintain their Authority To Operate.

Refer to Section 25 05 11.06 CYBERSECURITY FOR LIGHTING CONTROL SYSTEM for cybersecurity requirements related to automatic transfer switches.

1.6 DELIVERY AND STORAGE

Protect equipment placed in storage from humidity and temperature variations, moisture, water intrusion, dirt, dust, or other contaminants. In harsh environments where temperatures exceed non-operational parameters established within this specification, provide an environmentally controlled equipment storage facility to ensure temperature parameters are within equipment specification. Provide documentation of same to the Government when storage is implemented.

1.7 SEISMIC REQUIREMENTS

Provide seismic details conforming to Section 13 48 73, SEISMIC CONTROL FOR MISCELLANEOUS EQUIPMENT.

PART 2 PRODUCTS

2.1 AUTOMATIC TRANSFER SWITCHES

Each automatic transfer switch must be rated and marked for total system transfer and have the current and voltage ratings as indicated. Provide a switch operating mechanism that is electrically operated, have quick-make, quick-break, load break contacts, and be mechanically held in both positions. Switches utilizing circuit breakers are not acceptable. Provide an ATS that is UL listed. ATS must be manufactured and tested in accordance with applicable requirements of NEMA ICS 2, UL 1008 and UL 1066. ATS must conform to NFPA 110 for a Level 2, Type 10 system. Provide the ATS with the following characteristics:

a. Voltage: 480 volts ac.

b. Amperage: 480 amps ac. Provide an ATS with a continuous load current rating of the switch rating.

c. Number of Phases: Three.

d. Number of Wires: Four.

e. Frequency: 60 Hz.

f. Poles: Four switched. One of the poles is the neutral.

g. ATS Withstand Current Rating: Rated to withstand closing current short-circuit current of 42,000 amperes, RMS symmetrical.

h. Nonwelding Contacts: Provide contacts that are nonwelding at the available fault current rating.

i. Phase and Neutral Contacts: Provide contacts with silver alloy composition. Provide neutral contacts with the same continuous current rating as main or phase contacts.

j. Configuration. Provide an ATS for use in critical operations power systems described in NFPA 70.

k. ATS Configuration. Provide a open transition ATS.

l. Viewing Ports. Provide contacts that are viewable from the front of the device when the door is open. Comply with the requirements found in IEEE 602 and NFPA 99

2.1.1 Undervoltage Sensing - Normal/Preferred Source

Undervoltage Sensing - Normal Source. Provide undervoltage sensing for each phase in the normal/preferred source. Sense low phase-to-ground voltage on each phase. Provide sensing circuit with adjustable dropout, 75-98 percent of nominal value and adjustable pickup, 85-100 percent of nominal value. Factory set dropout value to 85 percent. Factory set pickup value to 90 percent.

2.1.2 Adjustable Time Delay - Override Transfer

Adjustable Time Delay - Override Transfer. For override of normal-source voltage sensing to delay transfer and engine starting signals. Engine starting control contacts with adjustable commit-to-start delay circuit, 0.0-6.0 seconds. Factory set at 1 second.

2.1.3 Adjustable Time Delay - Transfer to Alternate/Emergency Power Source

Adjustable Time Delay - Transfer to Alternate Power Source. Transfer to alternate power source time delay for transfer switches as indicated, adjustable 0-5 minutes. Factory set to 2 seconds. ATS is to monitor the frequency and voltage of alternate power source and transfer when frequency and voltage are stabilized.

2.1.4 Adjustable Time Delay- Re-transfer to Normal/Preferred Source

Adjustable Time Delay- Transfer to Source. Re-transfer to normal source time delay, adjustable 0-30 minutes. Factory set at 30 minutes. Time delay is automatically defeated upon loss or sustained undervoltage of alternate power source, provided that normal source has been restored.

2.1.5 Engine Shutdown Time Delay

Engine Shutdown. Provide time delay that is adjustable from 0 to 5 minutes and is factory set at 5 minutes.

2.1.6 Engine Starting Contacts

Provide 2 isolated normally closed and 2 isolated normally open contact that is rated 5 A at 250 VAC/30 VDC minimum.

2.1.7 Motor Disconnect And Timing Relay

Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.

2.1.8 Unassigned Auxiliary Contacts

Provide three normally open and three normally closed, single-pole, double-throw auxiliary contacts for each switch position rated at 10 amperes at 120 volts.

2.1.9 Front Panel Devices

Provide devices mounted on cabinet front consisting of:

a. Mode selector switch with the following positions and associated functions. Selector switch can be part of the microprocessor controller consisting of an LCD screen with a graphical interface or as a stand-alone test switch.

   (1) TEST - Simulates loss of normal/preferred source system operation.

   (2) NORMAL - Transfers system to normal/preferred source bypassing re-transfer time delay.

b. Switch position indicating lights or graphical LCD display. Indicate source to which load is connected.

c. Source-Available Monitor. Provide source-available indicating lights or graphical LCD display monitor that is labeled to show when one or both sources of power are available. If indicating lights are used, then the prefernce is to have Green be normal/preferred power and Red be for alternate/emergency power; however, other color schemes are allowes if clearly marked.

d. Provide a transfer override switch. Provide automatic transfer switch microprocess or based controller, which offers field selectable/adjustable inputs and outputs for transfer switch operation. Override switch must bypass automatic transfer controls so ATS will transfer and remain connected to emergency power source, regardless of condition of normal/preferred source. Provide an indicating light to show override status. If emergency source fails and normal source is available, ATS is to automatically retransfer to normal source.

e. Lamp test button.

2.1.10 Voltage Unbalance

Provide automatic transfer switch controller or control logic to include positive and negative sequence voltage detection to identify a phase loss condition that can adversely effect motor loads.

2.2 BY-PASS/ISOLATION SWITCH (BP/IS)

Include load-break by-pass/isolation switches for the indicated automatic transfer switches that are arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined by-pass/isolation switch and automatic transfer switch:

a. Bypass/isolation switch (BP/IS) and associated ATS are to be made by the same manufacturer and must be completely interconnected and tested at factory and at project site as specified.

b. ATS is to be manufactured, listed and tested in accordance with paragraph AUTOMATIC TRANSFER SWITCH. BP/IS switch current, voltage, closing, and short-circuit withstand closing ratings are to be equal or exceed comparable ratings specified for ATS and have the same phase arrangement and number of poles.

c. Provide externally operated and arranged selector switch or handle so designed and constructed not to stop in an intermediate or neutral position during operation and that one person can safely bypass the ATS. Accomplish isolation of the ATS externally by one person without opening a door. Provide interlocks that ensure ATS is disconnected from source and load during isolation. Interlocks prevent ATS operation, except for testing and mainteance, while isolated. BP/IS operation is to be accomplished without disconnecting switch load terminal conductors.

d. Provide drawout transfer switch that provides physical separation from bypass switch and live parts and accessibility for testing and maintenance operation.

e. Provide contacts that have the same contact temperature that do not exceed those of the ATS contacts when carrying rated load. Provide contacts as specified for associated ATS, including provisions for inspection of contacts without disassembly of BP/IS or removal of entire contact enclosure. Provide manufacturer instructions for determining contact integrity in order To facilitate maintenance.

f. The ATS controls remain functional with the ATS isolated or in bypass mode to permit monitoring of the normal power source and automatic starting of the generator in the event of a loss of the normal power source. In the isolated mode, the bypass section is capable of functioning as a manual transfer or automatic switch to transfer the load to either power source. The ATS can be completely removed from the enclosure, if required for maintenance or repair, while the bypass section continues to power the load.

h. Construct Bypass/isolation switch for convenient removal of parts from front of switch enclosure without removal of other parts or disconnection of external power conductors.

i. Achieve load by-pass to the source with no load interruption or a load interruption of not more than 0.16 seconds unless the time delay (neutral time delay) option is used.

j. Provide drawout bypass switch that provides physical separation from ATS and live parts and accessibility for testing and maintenance operation.

k. Provide a means to ensure the switch is transferred to the alternate or emergency power source when normal power source becomes unavailable.

2.2.1 Markings

Mark isolation handle positions with engraved plates or other approved means to indicate position or operating condition of associated ATS, as follows:

a. Provide an indication that shows that BP/IS section is providing power

to the load.

b. Provide indication of ATS isolation/test position.

c. Provide suitable control labels and instruction signs describing operating instructions.

d. Indicating lamps or LCD screen for indicating that shows the source availability, bypass switch position, transfer switch position, and isolation handle position. If indicating lights are used, provide a lamp test button that turns the indicating lights on, but does not cause any function to take place.

2.2.2 Interconnection

Interconnect BP/IS and associated ATS with suitably sized copper bus bars silver-plated at each connection point, and braced to withstand magnetic and thermal forces created at withstand current rating specified for associated ATS.

2.3 ENCLOSURE

Provide an enclosure that meets the following:

a. Provide ATS and accessories in a wall-mounted, unventilated NEMA 250, Type 1, smooth sheet metal enclosure constructed in accordance with applicable requirements of NEMA ICS 6, UL 508, UL 1066, and UL 1008. Provide door with suitable hinges, locking handle latch, and gasketed jamb. Provide at least No. 14 metal gauge.

b. Factory wiring within enclosure and field wiring terminating within enclosure must comply with NFPA 70. Provide wire that is permanently tagged or marked near terminal at each end with wire number shown on approved detail drawing, when wiring is not color coded. Conform terminal block to NEMA ICS 4. Arrange terminals for entrance of external conductors from top and bottom of enclosure as shown. Main switch terminals, including neutral terminal if used, must be pressure type suitable for termination of external copper conductors shown.

2.3.1 Construction

Construct enclosure for ease of removal and replacement of ATS components and control devices from front without disconnection of external power conductors or removal or disassembly of major components.

2.3.2 Cleaning and Painting

Protect both the inside and outside surfaces of an enclosure, including means for fastening against corrosion by enameling, galvanizing, plating, powder coating, or other equivalent means. Protection is not required for metal parts that are inherently resistant to corrosion, bearings, sliding surfaces of hinges, or other parts where such protection is impractical. Provide manufacturer's standard finish material, process, and color that is free from runs, sags, peeling, or other defects. An enclosure marked Type 1, 3R, 4 or 12 is acceptable if there is no visible rust at the conclusion of a salt spray (fog) test using the test method in ASTM B117, employing a 5 percent by weight, salt solution for 24 hours. Type 4X enclosures are acceptable following performance of the above test with an exposure time of 200 hours.

2.3.3 Field Fabricated Nameplates

Nameplate is to comply with ASTM D709. Provide laminated plastic nameplates for each equipment enclosure as specified or as indicated on the drawings. Provide an inscription on each nameplate that identifies the name of the equipment, sources of power, calculated short circuit with date and the location e.g. 'SWB-1 Electrical Room 103'. Provide nameplates that are made of melamine plastic, 0.125 inch thick, white with black center core. Provide the nameplate with a surface that is matte finished and that has square corners.. Accurately align lettering and engrave into the core. Provide nameplates that are at least 1.0 by 2.5 inches with a minimum lettering size of 0.25 inch high normal block style.

2.4 REMOTE ANNUNCIATOR PANEL

Provide a remote annunciator panel that utilizes a touchscreen human machine interface (HMI). Minimum screen size is 7 inches. The annunciator is to be configured to handle 1 transfer switches. Provide a surface mounted cabinet. Provide built-in power supply that accepts either 24 VDC or 120VAC. Provide a remote annunciation panel to annunciate the following conditions for the indicated transfer switch(es).

a. Sources available

b. Switch position.

c. Switch in test mode.

d. Failure of communication link.

2.5 FACTORY TESTING

Submit a description of proposed field test procedures, including proposed date and steps describing each test, its duration and expected results, not less than 2 weeks prior to test date. Submit certified factory and field test reports, within 14 days following completion of tests. Provide reports that are certified and dated and that demonstrate that tests were successfully completed prior to shipment of equipment.

2.5.1 Prototype Factory Testing

A prototype of specified ATS is to be factory tested in accordance with UL 1008. In addition, perform factory tests on each ATS as follows:

a. Insulation resistance test to ensure integrity and continuity of entire system

b. Main switch contact resistance test.

c. Visual inspection to verify that each ATS is as specified.

d. Mechanical test to verify that ATS sections are free of mechanical hindrances.

e. Electrical tests to verify complete system electrical operation and to set up time delays and voltage sensing settings.

2.5.2 Factory Test Reports

Provide three certified copies of factory test reports from the manufacturer.

2.6 FACTORY TESTING -MEDICAL FACILITIES

The factory tests for ATS and By-Pass/Isolation switches used in medical facilities must be conducted in the following sequence:

a. General

b. Normal

c. Overvoltage

d. Undervoltage

e. Overload

f. Endurance

g. Temperature Rise

h. Dielectric Voltage-Withstand

i. Contact Opening

j. Dielectric Voltage-Withstand (Repeated)

k. Withstand

l. Instrumentation and Calibration of High Capacity

m. Closing

n. Dielectric Voltage-Withstand (Repeated)

o. Strength of Insulating Base and Support

PART 3 EXECUTION

3.1 INSTALLATION

Installation must conform to the requirements of NFPA 70 and manufacturer's recommendation.

3.2 PREREQUISITES FOR FUNCTIONAL ACCEPTANCE TESTING

Completion of the following requirements is mandatory prior to scheduling functional acceptance tests for the automatic transfer switch.

3.2.1 Performance of Acceptance Checks and tests

Complete as specified in paragraph entitled "Acceptance Checks and Tests". The Acceptance Checks and Tests are to be accomplished by the Testing organization as described in Section 26 08 00 APPARATUS INSPECTION AND TESTING.

3.2.2 Manufacturers O&M Information

The manufacturers O&M information required by the paragraph entitled "SD-10 Operation and Maintenance Data", is to be submitted to and approved by the Contracting Officer.

3.2.3 Test Equipment

Ensure all test equipment and instruments is on hand prior to scheduling field tests, or subject to Contracting Officer's approval, evidence must be provided to show that arrangements have been made to have the necessary equipment and instruments on site prior to field testing.

3.3 FIELD APPLIED PAINTING

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance to manufacturer's instructions as specified in Section 09 96 00 HIGH-PERFORMANCE COATINGS.

3.4 FIELD QUALITY CONTROL

Give Contracting Officer 15 days notice of dates and times scheduled for tests which require the presence of the Contracting Officer. The Contracting Officer will coordinate with the using activity and schedule a time that will eliminate or minimize interruptions and interference with the activity operations. The contractor is responsible for costs associated with conducting tests outside of normal working hours and with incorporating special arrangements and procedures, including temporary power conditions. The contractor provides labor, equipment, apparatus, including test load, and consumables required for the specified tests. Calibration of all measuring devices and indicating devices must be certified. Provide the services of a qualified factory-trained manufacturer's representative to assist the contractor in installation and start-up of the equipment specified under this section. The manufacturer's representative is to provide technical direction and assistance to the contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly components contained herein. Provide a test load that is a cataloged product in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Perform the following field tests in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.4.1 Automatic Transfer Switch Acceptance Checks and Tests

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Confirm correct application of manufacturer's recommended lubricants.

(4) Verify that manual transfer warnings are attached and visible.

(5) Verify tightness of all control connections.

(6) Verify tightness of accessible bolted connections by calibrated torque-wrench method. Thermographic survey is not required.

(7) Perform manual transfer operation.

(8) Verify positive mechanical interlocking between normal and alternate sources.

b. Electrical Tests

(1) Measure contact-resistance. Correct values that exceed 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.

(2) Perform insulation-resistance on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole for one minute. Perform tests in both source positions.

(3) Verify settings and operations of control devices.

(4) Calibrate and set all relays and timers.

(5) Test ground-fault protective device.

3.4.2 Functional Acceptance Tests

Functional Acceptance Tests must be coordinated with Section 26 32 15.00 ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES. Include simulating power failure and demonstrating the following operations for each automatic transfer switch. Demonstrate in service that the automatic transfer switches are in good operating condition, and function not less than five times.

a. Perform automatic transfer tests:

(1) Simulate loss of normal/preferred power.

(2) Return to normal/preferred power.

(3) Simulate loss of emergency/alternate power.

(4) Simulate all forms of single-phase conditions.

b. Verify correct operation and timing of the following functions:

(1) Normal source voltage-sensing relays.

(2) Engine start sequence.

(3) Time delay upon transfer.

(4) Alternate source voltage-sensing relays.

(5) Automatic transfer operation.

(6) Interlocks and limit switch function.

(7) Time delay and retransfer upon normal power restoration.

(8) By-pass/isolation functional modes and related automatic transfer switch operations.

3.4.3 Infrared Scanning

After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after acceptance.

b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

c. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 TRAINING

Provide 4 hours of training to maintenance personnel on the proper operation, maintenance and adjustment of the automatic transfer switch. Coordinate this training with that of the generator equipment.

3.6 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

SECTION 26 41 00

LIGHTNING PROTECTION SYSTEM
11/13
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
NFPA 780	(2017) Standard for the Installation of Lightning Protection Systems

UNDERWRITERS LABORATORIES (UL)

UL 96	(2016a) UL Standard for Safety Lightning Protection Components
UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL Electrical Construction	(2012) Electrical Construction Equipment Directory

1.2 RELATED REQUIREMENTS

1.2.1 Verification of Dimensions

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before making any departures from the design.

