NAVFAC MID-ATLANTIC

WORK ORDER NO. 1312624 AND 1291651

SPECIAL PROJECT RM10-9004
REPAIR RUNWAY 14L-32R PAVEMENT AND LIGHTING

AND

SPECIAL PROJECT RM12-0469
ENERGY AND RELIABILITY MODERNIZATION OF AIRFIELD LIGHTING

At the

Naval Air Station Oceana
Va. Beach, VA

Final Submission, Volume II

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SECTION 23 00 00

AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS

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.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S12.51	(2012) Acoustics Determination of Sound Power Levels of Noise Sources using Sound Pressure Precision Method for Reverberation Rooms

AIR CONDITIONING CONTRACTORS OF AMERICA (ACCA)

ACCA Manual 4	(2001) Installation Techniques for Perimeter Heating and Cooling; 11th Edition

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 201	(2002; R 2011) Fans and Systems
AMCA 210	(2007) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 220	(2005) Test Methods for Air Curtain Units
AMCA 300	(2008) Reverberant Room Method for Sound Testing of Fans
AMCA 301	(1990; INT 2007) Methods for Calculating Fan Sound Ratings from Laboratory Test Data
AMCA 500-D	(2012) Laboratory Methods of Testing Dampers for Rating

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 260 I-P	(2012) Sound Rating of Ducted Air Moving and Conditioning Equipment
AHRI 350	(2008) Sound Rating of Non-Ducted Indoor Air-Conditioning Equipment
AHRI 410	(2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils
AHRI 430	(2009) Central-Station Air-Handling Units

AHRI 440	(2008) Room Fan-Coils and Unit Ventilators
AHRI 880 I-P	(2011) Performance Rating of Air Terminals
AHRI 885	(2008; Addendum 2011) Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets
AHRI DCAACP	(Online) Directory of Certified Applied Air-Conditioning Products
AHRI Guideline D	(1996) Application and Installation of Central Station Air-Handling Units

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings
ABMA 9	(1990; ERTA 2012; S 2013) Load Ratings and Fatigue Life for Ball Bearings

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013; Addenda A 2014; ERTA 2014) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 52.2	(2012; Errata 2013) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 62.1	(2010; Errata 2011; INT 3 2012; INT 4 2012; INT 5 2013) Ventilation for Acceptable Indoor Air Quality
ASHRAE 68	(1997) Laboratory Method of Testing to Determine the Sound Power In a Duct
ASHRAE 70	(2006; R 2011) Method of Testing for Rating the Performance of Air Outlets and Inlets
ASHRAE 84	(2013; Addenda A 2013) Method of Testing Air-to-Air Heat Exchangers
ASHRAE 90.1 - IP	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings

ASME INTERNATIONAL (ASME)

ASME A13.1	(2007; R 2013) Scheme for the Identification of Piping Systems

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A167	(1999; R 2009) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A924/A924M	(2013) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B152/B152M	(2013) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
ASTM B209	(2010) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2010) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B280	(2013) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B766	(1986; R 2008) Standard Specification for Electrodeposited Coatings of Cadmium
ASTM C1071	(2012) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM C553	(2013) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C916	(1985; R 2007) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM D1654	(2008) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D1785	(2012) Standard Specification for

	Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2466	(2013) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2564	(2012) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2855	(1996; R 2010) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D3359	(2009; E 2010; R 2010) Measuring Adhesion by Tape Test
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM E2016	(2011) Standard Specification for Industrial Woven Wire Cloth
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials

INSTITUTE OF ENVIRONMENTAL SCIENCES AND TECHNOLOGY (IEST)

IEST RP-CC-001	(2009) HEPA and ULPA Filters

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2011) Enclosures
NEMA MG 1	(2011; Errata 2012) Motors and Generators
NEMA MG 10	(2013) 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

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code
NFPA 701	(2010) Standard Methods of Fire Tests for Flame Propagation of Textiles and Films
NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 96	(2014) Standard for Ventilation Control

and Fire Protection of Commercial Cooking Operations

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS — Scientific Certification Systems (SCS)Indoor Advantage

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

SMACNA 1403 — (2008) Accepted Industry Practice for Industrial Duct Construction, 2nd Edition

SMACNA 1819 — (2002) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, 5th Edition

SMACNA 1884 — (2003) Fibrous Glass Duct Construction Standards, 7th Edition

SMACNA 1966 — (2005) HVAC Duct Construction Standards Metal and Flexible, 3rd Edition

SMACNA 1972 CD — (2012) HVAC Air Duct Leakage Test Manual - 2nd Edition

SMACNA 1981 — (2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101 — (2014; Rev C) Color Code for Pipelines & for Compressed Gas Cylinders

UFC 4-010-01 — (2012) DoD Minimum Antiterrorism Standards for Buildings

U.S. DEPARTMENT OF ENERGY (DOE)

PL-109-58 — (1992; R 2005) Energy Efficient Procurement Requirements

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

40 CFR 82 — Protection of Stratospheric Ozone

UL ENVIRONMENT (ULE)

ULE Greenguard — UL Greenguard Certification Program

UNDERWRITERS LABORATORIES (UL)

UL 181 — (2013) Factory-Made Air Ducts and Air Connectors

UL 1995 — (2011) Heating and Cooling Equipment

UL 555 — (2006; Reprint May 2014) Standard for Fire

	Dampers
UL 555S	(2014) Smoke Dampers
UL 586	(2009) Standard for High-Efficiency Particulate, Air Filter Units
UL 6	(2007; reprint Nov 2010) Electrical Rigid Metal Conduit-Steel
UL 705	(2004; Reprint Dec 2013) Standard for Power Ventilators
UL 723	(2008; Reprint Aug 2013) Test for Surface Burning Characteristics of Building Materials
UL 900	(2004; Reprint Feb 2012) Standard for Air Filter Units
UL 94	(2013; Reprint Jul 2014) Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL Bld Mat Dir	(2012) Building Materials Directory
UL Electrical Constructn	(2012) Electrical Construction Equipment Directory
UL Fire Resistance	(2012) Fire Resistance Directory

1.2 SYSTEM DESCRIPTION

Furnish ductwork, piping offsets, fittings, and accessories as required to provide a complete installation. Coordinate the work of the different trades to avoid interference between piping, equipment, structural, and electrical work. Provide complete, in place, all necessary offsets in piping and ductwork, and all fittings, and other components, required to install the work as indicated and specified.

1.2.1 Mechanical Equipment Identification

The number of charts and diagrams shall be equal to or greater than the number of mechanical equipment rooms. Where more than one chart or diagram per space is required, mount these in edge pivoted, swinging leaf, extruded aluminum frame holders which open to 170 degrees.

1.2.1.1 Charts

Provide chart listing of equipment by designation numbers and capacities such as flow rates, pressure and temperature differences, heating and cooling capacities, horsepower, pipe sizes, and voltage and current characteristics.

1.2.2 Service Labeling

Label equipment, including fans, air handlers, terminal units, etc. with labels made of self-sticking, plastic film designed for permanent

installation. Labels shall be in accordance with the typical examples below:

SERVICE	LABEL AND TAG DESIGNATION
Air handling unit Number	AHU -
Control and instrument air	CONTROL AND INSTR.
Exhaust Fan Number	EF -
VAV Box Number	VAV -
Fan Coil Unit Number	FC -
Terminal Box Number	TB -
Unit Ventilator Number	UV -

Identify similar services with different temperatures or pressures. Where pressures could exceed 125 pounds per square inch, gage, include the maximum system pressure in the label. Label and arrow piping in accordance with the following:

a. Each point of entry and exit of pipe passing through walls.

b. Each change in direction, i.e., elbows, tees.

c. In congested or hidden areas and at all access panels at each point required to clarify service or indicated hazard.

d. In long straight runs, locate labels at distances within eyesight of each other not to exceed 75 feet. All labels shall be visible and legible from the primary service and operating area.

For Bare or Insulated Pipes	
for Outside Diameters of	Lettering
1/2 thru 1-3/8 inch	1/2 inch
1-1/2 thru 2-3/8 inch	3/4 inch
2-1/2 inch and larger	1-1/4 inch

1.2.3 Color Coding

Color coding of all piping systems shall be in accordance with ASME A13.1.

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. Submit the following in accordance with Section 01 33 00

SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings

SD-03 Product Data

Metal Ductwork

Duct Connectors

Manual Balancing Dampers

Registers and Grilles

In-Line Centrifugal Fans

Test Procedures

Diagrams

SD-06 Test Reports

Performance Tests
Damper Acceptance Test

SD-07 Certificates

Bolts

SD-08 Manufacturer's Instructions

Manufacturer's Installation Instructions
Operation and Maintenance Training

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

In-Line Centrifugal Fans

1.4 QUALITY ASSURANCE

Except as otherwise specified, approval of materials and equipment is based on manufacturer's published data.

a. Where materials and equipment are specified to conform to the standards of the Underwriters Laboratories, the label of or listing with reexamination in UL Bld Mat Dir, and UL 6 is acceptable as sufficient evidence that the items conform to Underwriters Laboratories requirements. In lieu of such label or listing, submit a written certificate from any nationally recognized testing agency, adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the specified requirements. Outline methods of testing used by the specified agencies.

b. Where materials or equipment are specified to be constructed or tested, or both, in accordance with the standards of the ASTM International (ASTM), the ASME International (ASME), or other standards, a manufacturer's certificate of compliance of each item is acceptable as proof of compliance.

c. Conformance to such agency requirements does not relieve the item from compliance with other requirements of these specifications.

d. Where products are specified to meet or exceed the specified energy efficiency requirement of FEMP-designated or ENERGY STAR coveed product categories, equipment selected shall have as a minimum the efficiency rating identified under "Energy-Efficient Products" at http://femp.energy.gov/procurement and http://energy.gov/eere/femp/covered-product-category.

   These specifications conform to the efficiency requirements as defined in Public Law PL-109-58, "Energy Policy Act of 2005" for federal procurement of energy-efficient products. Equipment having a lower efficiency than ENERGY STAR or FEMP requirements may be specified if the designer determines the equipment to be more life-cycle cost effective using the life-cycle cost analysis methodology and procedure in 10 CFR 436.

1.4.1 Prevention of Corrosion

Protect metallic materials against corrosion. Manufacturer shall provide rust-inhibiting treatment and standard finish for the equipment enclosures. Do not use aluminum in contact with earth, and where connected to dissimilar metal. Protect aluminum by approved fittings, barrier material, or treatment. Ferrous parts such as anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous parts not of corrosion-resistant steel or nonferrous materials shall be hot-dip galvanized in accordance with ASTM A123/A123M for exterior locations and cadmium-plated in conformance with ASTM B766 for interior locations. Provide written certification from the bolt manufacturer that the bolts furnished comply with the requirements of this specification. Include illustrations of product markings, and the number of each type of bolt to be furnished in the certification.

1.4.2 Asbestos Prohibition

Do not use asbestos and asbestos-containing products.

1.4.3 Ozone Depleting Substances Used as Refrigerants

Minimize releases of Ozone Depleting Substances (ODS) during repair, maintenance, servicing or disposal of appliances containing ODS's by complying with all applicable sections of 40 CFR 82 Part 82 Subpart F. Any person conducting repair, maintenance, servicing or disposal of appliances owned by NASA shall comply with the following:

a. Do not knowingly vent or otherwise release into the environment, Class I or Class II substances used as a refrigerant.

b. Do not open appliances without meeting the requirements of 40 CFR 82 Part 82.156 Subpart F, regarding required practices for evacuation and collection of refrigerant, and 40 CFR 82 Part 82.158 Subpart F,

regarding standards of recycling and recovery equipment.

c. Only persons who comply with 40 CFR 82 Part 82.161 Subpart F, regarding technician certification, can conduct work on appliances containing refrigerant.

In addition, provide copies of all applicable certifications to the Contracting Officer at least 14 calendar days prior to initiating maintenance, repair, servicing, dismantling or disposal of appliances, including:

a. Proof of Technician Certification

b. Proof of Equipment Certification for recovery or recycling equipment.

c. Proof of availability of certified recovery or recycling equipment.

1.4.4 Use of Ozone Depleting Substances, Other than Refrigerants

The use of Class I or Class II ODS's listed as nonessential in 40 CFR 82 Part 82.66 Subpart C is prohibited. These prohibited materials and uses include:

a. Any plastic party spray streamer or noise horn which is propelled by a chlorofluorocarbon

b. Any cleaning fluid for electronic and photographic equipment which contains a chlorofluorocarbon; including liquid packaging, solvent wipes, solvent sprays, and gas sprays.

c. Any plastic flexible or packaging foam product which is manufactured with or contains a chlorofluorocarbon, including, open cell foam, open cell rigid polyurethane poured foam, closed cell extruded polystyrene sheet foam, closed cell polyethylene foam and closed cell polypropylene foam except for flexible or packaging foam used in coaxial cabling.

d. Any aerosol product or other pressurized dispenser which contains a chlorofluorocarbon, except for those listed in 40 CFR 82 Part 82.66 Subpart C.

Request a waiver if a facility requirement dictates that a prohibited material is necessary to achieve project goals. Submit the waiver request in writing to the Contracting Officer. The waiver will be evaluated and dispositioned.

1.4.5 Detail Drawings

Submit detail drawings showing equipment layout, including assembly and installation details and electrical connection diagrams; ductwork layout showing the location of all supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications. Include any information required to demonstrate that the system has been coordinated and functions properly as a unit on the drawings and show equipment relationship to other parts of the work, including clearances required for operation and maintenance. Submit drawings showing bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Submit

function designation of the equipment and any other requirements specified throughout this Section with the shop drawings.

1.4.6 Test Procedures

Submit proposed test procedures and test schedules for the performance tests of systems, at least 2 weeks prior to the start of related testing.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect stored equipment at the jobsite from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, cap or plug all pipes until installed.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Except for the fabricated duct, plenums and casings specified in paragraphs "Metal Ductwork" and "Plenums and Casings for Field-Fabricated Units",
provide components and equipment that are standard products of manufacturers regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. This requirement applies to all equipment, including diffusers, registers, fire dampers, and balancing dampers.

a. Standard products are defined as components and equipment that have been in satisfactory commercial or industrial use in similar applications of similar size for at least two years before bid opening.

b. Prior to this two year period, these standard products shall have been sold on the commercial market using advertisements in manufacturers' catalogs or brochures. These manufacturers' catalogs, or brochures shall have been copyrighted documents or have been identified with a manufacturer's document number.

c. Provide equipment items that are supported by a service organization. In product categories covered by ENERGY STAR or the Federal Energy Management Program, provide equipment that is listed on the ENERGY STAR Qualified Products List or that meets or exceeds the FEMP-designated Efficiency Requirements.

2.2 IDENTIFICATION PLATES

In addition to standard manufacturer's identification plates, provide engraved laminated phenolic identification plates for each piece of mechanical equipment. Identification plates are to designate the function of the equipment. Submit designation with the shop drawings. Identification plates shall be three layers, black-white-black, engraved to show white letters on black background. Letters shall be upper case. Identification plates 1-1/2-inches high and smaller shall be 1/16-inch thick, with engraved lettering 1/8-inch high; identification plates larger than 1-1/2-inches high shall be 1/8-inch thick, with engraved lettering of suitable height. Identification plates 1-1/2-inches high and larger shall have beveled edges. Install identification plates using a compatible adhesive.