1.2.2 System Requirements

Provide a system furnished under this specification consisting of the latest UL Listed products of a manufacturer regularly engaged in production of lightning protection system components. Comply with NFPA 70, NFPA 780, and UL 96.

1.2.3 Lightning Protection System Installers Documentation

Provide documentation showing that the installer is certified with a commercial third-party inspection company whose sole work is lightning protection, or is a UL Listed Lightning Protection Installer. In either case, the documentation must show that they have completed and passed the requirements for certification or listing, and have a minimum of 2 years documented experience installing lightning protection systems for DoD projects of similar scope and complexity.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Overall lightning protection system; G

Each major component; G

SD-06 Test Reports

Lightning Protection and Grounding System Test Plan; G

Lightning Protection and Grounding System Test; G

SD-07 Certificates

Lightning Protection System Installers Documentation; G

Component UL Listed and Labeled; G

Lightning protection system inspection certificate; G

Roof manufacturer's warranty; G

1.4 QUALITY ASSURANCE

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "must" has been substituted for "should" wherever it appears. Interpret references in these standards to "authority having jurisdiction," or words of similar meaning, to mean Contracting Officer.

1.4.1 Installation Drawings

1.4.1.1 Overall System Drawing

Submit installation shop drawing for the overall lightning protection system. Include on the drawings the physical layout of the equipment (plan view and elevations), mounting details, relationship to other parts of the work, and wiring diagrams.

1.4.1.2 Major Components

Submit detail drawings for each major component including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions.

1.4.2 Component UL Listed and Labeled

Submit proof of compliance that components are UL Listed and Labeled. Listing alone in UL Electrical Construction, which is the UL Electrical Construction Directory, is not acceptable evidence. In lieu of Listed and Labeled, submit written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that items have been tested and conform to requirements and testing methods of Underwriters Laboratories.

1.4.3 Lightning Protection and Grounding System Test Plan

Provide a lightning protection and grounding system test plan. Detail both the visual inspection and electrical testing of the system and components in the test plan. Identify (number) the system test points/locations along with a listing or description of the item to be tested and the type of test to be conducted. As a minimum, include a sketch of the facility and surrounding lightning protection system as part of the specific test plan for each structure. Include the requirements specified in paragraph, "Testing of Integral Lightning Protection System" in the test plan.

1.4.4 Lightning Protection System Inspection Certificate

Provide certification from a commercial third-party inspection company whose sole work is lightning protection, stating that the lightning protection system complies with NFPA 780. Third party inspection company cannot be the system installer or the system designer. Alternatively, provide a UL Lightning Protection Inspection Master Label Certificate for each facility indicating compliance to NFPA 780.

Inspection must cover every connection, air terminal, conductor, fastener, accessible grounding point and other components of the lightning protection system to ensure 100% system compliance. This includes witnessing the tests for the resistance measurements for ground rods with test wells, and for continuity measurements for bonds. It also includes verification of proper surge protective devices for power, data and telecommunication systems. Random sampling or partial inspection of a facility is not acceptable.

1.5 SITE CONDITIONS

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before changing the design.

PART 2 PRODUCTS

2.1 MATERIALS

Do not use a combination of materials that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture unless moisture is permanently excluded from the junction of such metals.

Where unusual conditions exist which would cause corrosion of conductors, provide conductors with protective coatings, such as tin or lead, or oversize conductors. Where a mechanical hazard is involved, increase conductor size to compensate for the hazard or protect conductors. When metallic conduit or tubing is provided, electrically bond conductor to conduit or tubing at the upper and lower ends by clamp type connectors or welds (including exothermic). All lightning protection components, such as bonding plates, air terminals, air terminal supports and braces, chimney bands, clips, connector fittings, and fasteners are to comply with the requirements of UL 96 classes as applicable.

2.1.1 Main and Bonding Conductors

NFPA 780 and UL 96 Class I, Class II, or Class II modified materials as applicable.

2.1.2 Material

Provide aluminum air terminals, conductors and non-penatrating clamp connectors on metal roof and wall panels where located 1 ft. 8 inches above finished first floor (AFF). Provide system supports masonry type anchors at conrete and masonry. Provide bi-metallic connectors mounted 1 ft. 8 inches AFF to centerline. Provide copper only below 1 ft. 8 inches AFF. Provide copper conductors except where aluminum conductors are required for connection to aluminum equipment. For ESC C3, C4, or C5 environments, do not use aluminum air terminals or conductors. Provide system support masonry type anchors at concrete and masonry.

2.2 COMPONENTS

2.2.1 Air Terminals

Provide solid air terminals with a blunt tip. Tubular air terminals are not permitted. Support air terminals more than 24 inches in length by suitable brace, supported at not less than one-half the height of the terminal.

2.2.2 Ground Rods

Provide ground rods made of copper-clad steel conforming to conform to UL 467. Provide ground rods that are not less than 3/4 inch in diameter and 10 feet in length. Do not mix ground rods of copper-clad steel or solid copper on the job.

2.2.3 Connections and Terminations

Provide connectors for splicing conductors that conform to UL 96, class as applicable. Conductor connections can be made by clamps or welds (including exothermic). Provide style and size connectors required for the installation.

2.2.4 Connector Fittings

Provide connector fittings for "end-to-end", "Tee", or "Y" splices that conform to NFPA 780 and UL 96.

PART 3 EXECUTION

3.1 INTEGRAL SYSTEM

Provide a lightning protection system that meets the requirements of NFPA 780. Lightning protection system consists of air terminals, roof conductors, down conductors, ground connections, grounding electrodes and ground ring electrode conductor. Bond secondary conductors with grounded metallic parts within the building. Make interconnections within side-flash distances at or below the level of the grounded metallic parts.

3.1.1 Roof-Mounted Components

Coordinate with the roofing manufacturer and provide certification that the roof manufacturer's warranty is not violated by the installation methods for air terminals and roof conductors.

3.1.1.1 Air Terminals

Use adhesive shoes with adhesive approved by the roof manufacturer when installing air terminals on "rubber" (EPDM) type roofs. In areas of snow or constant wind, ensure that a section of roofing material (minimum dimensional area of 1 square foot) is first glued to the roof and then the air terminal is glued to it unless the roof manufacturer recommends another solution. Use a standing seam base for installation of air terminals on a standing seam metal roof that does not produce any roof penetrations.

3.1.1.2 Roof Conductors

Use adhesive shoes with adhesive approved by the roof manufacturer when installing roof conductors on "rubber" (EPDM) type roofs. Use a standing seam base for installation of roof conductors on a standing seam metal roof that does not produce any roof penetrations.

3.1.2 Down Conductors

Protect exposed down conductors from physical damage as required by NFPA 780. Use Schedule 80 PVC to protect down conductors. Paint the Schedule 80 PVC to match the surrounding surface with paint that is approved for use on PVC. Down conductors are to be concealed within the wall cavities.

3.1.3 Ground Connections

Attach each down conductor and ground ring electrode to ground rods by welding (including exothermic), brazing, or compression. All connections to ground rods below ground level must be by exothermic weld connection or with a high compression connection using a hydraulic or electric compression tool to provide the correct circumferential pressure. Accessible connections above ground level and in test wells can be accomplished by mechanical clamping.

3.1.4 Grounding Electrodes

Extend driven ground rods vertically into the existing undisturbed earth for a distance of not less 10 feet. Set ground rods not less than 3 feet nor more than 8 feet, from the structure foundation, and at least beyond the drip line for the facility. After the completed installation, measure

the total resistance to ground using the fall-of-potential method described in IEEE 81. Maximum allowed resistance of a driven ground rod is 25 ohms, under normally dry conditions. Contact the Contracting Officer for direction on how to proceed when two of any three ground rods, driven not less than 10 feet into the ground, a minimum of 10 feet apart, and equally spaced around the perimeter, give a combined value exceeding 50 ohms immediately after having driven. For ground ring electrode, provide continuous No. 1/0 bare stranded copper cable. Lay ground ring electrode around the perimeter of the structure in a trench not less than 3 feet nor more than 8 feet from the nearest point of the structure foundation, and at least beyond the drip line for the facility. Install ground ring electrode to a minimum depth of 30 inches. Install a ground ring electrode in earth undisturbed by excavation, not earth fill, and do not locate beneath roof overhang, or wholly under paved areas or roadways where rainfall cannot penetrate to keep soil moist in the vicinity of the cable.

3.1.5 Grounding Plates

Provide a grounding plate for each down conductor. Set grounding plates not less than 3 feet nor more than 8 feet, from the structure foundation, and at least beyond the drip line for the facility. Grounding plate is to be buried as deeply in the existing dirt as local conditions allow, without exceeding 10 feet in depth.

3.2 APPLICATIONS

3.2.1 Nonmetallic Exterior Walls with Metallic Roof

Bond metal roof sections together which are insulated from each other so that they are electrically continuous, having a surface contact of at least 3 square inches.

3.3 INTERFACE WITH OTHER STRUCTURES

3.3.1 Fences

Bond metal fence and gate systems to the lightning protection system whenever the fence or gate is within 6 feet of any part of the lightning protection system in accordance with ANSI C2.

3.4 FIELD QUALITY CONTROL

3.4.1 Lightning Protection and Grounding System Test

Test the lightning protection and grounding system to ensure continuity is not in excess of 1 ohm and that resistance to ground is not in excess of 25 ohms. Provide documentation for the measured values at each test point. Test the ground rod for resistance to ground before making connections to the rod. Tie the grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Include in the written report: locations of test points, measured values for continuity and ground resistances, and soil conditions at the time that measurements were made. Submit results of each test to the Contracting Officer.

3.5 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section

01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 27 10 00

BUILDING TELECOMMUNICATIONS CABLING SYSTEM
08/11
AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E	(2005) Cabinets, Racks, Panels, and Associated Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-83-596	(2016) Indoor Optical Fiber Cables
ICEA S-90-661	(2012) Category 3, 5, & 5e Individually Unshielded Twisted Pair Indoor Cables for Use in General Purpose and LAN Communications Wiring Systems Technical Requirements

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA/BICSI 568	(2006) Standard for Installing Building Telecommunications Cabling

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA WC 66	(2019) Performance Standard for Category 6 and Category 7 100 Ohm Shielded and Unshielded Twisted Pairs

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-455-21	(1988a; R 2012) FOTP-21 - Mating Durability of Fiber Optic Interconnecting Devices
TIA-526-7	(2015a) OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
TIA-526-14	(2015c) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
TIA-568-C.0	(2009; Add 1 2010; Add 2 2012) Generic Telecommunications Cabling for Customer Premises
TIA-568-C.1	(2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard
TIA-568-C.2	(2009; Errata 2010; Add 2 2014; Add 1 2016) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568-C.3	(2008; Add 1 2011) Optical Fiber Cabling Components Standard
TIA-569	(2015d) Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-606	(2017c) Administration Standard for the Telecommunications Infrastructure
TIA-607	(2015c; Addendum 1 2017) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA/EIA-598	(2014D; Add 2 2018) Optical Fiber Cable Color Coding
TIA/EIA-604-3	(2004b; R 2014) Fiber Optic Connector Intermateability Standard (FOCIS), Type SC and SC-APC, FOCIS-3
TIA/EIA-606	***(2017) Cable Labeling Standards***

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 345-83	(1979; Rev Oct 1982) Gas Tube Surge Arrestors (PE-80)

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 68	Connection of Terminal Equipment to the Telephone Network (47 CFR 68)

UNDERWRITERS LABORATORIES (UL)

UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 94	(2013; Reprint Jun 2020) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 444	(2008; Reprint Apr 2015) Communications Cables
UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 497	(2001; Reprint Jul 2013) Protectors for Paired Conductor Communication Circuits
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 969	(2017; Reprint Mar 2018) UL Standard for Safety Marking and Labeling Systems
UL 1286	(2008; Reprint Jan 2018) UL Standard for Safety Office Furnishings
UL 1666	(2007; Reprint Jun 2012) Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
UL 1863	(2004; Reprint Oct 2019) UL Standard for Safety Communication Circuit Accessories

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and Section 33 82 00 TELECOMMUNICATIONS, OUTSIDE PLANT (OSP), apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, TIA-569, TIA-606 and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect (MC).)

1.3.2 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International

expression for intermediate cross-connect (IC).)

1.3.3 Floor Distributor (FD)

A distributor used to connect horizontal cable and cabling subsystems or equipment. (International expression for horizontal cross-connect (HC).)

1.3.4 Telecommunications Room (TR)

An enclosed space for housing telecommunications equipment, cable, terminations, and cross-connects. The room is the recognized cross-connect between the backbone cable and the horizontal cabling.

1.3.5 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including wireless) including the entrance point at the building wall and continuing to the equipment room.

1.3.6 Equipment Room (ER) (Telecommunications)

An environmentally controlled centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.7 Open Cable

Cabling that is not run in a raceway as defined by NFPA 70. This refers to cabling that is "open" to the space in which the cable has been installed and is therefore exposed to the environmental conditions associated with that space.

1.3.8 Open Office

A floor space division provided by furniture, moveable partitions, or other means instead of by building walls.

1.3.9 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The building telecommunications cabling and pathway system shall include permanently installed backbone and horizontal cabling, horizontal and backbone pathways, service entrance facilities, work area pathways, telecommunications outlet assemblies, conduit, raceway, and hardware for splicing, terminating, and interconnecting cabling necessary to transport telephone and data (including LAN) between equipment items in a building. The horizontal system shall be wired in a star topology from the telecommunications work area to the floor distributor or campus distributor at the center or hub of the star. The backbone cabling and pathway system includes intrabuilding and interbuilding interconnecting cabling, pathway, and terminal hardware. The intrabuilding backbone provides connectivity from the floor distributors to the building distributors or to the campus distributor and from the building distributors to the campus distributor as required. The backbone system

shall be wired in a star topology with the campus distributor at the center or hub of the star. The interbuilding backbone system provides connectivity between the campus distributors and is specified in Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP). Provide telecommunications pathway systems referenced herein as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications drawings; G

Telecommunications Space Drawings; G

In addition to Section 01 33 00 SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

Distribution Frames

SD-03 Product Data

Telecommunications cabling (backbone and horizontal); G

Patch panels; G

Telecommunications outlet/connector assemblies; G

Equipment support frame; G

Connector blocks; G

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Include performance and characteristic curves. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Telecommunications cabling testing; G

SD-07 Certificates

Telecommunications Contractor Qualifications; G

Key Personnel Qualifications; G

Manufacturer Qualifications; G

Test plan; G

SD-09 Manufacturer's Field Reports

Factory reel tests; G

SD-10 Operation and Maintenance Data

Telecommunications cabling and pathway system Data Package 5; G

SD-11 Closeout Submittals

Record Documentation; G

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

In exception to Section 01 33 00 SUBMITTAL PROCEDURES, submitted plan drawings shall be a minimum of 11 by 17 inches in size using a minimum scale of 1/8 inch per foot, except as specified otherwise. Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Drawings

Provide registered communications distribution designer (RCDD) approved, drawings in accordance with TIA-606. The identifier for each termination and cable shall appear on the drawings. Drawings shall depict final telecommunications installed wiring system infrastructure in accordance with TIA-606. The drawings should provide details required to prove that the distribution system shall properly support connectivity from the EF telecommunications and ER telecommunications, CD's, BD's, and FD's to the telecommunications work area outlets. Provide a plastic laminated schematic of the as-installed telecommunications cable system showing cabling, CD's, BD's, FD's, and the EF and ER for telecommunications keyed to floor plans by room number. Mount the laminated schematic in the EF telecommunications space as directed by the Contracting Officer. The following drawings shall be provided as a minimum:

a. T1 - Layout of complete building per floor - Building Area/Serving Zone Boundaries, Backbone Systems, and Horizontal Pathways. Layout of complete building per floor. The drawing indicates location of building areas, serving zones, vertical backbone diagrams, telecommunications rooms, access points, pathways, grounding system, and other systems that need to be viewed from the complete building perspective.

b. T2 - Serving Zones/Building Area Drawings - Drop Locations and Cable

Identification (ID'S). Shows a building area or serving zone. These drawings show drop locations, telecommunications rooms, access points and detail call outs for common equipment rooms and other congested areas.

c. T4 - Typical Detail Drawings - Faceplate Labeling, Firestopping, Americans with Disabilities Act (ADA), Safety, Department of Transportation (DOT). Detailed drawings of symbols and typicals such as faceplate labeling, faceplate types, faceplate population installation procedures, detail racking, and raceways.

1.6.1.2 Telecommunications Space Drawings

Provide T3 drawings in accordance with TIA-606 that include telecommunications rooms plan views, pathway layout (cable tray, racks, ladder-racks, etc.), mechanical/electrical layout, and cabinet, rack, backboard and wall elevations. Drawings shall show layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks, patch panels and equipment spaces and cabinet/racks. Drawings shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings.

1.6.1.3 Distribution Frames

Provide shop drawing showing layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks and equipment spaces and racks.