2.3 EQUIPMENT GUARDS AND ACCESS

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact according to OSHA requirements. Properly guard or cover with insulation of a type specified, high temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard.

2.4 ELECTRICAL WORK

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00INTERIOR DISTRIBUTION SYSTEM. Provide manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown. For packaged equipment, include manufacturer provided controllers with the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system , and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Select premium efficiency polyphase motors in accordance with NEMA MG 10.

d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Provide motors rated for continuous duty with the enclosure specified. Provide motor duty that allows for maximum frequency start-stop operation and minimum encountered interval between start and stop. Provide motor torque capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Fit motor bearings with grease supply fittings and grease relief to outside of the enclosure.

2.5 ANCHOR BOLTS

Provide anchor bolts for equipment placed on concrete equipment pads or on concrete slabs. Bolts to be of the size and number recommended by the equipment manufacturer and located by means of suitable templates. Installation of anchor bolts shall not degrade the surrounding concrete.

2.6 SEISMIC ANCHORAGE

Anchor equipment in accordance with applicable seismic criteria for the area and as defined in SMACNA 1981

2.7 PAINTING

Paint equipment units in accordance with approved equipment manufacturer's standards unless specified otherwise. Field retouch only if approved. Otherwise, return equipment to the factory for refinishing.

2.8 INDOOR AIR QUALITY

Provide equipment and components that comply with the requirements of ASHRAE 62.1 unless more stringent requirements are specified herein.

2.9 DUCT SYSTEMS

2.9.1 Metal Ductwork

Provide metal ductwork construction, including all fittings and components, that complies with SMACNA 1966, as supplemented and modified by this specification .

a. Ductwork shall be constructed meeting the requirements for the duct system static pressure specified in APPENDIX D of Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC.

b. Provide ductwork that meets the requirements of Seal Class A. Provide ductwork in VAV systems upstream of the VAV boxes that meets the requirements of Seal Class A.

c. Make spiral lock seam duct, and flat oval with duct sealant and lock with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA 1966. Apply the sealant to the exposed male part of the fitting collar so that the sealer is on the inside of the joint and fully protected by the metal of the duct fitting. Apply one brush coat of the sealant over the outside of the joint to at least 2 inch band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar are not acceptable. Fabricate outdoor air intake ducts and plenums with watertight soldered or brazed joints and seams.

2.9.1.1 Metallic Flexible Duct

a. Provide duct that conforms to UL 181 and NFPA 90A with factory-applied insulation, vapor barrier, and end connections. Provide duct assembly that does not exceed 25 for flame spread and 50 for smoke developed. Provide ducts designed for working pressures of 2 inches water gauge positive and 1.5 inches water gauge negative. Provide flexible round duct length that does not exceed 5 feet. Secure connections by applying adhesive for 2 inches over rigid duct, apply flexible duct 2 inches over rigid duct, apply metal clamp, and provide minimum of three No. 8 sheet metal screws through clamp and rigid duct.

b. Inner duct core: Provide interlocking spiral or helically corrugated flexible core constructed of zinc-coated steel, aluminum, or stainless steel; or constructed of inner liner of continuous galvanized spring steel wire helix fused to continuous, fire-retardant, flexible vapor barrier film, inner duct core.

c. Insulation: Provide inner duct core that is insulated with mineral fiber blanket type flexible insulation, minimum of 1 inch thick. Provide insulation covered on exterior with manufacturer's standard

fire retardant vapor barrier jacket for flexible round duct.

2.9.1.2 General Service Duct Connectors

Provide a flexible duct connector approximately 6 inches in width where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, secure the flexible material by stainless steel or zinc-coated, iron clinch-type draw bands. For rectangular ducts, install the flexible material locked to metal collars using normal duct construction methods. Provide a composite connector system that complies with NFPA 701 and is classified as "flame-retardent fabrics" in UL Bld Mat Dir.

2.9.1.3 Aluminum Ducts

ASTM B209, alloy 3003-H14 for aluminum sheet and alloy 6061-T6 or equivalent strength for aluminum connectors and bar stock.

2.9.1.4 Copper Sheets

ASTM B152/B152M, light cold rolled temper.

2.9.1.5 Corrosion Resisting (Stainless) Steel Sheets

ASTM A167

2.9.2 Manual Balancing Dampers

a. Furnish manual balancing dampers with accessible operating mechanisms. Use chromium plated operators (with all exposed edges rounded) in finished portions of the building. Provide manual volume control dampers that are operated by locking-type quadrant operators.

b. Unless otherwise indicated, provide opposed blade type multileaf dampers with maximum blade width of 12 inches. Provide access doors or panels for all concealed damper operators and locking setscrews. Provide access doors or panels in hard ceilings, partitions and walls for access to all concealed damper operators and damper locking setscrews. Coordinate location of doors or panels with other affected contractors.

c. Provide stand-off mounting brackets, bases, or adapters not less than the thickness of the insulation when the locking-type quadrant operators for dampers are installed on ducts to be thermally insulated, to provide clearance between the duct surface and the operator. Stand-off mounting items shall be integral with the operator or standard accessory of the damper manufacturer.

2.9.2.1 Square or Rectangular Dampers

2.9.2.1.1 Duct Height 12 inches and Less

2.9.2.1.1.1 Frames

Width	Height	Galvanized Steel Thickness	Length
Maximum 19 inches	Maximum 12 inches	Minimum 20 gauge	Minimum 3 inches
More than 19 inches	Maximum 12 inches	Minimum 16 gauge	Minimum 3 inches

2.9.2.1.1.2 Single Leaf Blades

Width	Height	Galvanized Steel Thickness	Length
Maximum 19 inches	Maximum 12 inches	Minimum 20 gauge	Minimum 3 inches
More than 19 inches	Maximum 12 inches	Minimum 16 gauge	Minimum 3 inches

2.9.2.1.1.3 Blade Axles

To support the blades of round dampers, provide galvanized steel shafts supporting the blade the entire duct diameter frame-to-frame. Axle shafts shall extend through standoff bracket and hand quadrant.

Width	Height	Material	Square Shaft
Maximum 19 inches	Maximum 12 inches	Galvanized Steel	Minimum 3/8 inch
More than 19 inches	Maximum 12 inches	Galvanized Steel	Minimum 1/2 inch

2.9.2.1.1.4 Axle Bearings

Support the shaft on each end at the frames with shaft bearings. Shaft bearings configuration shall be a pressed fit to provide a tight joint between blade shaft and damper frame.

Width	Height	Material
Maximum 19 inches	Maximum 12 inches	solid nylon, or equivalent solid plastic, or oil-impregnated bronze

Width	Height	Material
More than 19 inches	Maximum 12 inches	oil-impregnated bronze

2.9.2.1.1.5 Control Shaft/Hand Quadrant

Provide dampers with accessible locking-type control shaft/hand quadrant operators.

Provide stand-off mounting brackets, bases, or adapters for the locking-type quadrant operators on dampers installed on ducts to be thermally insulated. Stand-off distance shall be a minimum of 2 inches off the metal duct surface. Stand-off mounting items shall be integral with the operator or standard accessory of the damper manufacturer.

2.9.2.1.1.6 Finish

Mill Galvanized

2.9.2.1.2 Duct Height Greater than 12 inches

2.9.2.1.2.1 Dampers

Provide dampers with multi-leaf opposed-type blades.

2.9.2.1.2.2 Frames

Maximum 48 inches in height; maximum 48 inches in width; minimum of 16 gauge galvanized steel, minimum of 5 inches long.

2.9.2.1.2.3 Blades

Minimum of 16 gauge galvanized steel; 6 inch nominal width.

2.9.2.1.2.4 Blade Axles

To support the blades of round dampers, provide galvanized square steel shafts supporting the blade the entire duct diameter frame-to-frame. Axle shafts shall extend through standoff bracket and hand quadrant.

2.9.2.1.2.5 Axle Bearings

Support the shaft on each end at the frames with shaft bearings constructed of oil-impregnated bronze, or solid nylon, or a solid plastic equivalent to nylon. Shaft bearings configuration shall be a pressed fit to provide a tight joint between blade shaft and damper frame.

2.9.2.1.2.6 Blade Actuator

Minimum 1/2 inch diameter galvanized steel.

2.9.2.1.2.7 Blade Actuator Linkage

Mill Galvanized steel bar and crank plate with stainless steel pivots.

2.9.2.1.2.8 Control Shaft/Hand Quadrant

Provide dampers with accessible locking-type control shaft/hand quadrant operators.

Provide stand-off mounting brackets, bases, or adapters for the locking-type quadrant operators on dampers installed on ducts to be thermally insulated. Stand-off distance shall be a minimum of 2 inches off the metal duct surface. Stand-off mounting items shall be integral with the operator or standard accessory of the damper manufacturer.

2.9.2.1.2.9 Finish

Mill Galvanized

2.9.2.2 Round Dampers

2.9.2.2.1 Frames

Size	Galvanized Steel Thickness	Length
4 to 20 inches	Minimum 20 gauge	Minimum 6 inches
22 to 30 inches	Minimum 20 gauge	Minimum 10 inches
32 to 40 inches	Minimum 16 gauge	Minimum 10 inches

2.9.2.2.2 Blades

Size	Galvanized Steel Thickness
4 to 20 inches	Minimum 20 gauge
22 to 30 inches	Minimum 16 gauge
32 to 40 inches	Minimum 10 gauge

2.9.2.2.3 Blade Axles

To support the blades of round dampers, provide galvanized steel shafts supporting the blade the entire duct diameter frame-to-frame. Axle shafts shall extend through standoff bracket and hand quadrant.

Size	Shaft Size and Shape
4 to 20 inches	Minimum 3/8 inch square

Size	Shaft Size and Shape
22 to 30 inches	Minimum 1/2 inch square
32 to 40 inches	Minimum 3/4 inch square

2.9.2.2.4 Axle Bearings

Support the shaft on each end at the frames with shaft bearings constructed of oil-impregnated bronze, or solid nylon, or a solid plastic equivalent to nylon. Shaft bearings configuration shall be a pressed fit to provide a tight joint between blade shaft and damper frame.

Size	Material
4 to 20 inches	solid nylon, or equivalent solid plastic, or oil-impregnated bronze
22 to 30 inches	solid nylon, or equivalent solid plastic, or oil-impregnated bronze
32 to 40 inches	oil-impregnated bronze, or stainless steel sleeve bearing

2.9.2.2.5 Control Shaft/Hand Quadrant

Provide dampers with accessible locking-type control shaft/hand quadrant operators.

Provide stand-off mounting brackets, bases, or adapters for the locking-type quadrant operators on dampers installed on ducts to be thermally insulated. Stand-off distance shall be a minimum of 2 inches off the metal duct surface. Stand-off mounting items shall be integral with the operator or standard accessory of the damper manufacturer.

2.9.2.2.6 Finish

Mill Galvanized

2.9.3 Diffusers, Registers, and Grilles

2.9.3.1 Registers

Double-deflection supply registers. Provide exhaust and return registers as specified for supply registers, except provide exhaust and return registers that have a single set of nondirectional face bars or vanes having the same appearance as the supply registers.

2.9.4 Louvers

Provide louvers for installation in exterior walls that are associated with the air supply and distribution system as specified in Section 08 91 00 METAL WALL LOUVERS.

2.9.5 Bird Screens and Frames

Provide insect screens that conform to ASTM E2016, No. 2 mesh, aluminum or stainless steel. Provide "medium-light" rated aluminum screens. Provide "light" rated stainless steel screens. Provide removable type frames fabricated from either stainless steel or extruded aluminum.

2.10 AIR SYSTEMS EQUIPMENT

2.10.1 Fans

Test and rate fans according to AMCA 210. Calculate system effect on air moving devices in accordance with AMCA 201 where installed ductwork differs from that indicated on drawings. Install air moving devices to minimize fan system effect. Where system effect is unavoidable, determine the most effective way to accommodate the inefficiencies caused by system effect on the installed air moving device. The sound power level of the fans shall not exceed 85 dBA when tested according to AMCA 300 and rated in accordance with AMCA 301. Provide all fans with an AMCA seal. Connect fans to the motors either directly or indirectly with V-belt drive. Use V-belt drives designed for not less than 150 percent of the connected driving capacity. Provide variable pitch motor sheaves for 15 hp and below, and fixed pitch as defined by AHRI Guideline D (A fixed-pitch sheave is provided on both the fan shaft and the motor shaft. This is a non-adjustable speed drive.). Select variable pitch sheaves to drive the fan at a speed which can produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, provide a replaceable sheave when needed to achieve system air balance. Provide motors for V-belt drives with adjustable rails or bases. Provide removable metal guards for all exposed V-belt drives, and provide speed-test openings at the center of all rotating shafts. Provide fans with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Provide fan and motor assemblies with vibration-isolation supports or mountings as indicated. Use vibration-isolation units that are standard products with published loading ratings. Select each fan to produce the capacity required at the fan static pressure indicated. Provide sound power level as indicated. Obtain the sound power level values according to AMCA 300. Provide standard AMCA arrangement, rotation, and discharge as indicated. Provide power ventilators that conform to UL 705 and have a UL label.

2.10.1.1 In-Line Centrifugal Fans

Provide in-line fans with centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards, and adjustable motor mounts. Mount fans in a welded tubular casing. Provide a fan that axially flows the air in and out. Streamline inlets with conversion vanes to eliminate turbulence and provide smooth discharge air flow. Enclose and isolate fan bearings and drive shafts from the air stream. Provide precision, self aligning ball or roller type fan bearings that are sealed against dust and dirt and are permanently lubricated. Provide L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Provide motors with totally enclosed enclosure. Provide manual motor starters across-the-line with weather-resistant enclosures.

2.10.2 Corrosion Protection for Coastal Installations

Provide corrosion protection for exterior HVAC equipment, including air handling units, equipment casings, heat pumps, and air conditioning units. Provide factory or field anti-corrosion coatings for coastal applications to meet the following performance: Salt-spray test the factory-applied coating or paint system of equipment including packaged terminal units, heat pumps, and air conditioners in accordance with ASTM B117. Conduct test for 3000 hours for equipment installed outdoors, or 1000 hours for equipment installed indoors.

2.11 FACTORY PAINTING

Factory paint new equipment, which are not of galvanized construction. Paint with a corrosion resisting paint finish according to ASTM A123/A123M or ASTM A924/A924M. Clean, phosphatize and coat internal and external ferrous metal surfaces with a paint finish which has been tested according to ASTM B117, ASTM D1654, and ASTM D3359. Submit evidence of satisfactory paint performance for a minimum of 1000 hours for units to be installed indoors and 3000 hours for units to be installed outdoors. Provide rating of failure at the scribe mark that is not less than 6, average creepage not greater than 1/8 inch. Provide rating of the inscribed area that is not less than 10, no failure. On units constructed of galvanized steel that have been welded, provide a final shop docket of zinc-rich protective paint on exterior surfaces of welds or welds that have burned through from the interior according to ASTM D520 Type I.

Factory painting that has been damaged prior to acceptance by the Contracting Officer shall be field painted in compliance with the requirements of paragraph FIELD PAINTING OF MECHANICAL EQUIPMENT.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

a. Install materials and equipment in accordance with the requirements of the contract drawings and approved manufacturer's installation instructions. Accomplish installation by workers skilled in this type of work. Perform installation so that there is no degradation of the designed fire ratings of walls, partitions, ceilings, and floors.

b. No installation is permitted to block or otherwise impede access to any existing machine or system. Install all hinged doors to swing open a minimum of 120 degrees. Provide an area in front of all access doors that clears a minimum of 3 feet. In front of all access doors to electrical circuits, clear the area the minimum distance to energized circuits as specified in OSHA Standards, part 1910.333 (Electrical-Safety Related work practices)and an additional 3 feet.

c. Except as otherwise indicated, install emergency switches and alarms in conspicuous locations. Mount all indicators, to include gauges, meters, and alarms in order to be easily visible by people in the area.

3.2.1 Condensate Drain Lines

Provide water seals in the condensate drain from all units. Provide a depth of each seal of 2 inches plus the number of inches, measured in water gauge, of the total static pressure rating of the unit to which the drain is connected. Provide water seals that are constructed of 2 tees and an appropriate U-bend with the open end of each tee plugged. Provide pipe cap or plug cleanouts where indicated. Connect drains indicated to connect to the sanitary waste system using an indirect waste fitting. Insulate air conditioner drain lines as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.2.2 Equipment and Installation

Provide frames and supports for tanks, compressors, pumps, valves, air handling units, fans, coils, dampers, and other similar items requiring supports. Floor mount or ceiling hang air handling units as indicated. Anchor and fasten as detailed. Set floor-mounted equipment on not less than 6 inch concrete pads or curbs doweled in place unless otherwise indicated. Make concrete foundations heavy enough to minimize the intensity of the vibrations transmitted to the piping, duct work and the surrounding structure, as recommended in writing by the equipment manufacturer. In lieu of a concrete pad foundation, build a concrete pedestal block with isolators placed between the pedestal block and the floor. Make the concrete foundation or concrete pedestal block a mass not less than three times the weight of the components to be supported. Provide the lines connected to the pump mounted on pedestal blocks with flexible connectors. Submit foundation drawings as specified in paragraph DETAIL DRAWINGS. Provide concrete for foundations as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.3 CLEANING

Thoroughly clean surfaces of piping and equipment that have become covered with dirt, plaster, or other material during handling and construction before such surfaces are prepared for final finish painting or are enclosed within the building structure. Before final acceptance, clean mechanical equipment, including piping, ducting, and fixtures, and free from dirt, grease, and finger marks. Incorporate housekeeping for field construction work which leaves all furniture and equipment in the affected area free of construction generated dust and debris; and, all floor surfaces vacuum-swept clean.

3.4 PENETRATIONS

Provide sleeves and prepared openings for duct mains, branches, and other penetrating items, and install during the construction of the surface to be penetrated. Cut sleeves flush with each surface. Place sleeves for round duct 15 inches and smaller. Build framed, prepared openings for round duct larger than 15 inches and square, rectangular or oval ducts. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Provide one inch clearance between penetrating and penetrated surfaces except at grilles, registers, and diffusers. Pack spaces between sleeve or opening and duct or duct insulation with mineral fiber conforming with ASTM C553, Type 1, Class B-2.

3.4.1 Sleeves

Fabricate sleeves, except as otherwise specified or indicated, from 20

gauge thick mill galvanized sheet metal. Where sleeves are installed in bearing walls or partitions, provide black steel pipe conforming with ASTM A53/A53M, Schedule 20.

3.4.2 Framed Prepared Openings

Fabricate framed prepared openings from 20 gauge galvanized steel, unless otherwise indicated.

3.4.3 Closure Collars

Provide closure collars of a minimum 4 inches wide, unless otherwise indicated, for exposed ducts and items on each side of penetrated surface, except where equipment is installed. Install collar tight against the surface and fit snugly around the duct or insulation. Grind sharp edges smooth to prevent damage to penetrating surface. Fabricate collars for round ducts 15 inches in diameter or less from 20 gauge galvanized steel. Fabricate collars for square and rectangular ducts, or round ducts with minimum dimension over 15 inches from 18 gauge galvanized steel. Fabricate collars for square and rectangular ducts with a maximum side of 15 inches or less from 20 gauge galvanized steel. Install collars with fasteners a maximum of 6 inches on center. Attach to collars a minimum of 4 fasteners where the opening is 12 inches in diameter or less, and a minimum of 8 fasteners where the opening is 20 inches in diameter or less.

3.5 FIELD PAINTING OF MECHANICAL EQUIPMENT

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except clean to bare metal on metal surfaces subject to temperatures in excess of 120 degrees F. Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Provide aluminum or light gray finish coat.

3.5.1 Temperatures less than 120 degrees F

Immediately after cleaning, apply one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat to metal surfaces subject to temperatures less than 120 degrees F.

3.5.2 Temperatures between 120 and 400 degrees F

Apply two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of two mils to metal surfaces subject to temperatures between 120 and 400 degrees F.

3.5.3 Temperatures greater than 400 degrees F

Apply two coats of 315 degrees C 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of two mils to metal surfaces subject to temperatures greater than 400 degrees F.

3.6 DUCTWORK LEAK TESTS

The requirements for ductwork leak tests are specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC.

3.7 DAMPER ACCEPTANCE TEST

Submit the proposed schedule, at least 2 weeks prior to the start of test. Operate all fire dampers and smoke dampers under normal operating conditions, prior to the occupancy of a building to determine that they function properly. Test each fire damper equipped with fusible link by having the fusible link cut in place. Test dynamic fire dampers with the air handling and distribution system running. Reset all fire dampers with the fusible links replaced after acceptance testing. To ensure optimum operation and performance, install the damper so it is square and free from racking.

3.8 TESTING, ADJUSTING, AND BALANCING

The requirements for testing, adjusting, and balancing are specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC. Begin testing, adjusting, and balancing only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

3.9 PERFORMANCE TESTS

After testing, adjusting, and balancing is complete as specified, test each system as a whole to see that all items perform as integral parts of the system and temperatures and conditions are evenly controlled throughout the building. Record the testing during the applicable season. Make corrections and adjustments as necessary to produce the conditions indicated or specified. Conduct capacity tests and general operating tests by an experienced engineer. Provide tests that cover a period of not less than 5 days for each system and demonstrate that the entire system is functioning according to the specifications. Make coincidental chart recordings at points indicated on the drawings for the duration of the time period and record the temperature at space thermostats or space sensors, the humidity at space humidistats or space sensors and the ambient temperature and humidity in a shaded and weather protected area.

Submit test reports for the performance tests in booklet form, upon completion of testing. Document phases of tests performed including initial test summary, repairs/adjustments made, and final test results in the reports.

3.10 CLEANING AND ADJUSTING

Provide a temporary bypass for water coils to prevent flushing water from passing through coils. Thoroughly clean ducts, plenums, and casing of debris and blow free of small particles of rubbish and dust and then vacuum clean before installing outlet faces. Wipe equipment clean, with no traces of oil, dust, dirt, or paint spots. Provide temporary filters prior to startup of all fans that are operated during construction, and install new filters after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. Maintain system in this clean condition until final acceptance. Properly lubricate bearings with oil or grease as recommended

by the manufacturer. Tighten belts to proper tension. Adjust control valves and other miscellaneous equipment requiring adjustment to setting indicated or directed. Adjust fans to the speed indicated by the manufacturer to meet specified conditions. Maintain all equipment installed under the contract until close out documentation is received, the project is completed and the building has been documented as beneficially occupied.

3.11 OPERATION AND MAINTENANCE

3.11.1 Operation and Maintenance Manuals

Submit six manuals at least 2 weeks prior to field training. Submit data complying with the requirements specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA. Submit Data Package 3 for the items/units listed under SD-10 Operation and Maintenance Data

3.11.2 Operation And Maintenance Training

Conduct a training course for the members of the operating staff as designated by the Contracting Officer. Make the training period consist of a total of 3 hours of normal working time and start it after all work specified herein is functionally completed and the Performance Tests have been approved. Conduct field instruction that covers all of the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations. Submit the proposed On-site Training schedule concurrently with the Operation and Maintenance Manuals and at least 14 days prior to conducting the training course.

-- End of Section --

SECTION 23 03 00.00 20

BASIC MECHANICAL MATERIALS AND METHODS

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	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013) National Electrical Safety Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2011; Errata 2012) Motors and Generators
NEMA MG 10	(2013) 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

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS	Scientific Certification Systems (SCS)Indoor Advantage

UL ENVIRONMENT (ULE)

ULE Greenguard	UL Greenguard Certification Program

1.2 RELATED REQUIREMENTS

This section applies to all sections of Divisions: 21, FIRE SUPPRESSION; 22, PLUMBING; and 23, HEATING, VENTILATING, AND AIR CONDITIONING of this project specification, unless specified otherwise in the individual section.

1.3 QUALITY ASSURANCE

1.3.1 Material and Equipment Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacture of such products, which are of a similar material, design and workmanship. Standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

1.3.2 Alternative Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.3.3 Service Support

The equipment items shall be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.3.4 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.

1.3.5 Modification of References

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.

1.3.5.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions shall be considered mandatory, the word "should" shall be interpreted as "shall." Reference to the "code official" shall be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" shall be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" shall be interpreted to mean the "lessor." References to the "permit holder" shall be interpreted to mean the "Contractor."

1.3.5.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of

Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.4 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.5 ELECTRICAL REQUIREMENTS

Furnish motors, controllers, disconnects and contactors with their respective pieces of equipment. Motors, controllers, disconnects and contactors shall conform to and have electrical connections provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Furnish internal wiring for components of packaged equipment as an integral part of the equipment. Extended voltage range motors will not be permitted. Controllers and contactors shall have a maximum of 120 volt control circuits, and shall have auxiliary contacts for use with the controls furnished. When motors and equipment furnished are larger than sizes indicated, the cost of additional electrical service and related work shall be included under the section that specified that motor or equipment. Power wiring and conduit for field installed equipment shall be provided under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

1.6 ELECTRICAL INSTALLATION REQUIREMENTS

Electrical installations shall conform to IEEE C2, NFPA 70, and requirements specified herein.

1.6.1 New Work

Provide electrical components of mechanical equipment, such as motors, motor starters (except starters/controllers which are indicated as part of a motor control center), control or push-button stations, float or pressure switches, solenoid valves, integral disconnects, and other devices functioning to control mechanical equipment, as well as control wiring and conduit for circuits rated 100 volts or less, to conform with the requirements of the section covering the mechanical equipment. Extended voltage range motors shall not be permitted. The interconnecting power wiring and conduit, control wiring rated 120 volts (nominal) and conduit, the motor control equipment forming a part of motor control centers, and the electrical power circuits shall be provided under Division 26, except internal wiring for components of package equipment shall be provided as an integral part of the equipment. When motors and equipment furnished are larger than sizes indicated, provide any required changes to the electrical service as may be necessary and related work as a part of the work for the section specifying that motor or equipment.

1.6.2 High Efficiency Motors

1.6.2.1 High Efficiency Single-Phase Motors

Unless otherwise specified, single-phase fractional-horsepower alternating-current motors shall be high efficiency types corresponding to the applications listed in NEMA MG 11.

1.6.2.2 High Efficiency Polyphase Motors

Unless otherwise specified, polyphase motors shall be selected based on high efficiency characteristics relative to the applications as listed in NEMA MG 10. Additionally, polyphase squirrel-cage medium induction motors with continuous ratings shall meet or exceed energy efficient ratings in accordance with Table 12-6C of NEMA MG 1.

1.6.3 Three-Phase Motor Protection

Provide controllers for motors rated one 1 horsepower and larger 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.

1.7 INSTRUCTION TO GOVERNMENT PERSONNEL

When specified in other sections, furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work.

Instruction shall 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. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

1.8 ACCESSIBILITY

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 PAINTING OF NEW EQUIPMENT

New equipment painting shall be factory applied or shop applied, and shall be as specified herein, and provided under each individual section.

3.1.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 1 000 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 3000 hours in a salt-spray fog test. Salt-spray fog test shall be in accordance with ASTM B117, and for that test the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen shall show no signs of rust creepage beyond 0.125 inch on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120 degrees F, the factory painting system shall be designed for the temperature service.

3.1.2 Shop Painting Systems for Metal Surfaces

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 120 degrees F shall be cleaned to bare metal.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

a. Temperatures Less Than 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 120 degrees F shall receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of 1 mil; and two coats of enamel applied to a minimum dry film thickness of 1 mil per coat.

b. Temperatures Between 120 and 400 Degrees F: Metal surfaces subject to temperatures between 120 and 400 degrees F shall receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of 2 mils.

c. Temperatures Greater Than 400 Degrees F: Metal surfaces subject to temperatures greater than 400 degrees F shall receive two coats of 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 2 mils.

-- End of Section --

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

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.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S1.11	(2004; Errata 2005; R 2009) Specification for Octave- Band and Fractional-Octave-Band Analog and Digital Filters (ASA 65)
ASA S1.4	(1983; Amendment 1985; R 2006) Specification for Sound Level Meters (ASA 47)

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 203	(1990; R 2011) Field Performance Measurements of Fan Systems

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 62.1	(2010; Errata 2011; INT 3 2012; INT 4 2012; INT 5 2013) Ventilation for Acceptable Indoor Air Quality
ASHRAE HVAC APP IP HDBK	(2011) HVAC Applications Handbook, I-P Edition
ASHRAE HVAC APP SI HDBK	(2011) HVAC Applications Handbook, SI Edition

ASSOCIATED AIR BALANCE COUNCIL (AABC)

AABC MN-1	(2002; 6th ed) National Standards for Total System Balance
AABC MN-4	(1996) Test and Balance Procedures

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB MASV	(2006) Procedural Standards for Measurements and Assessment of Sound and

	Vibration
NEBB PROCEDURAL STANDARDS	(2005) Procedural Standards for TAB (Testing, Adjusting and Balancing) Environmental Systems

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

SMACNA 1780	(2002) HVAC Systems - Testing, Adjusting and Balancing, 3rd Edition
SMACNA 1858	(2013) HVAC Sound And Vibration Manual - First Edition
SMACNA 1972 CD	(2012) HVAC Air Duct Leakage Test Manual - 2nd Edition

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

40 CFR 82	Protection of Stratospheric Ozone

1.2 DEFINITIONS

a. AABC: Associated Air Balance Council.

b. COTR: Contracting Officer's Technical Representative.

c. HVAC: Heating, ventilating, and air conditioning; or heating, ventilating, and cooling.

d. NEBB: National Environmental Balancing Bureau

e. Season of maximum heating load: The time of year when the outdoor temperature at the project site remains within plus or minus 30 degrees Fahrenheit of the project site's winter outdoor design temperature, throughout the period of TAB data recording.

f. Season of maximum cooling load: The time of year when the outdoor temperature at the project site remains within plus or minus 5 degrees Fahrenheit of the project site's summer outdoor design temperature, throughout the period of TAB data recording.

g. Season 1, Season 2: Depending upon when the project HVAC is completed and ready for TAB, Season 1 is defined, thereby defining Season 2. Season 1 could be the season of maximum heating load, or the season of maximum cooling load.

h. Sound measurements terminology: Defined in AABC MN-1, NEBB MASV, or SMACNA 1858 (TABB).

i. TAB: Testing, adjusting, and balancing (of HVAC systems).

j. TAB'd: HVAC Testing/Adjusting/Balancing procedures performed.

k. TAB Agency: TAB Firm

l. TAB team field leader: TAB team field leader

m. TAB team supervisor: TAB team engineer.

n. TAB team technicians: TAB team assistants.

o. TABB: Testing Adjusting and Balancing Bureau.