1.6.2 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, and the supervisor (if different from the installer). A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems within the past 3 years of similar scope and size. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor.

1.6.2.2 Key Personnel

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of

the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Supervisors and installers assigned to the installation of this system or any of its components shall be Building Industry Consulting Services International (BICSI) Registered Cabling Installers, Technician Level. Submit documentation of current BICSI certification for each of the key personnel.

In lieu of BICSI certification, supervisors and installers assigned to the installation of this system or any of its components shall have a minimum of 3 years experience in the installation of the specified copper and fiber optic cable and components. They shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications systems and provide the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor's key personnel requires approval from The Contracting Officer.

1.6.2.3 Minimum Manufacturer Qualifications

Cabling, equipment and hardware manufacturers shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with TIA-568-C.1, TIA-568-C.2 and TIA-568-C.3.

1.6.3 Test Plan

Provide a complete and detailed test plan for the telecommunications cabling system including a complete list of test equipment for the

components and accessories for each cable type specified, 60 days prior to the proposed test date. Include procedures for certification, validation, and testing.

1.6.4 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.5 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.5.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 DELIVERY AND STORAGE

Provide protection from weather, moisture, extreme heat and cold, dirt, dust, and other contaminants for telecommunications cabling and equipment placed in storage.

1.8 ENVIRONMENTAL REQUIREMENTS

Connecting hardware shall be rated for operation under ambient conditions of32 to 140 degrees F and in the range of 0 to 95 percent relative humidity, noncondensing.

1.9 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis

during the warranty period of the contract.

1.10 MAINTENANCE

1.10.1 Operation and Maintenance Manuals

Commercial off the shelf manuals shall be furnished for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications cabling and pathway system, Data Package 5. Submit operations and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein not later than 2 months prior to the date of beneficial occupancy. In addition to requirements of Data Package 5, include the requirements of paragraphs TELECOMMUNICATIONS DRAWINGS, TELECOMMUNICATIONS SPACE DRAWINGS, and RECORD DOCUMENTATION. Ensure that these drawings and documents depict the as-built configuration.

1.10.2 Record Documentation

Provide T5 drawings including documentation on cables and termination hardware in accordance with TIA-606. T5 drawings shall include schedules to show information for cut-overs and cable plant management, patch panel layouts and cover plate assignments, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided on electronic media using Windows based computer cable management software. A licensed copy of the cable management software including documentation, shall be provided. Provide the following T5 drawing documentation as a minimum:

a. Cables - A record of installed cable shall be provided in accordance with TIA-606. The cable records shall include the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility in accordance with TIA-606. Include manufacture date of cable with submittal.

b. Termination Hardware - A record of installed patch panels, cross-connect points, distribution frames, terminating block arrangements and type, and outlets shall be provided in accordance with TIA-606. Documentation shall include the required data fields as a minimum in accordance with TIA-606.

PART 2 PRODUCTS

2.1 COMPONENTS

Components shall be UL or third party certified. Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations, submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard. Provide a complete system of telecommunications cabling and pathway components using star topology. Provide support structures and pathways, complete with outlets, cables, connecting hardware and telecommunications cabinets/racks.

Cabling and interconnecting hardware and components for telecommunications systems shall be UL listed or third party independent testing laboratory certified, and shall comply with NFPA 70 and conform to the requirements specified herein.

2.2 TELECOMMUNICATIONS PATHWAY

Provide telecommunications pathways in accordance with TIA-569 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide system furniture pathways in accordance with UL 1286. Poke-Thru devices shall not be used. Provide grounding and bonding as required by TIA-607. Cable wiring shall comply with NFPA 70. All conduits entering the Telecommunications Room should be grouped and consolidated, conduits can be "Home Run" or stubbed to cable tray, all must have bonding bushing / plastic insert, and shall extend down from the ceiling 3 to 4 inches or extended to ladder rack or onto the backboard. Bond conduit to the TMGB or TGB by minimum #6 AWG green sheathed stranded conductors. All penetrations will be sealed with fire stopping material in accordance with the requirements of D-B Contractor prepared Section 07 84 00 FIRESTOPPING. A minimum of three 4 inch conduits overhead will be installed between the Main Telecommunications Room and other telecommunications.

2.2.1 Work Area Pathways

Comply with TIA-569, except minimum 1-inch diameter conduit will be used. System furniture pathways shall comply with UL 1286. Horizontal cabling for open offices shall comply with TIA-568-C.1. In system furniture that blocks access to telecommunications wall outlets: each system furniture desk/cubical shall be equipped with system furniture communications outlets that are plugged into the telecommunications wall outlets. Every port that is blocked from access shall be extended into the furniture.

2.2.2 Pull Boxes

Construct of galvanized sheet steel with screw-fastened covers. Minimum size of boxes shall be not less than standard type 5 inches square by 2 1/8-inches deep for individual 1-inch diameter conduit; minimum size of boxes shall be not less than 12 inches W by 48 inches L by 5 inches D for 3 inch conduit, 15 inches W by 60 inches L by 8 inches D for 4 inch conduit per TIA-569, provide pull boxes where length of conduit exceeds 100 feet or where there are more than two 90 degree bends, or equivalent. Align conduit ends on opposite sides of pull boxes as in a pull through, do not turn or change direction in pull boxes. Provide pull boxes in straight lengths of conduit; pull points, LC, LB, condulets are not authorized.

2.3 CONDUIT BENDS

Inside radius of conduit bend shall be a minimum of 6 times the internal diameter of conduit for conduits of 2 inches or less. Inside radius of conduit bend shall be a minimum of 10 times the internal diameter of conduit for conduits larger than 2 inches.

2.4 TELECOMMUNICATIONS OUTLET BOXES

Telecommunications outlet boxes should be placed in all work areas and any area that can be converted to work areas; so any furniture package configuration will have a connection along the wall with a 6' base cord. Good practice is 12 inches to the left or right of every electrical outlet

box in workable office areas or any area that could be converted into workable office area such as a storage closet. Boxes shall be standard type 5 inches square by 2 7/8 inches deep for CAT6 with 1-inch diameter side knock-outs, with a single gang plaster ring. Mount flush in finished walls at height of 34 inches above finished floor or as indicated by drawings. Outlet boxes for wall-mounted telephones shall be 2 by 4 by 2 1/8 inches deep with 1 CAT6 cable terminated in a standard wall phone plate; mounted at 54 inches above finished floor. Outlet boxes for handicapped telephone station or work counter area shall be mounted at a height 48 inches above finished floor. Outlet boxes installed in floor for classrooms or open spaces shall be telecommunications floor boxes large enough to support a surge of users with proper cable protection and ports that are not parallel to the floor. Floor boxes and under slab cabling should not be used on the first floor in wet areas. Tele/electric poles or furniture managed pathways fed from above the wet area should be used. Multi-user Telecommunications Outlet Assembly i.e. Multimedia Outlet Assemblies (MUTOA) should be placed where best suited for the furniture used in open office spaces.

2.5 TELECOMMUNICATIONS CABLING

Cabling shall be UL listed for the application and shall comply with TIA-568-C.0, TIA-568-C.1, TIA-568-C.2, TIA-568-C.3 and NFPA 70. Provide a labeling system for cabling as required by TIA-606 and UL 969. Ship cable on reels or in boxes bearing manufacture date for for unshielded twisted pair (UTP) in accordance with ICEA S-90-661 and optical fiber cables in accordance with ICEA S-83-596 for all cable used on this project. Cabling manufactured more than 12 months prior to date of installation shall not be used.

2.5.1 Backbone Cabling

2.5.1.1 Backbone Copper

Copper backbone cable shall be solid conductor, 24 AWG, 100 ohm, , Category 3, UTP, pair count as indicated in accordance with ICEA S-90-661, TIA-568-C.1, TIA-568-C.2 and UL 444, formed into 25 pair binder groups covered with a gray thermoplastic jacket. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) at regular length marking intervals in accordance with ICEA S-90-661 . Provide plenum (CMP), riser (CMR), or general purpose (CM or CMG)communications rated cabling in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. Pair twist-lengths and frequency per unit length shall be determined by the manufacturer. A minimum of two conductor twists per foot is required. Color coding shall comply with industry standards for all cables. Sufficient pair counts CAT6 or (25, 50, 100, 200...)-pair UTP (Unshielded twisted pair) riser cable will be installed between the MDF and each of the BDF's. Voice Riser shall be terminated on 50 pair 66 type punch down 89D-Style Insulation Displacement Contact cross connect blocks with industry standard and 110 style jacks terminated in the patch panel’s last position. Any Backbone Copper run in under slab conduit shall be rated for outdoor use in accordance with AHJ and have lightning protection at each end.

2.5.1.2 Backbone Optical Fiber

Provide in accordance with ICEA S-83-596, TIA-568-C.3, UL 1666 and NFPA 70.

Cable shall be imprinted with fiber count, fiber type and aggregate length at regular intervals not to exceed 40 inches.

Provide the number of strands indicated, (but not less than 12 strands between the main telecommunication room and each of the other telecommunication rooms), of single-mode(OS1), tight buffered fiber optic cable.

Provide plenum (OFNP), riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598. Cable shall be imprinted with fiber count, fiber type and aggregate length at regular intervals not to exceed 40 inches. Nonconductive optical fiber Plenum (OFNP) cable may be substituted for type nonconductive optical fiber riser cable (OFNR).

Provide plenum (OFNP) riser (OFNR) , or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598.

The cable jacket shall be yellow. Terminate in a rack mounted fiber distribution center with sufficient slack for maintenance operations. A minimum slack of 9 foot in FDC and 18 foot coil on cable tray.

2.5.2 Horizontal Cabling

Provide horizontal cable in compliance with NFPA 70 and performance characteristics in accordance with TIA-568-C.1.

2.5.2.1 Horizontal Copper

Provide horizontal copper cable, UTP, 100 ohm in accordance with TIA-568-C.2, UL 444, ANSI/NEMA WC 66, ICEA S-90-661 . Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) and length marking at regular intervals in accordance with ICEA S-90-661. Provide a minimum of four cables to each work area outlet (faceplate), each individually twisted pair, 24/23 AWG conductors, Category 6A general purpose cable, with white PVC jacket for all white jacks (Telephone), and blue PVC jacket for all blue jacks (unclassified data service) NIPR. Plenum (CMP) or riser (CMR) cable may be substituted for general purpose cable. If the cabling passes through a plenum air space then plenum (CMP) rated cable is required. If the cabling is run in under slab conduit, outdoor rated cable shall be used. Contact Base Telephone via the Contracting Officer for special requirements on classified service, unclassified service, under slab cabling, using water block, and any item not covered in this document. Cable shall not run in front of any part of the Rack system but in the proper vertical management from through the cable guide. If the cable guide is too small to accommodate all the cables the next size up will be used.

2.5.2.2 Horizontal Optical Fiber

Provide optical fiber horizontal cable in accordance with ICEA S-83-596and TIA-568-C.3. Cable shall be tight buffered, single-mode, 8/125-um diameter, OS1. Cable shall be imprinted with manufacturer, flammability

rating and fiber count at regular intervals not to exceed 40 inches.

Provide plenum (OFNP), riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70.Cables installed in conduit within and under slabs be UL listed and labeled for wet locations in accordance with NFPA 70. The cable jacket shall be of single jacket construction with color coding of cordage jacket, fiber, unit, and group in accordance with TIA/EIA-598.

2.6 TELECOMMUNICATIONS SPACES

Provide connecting hardware and termination equipment in the telecommunications entrance facility to facilitate installation as shown on design drawings for terminating and cross-connecting permanent cabling. Provide telecommunications interconnecting hardware color coding in accordance with TIA-606.

2.6.1 Equipment Support Frame

Provide in accordance with ECIA EIA/ECA 310-E and UL 50.

a. Rack, wall mounted (for buildings with low jack/pair count) 16 gauge steel or 11 gauge aluminum construction treated to resist corrosion. Rack should be swing gate type, minimum 38 inches High by 25 inches Depth with standard 19 inch panel mounts. Rack must be installed in secured Telecommunication Room only.

b. Racks, floor mounted modular type, clear high-strength lightweight 11 gauge or higher aluminum construction, two top angles, alternating hole pattern, weight capacity of 1500 lbs., UL listed. Racks should be large enough to support all telephone / data equipment required plus 25 percent spare. Rack shall be compatible with 19 inches panel mounting. Racks shall be a height of 7 feet depending on the location. Provide rack with vertical and horizontal cable management channels. Vertical wire management shall be clear aluminum, 12 inches deep by 6 inches wide double-sided vertical cabling section, must have lockable cabling latches set 12 inches apart, have 2.5 inch diameter pass through ports. Front Horizontal cable management will be installed 1 per 2 patch panels and be a minimum of 2 Rack Units (RU) and of the open design. Rear Horizontal wire management will be installed 1 per 1 patch panel and be a minimum of 1 RU, rear cable management will be made to sit outward from the rack a minimum of 3 inches and have wire tie holes for maintaining proper wire relief. Rack installation will also have top and bottom cable troughs, grounding lug and a surge protected power strip with 20 amp dual-circuit rack mount receptacles. Power strip shall have two plugs with one 20 amp breakers and six color coded outlets each. Inlet plugs will be NEMA-L5-20P and the receptacles will be NEMA-5-20R. Racks must be installed in a secured Telecommunication Room only. Racks shall be clear or telco gray in color, black is not permitted.

c. Cabinets must be installed in areas that are not secured. Cabinet’s freestanding modular type, 16 gauge steel construction, minimum, treated to resist corrosion. Cabinets shall be no smaller than 24 inches W by 48 inches H by 30 inches D but can be as large as 7 foot H by 24 inches W by 39 inches D. Cabinet shall have removable and lockable side panels, front and rear doors. Cabinet shall be vented in the roof and rear door. Cabinet shall have cable access in the roof

and base and be compatible with 19 inches or 23 inches panel mounting. Provide cabinet with grounding bar, roof mounted 550 CFM fan and a surge protected power strip with 6 duplex 20 amp receptacles and cord long enough to reach dedicated building power through the top of the cabinet. All cabinets shall be lockable (keyed to current base key) and large enough to support all telephone / data equipment required in the building plus 25 percent spare. Dedicated electrical outlets should be installed on backboard within 6 feet of the cabinet. A backboard for mounting equipment is still needed when a cabinet is installed (see paragraph "BACKBOARDS" below). Cabinets shall be clear or telco gray in color, black is not permitted.

2.6.2 Building Protector Assemblies

Building protector assembly are required on all OSP cables and shall have 710 type connector blocks or scotchlok style connector for connection to the exterior cable at full capacity. Wire wrap or M150-66 type IDC for connection to the voice cross connects blocks. 110 type IDC protector assemblies are not approved

2.6.3 Protector Modules

UL 497, RUS Bull 345-83, solid state type rated for the application. Provide the number of surge protection modules equal to the number of pairs of exterior cable of the building protector assembly.

2.6.4 Connector Blocks

Provide insulation displacement connector (IDC) 50 pair 89D-Style with industry standard 66 blade punch down for Category 5e and higher systems. Provide blocks for the number of backbone cables terminated on the block plus 25 percent spare. Also provide sufficient blocks for cross connects for all IDF.

2.6.5 Cable Guides

Provide cable guides specifically manufactured for the purpose of routing cables, wires and patch cords horizontally and vertically on 19 inches equipment racks, cabinets, and telecommunications backboards. Cable guide will be of tubular design and shall be Telco Gray in color. Black is not permitted. Cable guides of ring, finger duct with cover, or bracket type devices mounted on backboard for horizontal cable management and individually mounted for vertical cable management. Mount cable guides with screws, and or nuts and lock washers. White cable management spools will be used on backboards to rout cross connect cables to 66 blocks.

2.6.6 Patch Panels

Provide ports for the number of horizontal and backbone cables terminated on the panel to include all blank positions at the outlet plus 25 percent spare within the top 2/3 of the equipment support frame (bottom 1/3 is reserved for DATA equipment). Provide pre-connectorized SC type for Single-Mode and ST type for Multi-Mode Optical fiber and copper patch cords for patch panels. Provide patch cords, as complete assemblies, with matching connectors as specified. Patch cords shall meet minimum performance requirements specified in TIA-568-C.1, TIA-568-C.2, and TIA-568-C.3 for cables, cable length and hardware specified.

2.6.6.1 Patch Cords

Contractor shall provide pre-connectorized patch cords one for each connected port or position in the IDF field, DATA field and FIBER field. SC/LC APC, LC/LC UPC, and SC/SC UPC type connector for Single-Mode and ST type for Multi-Mode Optical fiber and Cat6 copper patch cords for all patch panels. Provide patch cords, as complete assemblies, with matching connectors as specified and with the T568A pinout configuration. Patch cords shall meet minimum performance requirements specified in TIA-568-C.1, TIA-568-C.2, and TIA-568-C.3 for cables, cable length and hardware specified.