1.2.1 Similar Terms

In some instances, terminology differs between the Contract and the TAB Standard primarily because the intent of this Section is to use the industry standards specified, along with additional requirements listed herein to produce optimal results.

The following table of similar terms is provided for clarification only. Contract requirements take precedent over the corresponding AABC, NEBB, or TABB requirements where differences exist.

SIMILAR TERMS			
Contract Term	AABC Term	NEBB Term	TABB Term
TAB Standard	National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems	Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems	International Standards for Environmental Systems Balance
TAB Specialist	TAB Engineer	TAB Supervisor	TAB Supervisor
Systems Readiness Check	Construction Phase Inspection	Field Readiness Check & Preliminary Field Procedures	Field Readiness Check & Prelim. Field Procedures

1.3 WORK DESCRIPTION

The work includes testing, adjusting, and balancing (TAB) of new heating, ventilating, and cooling (HVAC) systems including refrigerant piping which is located within, on, under, between, and adjacent to buildings.

Perform TAB in accordance with the requirements of the TAB procedural standard recommended by the TAB trade association that approved the TAB Firm's qualifications. Comply with requirements of AABC MN-1, NEBB PROCEDURAL STANDARDS, or SMACNA 1780 (TABB) as supplemented and modified by this specification section. All recommendations and suggested practices contained in the TAB procedural standards are considered mandatory.

Conduct TAB of the indicated existing systems and equipment and submit the specified TAB reports for approval. Conduct TAB work in accordance with the requirements of this section.

1.3.1 Related Requirements

Requirements for price breakdown of HVAC TAB work are specified in Section 01 20 00.00 20 PRICE AND PAYMENT PROCEDURES.

Requirements for construction scheduling related to HVAC TAB work are specified in Section 01 32 17.00 20 NETWORK ANALYSIS SCHEDULES (NAS).

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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-07 Certificates

Independent TAB agency and personnel qualifications; G

Advance Notice of Season 1 TAB Field Work; G

Completed Season 1 Pre-TAB Work Checklist; G

1.5 QUALITY ASSURANCE

1.5.1 Independent TAB Agency and Personnel Qualifications

To secure approval for the proposed agency, submit information certifying that the TAB agency is a first tier subcontractor who is not affiliated with any other company participating in work on this contract, including design, furnishing equipment, or construction. Further, submit the following, for the agency, to Contracting Officer for approval:

a. Independent AABC or NEBB or TABB TAB agency:

TAB agency: AABC registration number and expiration date of current certification; or NEBB certification number and expiration date of current certification; or TABB certification number and expiration date of current certification.

TAB team supervisor: Name and copy of AABC or NEBB or TABB TAB supervisor certificate and expiration date of current certification.

TAB team field leader: Name and documented evidence that the team field leader has satisfactorily performed full-time supervision of TAB work in the field for not less than 3 years immediately preceding this contract's bid opening date.

TAB team field technicians: Names and documented evidence that each field technician has satisfactorily assisted a TAB team field leader in performance of TAB work in the field for not less than one year immediately preceding this contract's bid opening date.

Current certificates: Registrations and certifications are current, and valid for the duration of this contract. Renew Certifications which expire prior to completion of the TAB work, in a timely manner so that there is no lapse in registration or certification. TAB agency or TAB team personnel without a current

registration or current certification are not to perform TAB work on this contract.

b. TAB Team Members: TAB team approved to accomplish work on this contract are full-time employees of the TAB agency. No other personnel is allowed to do TAB work on this contract.

c. Replacement of TAB team members: Replacement of members may occur if each new member complies with the applicable personnel qualifications and each is approved by the Contracting Officer.

1.6 SEQUENCING AND SCHEDULING

1.6.1 TAB Submittal and Work Schedule

Comply with additional requirements specified in Appendix C: DALT AND TAB SUBMITTAL AND WORK SCHEDULE included at the end of this section.

1.6.2 Projects with Phased Construction

This specification section is structured as though the HVAC construction, and thereby the TAB work, will be completed in a single phase. When the construction is completed in phases, the DALT work and TAB work must be planned, completed, and accepted for each construction phase.

1.6.2.1 Phasing of Work

This specification section is structured as though the HVAC construction, and thereby the TAB work, is going to be completed in a single phase. All elements of the TAB work are addressed on this premise. When a contract is to be completed in construction phases, including the TAB work, and the DALT work, the TAB work and DALT work must be planned for, completed and approved by the Contracting Officer with each phase. An example of this case would be one contract that requires the rehabilitation of the HVAC in each of several separated buildings. At the completion of the final phase, compile all approved reports and submit as one document.

1.6.3 TAB Submittal and Work Schedule

Submit this schedule,and TAB Schematic Drawings, adapted for this particular contract, to the Contracting Officer (CO) for review and approval. Include with the submittal the planned calendar dates for each submittal or work item. Resubmit an updated version for CO approval every 90 calendar days days. Compliance with the following schedule is the Contractor's responsibility.

Qualify TAB Personnel: Within 45calendar days after date of contract award, submit TAB agency and personnel qualifications.

Pre-TAB Meeting: Within 30 calendar days after the date of approval of the TAB agency and personnel, meet with the COTR.

Design Review Report: Within 60 calendar days after the date of the TAB agency personnel qualifications approval, submit design review report.

Pre-Field TAB Engineering Report: Within 30 calendar days after approval of the TAB agency Personnel Qualifications, submit the Pre-Field TAB Engineering Report.

Prerequisite HVAC Work Check Out List For Season 1 and Advanced Notice For Season 1 TAB Field Work: At a minimum of 115 calendar days prior to CCD, submit Season 1 prerequisite HVAC work check out list certified as complete, and submit advance notice of commencement of Season 1 TAB field work.

Season 1 TAB Field Work: At a minimum of 90 calendar days prior to CCD, and when the ambient temperature is within Season 1 limits, accomplish Season 1 TAB field work.

Submit Season 1 TAB Report: Within 15 calendar days after completion of Season 1 TAB field work, submit Season 1 TAB report.

Season 1 TAB Field Check: 30 calendar days after Season 1 TAB report is approved by the Contracting Officer, conduct Season 1 field check.

Complete Season 1 TAB Work: Prior to CCD, complete all TAB work.

1.6.3.1 Design Review Report

Submit typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the duct leakage testing work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. State that no deficiencies are evident if that is the case.

1.6.3.2 Pre-Field TAB Engineering Report

Submit report containing the following information:

a. Step-by-step TAB procedure:

(1) Strategy: Describe the method of approach to the TAB field work from start to finish. Include in this description a complete methodology for accomplishing each seasonal TAB field work session.

(2) Air System Diagrams: Use the contract drawings and duct fabrication drawings if available to provide air system diagrams in the report showing the location of all terminal outlet supply, return, exhaust and transfer registers, grilles and diffusers. Use a key numbering system on the diagrams which identifies each outlet contained in the outlet airflow report sheets. Show intended locations of all traverses and static pressure readings.

(3) Procedural steps: Delineate fully the intended procedural steps to be taken by the TAB field team to accomplish the required TAB work of each air distribution system and each water distribution system. Include intended procedural steps for TAB work for subsystems and system components.

b. Pre-field data: Submit AABC or NEBB or SMACNA 1780 data report forms with the following pre-field information filled in:

(1) Design data obtained from system drawings, specifications, and approved submittals.

(2) Notations detailing additional data to be obtained from the contract site by the TAB field team.

(3) Designate the actual data to be measured in the TAB field work.

(4) Provide a list of the types of instruments, and the measuring range of each, which are anticipated to be used for measuring in the TAB field work. By means of a keying scheme, specify on each TAB data report form submitted, which instruments will be used for measuring each item of TAB data. If the selection of which instrument to use, is to be made in the field, specify from which instruments the choice will be made. Place the instrument key number in the blank space where the measured data would be entered.

c. Prerequisite HVAC work checkout list: Provide a list of inspections and work items which are to be completed by the Contractor. This list must be acted upon and completed by the Contractor and then submitted and approved by the Contracting Officer prior to the TAB team coming to the contract site.

At a minimum, a list of the applicable inspections and work items listed in the NEBB PROCEDURAL STANDARDS, Section III, "Preliminary TAB Procedures" under paragraphs titled, "Air Distribution System Inspection" and "Hydronic Distribution System Inspection" must be provided for each separate system to be TAB'd.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 WORK DESCRIPTIONS OF PARTICIPANTS

Comply with requirements of this section as specified in Appendix A WORK DESCRIPTIONS OF PARTICIPANTS.

3.2 PRE-TAB MEETING

Meet with the Contracting Officer's technical representative (COTR) and the designing engineer of the HVAC systems to develop a mutual understanding relative to the details of the TAB work requirements. Ensure that the TAB supervisor is present at this meeting. Requirements to be discussed include required submittals, work schedule, and field quality control.

3.3 TAB PROCEDURES

3.3.1 TAB Field Work

Test, adjust, and balance the HVAC systems until measured flow rates (air and water flow) are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents.

That is, comply with the the requirements of AABC MN-1, or SMACNA 1780 (TABB) and SMACNA 1858 (TABB),except as supplemented and modified by this section.

Provide instruments and consumables required to accomplish the TAB work. Calibrate and maintain instruments in accordance with manufacturer's written procedures.

Test, adjust, and balance the HVAC systems until measured flow rates (air flow) are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents. Conduct TAB work, including measurement accuracy, and sound measurement work in conformance with the AABC MN-1 and AABC MN-4, or NEBB TABES and NEBB MASV, or SMACNA 1780 (used by TABB) and SMACNA 1858 sound measurement procedures, except as supplemented and modified by this section.

3.3.2 Preliminary Procedures

Use the approved pre-field engineering report as instructions and procedures for accomplishing TAB field work. TAB engineer is to locate, in the field, test ports required for testing. It is the responsibility of the sheet metal contractor to provide and install test ports as required by the TAB engineer.

3.3.3 TAB Air Distribution Systems

3.3.3.1 Units With Coils

Report heating and cooling performance capacity tests for DX coils for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:

a. For units with capacities of 7.5 tons (90,000 Btu) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:

   Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

3.3.3.2 Fan Coils

Fan coil unit systems including fans, coils, ducts, plenums, and air distribution devices for supply air, return air, and outside air.

3.3.3.3 Fans

Exhaust fan systems including fans, ducts, plenums, grilles, and hoods for exhaust and return air.

3.3.4 TAB Work on Performance Tests With Seasonal Limitations

3.3.4.1 Performance Tests

Accomplish proportionate balancing TAB work on the air distribution systems and water distribution systems, in other words, accomplish adjusting and balancing of the air flows and water flows, any time during the duration of this contract, subject to the limitations specified elsewhere in this section. However, accomplish, within the following seasonal limitations, TAB work on HVAC systems which directly transfer thermal energy.

3.3.4.2 Season Of Maximum Load

Visit the contract site for at least two TAB work sessions for TAB field

measurements. Visit the contract site during the season of maximum heating load and visit the contract site during the season of maximum cooling load, the goal being to TAB the operational performance of the heating systems and cooling systems under their respective maximum outdoor environment-caused loading. During the seasonal limitations, TAB the operational performance of the heating systems and cooling systems.

3.3.4.3 Ambient Temperatures

On each tab report form used for recording data, record the outdoor and indoor ambient dry bulb temperature range and the outdoor and indoor ambient wet bulb temperature range within which the report form's data was recorded. Record these temperatures at beginning and at the end of data taking.

3.3.4.4 Sound Measurements

Comply with paragraph entitled "Sound Measurement Work," specifically, the requirement that a room must be operating in its noisiest mode at the time of sound measurements in the room. The maximum noise level measurements could depend on seasonally related heat or cooling transfer equipment.

3.3.5 Workmanship

Conduct TAB work on the HVAC systems until measured flow rates and capacities are within plus or minus 5 percent of the design flow rates and capacities as specified or indicated on the contract documents. This TAB work includes adjustment of equipment, balancing valves, balancing dampers, and sheaves. Further, this TAB work includes changing out fan sheaves and equipment changes if required to obtain air flow rates specified or indicated. If, with these adjustments and equipment changes, the specified or indicated design flow rates cannot be attained, contact the Contracting Officer for direction.

3.3.6 Deficiencies

Strive to meet the intent of this section to maximize the performance of the equipment as designed and installed. However, if deficiencies in equipment design or installation prevent TAB work from being accomplished within the range of design values specified in the paragraph entitled "Workmanship," provide written notice as soon as possible to the Contractor and the Contracting Officer describing the deficiency and recommended correction.

Responsibility for correction of installation deficiencies is the Contractor's. If a deficiency is in equipment design, call the TAB team supervisor for technical assistance. Responsibility for reporting design deficiencies to Contractor is the TAB team supervisor's.

3.3.7 TAB Reports

Additional requirements for TAB Reports are specified in Appendix B REPORTS - TAB

3.3.8 Quality Assurance - COTR TAB Field Acceptance Testing

3.3.8.1 TAB Field Acceptance Testing

During the field acceptance testing, verify, in the presence of the COTR,

random selections of data (air quantities, air motion) recorded in the TAB Report. Points and areas for field acceptance testing are to be selected by the COTR. Measurement and test procedures are the same as approved for TAB work for the TAB Report.

Further, if any data on the TAB Report for Groups 2 through 5 is found not to fall within the range of plus 5 to minus 5 percent of the TAB Report data, additional group data verification is required in the presence of the COTR. Verify TAB Report data for one additional piece of equipment in that group. Continue this additional group data verification until out-of-tolerance data ceases to be found.

3.3.8.2 Additional COTR TAB Field Acceptance Testing

If any of the acceptance testing measurements for a given equipment group is found not to fall within the range of plus 5 to minus 5 percent of the TAB Report data, terminate data verification for all affected data for that group. The affected data for the given group will be disapproved. Make the necessary corrections and prepare a revised TAB Report. Reschedule acceptance testing of the revised report data with the COTR.

3.3.8.3 Prerequisite for Approval

Compliance with the field acceptance testing requirements of this section is a prerequisite for the final Contracting Officer approval of the TAB Report submitted.

3.4 MARKING OF SETTINGS

Upon the final TAB work approval, permanently mark the settings of HVAC adjustment devices including valves, gauges, splitters, and dampers so that adjustment can be restored if disturbed at any time. Provide permanent markings clearly indicating the settings on the adjustment devices which result in the data reported on the submitted TAB report.

3.5 APPENDICES

Appendix A WORK DESCRIPTIONS OF PARTICIPANTS
Appendix B REPORTS - TAB
Appendix C TAB SUBMITTAL AND WORK SCHEDULE

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Appendix A

WORK DESCRIPTIONS OF PARTICIPANTS

The Contractor is responsible for ensuring compliance with all requirements of this specification section. However, the following delineation of specific work items is provided to facilitate and co-ordinate execution of the various work efforts by personnel from separate organizations.

1. Contractor

a. HVAC documentation: Provide pertinent contract documentation to the TAB Firm, to include the following: the contract drawings and specifications; copies of the approved submittal data for all HVAC equipment, air distribution devices, and air measuring/balancing devices; the construction work schedule; and other applicable documents requested by the TAB Firm. Provide the TAB Firm copies of contract revisions and modifications as they occur.

b. Schedules: Ensure the requirements specified under the paragraph "TAB Schedule" is met.

c. Pre-TAB meeting: Arrange and conduct the Pre-TAB meeting. Ensure that a representative is present for the sheet metal contractor, the mechanical contractor, the electrical contractor, and the automatic temperature controls contractor.

d. Coordinate Support: Provide and coordinate support personnel required by the TAB Firm in order to accomplish the DALT and TAB field work. Support personnel may include factory representatives, HVAC controls installers, HVAC equipment mechanics, sheet metal workers, pipe fitters, and insulators. Ensure support personnel are present at the work site at the times required.

e. Correct Deficiencies: Ensure the notifications of Construction Deficiencies are provided as specified herein. Refer to the paragraph entitled "Construction Deficiencies." Correct each deficiency as soon as practical with the Contracting Officer, and submit revised schedules and other required documentation.

f. Pre-TAB Work Checklists: Complete check out and debugging of HVAC equipment, ducts, and controls prior to the TAB engineer arriving at the project site to begin the TAB work. Debugging includes searching for and eliminating malfunctioning elements in the HVAC system installations, and verifying all adjustable devices are functioning as designed. Include as pre-TAB work checklist items, the deficiencies pointed out by the TAB team supervisor in the design review report.

Prior to the TAB field team's arrival, ensure completion of the applicable inspections and work items listed in the TAB team supervisor's DALT and TAB Work Procedures Summary. Do not allow the TAB team to commence TAB field work until all of the following are completed.

g. Give Notice of Testing: Submit advance notice of TAB field work accompanied by completed prerequisite HVAC Work List

2. TAB Team Supervisor

a. Overall management: Supervise and manage the overall TAB team work effort, including preliminary and technical DALT and TAB procedures and TAB team field work.

b. Schedule: Ensure the requirements specified under the paragraph "TAB Schedule" are met.

c. Submittals: Provide the submittals specified herein.

d. Pre-TAB meeting: Attend meeting with Contractor. Ensure TAB personnel that will be involved in the TAB work under this contract attend the meeting.

e. Design Review Report: Submit typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the duct leakage testing work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. State that no deficiencies are evident if that is the case.

f. Support required: Specify the technical support personnel required from the Contractor other than the TAB agency; such as factory representatives for temperature controls or for complex equipment. Inform the Contractor in writing of the support personnel needed and when they are needed. Furnish the notice as soon as the need is anticipated, either with the design review report, or the TAB Procedures Summary, the during the DALT or TAB field work.

Ensure the Contractor is properly notified and aware of all support personnel needed to perform the TAB work. Maintain communication with the Contractor regarding support personnel throughout the duration of the TAB field work, including the TAB field acceptance testing checking.

Ensure all inspections and verifications for the Pre-Final TAB and Pre-TAB Checklists are completely and successfully conducted before TAB field work is performed.

h. Technical Assistance: Provide technical assistance to the DALT and TAB field work.

i. Deficiencies Notification: Ensure the notifications of Construction Deficiencies are provided as specified herein. Comply with requirements of the paragraph entitled "Construction Deficiencies." Resolve each deficiency as soon as practical and submit revised schedules and other required documentation.

j. Procedures: Develop the required TAB procedures for systems or system components not covered in the TAB Standard.

3. TAB Team Field Leader

a. Field manager: Manage, in the field, the accomplishment of the work specified in Part 3, "Execution."

b. Full time: Be present at the contract site when DALT field work or

TAB field work is being performed by the TAB team; ensure day-to-day TAB team work accomplishments are in compliance with this section.

c. Prerequisite HVAC work: Do not bring the TAB team to the contract site until a copy of the prerequisite HVAC work list, with all work items certified by the Contractor to be working as designed, reaches the office of the TAB Agency.

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Appendix B

REPORTS - TAB

All submitted documentation must be typed, neat, and organized. All reports must have a waterproof front and back cover, a title page, a certification page, sequentially numbered pages throughout, and a table of contents. Tables, lists, and diagrams must be titled. Generate and submit for approval the following documentation:

1. TAB Work Execution Schedule

Submit a detailed schedule indicating the anticipated calendar date for each submittal and each portion of work required under this section. For each work entry, indicate the support personnel (such as controls provider, HVAC mechanic, etc.) that are needed to accomplish the work. Arrange schedule entries chronologically.

2. TAB Procedures Summary

Submit a detailed narrative describing all aspects of the TAB field work to be performed. Include the following:

a. A list of the intended procedural steps for the TAB field work from start to finish. Indicate how each type of data measurement will be obtained. Include what Contractor support personnel are required for each step, and the tasks they need to perform.

b. A list of the project's submittals that are needed by the TAB Firm in order to meet this Contract's requirements.

c. The schematic drawings to be used in the required reports, which may include building floor plans, mechanical room plans, duct system plans, and equipment elevations. Indicate intended TAB measurement locations, including where test ports need to be provided by the Contractor.

d. The data presentation forms to be used in the report, with the preliminary information and initial design values filled in.

e. A list of TAB instruments to be used, edited for this project, to include the instrument name and description, manufacturer, model number, scale range, published accuracy, most recent calibration date, and what the instrument will be used for on this project.g. A thorough checklist of the work items and inspections that need to be accomplished before the TAB field work can be performed. The Contractor must complete, submit, and receive approval of the Completed Pre-TAB Work Checklist before the TAB field work can be accomplished.

i. The checklists specified above shall be individually developed and tailored specifically for the work under this contract. Refer to NEBB PROCEDURAL STANDARDS, Section III, "Preliminary TAB Procedures" under the paragraphs titled, "Air Distribution System Inspection" and "Hydronic Distribution System Inspection" for examples of items to include in the checklists.

3. Design Review Report

Submit report containing the following information:

a. Review the contract specifications and drawings to verify that the TAB work can be successfully accomplished in compliance with the requirements of this section. Verify the presence and location of permanently installed test ports and other devices needed, including gauge cocks, thermometer wells, flow control devices, circuit setters, balancing valves, and manual volume dampers.

b. Submit a typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the DALT work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. If no deficiencies are evident, state so in the report.

6. TAB Report: Submit TAB Report in the following manner:

a. Procedure Summary: Submit a copy of the approved TAB Procedures Summary. When applicable, provide notations describing how actual field procedures differed from the procedures listed.

b. Report format: Submit the completed data forms approved in the pre-field TAB Engineering Report completed by TAB field team, reviewed, approved and signed by the TAB supervisor. Bind the report with a waterproof front and back cover. Include a table of contents identifying by page number the location of each report. Report forms and report data shall be typewritten. Handwritten report forms or report data are not acceptable.

c. Temperatures: On each TAB report form reporting TAB work accomplished on HVAC thermal energy transfer equipment, include the indoor and outdoor dry bulb temperature range and indoor and outdoor wet bulb temperature range within which the TAB data was recorded. Include in the TAB report continuous time versus temperature recording data of wet and dry bulb temperatures for the rooms, or zones, as designated in the following list:
Each Unit and the space it serves.

(1) Data shall be measured and compiled on a continuous basis for the period in which TAB work affecting those rooms is being done.

(2) Data shall be measured/recorded only after the HVAC systems installations are complete, the systems fully balanced and the HVAC systems controls operating in fully automatic mode. Provide a detailed explanation wherever a final measurement did not achieve the required value.

(3) Data may be compiled using direct digital controls trend logging where available. Otherwise, the Contractor shall temporarily install calibrated time versus temperature/humidity recorders for this purpose. The HVAC systems and controls shall have been fully operational a minimum of 24 hours in advance of commencing data compilation. The specified data shall be included in the Season I TAB Report.

d. Air System Diagrams: Provided updated diagrams with final installed locations of all terminals and devices, any numbering changes, and actual test locations.

g. Instruments: List the types of instruments actually used to measure the tab data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date.

Instrumentation, used for taking wet bulb temperature readings shall provide accuracy of plus or minus 5 percent at the measured face velocities. Submit instrument manufacturer's literature to document instrument accuracy performance is in compliance with that specified.

j. Data From TAB Field Work: After completion of the TAB field work, prepare the TAB field data for TAB supervisor's review and approval signature, using the reporting forms approved in the pre-field engineering report. Data required by those approved data report forms shall be furnished by the TAB team. Except as approved otherwise in writing by the Contracting Officer, the TAB work and thereby the TAB report shall be considered incomplete until the TAB work is accomplished to within the accuracy range specified in the paragraph entitled "Workmanship."

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Appendix C

TAB SUBMITTAL AND WORK SCHEDULE

Perform the following items of work in the order listed adhering to the dates schedule specified below. Include the major items listed in this schedule in the project network analysis schedule required by Section 01 32 17.00 20 NETWORK ANALYSIS SCHEDULES (NAS).

Submit TAB Agency and TAB Personnel Qualifications: Within 42calendar days after date of contract award.

Submit the TAB Work Execution Schedule: within 14 days after receipt of the TAB agency and TAB personnel qualifications approval. Revise and re-submit this schedule 28 days prior to the commencement of TAB Season 1 work and TAB Season 2 work.

Submit the TAB Work Procedures Summary: within 14 days after receipt of the initial approved TAB Work Execution Schedule.

Meet with the COTR at the Pre-TAB Meeting: Within 28 calendar days after receipt of the approved initial TAB Execution Schedule.

Submit Design Review Report: Within 56calendar days after the receipt of the approved initial TAB Work Execution Schedule.

Advance Notice of Season 1 TAB Field Work: At a minimum of 14 calendar days prior to Season 1 TAB Field Work, submit advance notice of TAB field work accompanied by completed Season 1 Pre-TAB Work Checklist.

Season 1 TAB Field Work: At a minimum of 84calendar days prior to CCD, and when the ambient temperature is within Season 1 limits, accomplish Season 1 TAB field work.

Submit Season 1 TAB Report: Within 14calendar days after completion of Season 1 TAB field work, submit initial Season 1 TAB report.

Season 1 Quality Assurance - COTR TAB Field Check: 30 calendar days after initial Season 1 TAB report is approved by the Contracting Officer, conduct Season 1 field check.

Receive the approved TAB report: Within calendar 21 days, receive the report from Contracting Officer.

-- End of Section --

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SECTION 23 07 00

THERMAL INSULATION FOR MECHANICAL SYSTEMS

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. At the discretion of the Government, the manufacturer of any material supplied will be required to furnish test reports pertaining to any of the tests necessary to assure compliance with the standard or standards referenced in this specification.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 189.1	(2011; Errata 1-2 2012; INT 1 2013; Errata 3-8 2013) Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - IP	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.2	(2007; Addendum B 2010) Energy Efficient Design of Low-Rise Residential Buildings

ASTM INTERNATIONAL (ASTM)

ASTM A167	(1999; R 2009) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A240/A240M	(2014) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A580/A580M	(2013b) Standard Specification for Stainless Steel Wire
ASTM B209	(2010) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2010) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM C1126	(2014) Standard Specification for Faced or

	Unfaced Rigid Cellular Phenolic Thermal Insulation
ASTM C1136	(2012) Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM C1290	(2011) Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts
ASTM C1710	(2011) Standard Guide for Installation of Flexible Closed Cell Preformed Insulation in Tube and Sheet Form
ASTM C195	(2007; R 2013) Standard Specification for Mineral Fiber Thermal Insulating Cement
ASTM C450	(2008) Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging
ASTM C533	(2013) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C534/C534M	(2014) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C547	(2012) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C552	(2013) Standard Specification for Cellular Glass Thermal Insulation
ASTM C585	(2010) Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing
ASTM C592	(2013) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C610	(2011) Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation
ASTM C612	(2014) Mineral Fiber Block and Board Thermal Insulation
ASTM C647	(2008; R 2013) Properties and Tests of Mastics and Coating Finishes for Thermal Insulation
ASTM C795	(2008; R 2013) Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel

ASTM C916	(1985; R 2007) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM C921	(2010) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM D2863	(2013) Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
ASTM D5590	(2000; R 2010; E 2012) Standard Test Method for Determining the Resistance of Paint Films and Related Coatings to Fungal Defacement by Accelerated Four-Week Agar Plate Assay
ASTM D882	(2012) Tensile Properties of Thin Plastic Sheeting
ASTM E2231	(2014) Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface Burning Characteristics
ASTM E2336	(2004; R 2013) Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E96/E96M	(2013) Standard Test Methods for Water Vapor Transmission of Materials

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 2758	(2014) Paper - Determination of Bursting Strength

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

MIDWEST INSULATION CONTRACTORS ASSOCIATION (MICA)

MICA Insulation Stds	(1999) National Commercial & Industrial

Insulation Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 90B	(2015) Standard for the Installation of Warm Air Heating and Air Conditioning Systems
NFPA 96	(2014) Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS	Scientific Certification Systems (SCS)Indoor Advantage

TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY (TAPPI)

TAPPI T403 OM	(2010) Bursting Strength of Paper

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-24179	(1969; Rev A; Am 2 1980; Notice 1 1987) Adhesive, Flexible Unicellular-Plastic Thermal Insulation
MIL-A-3316	(1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation
MIL-PRF-19565	(1988; Rev C) Coating Compounds, Thermal Insulation, Fire- and Water-Resistant, Vapor-Barrier

UL ENVIRONMENT (ULE)

ULE Greenguard	UL Greenguard Certification Program

UNDERWRITERS LABORATORIES (UL)

UL 723	(2008; Reprint Aug 2013) Test for Surface Burning Characteristics of Building Materials
UL 94	(2013; Reprint Jul 2014) Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.2 SYSTEM DESCRIPTION

1.2.1 General

Provide field-applied insulation and accessories on mechanical systems as specified herein; factory-applied insulation is specified under the piping, duct or equipment to be insulated.

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. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

Submit the three SD types, SD-02 Shop Drawings, SD-03 Product Data, and SD-08 Manufacturer's Instructions at the same time for each system.

SD-02 Shop Drawings

SD-03 Product Data

Pipe Insulation Systems

SD-08 Manufacturer's Instructions

Pipe Insulation Systems

1.4 QUALITY ASSURANCE

1.4.1 Installer Qualification

Qualified installers shall have successfully completed three or more similar type jobs within the last 5 years.

1.5 DELIVERY, STORAGE, AND HANDLING

Materials shall be delivered in the manufacturer's unopened containers. Materials delivered and placed in storage shall be provided with protection from weather, humidity, dirt, dust and other contaminants. The Contracting Officer may reject insulation material and supplies that become dirty, dusty, wet, or contaminated by some other means. Packages or standard containers of insulation, jacket material, cements, adhesives, and coatings delivered for use, and samples required for approval shall have manufacturer's stamp or label attached giving the name of the manufacturer and brand, and a description of the material, date codes, and approximate shelf life (if applicable). Insulation packages and containers shall be asbestos free.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials which are the standard products of manufacturers regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Submit a complete list of materials, including manufacturer's descriptive technical literature, performance data, catalog cuts, and installation instructions. The product number, k-value, thickness and furnished accessories including adhesives, sealants and jackets for each mechanical system requiring insulation shall be included. The product data must be copyrighted, have an identifying or publication number, and shall have been published prior to the issuance

date of this solicitation. Materials furnished under this section shall be submitted together in a booklet.