2.6.6.2 Modular to 110 Block Patch Panel

Provide in accordance with TIA-568-C.1 and TIA-568-C.2. Panels shall be third party verified and shall comply with TIA Category 6A requirements. Panel shall be constructed of 0.09 inches minimum aluminum and shall be rack mounted and compatible with an ECIA EIA/ECA 310-E 19 inches equipment rack. Each panel shall provide 48 unloaded ports wired to T568A. The rear of each panel shall have incoming cable strain-relief and routing guides. Provide and install horizontal wire managements in rear of each new patch panel and use holding tabs provided or hook and loop (DO NOT USE ZIP TIES). Panels shall have each port factory numbered and be equipped with manufacturer's labels and laminated plastic covers above each port. Each patch panel will take into account all “blank positions” at the outlet and add them into the port count.

2.6.6.3 Fiber Optic Patch Panel

Provide panel for maintenance and cross-connecting of optical fiber cables. Panel shall be constructed of 0.09 inches minimum aluminum and shall be rack wall mounted and compatible with an ECIA EIA/ECA 310-E 19 inches equipment rack. Each patch panel shall provide single-mode fiber optic cable mechanically connected or spliced into cassettes and installed into the patch plate with each patch plate being in a duplex design duplex SC-UPC or LC-UPC in accordance with TIA/EIA-604-3 with zirconia ceramic ferule. SC-APC shall not be used. Provide dust cover for unused adapters. The rear of each panel shall have a cable management tray a minimum of 8 inches deep with removable cover, incoming cable strain-relief, routing guides, and grounding lug for armored cable. Panels shall have each adapter factory numbered.

2.6.6.4 Special Network Requirements

Buildings with Special Networks Requirements such as Secured Internet Protocol, American Warrior Network, MCCS.org, and Naval Blue Network may require additional guidance outside this specification. Secured areas or secured networks in non-secured areas may require Protected Distribution System which is also outside this specification. In these cases contact Base Telephone for Guidance at (843) 228-7036.

2.6.7 Optical Fiber Distribution Panel

Rack mounted Fiber Optic Patch Panel (FOPP) shall be constructed in accordance with ECIA EIA/ECA 310-E utilizing 11 gauge aluminum minimum. Panel shall have strain relief, routing guides, splice tray and shall have a cover for patch cord protection. Each panel shall provide 12 single-mode adapters. Provide adapters as SC or LC. Provide dust covers for adapters. Provide patch cords as specified in the paragraph PATCH PANELS. Pigtails

are not recommended.

2.7 TELECOMMUNICATIONS WORK AREA OUTLET BOXES

Standard type 5 inch by 2 7/8 inch square box with a single gang plaster ring. Mount flush in finished walls or mount on surface at height indicated by drawings. Depth of boxes shall be large enough to allow manufacturer's recommended conductor bend radius normally 2 7/8 inch.

2.8 TELECOMMUNICATIONS OUTLET/CONNECTOR ASSEMBLIES

2.8.1 Outlet/Connector Copper

Outlet/connectors shall comply with FCC Part 68, TIA-568-C.1, and TIA-568-C.2. UTP Outlet/connectors shall be UL 1863 listed, non-keyed, 4-pair, 8-pin modular, constructed of high impact rated thermoplastic housing and shall be third party verified and shall comply with TIA-568-C.2 Category 6A requirements and Accepts FCC 6-position plugs. Provide outlet/connectors in indicated color (normally office white or blue.) Outlet/connectors provided for Category 6A UTP cabling shall meet or exceed the requirements for the cable provided. Outlet/connectors shall be terminated using a Type 110 IDC PC board connector, color-coded for both T568A and T568B wiring. Each outlet/connector shall be wired T568A. UTP outlet/connectors shall comply with TIA-568-C.2 and must meet 2500 mating cycles. UTP outlet/connectors installed in outdoor or marine environments shall be rated for that use or protected with weatherproof enclosure.

2.8.2 Cover Plates

Telecommunications cover plates shall comply with UL 94 V-0, and TIA-568-C.1, TIA-568-C.2, TIA-568-C.3; oversized design constructed of high impact thermoplastic material, equipped with laminated plastic cover for label. Cover plate base will be angled down 45 degrees and must be able to accept a minimum of four 8-pin modular snap in connectors. Color will be Office White. The outlet cover plate will have a sliding protective cover with clear labeling field on the top.

2.8.3 Optical Fiber Adapters(Couplers)

Provide optical fiber adapters suitable for duplex SC in Accordance with TIA/EIA-604-3 with zirconia ceramic alignment sleeves, as indicated. Provide dust cover for adapters. Optical fiber adapters shall comply with TIA-455-21 for 500 mating cycles.

2.8.4 Optical Fiber Connectors

Provide in accordance with TIA-455-21. Optical fiber connectors shall be duplex SC in accordance with TIA/EIA-604-3 with zirconia ceramic ferrule, epoxyless compatible with 8/125 single-mode fiber. The connectors shall provide a maximum attenuation of 0.3 dB at 1550 nm with less than a 0.2 dB change after 500 mating cycles.

2.8.5 Cover Plates

Telecommunications cover plates shall comply with UL 514C, and TIA-568-C.1, TIA-568-C.2, TIA-568-C.3; flush design constructed of high impact thermoplastic material to match color of receptacle/switch cover plates specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide

labeling in accordance with the paragraph LABELING in this section.

2.9 BACKBOARDS

Provide void-free, minimum grade of A/C grade plywood (3/4 inch) thick. Backboards shall be covered with two coats of fire-retardant paint, white in color, nonconductive, and on all six sides. Boards should be installed 4 foot Width by 8 foot Height with best side facing outward and cover at a minimum of two adjacent walls in the Telecommunication spaces starting on the long wall farthest from the door. This backboard space will be used by Base Telephone and their equipment only. Additional boards may be needed where any other electronic equipment is to be mounted. Only full 4 foot by 8 foot plywood sheets will be used where backboards are indicated on the drawing.

2.10 GROUNDING AND BONDING PRODUCTS

Comply with UL 467, TIA-607, and NFPA 70. Components shall be identified as required by TIA-606. Ground rods shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEMS. The preferred ground for the Telecommunications Main Grounding Bus (TMGB) bar will be to the Main electrical Distribution Panel (MDP) bus bar and building steel. In most cases a #6 AWG bonding conductor is recommended for telecommunications. All grounding and bonding conductors within the Telecommunications room will be green sheathed copper conductor, stranded, and labeled as suitable for use as such and tagged "DO NOT REMOVE". All grounding and bonding conductors running outside of the Telecommunications room should be protected in conduit and sized according to references. The minimum size of the TMGB shall be no smaller than 4 inches by 10 inches by 1/4 inch thick; bus bar should be factory made and factory drilled - not fabricated or drilled onsite. Holes should be double pattern with both 5/16 and 7/16 size holes. All bonding and grounding terminations shall be irreversible and secured with a double hole crimp termination. Do not exceed minimum bend radius on bonding and grounding conductors.

2.11 FIRESTOPPING MATERIAL

Provide as specified in Section 07 84 00 FIRESTOPPING. Provide asbestos-free fire stopping system capable of maintaining an effective barrier against flame and gases. System shall be UL listed and comply with ASTM E814. Include UL system number UL listed print from manufacturer for all type (floor, wall, and ceiling)penetrations.

2.12 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.13 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inches thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches.

Lettering shall be a minimum of 0.25 inches high normal block style.

2.14 TESTS, INSPECTIONS, AND VERIFICATIONS

2.14.1 Factory Reel Tests

Provide documentation of the testing and verification actions taken by manufacturer to confirm compliance with TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, TIA-526-7 for single mode optical fiber cables.

PART 3 EXECUTION

3.1 INSTALLATION

Telecommunications pathway systems, including the horizontal and backbone pathway systems, telecommunications outlet/connector assemblies, and associated hardware shall be installed in accordance with TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, TIA-569, NFPA 70, NECA/BICSI 568, manufacturer instructions, current industry best practices, UL standards as applicable, and approval of Base Telephone via the Contracting Officer. Base Telephone requirements will be coordinated through the Contracting Officer. Provide in a star topology network. Metal raceway bases, covers, and dividers shall be bonded and grounded in accordance with TIA-606. Pathways shall be installed in accordance with the following minimum clearance distances of 4 feet from motors, generators, frequency converters, transformers, x-ray equipment or uninterruptible power system, 12 inches from power conduits and cable systems, 5 inches from fluorescent or high frequency lighting system fixtures.

3.1.1 Cabling

Install Category 6A UTP and optical fiber telecommunications cabling and pathway system as detailed in TIA-568-C.1, TIA-568-C.2, and TIA-568-C.3. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations. Screw terminals shall not be used. Do not untwist Category 6A UTP cables more than 1/2 inch from the point of termination to maintain cable geometry. Provide service loop on each end of the cable, minimum of 15 feet in the telecommunications room and 6 feet above the work area outlet for UTP. Do not exceed manufacturers' cable pull tensions for copper cables. Provide a device to monitor cable pull tensions. Do not exceed 110 Newton pull tension for four pair copper cables. Do not chafe or damage outer jacket materials. Use only lubricants approved by cable manufacturer. Do not over cinch cables, or use staples. Only use Velcro type cable straps on Category 6A cable and optical fiber cable. ZIP TIES WILL NOT BE ACCEPTED. UTP cable bend radii shall not be less than four times the cable outer diameter. All cables shall be terminated; no cable shall contain unterminated elements. Cables shall not be spliced.

3.1.1.1 Backbone Cable

a. Copper Backbone Cable. Install backbone copper cable in 4 inch conduit pathways between MDF, BDF, and IDF equipment as indicated in this specification and on drawings. All under slab cables shall be rated for outdoor use and protected at both ends by a proper building protector assembly. All cabling connecting the BDF to the IDF will be connected using 66 blocks mounted on the backboard and unloaded patch panel’s in the relay rack. There will be a connection using 4 pairs per outlet connector in the patch panel from the 66 block. Indoor UTP

telephone cable, cat5e (for this connection only), or cat6 can be used.

b. Optical fiber Backbone Cable. Install backbone optical fiber in one of four 1 inch inter ducts or 4 cell fiber mesh inside 4 inch conduit pathways between MDF, BDF, and IDF equipment as indicated in this spec and on drawings. Do not exceed manufacturer's recommended bending radii and pull tension. Prepare cable for pulling by cutting outer jacket 10 inches leaving strength members exposed for approximately 10 inches. Twist strength members together and attach to pulling eye. Vertical cable support intervals shall be every 12 inches or in accordance with Manufacturer's recommendations.

3.1.1.2 Horizontal Cabling

Install horizontal cabling in an approved pathway as indicated in this specification and on drawings between MDF, BDF, IDF, and telecommunications outlet assemblies at workstations. Unless directed by the Telephone Office all ports in the IDF will have a corresponding port on the MDF patch panel and back to the backboard even if the IDF port is a blank port. All cabling will be dressed in the vertical wire management in a way as to not have slack in the management. All cables will connect to the outlet connector run through the rear management and straight up into the cable guide. All cables will maintain the same direction of pull from the connector to the cable guides on all racks. All runs will use a raceway system cable tray. All under slab cables shall be rated for outdoor use. Do not untwist Category 6A UTP cables more than one half inch from the point of termination to maintain cable geometry. Provide slack cable in the form of a service loop on each end of the cable, 15 feet in the telecommunications room, and 72 inches above the work area outlet.

3.1.2 Pathway Installations

Provide in accordance with TIA-569 and NFPA 70. Provide building pathway as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Comply with TIA-569, except provide a minimum of a 1 inch diameter conduit to each work area outlet from cable tray, or telecommunication room backboard. Conceal conduit within finished walls, ceilings, and floors (not in wet areas). Keep conduit minimum 12 inches away from parallel runs of electrical power equipment, flues, steam, light ballast, and hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit is visible after completion of project. Run conduits in crawl spaces as if exposed. Install no more than two 90 degree bends for a single horizontal cable run. All bends/turns in conduits will be in straight runs of conduit; a pull box shall be installed after every 180 degrees of bends or 100'; in no case will a turn be made within a pull box. The minimum size for a pull box for a single 1 inch conduit will be a standard 5 inch long by 5 inch wide by 2 1/8 inch deep, and for a 3 inch conduit 30 inch W by 54 inch L by 9 inch D. All conduits should contain a bushing at the end (to protectthe cable from damage) and require proper bonding. Pull points, LC, LB, and consolidation points are not authorized.

3.1.3 Under Floor Duct Pathway Systems

Under floor cabling and under floor duct are not authorized without approval in wet areas. If approved by Base Telephone via the Contracting Officer, they shall be installed in accordance with manufacturers' recommendations. Use CMP in plenum spaces and CMX or water block cable

designed for outdoor applications in wet areas.

3.1.4 Conduit Installed Under Floor Slabs

Conduit under floor slabs should be avoided on the Marine Corps Air Station due to wet area close to coastal waters. If under slab installation is approved by Base Telephone via the Contracting Officer, conduit shall be located a minimum of 12 inches below the vapor barrier. Seal all conduit connections and at penetrations through vapor barrier. Use a CMX or water block cable designed for outdoor applications.

3.1.5 Service Entrance Conduit, Underground

Provide service entrance underground as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. PVC Type EPC-40, galvanized rigid steel, or steel IMC. Underground portion shall be encased in minimum of 3 inches of concrete extending from the building entrance to 5 feet out from the building footer or walkway and shall be a minimum of 24 inches below slab or grade. Mark the end with a durable marking source so it can be tied to the Outside Plant distribution.

3.1.6 Cable Tray Installation

Install cable tray components in accordance with TIA-569 and manufacturer's instructions. Ensure proper bonding as required by TIA-606. Only CMP and OFNP type cable shall be installed in a plenum space. A continuous, stranded, bonding conductor shall be run along the tray tapped to each section to ensure bonding. Remove all sharps from cable tray and pathways. Ensure bonding is on the pathway so as not to obstruct horizontal cabling. All installed cables will be separated white on one side and blue on the other side of the cable tray.

3.1.7 Work Area Outlets

3.1.7.1 Terminations

Terminate UTP cable in accordance with TIA-568-C.1, TIA-568-C.2 and wiring configuration as specified. Terminate fiber optic cables in accordance with TIA-568-C.3

3.1.7.2 Cover Plates

At a minimum, each jack shall have all manufacturer labels numbered and be equipped with laminated plastic cover over the label. Also it shall be labeled as to its function V for voice, D for data. For secured networks contact Base Telephone and the Base Local Command Center via the Contracting Officer.

3.1.7.3 Cables

Unshielded twisted pair shall have a minimum of 6 feet slack cable loosely coiled above the telecommunications work area outlet boxes. Minimum manufacturer's bend radius for each type of cable shall not be exceeded. All telecommunications work area outlet boxes shall have a minimum of 2 cat6 cables (four cat6 is recommended) to a double gang box if wiring is included in contract.

3.1.7.4 Pull Cords

Pull cords shall be installed in conduit serving telecommunications outlets that do not have cable installed.

3.1.8 Telecommunications Space Termination

Install termination hardware required for Category 6A and optical fiber system. A single punch insulation displacement tool shall be used for terminating copper cable to insulation displacement connectors. No multi-punch tools can be used.

3.1.8.1 Connector Blocks

Connector blocks shall be mounted in orderly rows and columns. Adequate vertical and horizontal wire routing areas shall be provided between groups of blocks. Install in accordance with industry standard wire routing guides in accordance with TIA-569.

3.1.8.2 Patch Panels

Patch panels shall be mounted racks with sufficient ports to accommodate the installed cable plant plus 25 percent spares.

a. Copper Patch Panel. Copper cable entering a patch panel shall be secured to the panel with cable tiesas recommended by the manufacturer to prevent movement of the cable.

b. Fiber Optic Patch Panel. Fiber optic cable loop shall be 3 feet in lengthprovided as recommended by the manufacturer. The outer jacket of each cable entering a patch panel shall be secured to the panel to prevent movement of the fibers within the panel, using clamps or brackets specifically manufactured for that purpose.

3.1.8.3 Equipment Support Frames

Install in accordance with TIA-569:

a. Bracket / lockable cabinet, wall mounted, approved by Base Telephone. Mount to plywood backboard per manufacturer's recommendations. Mount so height of highest panel does not exceed 78 inches above the finished floor. Mount so there is sufficient space remaining on backboard to mount lightning protection, bonding, and cable managers, or install additional backboard. Ensure proper low voltage clearance in accordance with NFPA 70.

b. Racks / lockable cabinet, floor mounted modular type. Permanently anchor rack to the floor per manufacturer's recommendations. Mount so there is sufficient space remaining on backboard to mount lightning protection, bonding, and cable managers, or install additional backboard. Install sections of ladder rack anchored to telephone rack/cabinet and at least two walls. Ensure proper low voltage clearance in accordance with NFPA 70. Install all open racks facing the backboard housing the backbone cable to optimize space within the Telecommunications Room.

c. Cabinets, freestanding modular type. When cabinets are connected together, remove adjoining side panels for cable routing between cabinets. Mount rack mounted fan in roof of cabinet.

3.1.9 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings as specified in Section 07 84 00 FIRESTOPPING.

3.1.10 Grounding and Bonding

Will be conducted in accordance with TIA-606, and NFPA 70 except only two hole irreversible compression lugs will be accepted. Connections will be made using both holes and no/ox will be applied. All grounding connections shall be tagged with “ground do not remove”. All grounding will be installed home run to the TGMB 2 inches under the ladder racking using drop brackets.

3.1.11 Fire Stopping

Seal openings around raceway penetrations through fire resistance rated walls, partitions, floors and ceiling utilizing proper fire stopping materials to maintain fire resistive integrity in accordance with Section 07 84 00 FIRESTOPPING.

3.2 LABELING

3.2.1 Labels

All labels shall be in accordance with TIA/EIA-606; except jacks will be numbered in a sequential numbering system from 1 to X. Within room numbering, the work area outlets will start to the left of the door and continue clockwise around the room. Each WAO will be numbered with the room number and outlet number; example: 101.1V/101.1D, 101.2V/101.2D etc. All WAO’s will account for labels at unterminated positions as if it were terminated. All terminated and unterminated outlets in the room will have a respective label at the TR’s IDF relay rack staying in sequential order (clockwise in the room and from top to bottom left to right at the IDF relay rack). All labels shall be numbered with manufacturers labeling system or with a proper labeling tool and be equipped with laminated plastic cover (do not use a pin or marker.) All terminations that are not to work area outlets should be in the last patch panel locations and labeled accordingly, i.e. DDC, FACP, Elevator, Wall phones. Along with the label on the work area outlet there will be a label on the wall directly above each outlet 6 inches below the finished ceiling and be a minimum size of 1/2 inch with a minimum font size of 1/4 inch.

3.2.2 Cable

Workstation outlets and patch panel connections shall be labeled using manufacturer labeling system or a proper labeling system, color coded with identifiers in accordance with TIA-606.

3.2.3 Termination Hardware

Workstation outlets and patch panel connections shall be labeled using color coded labels with identifiers in accordance with TIA-606.

3.3 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

In spaces indentified on the drawings as requiring corrosion protection and control, paint electrical equipment, boxes, and conduig as required to match finish of adjacent surfaces and to meet the indicated or specified safety criteria. Painting: as specified in Section 09 96 00 HIGH-PERFORMANCE COATINGS.

3.3.1 Painting Backboards

If backboards are required to be painted, then the manufactured fire retardant backboard must be painted with fire retardant paint, so as not to increase flame spread and smoke density and must be appropriately labeled. Label and fire rating stamp must be unpainted.

3.4 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.5 TESTING

3.5.1 Telecommunications Cabling Testing

Perform telecommunications cabling inspection, verification, and performance tests in accordance with TIA-568-C.1, TIA-568-C.2, and TIA-568-C.3. Perform optical fiber field inspection tests via attenuation measurements on factory reels and provide results along with manufacturer certification for factory reel tests. Remove failed cable reels from project site upon attenuation test failure. UTP backbone copper cabling shall be tested from the DCO/ADN to end for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors, and between conductors and shield, if cable has overall shield. Test operation of shorting bars in connection blocks. Test cables after termination but not cross connected. Perform 100 MHz near-end-cross-talk (NEXT) and attenuation tests for Category 6A systems installations. Category 6A Links perform UTP permanent link tests in accordance with TIA-568-C.1, TIA-568-C.2, and TIA-568-C.3. Tests shall include wire map, length, attenuation, NEXT, and propagation delay. A channel test is not acceptable. The Data Field will be tested from the IDF in the Telecommunication Room (TR) to the telecommunications work area outlet. The Voice Field will be tested from the 66 block termination to the IDF and from the IDF to the telecommunications work area outlet.

3.5.1.1 Inspection

Visually inspect cabling jacket materials for UL or third party certification markings. Visually inspect UTP and optical fiber jacket materials for UL or third party certification markings. Inspect cabling terminations in telecommunications rooms and at workstations to confirm color code for tip and ring pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1, TIA-568-C.2, and TIA-568-C.3. Visually confirm Category 6A marking of outlets, wall plates,

outlet/ connectors, cables, and patch panels.

3.5.1.2 Verification Tests

UTP backbone copper cabling shall be tested for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors, and between conductors and shield, if cable has overall shield. Test operation of shorting bars in connection blocks. Test cables after termination but not cross connected. Perform 100 MHz near-end-cross-talk (NEXT) and attenuation tests for Category 6A systems installations. Perform optical fiber end to end attenuation tests using a power meter and light source and optical time domain reflectometer (OTDR) and manufacturer's recommended test procedures. Perform tests in accordancewith TIA-526-14, Method A for horizontal, multimode optical fiber and TIA-526-7, Method A for backbone, single mode optical fiber. Perform verification acceptance tests and factory reel tests.

3.5.1.3 Performance Tests

Perform testing for each outlet and MUTOA as follows:

a. Category 6A Links. Perform UTP permanent link tests in accordance with TIA-568-C.1, TIA-568-C.2, TIA-568-C.3. Tests shall include wire map, length, attenuation, NEXT, and propagation delay. A channel test is not acceptable.

b. Optical Fiber Links. Perform optical fiber end-to-end attenuation tests and reel tests at jobsite.

3.5.1.4 Final Verification Tests

Perform verification tests for UTP and optical fiber systems after the complete telecommunications cabling and workstation outlet/connectors are installed. Provide summary in .pdf and detailed test results in tester format .flw, as built drawings in .pdf and .dwg, and fiber power meter/OTDR reports on a CD/CDRW to Base Telephone office. All Test reports should have a building or project number on it. The final QC and certification of installation will be performed by Base Telephone after the contractor has provided passing and acceptable results on all test and As Built drawings showing all telecommunications outlets and their numbers. Test results that are a marginal may not be accepted. Also Fiber tests that pass the link budget but exceed tolerance on any connector or splice are considereda failure. All discrepancies shall be repaired and retested. Base Telephonewill not test, run any cables or install equipment until the proper testresults have been received.

3.5.1.5 Records

a. Records to be provided for copper shall include the cable specification sheets from the manufacturer, the cable routing and locations, all splice point locations, patch panel and jack locations, cable length, cable reel numbers and installation location, building or project number. The test results shall be submitted in an electronic version on a CD/CDRW (do not e-mail).

b. Records to be provided for fiber shall include the cable specification sheets from the manufacturer, the cable routing and locations, all splice point locations, patch panel and jack locations, cable length, cable reel numbers and installation location, building

or project number. The test results shall be submitted in an electronic version on a CD/CDRW (do not e-mail).

c. As built drawings showing all telecommunications outlets and their numbers, Rack Elevations, communication room locations, building or project number, and pathways should be submitted in an electronic version on a CD/CDRW (do not e-mail) and a hard copy will be delivered with the electronic version.

d. As built drawings will be summited in AutoCAD and .pdf not hand written showing all telecommunications work area outlets and their numbers. The .pdf version will be generated from .dwg drawing and not a scanned drawing to .pdf.

3.6 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

SECTION 27 51 16

PUBLIC ADDRESS SYSTEMS
05/20
AMENDMENT 01

PART 1 GENERAL

1.1 RELATED SECTIONS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, applies to this section, with the additions and modifications specified herein. In addition, refer to the following sections for related work and coordination:

Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.
Section 07 84 00 FIRESTOPPING for additional work related to firestopping.

1.2 SUMMARY

1.2.1 Scope

a. This work includes design and providing a new, complete, public address system as required and as described herein. Provide a turnkey system capable of receiving, processing, and transmitting indicated input signals including the system wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, amplifiers, microphones, speakers, mounting hardware and other accessories and miscellaneous items required for a complete operating system even though each item is not specifically mentioned or described. Provide system complete and ready for operation. See paragraph titled SYSTEM DESCRIPTION for additional requirements.

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S3.2	(2009; R 2014) Method for Measuring the Intelligibility of Speech Over Communication Systems (ASA 85)

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E	(2005) Cabinets, Racks, Panels, and Associated Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on

Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST SP 800-82 (2015; Rev 2) Guide to Industrial Control Systems (ICS) Security

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD 8510.01 (2014; Change 1-2016; Change 2-2017) Risk Management Framework (RMF) for DoD Information Technology (IT)

UFC 4-010-06 (2023) Cybersecurity of Facility-Related Control Systems

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15 Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 1449 (2021; Reprint Dec 2022) UL Standard for Safety Surge Protective Devices

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualifications; G

SD-02 Shop Drawings

Detail Drawings; G

SD-03 Product Data

Spare Parts

SD-06 Test Reports

Approved Test Procedures; G

Acceptance Tests

Accreditation; G

SD-07 Certificates

Components

SD-10 Operation and Maintenance Data

Public Address System; G

Submit Data Package 5 for each component in accordance with the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.5 SYSTEM DESCRIPTION

1.5.1 Design Requirements

Provide a Public Address System, capable of distributing the indicated audio signals from equipment including LAN controllers, communication links, cabling, battery backup, power line surge protection and all other necessary components to make a complete and operational system. Complete coverage will be provided for all interior public spaces and other spaces as indicated on the drawings.

Provide a zoned system capable of evenly distributing live paging and music program sources. Provide balanced and highly intelligible distributed sound free of noise and distortion. Provide capability of both individual and simultaneous paging all separate paging zones. Intelligibility must meet the requirements of Modified Rhyme Test (MRT) of ASA S3.2

Provide all headend interface, amplification components, conditioners and any other equipment necessary. Provide system capable of interfacing with the GFGI telephone system for zone paging.

Provide all materials and labor needed for a complete and operational system for the services in this specification plus the additional system capabilities as indicated. This includes but not limited to all necessary equipment, interfaces, jumpers, terminations, cabling, amplifiers, conditioners, power supplies, battery backup, software and all components required for system operation.

1.5.2 System Application Design

Provide the system application design required to provide a public address system that complies with and satisfies all of the requirements specified in this Section and indicated on the Telecommunications Drawings for this application and project.

1.5.3 Standard Products

Provide an application design that utilizes standard system components that are the product of a Manufacturer regularly engaged in the manufacture of networked public address system, and that have been in satisfactory use for at least six months. Provide all major components from the same manufacturer. The System must be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the facility. Do not deliver material to the project site more than six months prior to the scheduled date of

installation.

Provide hardware, software, and installation of a complete and engineered system. Provide a submitted design that is properly engineered for the operational requirements. Include all components required to meet this specification section in the design, other than a change in, or in addition to the operational frequencies identified herein.

1.5.4 Local Products

Incorporate local materials to the greatest extent possible. All proposed local products must meet all applicable hardware and software requirements set forth in these specifications.

1.5.5 Minimum Requirements

Specifications are minimum requirements. If the provided system requires enhanced specifications that exceed those specified herein in order to satisfy the specified design, configuration, capability, and performance requirements, then a provide a system with the enhanced specifications.

1.5.6 Current State-of-the-Art Technology

Provide application design and products that utilize current state-of-the-art products that provide the enhanced capability and performance specified herein. Provide design and products representing the latest manufacturer make and model.

1.5.7 Environmental Requirements

Provide equipment to be used indoors rated for continuous duty operation under ambient environmental conditions of 35 to 120 degrees F dry bulb and 10 to 95 percent reflective humidity, noncondensing. Provide all other equipment rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.

1.5.8 Electrical Requirements

105 VAC to 130 VAC at 60 Hz operating voltage range, plus or minus 2 percent.

1.5.9 Power supplies

Provide power supplies that provide sufficient power for worst-case conditions of system operation that could occur without signal loss or perceptible degradation.

1.5.10 Power Line Surge Protection

Provide power line surge protection for all equipment connected to AC power. Provide surge protection integral to the equipment or installed as an accessory item in accordance to manufacturer's recommendations. Do not use fuses for surge protection.

1.5.11 Shielding and Grounding

Provide shielding and grounded as required by the system design, Manufacturer's instructions, FCC Part 15 listing, and regulatory

requirements.

1.5.12 System Capability and Configuration

1.5.12.1 System Capability

Provide a public address system with capabilities to support zone paging,background music,all-call,priority paging,software,input modules,controllers,interface modules, and .

1.5.13 Performance Requirements

1.5.13.1 System Initiation and Operation

No user controlled features are permitted on this system. System is to be active on power up and perform as specified without any form of manual control.

1.5.13.2 Priority
Provide paging priorities as indicated.

1.6 CYBERSECURITY

a. The Risk Management Framework (RMF) is the process by which information systems are accredited for operation by a designated official from the Using Military Department. It is the standard process under which all DoD information systems must achieve and maintain their Authority To Operate. The Cyber Security process is documented in DOD 8510.01 and NIST SP 800-82. Refer to UFC 4-010-06 for additional requirements.

b. All systems that are IP addressable or interface with the Assured Network must be certified to operate. Coordinate with the Government to initiate and complete the accreditation process.

c. Cybersecurity requires input from the system vendor or provider and support from the local IMD. The local IMD-IA office is the point of contact for all Cybersecurity requirements. The local CMIO is the point of contact for all clinical and functional system requirements.

1.7 QUALIFICATIONS

1.7.1 General Qualification Requirements

a. The System Contractor, Installer and Manufacturer must each have the minimum qualifications specified, related to the type of system specified for this project.

b. The Government reserves the right to accept or reject the System Contractor, Installer or Manufacturer based upon qualifications and ability to conform to specified technical or licensing requirements of this Section. System Contractors, Installers and Manufacturers that do not have the specified qualifications will not be acceptable and will not be allowed to perform the work of this section.

c. The Government will determine the acceptability of any proposed System Contractor, Installer and Manufacturer based on submitted and verified documentation that substantiates that the proposed System Contractor, Installer and Manufacturer have the qualifications specified in this

Section.

d. Submit documented verification of the specified qualifications as part of the Data Qualifications submittal. The Government maintains the right to request, inspect and verify references and resumes of all technical and managerial personnel assigned to the project.

e. Include qualification documentation, but not limited to the information outlined below:

(1) A list of projects performed by the System Contractor and Installer during the last five years explicitly involving the type of system specified in this section, including:

(a) Name of facility where work was completed.

(b) Name, title, address and telephone number of a point of contact for the listed facility.

(c) The make and model of the system provided and total scope of work for the facility.

(d) Restrict list to the facilities where the same type of system was installed for the same purpose provided.

1.7.2 System Contractor Qualifications

a. Contractor qualifications must include the following:

(1) The Contractor is regularly engaged in the system application design, documentation, installation, testing, training, and maintenance of the type of system specified in this section.

(2) The Contractor has a minimum of five years experience providing these services for systems having the same level of features and functions as the system being provided.

(3) The Contractor has a minimum of five years as the manufacturer or an authorized distributor and service organization for the manufacturer of the system provided.

b. Contactor personnel qualifications must:

(1) Be factory trained or certified for the make and model of the system provided.

(2) Have a minimum of five years experience performing the services specified in this specification section.

(3) Maintain a full compliment of spare parts for the provided system with the ability to furnish on-call maintenance 24 hours per day, 365 days per year.

1.7.3 Installer Qualifications

a. The installer personnel must be regularly engaged in the installation of the type of system in this specification section.

b. The installation supervisor must be factory trained or certified for

the make and model of the system provided.

c. The installation supervisor must have a minimum of five years experience providing services having the same level of features and functions for the system included in this specification section.

d. The installation personnel must have a minimum of three years experience providing services having the same level of features and functions for the system included in this specification section.

1.7.4 Manufacturer Qualifications

The system manufacturer must:

a. Have a minimum of five years experience in producing the products and type of system included in this specification section.

b. Produce a system that satisfies all specified features, functions and product requirements.

c. Guarantee the availability of the replacement parts for the designed system for a minimum of seven years from the date of final acceptance of the system by the Contracting Officer.

1.8 DELIVERY, STORAGE, AND HANDLING

Equipment placed in storage until installation shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, and other contaminants.

1.9 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than 2 months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The public address system shall consist of an audio distribution network to include amplifiers, mixers, microphones, speakers, cabling, and ancillary components required to meet the required system configuration and operation. Submit Data Package 3 in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

2.1.1 Multi-Channel System with Paging

The system shall include microphones, microphone outlet receptacles, microphone inputs with preamplifiers, inputs for digital music and telephone program sources, all channel paging, control for each input, power amplifying equipment, and accessories required to output the public address and paging audio signals through selected portions of the audio distribution network as indicated. The paging signal shall be replaced by zones of the system output, when the paging function is activated.

2.1.2 Single-Channel System

The system shall control and amplify an audio program for distribution within the areas indicated. Components of the system shall include a mixer-preamplifier, mixer-amplifier, mike input expander, power amplifier, microphone, speaker system, cabling and other associated hardware.

2.1.3 System Performance

The system shall provide even sound distribution throughout the designated area, plus or minus 3 dB for the 1/1 octave band centered at 4000 Hz. The system shall provide uniform frequency response throughout the designated area, plus or minus 3 dB as measured with 1/3-octave bands of pink noise at locations across the designated area selected by the Contracting Officer. The system shall be capable of delivering 75 dB average program level with additional 10 dB peaking margin sound pressure level (SPL) in the area at an acoustic distortion level below 5 percent total harmonic distortion (THD). Unless otherwise specified the sound pressure reference level is 20 micro Pascal (0.00002 Newtons per square meter).