2.1.1 Insulation System

Provide insulation systems in accordance with the approved MICA National Insulation Standards plates as supplemented by this specification. Provide field-applied insulation for heating, ventilating, and cooling (HVAC) air distribution systems and piping systems that are located within, on, under, and adjacent to buildings; and for plumbing systems. Insulation shall be CFC and HCFC free.

2.1.2 Surface Burning Characteristics

Unless otherwise specified, insulation shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Flame spread, and smoke developed indexes, shall be determined by ASTM E84 or UL 723. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Test specimens shall be prepared and mounted according to ASTM E2231.

2.2 MATERIALS

Provide insulation that meets or exceed the requirements of ASHRAE 90.1 - IP. Insulation exterior shall be cleanable, grease resistant, non-flaking and non-peeling. Materials shall be compatible and shall not contribute to corrosion, soften, or otherwise attack surfaces to which applied in either wet or dry state. Materials to be used on stainless steel surfaces shall meet ASTM C795 requirements. Calcium silicate shall not be used on chilled or cold water systems. Materials shall be asbestos free. Provide product recognized under UL 94 (if containing plastic) and listed in FM APP GUIDE.

2.2.1 Adhesives

2.2.1.1 Acoustical Lining Insulation Adhesive

Adhesive shall be a nonflammable, fire-resistant adhesive conforming to ASTM C916, Type I.

2.2.1.2 Mineral Fiber Insulation Cement

Cement shall be in accordance with ASTM C195.

2.2.1.3 Contact Adhesive

Adhesives may be any of, but not limited to, the neoprene based, rubber based, or elastomeric type that have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. The adhesive shall not adversely affect, initially or in service, the insulation to which it is applied, nor shall it cause any corrosive effect on metal to which it is applied. Any solvent dispersing medium or volatile component of the adhesive shall have no objectionable odor and shall not contain any benzene or carbon tetrachloride. The dried adhesive shall not emit nauseous, irritating, or toxic volatile matters or aerosols when the adhesive is heated to any temperature up to 212 degrees F. The dried adhesive shall be nonflammable and fire resistant. Flexible Elastomeric Adhesive: Comply with MIL-A-24179, Type II, Class I. Provide

product listed in FM APP GUIDE.

2.2.2 Caulking

ASTM C920, Type S, Grade NS, Class 25, Use A.

2.2.3 Corner Angles

Nominal 0.016 inch aluminum 1 by 1 inch with factory applied kraft backing. Aluminum shall be ASTM B209, Alloy 3003, 3105, or 5005.

2.2.4 Fittings

Fabricated Fittings are the prefabricated fittings for flexible elastomeric pipe insulation systems in accordance with ASTM C1710. Together with the flexible elastomeric tubes, they provide complete system integrity for retarding heat gain and controlling condensation drip from chilled-water and refrigeration systems. Flexible elastomeric, fabricated fittings provide thermal protection (0.25 k) and condensation resistance (0.05 Water Vapor Transmission factor). For satisfactory performance, properly installed protective vapor retarder/barriers and vapor stops shall be used on high relative humidity and below ambient temperature applications to reduce movement of moisture through or around the insulation to the colder interior surface.

2.2.5 Finishing Cement

ASTM C450: Mineral fiber hydraulic-setting thermal insulating and finishing cement. All cements that may come in contact with Austenitic stainless steel must comply with ASTM C795.

2.2.6 Fibrous Glass Cloth and Glass Tape

Fibrous glass cloth, with 20X20 maximum mesh size, and glass tape shall have maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Tape shall be 4 inch wide rolls. Class 3 tape shall be 4.5 ounces/square yard. Elastomeric Foam Tape: Black vapor-retarder foam tape with acrylic adhesive containing an anti-microbial additive.

2.2.7 Staples

Outward clinching type ASTM A167, Type 304 or 316 stainless steel.

2.2.8 Jackets

2.2.8.1 Polyvinyl Chloride (PVC) Jackets

Polyvinyl chloride (PVC) jacket and fitting covers shall have high impact strength, ultraviolet (UV) resistant rating or treatment and moderate chemical resistance with minimum thickness 0.030 inch.

2.3 PIPE INSULATION SYSTEMS

Insulation materials shall conform to Table 1. Insulation thickness shall be as listed in Table 2 and meet or exceed the requirements of ASHRAE 90.1 - IP. Insulation thickness shall be 1 inch. Comply with EPA requirements in accordance with Section 01 62 35 RECYCLED/RECOVERED/BIOBASED MATERIALS. Pipe insulation materials shall be

limited to those listed herein and shall meet the following requirements:

2.3.1 Aboveground Cold Pipeline (-30 to 60 deg. F)

Insulation for outdoor, indoor, exposed or concealed applications, shall be as follows:

2.3.1.1 Flexible Elastomeric Cellular Insulation

Closed-cell, foam- or expanded-rubber materials containing anti-microbial additive, complying with ASTM C534/C534M, Grade 1, Type I or II. Type I, Grade 1 for tubular materials. Type II, Grade 1, for sheet materials. Type I and II shall have vapor retarder/vapor barrier skin on one or both sides of the insulation, and require an additional exterior vapor retarder covering for high relative humidity and below ambient temperature applications.

PART 3 EXECUTION

3.1 APPLICATION - GENERAL

Insulation shall only be applied to unheated and uncooled piping and equipment. Flexible elastomeric cellular insulation shall not be compressed at joists, studs, columns, ducts, hangers, etc. The insulation shall not pull apart after a one hour period; any insulation found to pull apart after one hour, shall be replaced.

3.1.1 Display Samples

Submit and display, after approval of materials, actual sections of installed systems, properly insulated in accordance with the specification requirements. Such actual sections must remain accessible to inspection throughout the job and will be reviewed from time to time for controlling the quality of the work throughout the construction site. Each material used shall be identified, by indicating on an attached sheet the specification requirement for the material and the material by each manufacturer intended to meet the requirement. The Contracting Officer will inspect display sample sections at the jobsite. Approved display sample sections shall remain on display at the jobsite during the construction period. Upon completion of construction, the display sample sections will be closed and sealed.

3.1.1.1 Pipe Insulation Display Sections

Display sample sections shall include as a minimum an elbow or tee, a valve, dielectric waterways and flanges, a hanger with protection shield and insulation insert, or dowel as required, at support point, method of fastening and sealing insulation at longitudinal lap, circumferential lap, butt joints at fittings and on pipe runs, and terminating points for each type of pipe insulation used on the job, and for hot pipelines and cold pipelines, both interior and exterior, even when the same type of insulation is used for these services.

3.1.2 Installation

Except as otherwise specified, material shall be installed in accordance with the manufacturer's written instructions. Insulation materials shall not be applied until tests specified in other sections of this specification are completed. Material such as rust, scale, dirt and

moisture shall be removed from surfaces to receive insulation. Insulation shall be kept clean and dry. Insulation shall not be removed from its shipping containers until the day it is ready to use and shall be returned to like containers or equally protected from dirt and moisture at the end of each workday. Insulation that becomes dirty shall be thoroughly cleaned prior to use. If insulation becomes wet or if cleaning does not restore the surfaces to like new condition, the insulation will be rejected, and shall be immediately removed from the jobsite. Joints shall be staggered on multi layer insulation. Mineral fiber thermal insulating cement shall be mixed with demineralized water when used on stainless steel surfaces. Insulation, jacketing and accessories shall be installed in accordance with MICA Insulation Stds plates except where modified herein or on the drawings.

3.1.3 Firestopping

Where pipes and pass through fire walls, fire partitions, above grade floors, and fire rated chase walls, the penetration shall be sealed with fire stopping materials as specified in Section 07 84 00 FIRESTOPPING. The protection of ducts at point of passage through firewalls must be in accordance with NFPA 90A and/or NFPA 90B. All other penetrations, such as piping, conduit, and wiring, through firewalls must be protected with a material or system of the same hourly rating that is listed by UL, FM, or a NRTL.

3.1.4 Painting and Finishing

Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.1.5 Installation of Flexible Elastomeric Cellular Insulation

Install flexible elastomeric cellular insulation with seams and joints sealed with rubberized contact adhesive. Flexible elastomeric cellular insulation shall not be used on surfaces greater than 220 degrees F. Stagger seams when applying multiple layers of insulation. Protect insulation exposed to weather and not shown to have vapor barrier weatherproof jacketing with two coats of UV resistant finish or PVC or metal jacketing as recommended by the manufacturer after the adhesive is dry and cured.

3.1.5.1 Adhesive Application

Apply a brush coating of adhesive to both butt ends to be joined and to both slit surfaces to be sealed. Allow the adhesive to set until dry to touch but tacky under slight pressure before joining the surfaces. Insulation seals at seams and joints shall not be capable of being pulled apart one hour after application. Insulation that can be pulled apart one hour after installation shall be replaced.

3.1.5.2 Adhesive Safety Precautions

Use natural cross-ventilation, local (mechanical) pickup, and/or general area (mechanical) ventilation to prevent an accumulation of solvent vapors, keeping in mind the ventilation pattern must remove any heavier-than-air solvent vapors from lower levels of the workspaces. Gloves and spectacle-type safety glasses are recommended in accordance with safe installation practices.

3.1.6 Welding

No welding shall be done on piping, or without written approval of the Contracting Officer. .

3.1.7 Pipes That Require Insulation

Insulation is required on all pipes, or except for omitted items as specified.

3.2 PIPE INSULATION SYSTEMS INSTALLATION

3.2.1 Pipe Insulation

3.2.1.1 General

Pipe insulation shall be installed on aboveground hot and cold pipeline systems as specified below to form a continuous thermal retarder/barrier, including straight runs, fittings and appurtenances unless specified otherwise. Installation shall be with full length units of insulation and using a single cut piece to complete a run. Cut pieces or scraps abutting each other shall not be used. Pipe insulation shall be omitted on the following:

a. Pipe used solely for fire protection.

b. Chromium plated pipe to plumbing fixtures. However, fixtures for use by the physically handicapped shall have the hot water supply and drain, including the trap, insulated where exposed.

c. Sanitary drain lines.

d. Air chambers.

e. Adjacent insulation.

f. ASME stamps.

g. Access plates of fan housings.

h. Cleanouts or handholes.

3.2.1.2 Pipes Passing Through Walls, Roofs, and Floors

Pipe insulation shall be continuous through the sleeve.

An aluminum jacket or vapor barrier/weatherproofingJacket or Vapor Barrier/Weatherproofing - self adhesive jacket (minimum 2 mils adhesive, 3 mils embossed) less than 0.0000 permeability, greater than 3 ply standard grade, silver, white, black and embossed with factory applied moisture retarder shall be provided over the insulation wherever penetrations require sealing.

3.2.1.2.1 Penetrate Interior Walls

The aluminum jacket or vapor barrier/weatherproofing - self adhesive jacket (minimum 2 mils adhesive, 3 mils embossed) less than 0.0000 permeability, greater than 3 plies standard grade, silver, white, black and embossed shall extend 2 inches beyond either side of the wall and

shall be secured on each end with a band.

3.2.1.2.2 Penetrating Floors

Extend the aluminum jacket from a point below the backup material to a point 10 inches above the floor with one band at the floor and one not more than 1 inch from the end of the aluminum jacket.

3.2.1.2.3 Penetrating Waterproofed Floors

Extend the aluminum jacket rom below the backup material to a point 2 inches above the flashing with a band 1 inch from the end of the aluminum jacket.

3.2.1.2.4 Penetrating Exterior Walls

Continue the aluminum jacket required for pipe exposed to weather through the sleeve to a point 2 inches beyond the interior surface of the wall.

3.2.1.3 Pipes Passing Through Hangers

Insulation, whether hot or cold application, shall be continuous through hangers. All horizontal pipes 2 inches and smaller shall be supported on hangers with the addition of a Type 40 protection shield to protect the insulation in accordance with MSS SP-69. Whenever insulation shows signs of being compressed, or when the insulation or jacket shows visible signs of distortion at or near the support shield, insulation inserts as specified below for piping larger than 2 inches shall be installed, or factory insulated hangers (designed with a load bearing core) can be used.

3.2.1.3.1 Vertical Pipes

Supported with either Type 8 or Type 42 riser clamps with the addition of two Type 40 protection shields in accordance with MSS SP-69 covering the 360-degree arc of the insulation. An insulation insert of cellular glass or calcium silicate shall be installed between each shield and the pipe. The insert shall cover the 360-degree arc of the pipe. Inserts shall be the same thickness as the insulation, and shall extend 2 inches on each end beyond the protection shield. When insulation inserts are required in accordance with the above, and the insulation thickness is less than 1 inch, wooden or cork dowels or blocks may be installed between the pipe and the shield to prevent the hanger from crushing the insulation, as an option instead of installing insulation inserts. The insulation jacket shall be continuous over the wooden dowel, wooden block, or insulation insert. The vertical weight of the pipe shall be supported with hangers located in a horizontal section of the pipe. When the pipe riser is longer than 30 feet, the weight of the pipe shall be additionally supported with hangers in the vertical run of the pipe that are directly clamped to the pipe, penetrating the pipe insulation. These hangers shall be insulated and the insulation jacket sealed as indicated herein for anchors in a similar service.

3.2.1.3.2 Inserts

Covered with a jacket material of the same appearance and quality as the adjoining pipe insulation jacket, overlap the adjoining pipe jacket 1-1/2 inches, and seal as required for the pipe jacket. The jacket material used to cover inserts in flexible elastomeric cellular insulation shall conform to ASTM C1136, Type 1, and is allowed to be of a different

material than the adjoining insulation material.

3.2.1.4 Flexible Elastomeric Cellular Pipe Insulation

Flexible elastomeric cellular pipe insulation shall be tubular form for pipe sizes 6 inches and less. Grade 1, Type II sheet insulation used on pipes larger than 6 inches shall not be stretched around the pipe. On pipes larger than 12 inches, the insulation shall be adhered directly to the pipe on the lower 1/3 of the pipe. Seams shall be staggered when applying multiple layers of insulation. Sweat fittings shall be insulated with miter-cut pieces the same size as on adjacent piping. Screwed fittings shall be insulated with sleeved fitting covers fabricated from miter-cut pieces and shall be overlapped and sealed to the adjacent pipe insulation. Type II requires an additional exterior vapor retarder/barrier covering for high relative humidity and below ambient temperature applications.

3.2.1.5 Pipe Insulation Material and Thickness

TABLE 1					
Insulation Material for Piping					
Service					
	Material	Specification	Type	Class	VR/VB Req'd
Refrigerant Suction Piping (35 degrees F nominal)					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Condensate Drain Located Inside Building					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Note: VR/VB = Vapor Retarder/Vapor Barrier					

TABLE 2						
Piping Insulation Thickness (inch) Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.						
Service						
	Material	Tube And Pipe Size (inch)				
		<1	1-<1.5	1.5-<4	4-<8	> or = >8
Refrigerant Suction Piping (35 degrees F nominal)						
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A

TABLE 2						
Piping Insulation Thickness (inch) Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.						
Service						
	Material	Tube And Pipe Size (inch)				
		<1	1-<1.5	1.5-<4	4-<8	> or = >8
Condensate Drain Located Inside Building						
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A

3.2.2 Aboveground Cold Pipelines

The following cold pipelines for minus 30 to plus 60 degrees F, shall be insulated in accordance with Table 2 except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted. This includes but is not limited to the following:

a. Air conditioner condensate drains.