2.1.4 Detail Drawings

Submit detail drawings consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions. Note that the contract drawings show layouts based on typical speakers. Check the layout based on the actual speakers to be installed and make necessary revisions in the detail drawings. Detail drawings shall also contain complete point to point wiring, schematic diagrams and other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

2.2 STANDARD PRODUCTS

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products, and that essentially duplicate material and equipment that have been in satisfactory use at least 2 years. All components used in the system shall be commercial designs that comply with the requirements specified. Submit copies of current approvals or listings issued by UL, or other nationally recognized testing laboratory for all components. Equipment shall be supported by a service organization that is within 100 miles of the site.

2.2.1 Identical Items

Items of the same classification shall be identical. This requirement includes equipment, modules, assemblies, parts, and components.

2.2.2 Nameplates

Each major component of equipment shall have the manufacturer's name, address, model and catalog number, and serial number on a plate secured to the equipment.

2.3 IP NETWORKED PUBLIC ADDRESS SYSTEM

Provide complete digital IP based audio network as required to deliver high quality audio signals to paging speakers as indicated on the drawings. Provide amplifiers of sufficient power to drive speakers indicated based on the defined paging zones. Provide additional amplifiers or modules as required for indicated paging zones.

2.3.1 System Components

Provide all system components as required for a complete and operational system to include the following minimum components.

2.3.1.1 Headend Equipment

Provide floor mounted equipment rack to house all headend equipment.

2.3.1.2 Auxiliary Inputs

Provide rack space and input modules for a minimum of two auxiliary inputs. Input sources are Government furnished, Government installed..

2.3.2 Distribution Equipment

Provide all distribution equipment necessary to process and distribute paging and music to zones as indicated on the drawings.

2.3.2.1 Monitor Panel

Provide system monitor panel with speaker and zone selection capability to check each output, voice input, and zone selection.

2.3.2.2 Loudspeaker System

Provide low power loudspeakers for uniform sound distribution at low volume levels. Space speakers as indicated on the drawings. Provide separate volume control for individual rooms as indicated on the drawings. In rooms designated on the drawings, provide volume control with bypass feature to allow for all-call paging to bypass the local volume control and be audible at normal system volume.

Provide speakers that are designed to provide even sound dispersion over the 20 Hz to 20 kHZ frequency range within the entire area the speaker covers.

2.3.2.3 Indoor Loudspeaker Assemblies

Provide cone type speakers with wall or ceiling enclosures and baffles as indicated on the drawings.

2.3.2.4 Microphones

Provide types and quantities of microphones as indicated on the drawings.

2.3.3 System Configuration

2.3.3.1 All Call

Provide all call paging capability. All call paging will have priority

over all other paging zones. Provide access to all call paging via a microphone, telephone, or both. Microphone access will have priority over telephone access for all paging zone types.

2.3.3.2 Zone Paging

Provide local paging zones as indicated on the drawings. Provide access to local zones using the telephone system, microphones, or both. All call paging will have priority over all local paging zones. Provide zone volume control at a controlled access location as indicated on the drawings.

2.3.4 System Performance

Provide system that evenly distributes sound throughout loudspeaker zones at plus or minus 3 dB for the 1/1 octave band centered at 4,000 Hz. Provide system that has uniform frequency response throughput loudspeaker zones of plus or minus 3 DB as measured with 1/3 octave bands of pink noise at locations as selected by the Contracting Officer. Provide system capable of delivering 75 dB average program level with additional 10 dB peaking margin sound pressure level without causing the associated amplifier to exceed normal operating specifications for power or distortion. Reference sound pressure level is 20 micropascal, unless otherwise indicated. Minimum audio sound pressure level must be at least +15 dB in all areas. System must not produce audible hum, noise, buzz, or rattles at any loudspeaker. Electoral/acoustic signal-to-noise ratio for the entire system must be at least 66 dB.

2.4 LOUDSPEAKERS

2.4.1 Cone Speaker

The cone speaker shall as a minimum conform to the following specifications:

Application	Ceiling
Frequency range	60 to 12,000 Hz
Power Rating	Normal - 7 watts
	Peak - 10 watts
Voice Coil Impedance	8 ohms
Line Matching Transformer Type	25/ 70.7 volt line
Capacity	4 watts
Magnet	10 ounces or greater
Primary Taps	0.5, 1, 2 and 4 watts
Primary Impedance	25 volts - 1250, 625, and 312 ohms
	70.7 volts - 10k, 5k, and 2.5k ohms

Frequency Response	30 - 20,000 Hz
Insertion Loss	Less than 1 dB

2.4.2 Horn Speaker

The horn speaker shall as a minimum conform to the following specifications:

Application	Indoor
Frequency Response	400 - 14,000 Hz
Power Taps	70 volt line - .9, 1.8, 3.8, 7.5, and 15 watts
Impedance	5000, 2500, 1300, 670, 330, 90, and 45 ohms
	Normal - 7 watts
	Peak - 15 watts
Dispersion	110 degrees

2.4.3 Dual Horn Speaker

The dual horn speaker shall meet the minimum requirements of horn speaker except the dispersion shall be 100 degrees. ***The speaker must be constructed to be installed in corrosive environments. Enclosure must be 316 stainless steel with IP66 ingress protection and powder coated finish.***

2.4.4 Ceiling Speaker Enclosures

Ceiling speaker enclosure shall be constructed of heavy gauge cold steel with interior undercoating and 1-1/2 inch thick high density fiberglass 1-1/2 lbs/cu. ft. The unit shall be round and designed for recessed installations which will be accomplished via standard screw mounting. Recessed models shall have a rust-preventive, textured black coating and the surface mount unit finished in textured white . Enclosure shall include four triple compound conduit knockouts.

2.5 SYSTEM POWER SUPPLY

Power supply shall be provided for priority relays and controls, rack-mounted and sized for a capacity equal to 200 percent of the as-built control system, and shall operate at 24 Vdc. Input and output shall be protected to permit Class 2 wiring in accordance with NFPA 70.

2.6 PRIORITY RELAYS AND CONTROLS

Provide priority relays and controls required to accomplish operations specified. Relays shall be completely enclosed with a plastic dust cover for maximum protection against foreign matter, and shall be plug-in type.

Relays shall be provided with a diode wired across the relay coil for transient suppression and shall be installed utilizing factory-prewired, rack-mounted receptacle strips. Coil shall be maximum 24 volts dc.

2.7 SWITCHES AND CONTROLS

2.7.1 Remote Loudspeaker ON/OFF Switches

Remote switches shall be toggle switch 2-pole, wall-mounted, single gang type with engraved switch plates finished to match the approved finish of electrical wall switches. Low-voltage priority override relays shall be provided as part of the switches with all wiring to the racks to allow override of the ON/OFF switches for priority announcements.

2.7.2 Remote Loudspeaker Volume Controls

Remote volume controls shall be an auto transformer type with detented 3 dB steps and an OFF position. The controls shall be wall-mounted in single-gang outlet boxes and furnished with engraved switching plates finished to match approved finish of electrical wall switches. Insertion loss of the controls shall not exceed 0.6 dB and the power-handling capacities of the control shall be 35 watts. Low-voltage priority override relays shall be furnished as part of these controls with all wiring to the racks to allow override of the volume controls for priority announcements.

2.8 EQUIPMENT RACKS AND CABINETS

Equipment shall be mounted on 19 inch racks swing wall mounted cabinets with hinged front removable and reversible door and hinged rear section that provides access to equipment with 19 inch mounting rails as indicated on the drawings UL listed andin accordance with ECIA EIA/ECA 310-E and located as shown on drawings. Ventilated rear panels, solid side panels, and solid top panels shall be provided for cabinets. Equipment cabinets shall be provided with lockable front panels that limit access to equipment. The lockable front shall not cover items that require operator access. Cabinet cooling shall be through top cabinet mounted fan. The racks and cabinets shall be factory finished with a uniform baked enamel over rust inhibiting primer.

2.9 CABLES

2.9.1 Speaker Cable

Cables shall be of the gauge required depending upon the cable run length. In no case shall cable be used which is smaller than 18 AWG. Insulation on the conductors shall be polyvinyl chloride (PVC) or an equivalent synthetic thermoplastic not less than 0.009 inch. Cables shall be jacketed with a PVC compound. The jacket thickness shall be 0.02 inch minimum.

2.9.2 Microphone Cable

Cable conductor shall be stranded copper 20 AWG. Insulation on the conductors shall be polyvinyl chloride (PVC) or an equivalent synthetic thermoplastic not less than 0.009 inch. Cable shall be shielded 100 percent of aluminum polyester foil with a bare 22 gauge stranded soft copper drain conductor. Cables shall be jacketed with a PVC compound. The jacket thickness shall be 0.02 inch minimum.

2.10 TERMINALS

Terminals shall be solderless, tool-crimped pressure type.

2.11 SURGE PROTECTION

2.11.1 Power Line Surge Protection

Major components of the system such as power amplifiers, mixer-preamplifiers, and tuners, shall have a device, whether internal or external, which provides protection against voltage spikes and current surges originating from commercial power sources in accordance with IEEE C62.41.1/IEEE C62.41.2 B3 combination waveform and NFPA 70. Fuses shall not be used for surge protection. The surge protector shall be rated for a maximum let thru voltage of 350 Volts ac (line-to-neutral) and 350 Volt ac (neutral-to-ground). Surge protection device shall be UL listed and labeled as having been tested in accordance with UL 1449.

2.11.2 SIGNAL SURGE PROTECTION

Major components of the system shall have internal protection circuits which protects the component from mismatched loads, direct current, and shorted output lines. Communication cables/conductors shall have surge protection installed at each point where it exits or enters a building.

2.12 TELEPHONE INTERFACE MODULE

2.12.1 Analog Interface Module

Telephone Interface module shall provide one way all call paging access from telephone to PA system. Paging shall be accomplished by the building telephone system instruments interconnected to the PA system via an interface module to allow telephone dial up access to the paging amplifier. Telephone interface module shall as a minimum conform to the following specifications:

Impedance	600 ohms
Frequency response	100Hz to 10Khz
70V Input Impedance	200K ohms
Output level	400mV rms
Input Power Requirement	12-24Vdc (from power supply)
Access requirement	Electronic (analog) or IA2 line key (line card required) PABX loop or ground-start trunk port, or dedicated single-line phone

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with the details of the work and working

conditions, verify dimensions in the field, and advise the Contracting Officer of any discrepancies before performing the work.

3.2 INSTALLATION

Install equipment as indicated and specified, and in accordance with the manufacturer's recommendations except where otherwise indicated. Equipment mounted out-of-doors or subject to inclement conditions shall be weatherproofed.

3.2.1 Equipment Racks

Mount racks side-by-side and bolt together. Group items of the same function together, either vertically or side-by-side. Arrange controls symmetrically at a height as indicated. Make audio input and interconnections with approved shielded cable and plug connectors; output connections may be screw terminal type. All connections to power supplies shall utilize standard male plug and female receptacle connectors with the female receptacle being the source side of the connection. Inputs, outputs, interconnections, test points, and relays shall be accessible at the rear of the equipment rack for maintenance and testing. Each item shall be removable from the rack without disturbing other items or connections. Empty space in equipment racks shall be covered by blank panels so that the entire front of the rack is occupied by panels.

3.2.2 Wiring

Install wiring in rigid steel conduit, intermediate metal conduit, cable trays, or electric metallic tubing as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Wiring for microphone, grounding, line level, speaker and power cables shall be isolated from each other by physical isolation and metallic shielding. Shielding shall be terminated at only one end.

3.3 GROUNDING

All grounding practices shall comply with NFPA 70. Equipment shall be grounded to the serving panelboard ground bus through a green grounding conductor. Metallic conduits serving the equipment shall be isolated on the equipment end with an insulating bushing to prevent noise from being transferred to the circuit. Equipment racks shall be grounded to the panelboard ground bus utilizing a 8 AWG conductor. Grounding conductor shall be terminated to the rack using connector suitable for that purpose.

3.4 TRAINING

Conduct a training course for six members of the operating and maintenance staff as designated by the Contracting Officer. The training course will be given at the installation during normal working hours for a total of 8 hours and shall start after the system is functionally complete but prior to final acceptance tests. The field instructions shall cover all of the items contained in the approved operating and maintenance manuals, as well as demonstrations of routine maintenance operations. Notify the Contracting Officer at least 14 days prior to the start of the training course.

3.5 ACCEPTANCE TESTS

Submit test reports in booklet form showing all field tests performed to

adjust each component and to prove compliance with the specified performance criteria, upon completion and testing of the installed system. The reports shall include the manufacturer, model number, and serial number of test equipment used in each test. Each report shall indicate the final position of controls and operating mode of the system. After installation has been completed, conduct acceptance tests, utilizing the approved test procedures, to demonstrate that equipment operates in accordance with specification requirements. Submit test plan and test procedures for the acceptance tests. The test plan and test procedures shall explain in detail, step-by-step actions and expected results to demonstrate compliance with the requirements specified. The procedure shall also explain methods for simulating the necessary conditions of operation to demonstrate system performance. Notify the Contracting Officer 14 days prior to the performance of tests. In no case shall notice be given until after the Contractor has received written Contracting Officer approval of the test plans as specified.

3.5.1 Testing Requirements

Include the following minimum testing:

a. Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.

b. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:

   (1) Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.

   (2) Repeat test for each separately controlled zone of loudspeakers.

   (3) Minimum acceptance ratio is 50 dB

c. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.

d. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.

e. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.

f. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.

Public address system will be considered defective if it does not pass any of the required individual tests and inspections listed above.

3.6 CONSTRUCTION WASTE MANAGEMENT

Comply with requirements of the Waste Management Plan specified in Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

-- End of Section --

SECTION 32 12 16.16

ROAD-MIX ASPHALT PAVING
11/20
AMENDMENT 01

PART 1 GENERAL

1.1 PAYMENT

1.1.1 Method of Measurement

Measurement of the quantity of hot-mix asphalt pavement per lot will be made for the purposes of assessing acceptance stipulated in paragraph ACCEPTANCE.

1.1.2 Basis of Payment

The measured quantity of hot-mixed asphalt pavement will be paid for and included in the lump sum contract price.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 156	(2013; R 2017) Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
AASHTO M 320	(2017) Standard Specification for Performance-Graded Asphalt Binder
AASHTO T 304	(2011; R 2015) Standard Method of Test for Uncompacted Void Content of Fine Aggregate
AASHTO T 329	(2015) Standard Test Method for Moisture Content of Hot Mix Asphalt (HMA) by Oven Method

ASPHALT INSTITUTE (AI)

AI MS-2	(2015) Asphalt Mix Design Methods

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C127	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and

	Absorption of Coarse Aggregate
ASTM C128	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C566	(2013) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM D979/D979M	(2015) Sampling Bituminous Paving Mixtures
ASTM D2041/D2041M	(2011) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D2172/D2172M	(2017; E 2018) Standard Test Methods for Quantitative Extraction of Asphalt Binder from Asphalt Mixtures
ASTM D2726/D2726M	(2019) Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D3203/D3203M	(2017) Standard Test Method for Percent Air Voids in Compacted Asphalt Mixtures
ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D3666	(2016) Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D5361/D5361M	(2016) Standard Practice for Sampling Compacted Asphalt Mixtures for Laboratory Testing
ASTM D5444	(2015) Mechanical Size Analysis of Extracted Aggregate
ASTM D5821	(2013; R 2017) Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6307	(2019) Standard Test Method for Asphalt Content of Asphalt Mixture by Ignition Method
ASTM D6925	(2014) Standard Test Method for Preparation and Determination of the Relative Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION (SCDOT)

SCDOT SS	(2007 & Supplemental Specifications) Standard Specifications for Highway Construction

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Placement Plan; G

SD-03 Product Data

Mix Design; G

Contractor Quality Control; G

SD-06 Test Reports

Aggregates; G

QC Monitoring

SD-07 Certificates

Asphalt Cement Binder; G

Laboratory Accreditation and Validation

1.4 ACCEPTANCE

1.4.1 Acceptability of Work

Acquire the services of an independent commercial laboratory to perform acceptance testing. Acceptance of the plant produced mix and in-place requirements will be on a lot to lot basis. The materials and the pavement itself will be accepted on the basis of production testing. The Government may make check tests from split samples to validate the results of the production testing. Testing performed by the Government does not reduce the required testing of the independent commercial laboratory. Split samples will be taken for Government testing to reduce the variability between the independent commercial laboratory and the Government's test results. When the difference between the independent commercial laboratory and the Government's test results for split samples exceed the acceptable range of two results for multilaboratory precision for the appropriate test method (i.e. ASTM) then at least one of the laboratories is determined to be in error. An evaluation of procedures and equipment in both laboratories will be made to determine the cause(s) for the differences. Develop steps to correct procedures and equipment to bring multilaboratory precision to within acceptable limits.

1.4.2 Acceptance Requirements

Provide all sampling and testing required for acceptance. Where appropriate, acceptance for individual lots of asphalt pavement will be made based on laboratory air voids, in-place density, smoothness, and grade in accordance with the following paragraphs. Surface smoothness and grade determinations will be made on the lot as a whole. Exceptions or adjustments to this will be made in situations where the mix within one lot is placed as part of both the intermediate and surface courses, thus smoothness and grade measurements for the entire lot cannot be made.

1.4.3 Pavement Lots

A standard lot for all requirements is equal to one day's production or 2,000 tons, whichever is smaller. Divide each lot into four equal sublots in order to evaluate laboratory air voids and in-place density. When operational conditions cause a lot to be terminated before the specified four sublots have been completed, use the following procedure to adjust the lot size and number of tests for the lot. Where three sublots have been completed, they constitute a lot. Where one or two sublots have been completed, incorporate them into the next lot and the total number of sublots (i.e. 5 or 6 sublots) is used for acceptance criteria. Include partial lots at the end of asphalt production into the previous lot. Complete and report all theoretical maximum density, laboratory air voids, and in-place density testing within 24 hours after construction of each lot.

1.4.4 Sublot Sampling

Take one mixture sample for each sublot in accordance with ASTM D979/D979M from a random truck or another location for determining theoretical maximum density, laboratory air voids, any additional testing the Government desires, and Contractor Quality Control. All samples will be selected randomly, using commonly recognized methods of assuring randomness conforming to ASTM D3665 and employing tables of random numbers or computer programs.

1.4.5 Additional Sampling and Testing

The Government reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. The cost of any additional testing will be paid for by the Government. Testing in these areas will be treated as a separate lot. Acceptance will be made for the quantity of asphalt pavement represented by these tests in accordance with the provisions of this section.

1.4.6 Theoretical Maximum Density (TMD)

Measure theoretical maximum density one time for each sublot in accordance with ASTM D2041/D2041M for purposes of calculating laboratory air voids and determining in-place density. The average TMD for each lot will be determined as the average TMD of the random sublot samples. When the TMD on both sides of a longitudinal joint is different, the average of these two TMD values will be used as the TMD needed to calculate the percent joint density.

1.4.7 Laboratory Air Voids

Prepare one set of laboratory compacted specimens for each sublot in

accordance with ASTM D6925 using the Superpave gyratory compactor. Provide three test specimens prepared from the same sample for each set of laboratory compacted specimens. Compact the specimens within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Do not reheat samples prior to compaction. Provide insulated containers as necessary to maintain the sample temperature. Measure the bulk density of laboratory compacted specimens in accordance with ASTM D2726/D2726M. Determine laboratory air voids from one set (three laboratory compacted specimens) for each sublot sample in accordance with ASTM D3203/D3203M.

1.4.7.1 Tolerance

Provide laboratory air voids with a mean absolute deviation of 1.00 percent or less from the JMF for each lot. Remove and replace lots that do not meet the laboratory air voids requirement at least 4 inches into the cold (existing) lane adjacent to the longitudinal joint, at no additional cost to the Government. The mean absolute deviation of the laboratory air void contents from the JMF air void content will be evaluated as shown in the example below.

1.4.7.2 Calculating Laboratory Air Voids

Laboratory air void calculations for each lot will use the average theoretical maximum density values obtained for the lot. Determine the average TMD in accordance with paragraph THEORETICAL MAXIMUM DENSITY (TMD). The mean absolute deviation of the laboratory air void contents (one from each sublot) from the JMF air void content will be evaluated as in the following example:

Assume that the laboratory air voids are determined from 4 sublots where one set of laboratory compacted specimens is from a single sublot. The laboratory air voids for the 4 sublots are determined to be 3.5, 3.0, 4.0, and 3.7. Assume that the target air voids from the JMF is 4.0. The mean absolute deviation is then:

Mean Absolute Deviation = (|3.5 - 4.0| + |3.0 - 4.0| + |4.0 - 4.0| + |3.7 - 4.0|)/4

Mean Absolute Deviation = (0.5 + 1.0 + 0.0 + 0.3)/4 = (1.8)/4 = 0.45

The mean absolute deviation for laboratory air voids is determined to be 0.45. It can be seen that 0.45 is less than 1.00 percent. The lot is acceptable for laboratory air voids.

1.4.8 In-place Density

Obtain one random 4 inch or 6 inch diameter core from the mat and joint of each sublot in accordance with ASTM D5361/D5361M for determining in-place density. Cut samples neatly with a diamond core drill bit. Obtain random cores that are the full thickness of the layer being placed. Select core locations randomly using the procedures contained in ASTM D3665. Locate cores for mat density no closer than 12 inches from a transverse or longitudinal joint including the pavement edge. Center all cores for joint density on the joint. Discard samples that are clearly defective as a result of sampling and take an additional random core. When the random core is less than 1 inch thick, it will not be included in the analysis. In this case, obtain another random core sample. Clean and tack coat dry core holes before filling with asphalt mixture. Fill all core holes with asphalt mixture and compact using a standard Marshall hammer to the

density specified. Provide all tools, labor, and materials for cutting samples, cleaning, and filling the cored pavement. Measure in-place density in accordance with ASTM D2726/D2726M using each core obtained from the mat and joint.

1.4.8.1 Tolerance

Provide a minimum in-place mat density of 93.0 percent and a minimum in-place joint density of 90.0 percent for each lot. The average in-place mat and joint densities are expressed as a percentage of the average theoretical maximum density (TMD) for the lot. Determine the average TMD in accordance with paragraph THEORETICAL MAXIMUM DENSITY (TMD). Remove and replace lots that do not meet the in-place mat density requirement at least 4 inches into the cold (existing) lane adjacent to the longitudinal joint, at no additional cost to the Government. Remove and replace the longitudinal joint when the lot does not meet the in-place joint density, at no additional cost to the Government. Use a 10 feet wide paving lane that is centered over the joint.

1.4.9 Surface Smoothness

Use a straightedge for measuring surface smoothness. Smoothness requirements do not apply over crowns or grade breaks. Maintain detailed notes of the testing results and provide a copy to the Government immediately after each day's testing.

1.4.9.1 Smoothness Requirements

1.4.9.1.1 Straightedge Testing

Provide finished surfaces of the pavements with no abrupt change of 1/4 inch or more when checked with an approved 12 foot straightedge. Remove and replace surface lift lots when the surface smoothness exceeds 3/8 inch, at no additional cost to the Government.

1.4.9.2 Testing Method

After the final rolling, but not later than 24 hours after placement, test the surface of the pavement in each entire lot in a manner to reveal surface irregularities exceeding the tolerances specified above. Check a number of random locations along with any observed suspicious locations primarily at transverse and longitudinal joints with the straightedge.

1.4.9.2.1 Straightedge Testing

Use the straightedge to measure abrupt changes in surface smoothness. Hold the straightedge in contact with the pavement surface and measure the maximum distance between the straightedge and the pavement surface. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points.

1.4.10 Plan Grade

Provide a final wearing surface of pavement conforming to the elevations and cross sections shown and not vary more than 0.05 foot from the plan grade established and approved at site of work. Within 5 working days

after completion of a particular lot incorporating the final wearing course, test the final wearing surface of the pavement for conformance with specified plan grade requirements. Match finished surfaces at juncture with other pavements with finished surfaces of abutting pavements. Deviation from the plan elevation will not be permitted in areas of pavements where closer conformance with planned elevation is required for the proper functioning of drainage and other appurtenant structures involved.The grade will be determined by running lines of levels at intervals of 25 feet or less longitudinally and transversely to determine the elevation of the completed pavement surface. Diamond grinding can be used to remove high spots to meet grade requirements. Skin patching for correcting low areas or planing or milling for correcting high areas will not be permitted. Maintain detailed notes of the results of the testing and provide a copy to the Government immediately after each day's testing. Remove and replace surface lift lots when individual locations exceed 0.05 foot tolerance, at no additional cost to the Government.

1.4.11 Laboratory Accreditation and Validation

Provide laboratories used to develop the Job Mix Formula (JMF), perform acceptance testing, and Contractor Quality Control testing that meet the requirements of ASTM D3666. Provide laboratories with a masonry saw having a diamond blade for trimming pavement cores and samples. Perform all required test methods by an accredited laboratory. Schedule and provide payment for laboratory inspections. Additional payment or a time extension due to failure to acquire the required laboratory accreditation is not allowed. Submit a certificate of compliance signed by the manager of the laboratory stating that it meets these requirements to the Government prior to the start of construction. At a minimum, include the following certifications:

a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.

b. A listing of equipment to be used in developing the job mix.

c. A copy of the laboratory's quality control system.

1.4.12 Regulatory Requirements

Provide work and materials in accordance with applicable requirements of SCDOT SS except as noted otherwise herein. Divisions and Sections mentioned herein refer to those specifications. SCDOT SS paragraphs "Measurement and Payyment" shall not apply.

1.4.12.1 Modifications of References

Where term "Engineer" and "State" is used in SCDOT SS it shall be constructed to mean Contracting Officer and Federal Government, respectively.

1.5 ENVIRONMENTAL REQUIREMENTS

Do not place the asphalt mixture upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 1. The temperature requirements may be waived by the Government, if requested; however, meet all other requirements including compaction.

Table 1. Surface Temperature Limitations of Underlying Course	
Mat Thickness, inches	Degrees F
3 or greater	40
Less than 3	45

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Perform the work consisting of pavement courses composed of mineral aggregate and asphalt material heated and mixed in a central mixing plant and placed on a prepared course. Provide asphalt pavement designed and constructed in accordance with this section conforming to the lines, grades, thicknesses, and typical cross sections shown on the drawings. Construct each course to the depth, section, or elevation required by the drawings and rolled, finished, and approved before the placement of the next course. Submit proposed Placement Plan indicating lane widths and longitudinal joints for each course or lift.

2.1.1 Asphalt Mixing Plant

Provide plants used for the preparation of asphalt mixture conforming to the requirements of AASHTO M 156 with the following changes:

2.1.1.1 Truck Scales

Weigh the asphalt mixture on approved scales, or on certified public scales at no additional expense to the Government. Inspect and seal scales at least annually by an approved calibration laboratory.

2.1.1.2 Inspection of Plant

Provide access to the Government at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; checking the temperatures maintained in the preparation of the mixtures and for taking samples. Provide assistance as requested, for the Government to procure any desired samples.

2.1.1.3 Storage bins

The asphalt mixture can be stored in non-insulated storage bins for a period of time not exceeding 3 hours. The asphalt mixture can be stored in insulated storage bins for a period of time not exceeding 8 hours. Provide the mix drawn from bins that meets the same requirements as mix loaded directly into trucks.

2.1.2 Hauling Equipment

Provide trucks used for hauling asphalt mixture that have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, lightly coat the truck beds with a minimum amount of paraffin oil, lime solution, or other approved material. Do not use petroleum based products as a release agent. Provide each truck with a suitable cover to protect

the mixture from adverse weather, contamination, and loss of material during hauling. When necessary due to long haul distance and cold weather, provide insulated truck beds with covers (tarps) that are securely fastened.

2.1.3 Asphalt Pavers

Provide mechanical spreading and finishing equipment consisting of a self-powered paver, capable of spreading and finishing the mixture to the specified line, grade, and cross section. Provide paver screed capable of laying a uniform mixture to meet the specified thickness, smoothness, and grade without physical or temperature segregation, the full width of the material being placed. Provide a paver with a vibrating screed to be used during all placement.

2.1.3.1 Receiving Hopper

Provide paver with a receiving hopper of sufficient capacity to permit a uniform spreading operation and a distribution system to place the mixture uniformly in front of the screed without segregation. Provide a screed that effectively produces a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

2.1.3.2 Automatic Grade Controls

Provide a paver equipped with a control system capable of maintaining the specified screed elevation. One of three methods can be used to control grade: stringline, laser, or computerized elevations along with GPS. For multiple layers it is acceptable to control the grade in the underlying layer and control the grade of the surface layer by applying a constant thickness over the underlying layer which has been placed to the desired grade. Slope control can also be used to control the grade of the surface for roads, but is not acceptable for wide pavements such as parking lots. Provide transverse slope controller capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. A ski-type device of not less than 30 ft can be used to provide improved smoothness. Use a shoe on one side of the paver to match an existing paved surface to provide a smooth joint.

2.1.4 Rollers

Provide rollers in good condition and operate at slow speeds to avoid displacement of the asphalt mixture. Provide sufficient number, type, and weight of rollers to compact the mixture to the required density while it is still in a workable condition. Do not use equipment which causes excessive crushing of the aggregate.

2.2 AGGREGATES

Provide aggregates meeting requirements of SCDOT SS Section 401The portion of material retained on the No. 4 sieve is coarse aggregate. The portion of material passing the No. 4 sieve and retained on the No. 200 sieve is fine aggregate. The portion passing the No. 200 sieve is defined as mineral filler. Submit all aggregate test results and samples to the Government at least 14 days prior to start of construction. Perform job aggregate testing no earlier than 6 months before contract award.

2.2.1 Mineral Filler

Provide mineral filler meeting the requirements of ***SCDOT SS***.

2.2.2 Aggregate Gradation

Provide a combined aggregate gradation that conforms to gradations in SCDOT SS Section 401, HOT MIXED ASPHALT (HMA) PAVEMENT, for the following: (A) Bituminous Concrete Surface Course-Type C; and, (B) Bituminous Concrete Base Course - Type B, as indicated.

2.3 ASPHALT CEMENT BINDER

Provide asphalt cement binder that conforms to SCDOT SS Section 401, HOT MIXED ASPHALT (HMA) PAVEMENT, AASHTO M 320 Performance Grade (PG) 64-22. Provide test data indicating grade certification by the supplier at the time of delivery of each load to the mix plant. Submit copies of these certifications to the Government. The supplier is defined as the last source of any modification to the binder. The Government may sample and test the binder at the mix plant at any time before or during mix production.

2.4 MIX DESIGN

Develop the mix design conforming to SCDOT SS Section 401, HOT MIXED ASPHALT (HMA) PAVEMENT ***for each asphalt mix type specified in paragraph "Aggregate Gradation".*** Provide a currently used DOT certified approved superpave hot-mix formula information sheet. The sheet must include the Contractor's name, plant location, testing data, along with the mix acceptance and expiration date. Initial job mix formulas are valid for 2 years with a maximum of 3 revisions. If more than 3 revisions have been made, new job mix formula is required. Perform Job Mix formula (JMF) and aggregates testing no earlier than 12 months before contract award. Provide asphalt mixture composed of well-graded aggregate, mineral filler if required, and asphalt material. Provide aggregate fractions sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the required grading requirements. Do not produce asphalt pavement for acceptance until a JMF has been approved. If an antistrip agent is required, provide it at no additional cost to the Government.

2.4.1 JMF Requirements

With the DOT certified approved hot-mix formula information sheet, submit the proposed JMF in writing, for approval, at least 14 days prior to the start of paving including, as a minimum:

a. Percent passing each sieve size.

b. Percent of asphalt cement.

c. Percent of each aggregate and mineral filler to be used.

d. Asphalt performance grade or penetration grade.

e. Number of Superpave gyratory compactor gyrations.

f. Laboratory mixing temperature.

g. Laboratory compaction temperature.

h. Temperature-viscosity relationship of the asphalt cement

j. Antistrip agent (if required).

k. List of all modifiers.

l. Percentage and properties (asphalt content, aggregate gradation, and aggregate properties) of RAP in accordance with paragraph RECYCLED ASPHALT PAVEMENT, if RAP is used.

2.4.2 Adjustments to JMF

The JMF for each mixture is in effect until a new formula is approved in writing by the Government. Should a change in sources of any materials be made, perform a new mix design and a new JMF approved before the new material is used. Make minor adjustments within the specification limits to the JMF to optimize mix volumetric properties. Adjustments to the original JMF are limited to plus or minus 4 percent on the No. 4 and coarser sieves; plus or minus 3 percent on the No. 8 to No. 50 sieves; and plus or minus 1 percent on the No. 100 sieve and No. 200 sieve. Asphalt content adjustments are limited to plus or minus 0.40 from the original JMF. If adjustments are needed that exceed these limits, develop a new mix design.

2.5 RECYCLED HOT MIX ASPHALT

Provide recycled asphalt mixture consisting of reclaimed asphalted pavement (RAP), category 1, conforming to SCDOT SS Section 401, HOT MIXED ASPHALT (HMA) PAVEMENT. Do not use crushed glass or shingles.

PART 3 EXECUTION

3.1 CONTRACTOR QUALITY CONTROL

3.1.1 General Quality Control Requirements

Submit the Quality Control Plan. Do not produce hot-mix asphalt for acceptance until the quality control plan has been approved. In the quality control plan, address all elements which affect the quality of the pavement including, but not limited to:

a. Mix Design and unique JMF identification code

b. Aggregate Grading

c. Quality of Materials

d. Stockpile Management and procedures to prevent contamination

e. Proportioning

f. Mixing and Transportation

g. Mixture Volumetrics

h. Moisture Content of Mixtures

i. Placing and Compaction

j. Joints

k. Surface Smoothness

l. Truck bed release agent

3.1.2 Testing Laboratory

Provide a fully equipped asphalt laboratory located at the plant or job site that is equipped with heating and air conditioning units to maintain a temperature of 75 plus or minus 5 degrees F. Provide laboratory facilities that are kept clean and all equipment maintained in proper working condition. Provide the Government with unrestricted access to inspect the laboratory facility, to witness quality control activities, and to perform any check testing desired. The Government will advise in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to adversely affect test results, immediately suspend the incorporation of the materials into the work. Incorporation of the materials into the work will not be permitted to resume until the deficiencies are corrected.