3.2.2.1 Insulation Material and Thickness

Insulation thickness for cold pipelines shall be determined using Table 2.

3.2.2.2 Factory or Field applied Jacket

Insulation shall be covered with a factory applied vapor retarder jacket/vapor barrier or field applied seal welded PVC jacket or greater than 3 ply laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability, standard grade, sliver, white, black and embossed for use with Mineral Fiber, Cellular Glass, and Phenolic Foam Insulated Pipe. Insulation inside the building, to be protected with an aluminum jacket or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, Embossed Silver, White & Black, shall have the insulation and vapor retarder jacket installed as specified herein. The aluminum jacket or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, embossed silver, White & Black, shall be installed as specified for piping exposed to weather, except sealing of the laps of the aluminum jacket is not required.

3.2.2.3 Installing Insulation for Straight Runs Hot and Cold Pipe

Apply insulation to the pipe with tight butt joints. Seal all butted joints and ends with joint sealant and seal with a vapor retarder coating,

greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or PVDC adhesive tape.

3.2.2.3.1 Longitudinal Laps of the Jacket Material

Overlap not less than 1-1/2 inches. Provide butt strips 3 inches wide for circumferential joints.

3.2.2.3.2 Laps and Butt Strips

Secure with adhesive and staple on 4 inch centers if not factory self-sealing. If staples are used, seal in accordance with paragraph STAPLES below. Note that staples are not required with cellular glass systems.

3.2.2.3.3 Factory Self-Sealing Lap Systems

May be used when the ambient temperature is between 40 and 120 degrees F during installation. Install the lap system in accordance with manufacturer's recommendations. Use a stapler only if specifically recommended by the manufacturer. Where gaps occur, replace the section or repair the gap by applying adhesive under the lap and then stapling.

3.2.2.3.4 Staples

coat all staples, including those used to repair factory self-seal lap systems, with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape. Coat all seams, except those on factory self-seal systems, with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

3.2.2.3.5 Breaks and Punctures in the Jacket Material

Patch by wrapping a strip of jacket material around the pipe and secure it with adhesive, staple, and coat with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape. Extend the patch not less than 1-1/2 inches past the break.

3.2.2.3.6 Penetrations Such as Thermometers

Fill the voids in the insulation and seal with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

3.2.2.3.7 Flexible Elastomeric Cellular Pipe Insulation

Install by slitting the tubular sections and applying them onto the piping or tubing. Alternately, whenever possible slide un-slit sections over the open ends of piping or tubing. Secure all seams and butt joints and seal with adhesive. When using self seal products only the butt joints shall be secured with adhesive. Push insulation on the pipe, never pulled. Stretching of insulation may result in open seams and joints. Clean cut all edges. Rough or jagged edges of the insulation are not be permitted. Use proper tools such as sharp knives. Do not stretch Grade 1, Type II sheet insulation around the pipe when used on pipe larger than 6 inches. On pipes larger than 12 inches, adhere sheet insulation directly to the pipe on the lower 1/3 of the pipe.

3.2.2.4 Insulation for Fittings and Accessories

a. Pipe insulation shall be tightly butted to the insulation of the fittings and accessories. The butted joints and ends shall be sealed with joint sealant and sealed with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

b. Precut or preformed insulation shall be placed around all fittings and accessories and shall conform to MICA plates except as modified herein: 5 for anchors; 10, 11, and 13 for fittings; 14 for valves; and 17 for flanges and unions. Insulation shall be the same insulation as the pipe insulation, including same density, thickness, and thermal conductivity. Where precut/preformed is unavailable, rigid preformed pipe insulation sections may be segmented into the shape required. Insulation of the same thickness and conductivity as the adjoining pipe insulation shall be used. If nesting size insulation is used, the insulation shall be overlapped 2 inches or one pipe diameter. Elbows insulated using segments shall conform to MICA Tables 12.20 "Mitered Insulation Elbow'. Submit a booklet containing completed MICA Insulation Stds plates detailing each insulating system for each pipe, insulating system, after approval of materials and prior to applying insulation.

(1) The MICA plates shall detail the materials to be installed and the specific insulation application. Submit all MICA plates required showing the entire insulating system, including plates required to show insulation penetrations, vessel bottom and top heads, legs, and skirt insulation as applicable. The MICA plates shall present all variations of insulation systems including locations, materials, vaporproofing, jackets and insulation accessories.

(2) If the Contractor elects to submit detailed drawings instead of edited MICA Plates, the detail drawings shall be technically equivalent to the edited MICA Plate submittal.

c. Upon completion of insulation installation on flanges, unions, valves, anchors, fittings and accessories, terminations, seams, joints and insulation not protected by factory vapor retarder jackets or PVC fitting covers shall be protected with PVDC or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or two coats of vapor retarder coating with a minimum total thickness of 1/16 inch, applied with glass tape embedded between coats. Tape seams shall overlap 1 inch. The coating shall extend out onto the adjoining pipe insulation 2 inches. Fabricated insulation with a factory vapor retarder jacket shall be protected with either greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape, standard grade, silver, white, black and embossed or PVDC adhesive tape or two coats of vapor retarder coating with a minimum thickness of 1/16 inch and with a 2 inch wide glass tape embedded between coats. Where fitting insulation butts to pipe insulation, the joints shall be sealed with a vapor retarder coating and a 4 inch wide ASJ tape which matches the jacket of the pipe insulation.

d. Anchors attached directly to the pipe shall be insulated for a sufficient distance to prevent condensation but not less than 6 inches from the insulation surface.

e. Insulation shall be marked showing the location of unions, strainers, and check valves.

3.2.2.5 Optional PVC Fitting Covers

At the option of the Contractor, premolded, one or two piece PVC fitting covers may be used in lieu of the vapor retarder and embedded glass tape. Factory precut or premolded insulation segments shall be used under the fitting covers for elbows. Insulation segments shall be the same insulation as the pipe insulation including same density, thickness, and thermal conductivity. The covers shall be secured by PVC vapor retarder tape, adhesive, seal welding or with tacks made for securing PVC covers. Seams in the cover, and tacks and laps to adjoining pipe insulation jacket, shall be sealed with vapor retarder tape to ensure that the assembly has a continuous vapor seal.

3.2.3 Piping Exposed to Weather

Piping exposed to weather shall be insulated and jacketed as specified for the applicable service inside the building. After this procedure, a laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability (greater than 3 ply, standard grade, silver, white, black and embossed aluminum jacket or PVC jacket shall be applied. PVC jacketing requires no factory-applied jacket beneath it, however an all service jacket shall be applied if factory applied jacketing is not furnished. Flexible elastomeric cellular insulation exposed to weather shall be treated in accordance with paragraph INSTALLATION OF FLEXIBLE ELASTOMERIC CELLULAR INSULATION in PART 3.

-- End of Section --

SECTION 23 81 00.00 20

UNITARY AIR CONDITIONING EQUIPMENT

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.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 350	(2008) Sound Rating of Non-Ducted Indoor Air-Conditioning Equipment
AHRI DCAACP	(Online) Directory of Certified Applied Air-Conditioning Products
AHRI DCUP	(Online) Directory of Certified Unitary Products
ANSI/AHRI 210/240	(2008; Add 1 2011; Add 2 2012) Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment
ANSI/AHRI 340/360	(2007) Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment
ANSI/AHRI/CSA 310/380	(2004) Standard for Packaged Terminal Air-Conditioners and Heat Pumps

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013; Addenda A 2014; ERTA 2014) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 52.2	(2012; Errata 2013) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 55	(2013; ERTA 2014) Thermal Environmental Conditions for Human Occupancy
ASHRAE 62.1	(2010; Errata 2011; INT 3 2012; INT 4 2012; INT 5 2013) Ventilation for Acceptable Indoor Air Quality
ASHRAE 90.1 - IP	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings

ASHRAE 90.1 - SI	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2011; Amendment 2012) Specification for Filler Metals for Brazing and Braze Welding

ASME INTERNATIONAL (ASME)

ASME B16.22	(2013) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B31.5	(2013) Refrigeration Piping and Heat Transfer Components

ASSOCIATION OF HOME APPLIANCE MANUFACTURERS (AHAM)

AHAM RAC-1	(1982; R2008) Directory of Certified Room Air Conditioners

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B280	(2013) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B88	(2009) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2013) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM C534/C534M	(2014) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM D1654	(2008) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM E2129	(2010) Standard Practice for Data Collection for Sustainability Assessment of Building Products

ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(2000; R 2008; E 2010) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA MG 1	(2011; Errata 2012) Motors and Generators

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-DTL-5541	(2006; Rev F) Chemical Conversion Coatings on Aluminum and Aluminum Alloys

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-50502	(Basic) Air Conditioners, (Unitary Heat Pump), Air to Air (3,000 to 300,000 BTU)

U.S. GREEN BUILDING COUNCIL (USGBC)

LEED NC	(2009) Leadership in Energy and Environmental Design(tm) New Construction Rating System

UNDERWRITERS LABORATORIES (UL)

UL 109	(1997; Reprint Aug 2013) Tube Fittings for Flammable and Combustible Fluids, Refrigeration Service, and Marine Use
UL 484	(2014; Reprint Mar 2014) Standard for Room Air Conditioners

UL 873	(2007; Reprint Aug 2013) Standard for Temperature-Indicating and -Regulating Equipment
UL 900	(2004; Reprint Feb 2012) Standard for Air Filter Units

1.2 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, 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. When used, a designation following the "G" designation 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

Field-assembled refrigerant piping

Control system wiring diagrams

SD-03 Product Data

Packaged terminal units

Air conditioners

Submit documentation for Energy Star qualifications or meeting FEMP requirements. Indicate Energy Efficiency Rating.

Filters

Thermostats

Refrigerant piping and accessories

Coatings for finned tube coils

For packaged terminal units, include indoor noise rating.

SD-06 Test Reports

Salt-spray tests

Start-up and initial operational tests

SD-08 Manufacturer's Instructions

Packaged terminal units

Air conditioners

Filters

Thermostats

Refrigerant piping and accessories

SD-10 Operation and Maintenance Data

Packaged terminal units, Data Package 3

Air conditioners, Data Package 3

Filters, Data Package 2

Thermostats, Data Package 2

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

SD-11 Closeout Submittals

Posted operating instructions

1.4 QUALITY ASSURANCE

1.4.1 Modification of References

Accomplish work in accordance with the referenced publications, except as modified by this section. Consider the advisory or recommended provisions to be mandatory, as though the word "shall" had been substituted for the words "should" or "could" or "may," wherever they appear. Interpret reference to "the Authority having jurisdiction," "the Administrative Authority," "the Owner," or "the Design Engineer" to mean the Contracting Officer.

1.4.2 Detail Drawing

For refrigerant piping, submit piping, including pipe sizes. Submit control system wiring diagrams.

1.4.3 Safety

Design, manufacture, and installation of unitary air conditioning equipment shall conform to ANSI/ASHRAE 15 & 34.

1.4.4 Posted Operating Instructions

Submit posted operating instructions for each packaged air conditioning unit.

1.4.5 Sizing

Size equipment based on Design Manual CS from the Air Conditioning Contractors of America; do not oversize.

1.5 REFRIGERANTS

Refrigerants shall have an Ozone Depletion Factor (ODF) of 0.05 or less. The ODF shall be in accordance with the "Montreal Protocol On Substances

That Deplete The Ozone Layer," September 1987, sponsored by the United Nations Environment Programme. CFCs and HCFCs and Halons shall not be permitted. Refrigerant shall be an approved alternative refrigerant per EPA's Significant New Alternative Policy (SNAP) listing.

1.6 ENVIRONMENTAL REQUIREMENTS

For proper Indoor Environmental Quality, maintain positive pressure within the building. Ventilation shall meet or exceed ASHRAE 62.1 and all published addenda. Meet or exceed filter media efficiency as tested in accordance with ASHRAE 52.2. Thermal comfort shall meet or exceed ASHRAE 55.

PART 2 PRODUCTS

2.1 PACKAGED TERMINAL UNITS

2.1.1 Heat Pumps

ANSI/AHRI/CSA 310/380, UL 484, air-cooled, thru-wall type, AHRI certified, and UL listed. Minimum energy efficiency shall be in accordance with ASHRAE 90.1 - IP, at a minimum. Heat pumps shall have a minimum energy efficiency ratio (EER) of 11, and a minimum Coefficient of Performance (COP) of 2.3. Provide units listed in AHRI DCAACP.

2.1.2 Unit Cabinets

Fabricate of 18-gage minimum stainless steel (MSS). Provide removable front panel and access panels for equipment machinery, coils, controls, and filters. In lieu of steel, front panel may be constructed of high impact styrene structural foam conforming to requirements of UL 484. Structural foam shall pass tests specified in UL 484 for classification of 94 HB. Line interior of steel cabinets with insulation having a fire hazard rating not exceeding 25 for flame spread, and 50 for smoke developed, as determined by ASTM E84. Caulk around floor mounted units at the floor. Locate outdoor wall-mounted units 36 inches minimum above the outdoor grade.

2.1.3 Grilles

Provide manufacturer's standard anodized aluminum outdoor grilles and caulk and seal on all sides when required by manufacturer's instructions. Provide for air return under the front panel or a return air grille in the lower part of the front panel.

2.1.4 Wall Sleeves and Mounts

Provide manufacturer's standard wall sleeves and mounts. Wall sleeves shall have seals designed to restrict driving rain and wind.

2.1.5 Refrigeration Sections

Completely self-contained, slide-in assembly or removable chassis with welded, hermetically sealed, air-cooled refrigeration system, outdoor fan, indoor fan, control box, and ventilation damper. Provide refrigeration sections capable of installation or removal without the use of tools. Refrigeration sections shall include refrigeration circuit tubing, wiring, and safety controls, and shall operate down to 10 degrees F outdoor temperature and 80 degrees F indoor temperature, without compressor short

cycling while delivering not less than 100 percent of rated cooling capacity. Units shall have drains to the building exterior to eliminate excess driving rain. Condensate shall not drain onto building exterior or interior.

a. Compressors: Hermetic type with vibration isolation devices.

b. Coils: Constructed of seamless copper or aluminum tubing with copper or aluminum fins bonded to tubes. Coat outdoor air coils with factory applied corrosion resistant treatment. Coils to be coated shall be part of manufacturer's standard product for capacities and ratings indicated and specified. Provide plate type fins.

c. Outdoor Fans: Direct connected centrifugal type with aluminum or plastic wheel and forward curved blades or direct connected aluminum propeller type. Design fans so that condensate will evaporate without drip, splash, or spray on building exterior.

d. Indoor Fans: Direct connected centrifugal type with aluminum, galvanized steel, or plastic wheel and forward curved blades. Provide minimum two-speed motor with built-in overload protection.

2.1.6 Air Filters

Removable without use of tools, and shall filter both recirculated and ventilating air.