3.1.3 Quality Control Testing

Perform all quality control tests applicable to these specifications and as set forth in the Quality Control Program. Use the independent commercial laboratory for acceptance testing in paragraph ACCEPTANCE. Use in-house capabilities or the independent commercial laboratory for quality control testing. Required elements of the testing program include, but are not limited to tests for the control of asphalt content, aggregate gradation, aggregate moisture, moisture in the asphalt mixture, temperatures, VMA, and in-place density. Develop a Quality Control Testing Plan as part of the Quality Control Program.

3.1.3.1 Asphalt Content

Determine asphalt content a minimum of twice per lot (a lot is defined in paragraph PAVEMENT LOTS) using the ignition method in accordance with ASTM D6307. Use the extraction method in accordance with ASTM D2172/D2172M if the correction factor for the ignition method in ASTM D6307 is greater than 1.0. The asphalt content for the lot will be determined by averaging the test results.

3.1.3.2 Aggregate Properties

Determine aggregate gradations a minimum of twice per lot from mechanical analysis of extracted aggregate in accordance with ASTM D5444, ASTM C136/C136M, and ASTM C117. Determine the specific gravity of each aggregate size grouping for each 20,000 tons in accordance with ASTM C127 or ASTM C128. Determine fractured faces for gravel sources for each 20,000 tons in accordance with ASTM D5821. Determine the uncompacted void content of natural sand, manufactured sand, and blended aggregate for each 20,000 tons in accordance with AASHTO T 304 Method A.

3.1.3.3 Moisture Content of Aggregate

Determine the moisture content of aggregate used for production a minimum

of once per lot in accordance with ASTM C566.

3.1.3.4 Moisture Content of Asphalt Mixture

Determine the moisture content of the asphalt mixture at least once per lot in accordance with AASHTO T 329.

3.1.3.5 Temperatures

Check temperatures at least four times per lot, at necessary locations to determine the temperature at the dryer, the asphalt cement binder in the storage tank, the asphalt mixture at the plant, and the asphalt mixture at the job site.

3.1.3.6 VMA

Obtain mixture samples at least four times per lot. Calculate the VMA of each specimen in accordance with AI MS-2 based on ASTM C127 and ASTM C128 bulk specific gravity for the aggregate. Provide VMA greater than 14 percent.

3.1.3.7 In-Place Density

Conduct any necessary testing to ensure the specified density is achieved. A nuclear gauge or other non-destructive testing device can be used to monitor pavement density.

3.1.3.8 Additional Testing

Perform any additional testing deemed necessary to control the process.

3.1.3.9 QC Monitoring

Submit all QC test results to the Government on a daily basis as the tests are performed. The Government reserves the right to monitor any of the Contractor's quality control testing and to perform duplicate testing as a check to the Contractor's quality control testing.

3.1.4 Sampling

When directed by the Government, sample and test any material which appears to not meet specification requirements unless such material is voluntarily removed and replaced or deficiencies corrected. Perform all sampling in accordance with standard procedures specified.

3.2 PREPARATION OF ASPHALT BINDER MATERIAL

Heat the asphalt cement material while avoiding local overheating. Provide a continuous supply of the asphalt material to the mixer at a uniform temperature. Maintain the temperature of the asphalt delivered to the mixer to provide a suitable viscosity for adequate coating of the aggregate particles. For hot-mix, do not heat unmodified asphalt to a temperature exceeding 325 degrees F when added to the aggregate. Do not heat modified asphalt to a temperature exceeding 350 degrees F when added to the aggregate.

3.3 PREPARATION OF MINERAL AGGREGATE

Heat and dry the aggregate prior to mixing. Provide a rate of heating and a maximum temperature that does not damage the aggregates. Do not heat the aggregate to a temperature exceeding 350 degrees F when the asphalt binder is added. Maintain the temperature no lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

3.4 PREPARATION OF ASPHALT MIXTURE

Weigh or meter the aggregates and the asphalt cement and introduce into the mixer the amount specified by the JMF. Mix the combined materials until the aggregate obtains a uniform coating of asphalt binder and is thoroughly distributed throughout the mixture. The moisture content of all asphalt mixture upon discharge from the plant is not to exceed 0.5 percent by total weight of mixture as measured by AASHTO T 329.

3.5 PREPARATION OF THE UNDERLYING SURFACE

Immediately before placing the asphalt mixture, clean the underlying course of dust and debris. Apply a prime coat or tack coat in accordance with Section 32 12 13 BITUMINOUS TACK AND PRIME COATS.

3.6 TRANSPORTING AND PLACING

3.6.1 Transporting

Transport asphalt mixture from the mixing plant to the site in clean, tight vehicles. Schedule deliveries so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Provide adequate artificial lighting for night placements. Hauling over freshly placed material will not be permitted until the material has been compacted as specified, and allowed to cool to 140 degrees F.

3.6.2 Placing

Place the mix in lifts of adequate thickness and compact at a temperature suitable for obtaining density, surface smoothness, and other specified requirements. Upon arrival, place the mixture to the full width by an asphalt paver; strike off in a uniform layer of such depth that, when the work is completed, the required thickness is obtained and the surface conforms to the grade and contour indicated. Do not broadcast waste mixture onto the mat or recycle into the paver hopper. Collect waste mixture and dispose off site. Regulate the speed of the paver to eliminate pulling and tearing of the asphalt mat. Begin placement of the mixture along the centerline of a crowned section or on the high side of areas with a one-way slope. Place the mixture in consecutive adjacent strips having a minimum width of 10 feet ***and such that the longitudinal joint between lanes does not deviate more than 6" from the centerline of the joint when observed over each 250 feet length, or fraction thereof, of joint***. Offset the longitudinal joint in one course from the longitudinal joint in the course immediately below by at least 1 foot; however, locate the joint in the surface course at the centerline of the pavement. Offset transverse joints in one course by at least 10 feet from transverse joints in the previous course. Offset transverse joints in adjacent lanes a minimum of 10 feet. On isolated areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture can be spread and luted by hand tools.

3.7 COMPACTION OF MIXTURE

3.7.1 General

a. After placing, thoroughly and uniformly compact the mixture by rolling. Compact the surface as soon as possible without causing displacement, cracking, or shoving. Determine the sequence of rolling operations and the type of rollers used with the exception that application of more than three passes with a vibratory roller in the vibrating mode is prohibited. Maintain the speed of the roller, at all times, sufficiently slow to avoid displacement of the asphalt mixture and to be effective in compaction. Correct at once any displacement occurring as a result of reversing the direction of the roller, or from any other cause.

b. Furnish sufficient rollers to handle the output of the plant. Continue rolling until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. To prevent adhesion of the mixture to the roller, keep the wheels properly moistened, but excessive water is not permitted. In areas not accessible to the roller, thoroughly compact the mixture with hand tampers or small compactors. Remove the full depth of any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or is in any way defective. Replace with fresh asphalt mixture and immediately compact to conform to the surrounding area. Perform this work at no expense to the Government. Skin patching is not allowed.

3.7.2 Segregation

The Government can sample and test any material that looks deficient. When the in-place material appears to be segregated, the Government has the option to sample the material and have it tested and compared to the in-place density requirements in ***SCDOT SS Section 401***. If the material fails to meet these specification requirements, remove and replace the extent of the segregated material the full depth of the layer of asphalt mixture at no additional cost to the Government. When segregation occurs in the mat, take appropriate action to correct the process so that additional segregation does not occur.

3.8 JOINTS

Construct joints to ensure a continuous bond between the courses and to obtain the required density. Provide all joints with the same texture as other sections of the course and meet the requirements for smoothness and grade.

3.8.1 Transverse Joints

Do not pass the roller over the unprotected end of the freshly laid mixture, except when necessary to form a transverse joint. When necessary to form a transverse joint, construct by means of placing a bulkhead or by tapering the course. Utilize a dry saw cut on the transverse joint full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. Remove the cutback material from the project. In both methods, provide a light tack coat of asphalt material to all contact surfaces before placing any fresh mixture against the joint.

3.8.2 Longitudinal Joints

Provide a joint that meets density and smoothness requirements for joints and has uniform texture. Cut back longitudinal joints which are irregular, damaged, uncompacted, cold (less than 175 degrees F at the time of placing adjacent lanes), or otherwise defective, a maximum of 3 inches from the top of the course with a cutting wheel to expose a clean, sound, near vertical surface for the full depth of the course. Remove all cutback material from the project. Provide a light tack coat of asphalt material to all contact surfaces prior to placing any fresh mixture against the joint.

-- End of Section --

SECTION 46 25 15

BJWSA GREASE TRAP AMENDMENT 01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

BEAUFORT JASPER WATER AND SEWER AUTHORITY (BJWSA)

BJWSA GREASE TRAP STDS	(2011) Grease Trap and Grease Interceptor Standards
BJWSA TECH SPECS	(2009) Technical Specifications

1.2 SYSTEM DESCRIPTION

1.2.1 Applications

The Grease trap shall remove free oil and grease from oil-in-water mixtures of freshwater originating from maintenance and fire protection operations. The influent oil-in-water mixture will flow by gravity to the unit which will not be located in an area with a corrosive atmosphere.

1.2.2 Influent Characteristics

Provide grease trap designed for a maximum flow of 250 gallons per minute.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Grease Trap; G

Submit shop drawings for trap including principal dimensions, location of fittings and unit foundation. Include data to verify center of gravity with the unit empty and filled with water.

SD-05 Design Data

Grease Trap; G

Submit analysis, signed by a registered professional engineer, which indicates that at the calculated overflow rate, the grease trap will be provided in accordance with the requirements of BJWSA Grease Trap and Grease Interceptor Standards and BJWSA Deatil S-04 as included in the contract drawings. Flow rate shall be 250

gallons per minute and storage capacity factor shall be equal to 2. All applicable provisions of specification section 33 30 00 BJWSA SANITARY SEWERAGE shall apply. Calculations shall take into account the rate of flow, potential surge flow, and hydrostatic uplift while empty.

SD-06 Test Reports

Shop hydrostatic test; G

Submit results of hydrostatic testing.

Inspection

Field hydrostatic test

Preoperational test

In-service test

SD-07 Certificates

Grease trap protection; G

Submit written verification on the fabricator's letterhead that surface preparation and coating application were performed in accordance with the manufacturer's printed recommendations for the coating system.

1.4 QUALITY CONTROL

1.4.1 Regulatory Requirements

All installations shall be in accordance with regulations and requirements of the South Carolina Department of Environmental Services (SCDES).

All materials and installation for the grease trap shall comply with BJWSA GREASE TRAP STDS and BJWSA TECH SPECS.

1.4.2 Manufacturer Qualifications

Provide materials and equipment from BJWSA approved manufacturers.

1.4.3 Installer Qualifications

Install specified materials by a licensed underground utility Contractor licensed for such work in the state where the work is to be performed. Verify installing Contractor's License is current and state certified or state registered.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery and Storage

Inspect materials delivered to site for damage; unload and store with minimum handling. Store materials on-site in enclosures or under protective coverings. Protect materials not suitable for outdoor storage to prevent damage during periods of inclement weather, such as subfreezing temperatures, precipitation, and high winds. Store materials susceptible

to deterioration by direct sunlight under cover and avoid damage due to high temperatures. Do not store materials directly on ground. If special precautions are required, prominently and legibly stencil instructions for such precautions on outside of equipment or its crating.

1.5.2 Handling

Handle Grease Trap in such a manner as to ensure delivery to final location in sound, undamaged condition. Take special care not to damage interior and exterior surfaces of trap or tubes and associated supports and pipe coatings or linings. Make satisfactory repairs to damaged materials at no cost to Government. Carry and do not drag materials.

PART 2 PRODUCTS

2.1 MATERIALS

Grease Trap shall be constructed of precast concrete. Provide unit with lifting straps. Surfaces shall be seamless, chemically resistant to oil-in-water mixture.

2.1.1 Grease Trap Protection

2.1.1.1 Precast Concrete Grease Trap

After shop conducted hydrostatic tests and have been successfully completed, provide a coating system which will protect the unit from the oil-in-water mixture, and in situ soil conditions specified herein.

2.1.2 External Surfaces

External surfaces and appurtenances shall be resistant to corrosion from the in situ soil, backfill material, soil pH and soil resistivity.

2.1.3 Internal Surfaces

Internal surfaces shall be corrosion and chemically resistant to the oil-in-water mixture as specified in paragraph entitled "SYSTEM DESCRIPTION."

2.1.4 Hardware

Bolts, stiffeners, washers, nuts, screws, pins, and fittings as required shall be corrosion resistant. Provide materials that are inherently corrosion resistant and not merely treated with a corrosion-resistant coating, such as provided by the galvanizing process.

2.1.5 Accessibility

Parts subject to wear or requiring adjustment, inspection, cleaning or repair shall be accessible and capable of convenient removal when required.

2.2 SEPARATION CHAMBER

Provide below ground unit to withstand hydraulic and soil loadings under static and dynamic conditions while empty and during operating conditions. Provide adequate support for equipment transportation, and rapid lowering and braking of load during handling operations.

2.2.1 Lifting Mechanism

Fit unit with lifting lugs or straps for handling and installation. Each lug or strap shall carry the total dry weight of the unit and attendant appurtenances. Prominently display lifting instructions on anodized aluminum plate located on outside of unit.

2.2.2 Identification Plates

Provide anodized aluminum identification and instruction plates and stamp necessary data. Securely affix plates, in prominent location, to unit with nonferrous screws or bolts of not less than 1/8 inch in diameter.

2.2.3 Warning Sign

Place a permanent sign which states the following: "DO NOT ENTER Grease Trap OR PERFORM HOT WORK ON OR IN separator UNTIL THE ATMOSPHERE HAS BEEN TESTED AND CERTIFIED GAS FREE AND SAFE."

2.3 INLET COMPARTMENT

Provide inlet compartment of sufficient volume to effectively reduce influent suspended solids and dissipate energy. Use inlet compartment that provides a minimum of 2.5 minutes detention ahead of the outlet compartment.

2.4 FABRICATION

Provide precast shop fabricated unit approved by the Contracting Officer, which is comprised of an inlet compartment, and outlet compartment:

2.4.1 Shop Hydrostatic Test

Prior to applying coatings, perform hydrostatic test at atmospheric pressure by filling grease trap with water in the shop for a minimum of 4 hours. Acceptance criteria, for the hydrostatic test, is no leakage after 4 hours using a thorough visual inspection for the leaks.

2.4.2 Connections

Connect the grease trap at the inlet and outlet pipe invert elevations indicated.

PART 3 EXECUTION

3.1 INSPECTION

Inspect each component of grease trap for compliance with requirements specified in PART 2 PRODUCTS. Redesign or modification of equipment to comply with specified requirements, or necessary redesign or modification following failure to meet specified requirements, shall receive particular attention for adequacy and suitability. This element of inspection shall encompass visual examinations and dimensional measurements. Noncompliance with specified requirements, or presence of one or more defects preventing or lessening maximum efficiency of grease trap operation, shall constitute cause for rejection.

3.2 INSTALLATION

Lift grease trap as required onto level foundation. Level grease trap and bolt to supports to prevent hydrostatic uplift and ensure unit stability. Installation shall be conducted in accordance with manufacturer's recommendations.

3.3 FIELD QUALITY CONTROL

3.3.1 Field Hydrostatic Test

After unit has been leveled and secured to foundation hydrostatically test unit at atmospheric or operational pressure (for no leakage) for an additional 8 hours by filling with water. Perform the hydrostatic test prior to backfilling below ground or partially below ground installations.

3.3.2 Preoperational Test

The manufacturer's service representative shall inspect, operate, and test unit before in-service testing by the Contractor.

3.3.2.1 Tests

Tests shall include but not be limited to the following:

a. Soundness (without cracked or otherwise damaged parts).

b. Completeness in all details, as specified.

c. Correctness of setting, alignment, and relative arrangement of each component.

d. Verification of proper operation for all system components.

3.3.2.2 Preoperational Investigation and Test Report

Submit manufacturer's service representative's preoperational test report. Document inspections, operations, adjustments, and tests performed and indicate whether they were acceptable or not. For unacceptable items, describe corrective action taken or recommended. Include detailed descriptions of points inspected, tests and adjustments made, quantitative results obtained if such are specified, and suggestions for precautions to be taken to ensure proper maintenance. Include the manufacturer's certificate that equipment conforms to specified requirements and is ready for permanent operation and that nothing in installation will render manufacturer's warranty null and void.

3.3.3 In-Service Test

After hydrostatic test and preoperational test have been successfully completed and unit has been properly connected to influent and effluent piping, allow influent oil-in-water mixture previously described in paragraph entitled "SYSTEM DESCRIPTION" to flow into unit filled with water. Optimize operation of unit within 5 working days. Operate unit for a minimum of ten unit volume changes prior to testing for removal of contaminants and document testing results.

-- End of Section --

THIS PAGE INTENTIONALLY LEFT BLANK