2.1.7 Controls

Provide controls including, an adjustable thermostat, and switches, to regulate room air temperature through control of refrigerant compressors or heating elements. Controls shall at least have positions for off, high or low fan speed for heating and cooling, and fan only operation.

2.2 AIR CONDITIONERS

2.2.1 Single Package Type

Provide factory packaged combination heating and cooling units. Provide units suitable for outdoor installation. Provide units with suitable lifting attachments, remote control panel. Minimum energy efficiency shall be in accordance with ASHRAE 90.1 - IP, at a minimum. List units with capacities smaller than 135,000 Btu/hr in the AHRI DCUP; in lieu of listing in the AHRI Directory, a letter of certification from AHRI that the units have been certified and will be listed in the next Directory will be acceptable. Provide capacity, electrical characteristics, and operating conditions as indicated.

2.2.2 Split-System Type

Provide separate assemblies designed to be used together. Base ratings on the use of matched assemblies. Provide performance diagrams for units with capacities not certified by AHRI to verify that components of the air conditioning system furnished will satisfy the capacity requirement specified or indicated. Minimum energy efficiency shall be in accordance with ASHRAE 90.1 - IP, at a minimum. List units with capacities smaller than 135,000 Btu/hr in the AHRI DCUP; in lieu of listing in the AHRI Directory, a letter of certification from AHRI that units have been certified and will be listed in the next Directory will be acceptable.

Provide capacity, electrical characteristics and operating conditions as indicated.

2.2.3 Single Zone Units

Provide single zone type units arranged to draw or blow through coil sections.

2.2.4 Compressors

For compressors over 20 tons, compressor speed shall not exceed 3450 rpm. For systems over 10 tons provide automatic capacity reduction of at least 50 percent of rated capacity. Capacity reduction may be accomplished by cylinder unloading, use of multi- or variable speed compressors, use of multiple, but not more than four compressors, or a combination of the two methods. Units with cylinder unloading shall start with capacity reduction devices in the unloaded position. Units with multiple compressors shall have means to sequence starting of compressors. Provide compressors with devices to prevent short cycling when shut down by safety controls. Device shall delay operation of compressor motor for at least 3 minutes but not more than 6 minutes. Provide a pumpdown cycle for units 20 tons and over. Provide reciprocating compressors with crankcase heaters in accordance with the manufacturer's recommendations. If compressors are paralleled, provide not less than two independent circuits.

2.2.5 Coils

Constructed of seamless copper or aluminum tubing with copper or aluminum fins bonded to tubes. Coat outdoor air coils with factory applied corrosion resistant treatment. Coils to be coated shall be part of manufacturer's standard product for capacities and ratings indicated and specified. Provide plate type fins.

On coils with all-aluminum construction, provide tubes of aluminum alloy 1100, 1200, or 3102; provide fins of aluminum alloy 7072; and provide tube sheets of aluminum alloy 7072 or 5052. Provide a separate air cooled condenser circuit for each compressor or parallel compressor installation. Provide a coating on condenser and evaporator coils and fins as specified in the paragraph entitled "Coatings for Finned Tube Coils." Coils to be coated shall be part of manufacturer's standard product for capacities and ratings indicated and specified. Provide plate type fins.

2.2.6 Condenser Controls

Provide start-up and head pressure controls to allow for system operation at ambient temperatures down to 10 degrees F.

2.2.7 Fans

Provide belt-driven evaporator fans with adjustable pitch pulleys; except for units less than 5 ton capacity, direct drive with at least two speed taps may be used. Select pulleys at approximately midpoint of the adjustable range.

2.2.8 Filters

Provide filters of the type specified in this section.

2.2.9 Filter Boxes

Provide when filters are not included integral with air conditioning units. Construct of not less than No. 20 US gage steel with track, hinged access doors with latches, and gaskets between frame and filters. Arrange filters to filter outside and return air. Provide removable filter assemblies, replaceable without the use of tools.

2.2.10 Mixing Boxes

Provide of the physical size to match the basic unit and include equal sized flanged openings, sized to individually handle full air flow. Arrange openings as indicated. Provide openings with dampers of parallel or opposed blade type. Provide opposed blade type for modulating dampers and parallel type for two-position dampers. Connect damper shafts together by one continuous linkage bar. Arrange dampers for automatic operation so that when one starts to close from its opened position, the other starts to open from its closed position.

2.2.11 Thermostats

Provide adjustable type that conforms to applicable requirements of UL 873. Provide combination heating-cooling type with contacts hermetically sealed against moisture, corrosion, lint, dust, and foreign material. Design to operate on not more than 1.5 degrees Fdifferential and of suitable range calibrated in degrees F. Provide adjustable heat anticipation and fixed cooling anticipation. Provide two independent temperature sensing elements electrically connected to control the compressor and heating equipment, respectively. Accomplish manual switching for system changeover from heating to cooling or cooling to heating and fan operation through the use of a thermostat subbase. Provide system selector switches to provide "COOL" and "OFF" and "HEAT" and fan selector switches to provide "AUTOMATIC" and "ON." Provide relays, contactors, and transformers located in a panel or panels for replacement and service.

2.2.11.1 Cooling

a. When thermostat is in "COOL" position with fan selector switch in "AUTO" position, compressor, evaporator fan, and condenser fan shall cycle together.

b. When thermostat is in "COOL" position with fan selector switch in "ON" position, compressor, and condenser fan shall cycle together and evaporator fan shall run continuously.

2.2.11.2 Heating

a. When thermostat is in "HEAT" position with fan selector switch in "AUTO" position, heater and supply air fan shall cycle together. Provide a separate thermostat to keep the fan running until the heater cools.

b. When thermostat is in "HEAT" position with fan selector switch in "ON" position, heater shall cycle and supply air fan shall run continuously.

2.2.11.3 Supply Air Fan

a. When fan selector switch is in "AUTO" position with thermostat in "OFF" position, fan shall not run.

b. When fan selector switch is in "ON" position, fan shall run continuously.

2.3 FILTERS

Provide filters to filter outside air and return air and locate inside air conditioners. Provide replaceable (throw-away) type. Filters shall conform to UL 900, Class 1 or Class 2.

2.3.1 Replaceable Type Filters

Throw-away frames and media, standard dust holding capacity, 350 fpm maximum face velocity, and 2 inches thick. Filters shall have a minimum efficiency reporting value (MERV) of 8 when tested in accordance with ASHRAE 52.2.

2.3.2 Cleanable Type Filters

Provide sufficient oil to coat filters six times based on one pint of oil per each 10 square feet of filter area. Provide washing and charging tanks for cleaning and coating filters. Filters shall have a MERV of 6 when tested in accordance with ASHRAE 52.2.

2.4 COATINGS FOR FINNED TUBE COILS

Where stipulated in equipment specifications of this section, coat finned tube coils of the affected equipment as specified below. Apply coating at the premises of a company specializing in such work. Degrease and prepare for coating in accordance with the coating applicator's procedures for the type of metals involved. Completed coating shall show no evidence of softening, blistering, cracking, crazing, flaking, loss of adhesion, or "bridging" between the fins.

2.4.1 Phenolic Coating

Provide a resin base thermosetting phenolic coating. Apply coating by immersion dipping of the entire coil. Provide a minimum of two coats. Bake or heat dry coils following immersions. After final immersion and prior to final baking, spray entire coil with particular emphasis given to building up coating on sheared edges. Total dry film thickness shall be 2.5 to 3.0 mils.

2.4.2 Chemical Conversion Coating with Polyelastomer Finish Coat

Dip coils in a chemical conversion solution to molecularly deposit a corrosion resistant coating by electrolysis action. Chemical conversion coatings shall conform to MIL-DTL-5541, Class 1A. Cure conversion coating at a temperature of 110 to 140 degrees F for a minimum of 3 hours. Coat coil surfaces with a complex polymer primer with a dry film thickness of 1 mil. Cure primer coat for a minimum of 1 hour. Using dip tank method, provide three coats of a complex polyelastomer finish coat. After each of the first two finish coats, cure the coils for 1 hour. Following the third coat, spray a fog coat of an inert sealer on the coil surfaces. Total dry film thickness shall be 2.5 to 3.0 mils. Cure finish coat for a minimum of 3 hours. Coating materials shall have 300 percent flexibility, operate in temperatures of minus 50 to plus 220 degrees F, and protect against atmospheres of a pH range of 1 to 14.

2.4.3 Vinyl Coating

Apply coating using an airless fog nozzle. For each coat, make at least two passes with the nozzle. Materials to be applied are as follows:

Total dry film thickness, 6.5 mils maximum.

Vinyl Primer, 24 percent solids by volume: One coat 2 mils thick

Vinyl Copolymer, 30 percent solids by volume: One coat 4.5 mils thick.

2.5 MOTORS AND STARTERS

NEMA MG 1, NEMA ICS 1, and NEMA ICS 2. Variable speed. Motors less than 1 hp shall meet NEMA High Efficiency requirements. Motors 1 hp and larger shall meet NEMA Premium Efficiency requirements. Determine specific motor characteristics to ensure provision of correctly sized starters and overload heaters. Provide motors to operate at full capacity with a voltage variation of plus or minus 10 percent of the motor voltage rating. Motor size shall be sufficient for the duty to be performed and shall not exceed its full load nameplate current rating when driven equipment is operated at specified capacity under the most severe conditions likely to be encountered. When motor size provided differs from size indicated or specified, the Contractor shall make the necessary adjustments to the wiring, disconnect devices, and branch circuit protection to accommodate equipment actually provided. Provide weather-resistant type starter enclosures in accordance with NEMA ICS 6.

2.6 REFRIGERANT PIPING AND ACCESSORIES

Provide accessories as specified in CID A-A-50502 and this section. Provide suction line accumulators as recommended by equipment manufacturer's installation instructions.

2.6.1 Factory Charged Tubing

Provide extra soft, deoxidized, bright annealed copper tubing conforming to ASTM B280, factory dehydrated and furnished with a balanced charge of refrigerant recommended by manufacturer of equipment being connected. Factory insulate suction line tubing with 3/8 inchminimum thickness of closed cell, foamed plastic conforming to ASTM C534/C534M with a permeance rating not to exceed 1.0. Provide quick-connectors with caps or plugs to protect couplings. Include couplings for suction and liquid line connections of the indoor and outdoor sections.

2.6.2 Field-Assembled Refrigerant Piping

Material and dimensional requirements for field-assembled refrigerant piping, valves, fittings, and accessories shall conform to ANSI/ASHRAE 15 & 34 and ASME B31.5, except as herein specified. Factory clean, dehydrate, and seal piping before delivery to the project location. Provide seamless copper tubing, hard drawn, Type K or L, conforming to ASTM B88, except that tubing with outside diameters of 1/4 inch and 3/8 inch shall have nominal wall thickness of not less than 0.030 inch and 0.032 inch, respectively. Soft annealed copper tubing conforming to ASTM B280 may be used where flare connections to equipment are required only in nominal sizes less than one inch outside diameter.

2.6.3 Fittings

ASME B16.22 for solder-joint fittings. UL 109 for flared tube fittings.

2.6.4 Brazing Filler Material

AWS A5.8/A5.8M.

2.6.5 Pipe Hangers and Supports

MSS SP-69 and MSS SP-58, Type 1, except as indicated otherwise.

2.6.6 Pipe Sleeves

Provide sleeves where piping passes through walls, floors, roofs, and partitions. Secure sleeves in proper position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, floors, roofs, and partitions. Provide not less than 0.25 inch space between exterior of piping or pipe insulation and interior of sleeve. Firmly pack space with insulation and caulk at both ends of the sleeve with plastic waterproof cement which will dry to a firm but pliable mass, or provide a segmented elastomeric seal.

2.6.6.1 Sleeves in Masonry and Concrete Walls, Floors, and Roofs

Provide Schedule 40 or Standard Weight zinc-coated steel pipe sleeves. Extend sleeves in floor slabs 3 inches above finished floor.

2.6.6.2 Sleeves in Partitions and Non-Masonry Structures

Provide zinc-coated steel sheet sleeves having a nominal weight of not less than 0.90 pound per square foot, in partitions and other than masonry and concrete walls, floors, and roofs.

2.7 FINISHES

Provide steel surfaces of equipment including packaged terminal units, heat pumps, and air conditioners, that do not have a zinc coating conforming to ASTM A653/A653M, or a duplex coating of zinc and paint, with a factory applied coating or paint system. Provide a coating or paint system on actual equipment identical to that on salt-spray test specimens with respect to materials, conditions of application, and dry-film thickness.

2.8 SOURCE QUALITY CONTROL

2.8.1 Salt-Spray Tests

Salt-spray test the factory-applied coating or paint system of equipment including packaged terminal units, heat pumps, and air conditioners in accordance with ASTM B117. Conduct test for 3000 hours for equipment installed outdoors, or 1000 hours for equipment installed indoors. Test specimens shall have a standard scribe mark as defined in ASTM D1654. Upon completion of exposure, evaluate and rate the coating or paint system in accordance with procedures A and B of ASTM D1654. Rating of failure at the scribe mark shall not be less than six, average creepage not greater than 1/8 inch. Rating of the unscribed area shall not be less than 10, no failure.

PART 3 EXECUTION

3.1 EQUIPMENT INSTALLATION

Install equipment and components in a manner to ensure proper and sequential operation of equipment and equipment controls. Install equipment not covered in this section, or in manufacturer's instructions, as recommended by manufacturer's representative. Provide proper foundations for mounting of equipment, accessories, appurtenances, piping and controls including, but not limited to, supports, vibration isolators, stands, guides, anchors, clamps and brackets. Foundations for equipment shall conform to equipment manufacturer's recommendation, unless otherwise indicated. Set anchor bolts and sleeves using templates. Provide anchor bolts of adequate length, and provide with welded-on plates on the head end embedded in the concrete. Level equipment bases, using jacks or steel wedges, and neatly grout-in with a nonshrinking type of grouting mortar. Locate equipment to allow working space for servicing including shaft removal, disassembling compressor cylinders and pistons, replacing or adjusting drives, motors, or shaft seals, access to water heads and valves of shell and tube equipment, tube cleaning or replacement, access to automatic controls, refrigerant charging, lubrication, oil draining and working clearance under overhead lines. Provide electric isolation between dissimilar metals for the purpose of minimizing galvanic corrosion.

3.1.1 Packaged Terminal Air Conditioners and Heat Pumps

Wall sleeve installation shall provide a positive weathertight and airtight seal.

3.1.2 Room Air Conditioners

Install units in accordance with manufacturer's instructions. Provide structural mountings, closures, and seals for weathertight assembly. Pitch unit as recommended by manufacturer to ensure condensate drain to drain pan without overflow.

3.2 PIPING

Brazing, bending, forming and assembly of refrigerant piping shall conform to ASME B31.5.

3.2.1 Pipe Hangers and Supports

Design and fabrication of pipe hangers, supports, and welding attachments shall conform to MSS SP-58. Installation of hanger types and supports for bare and covered pipes shall conform to MSS SP-69 for the system temperature range. Unless otherwise indicated, horizontal and vertical piping attachments shall conform to MSS SP-58.

3.2.2 Refrigerant Piping

Cut pipe to measurements established at the site and work into place without springing or forcing. Install piping with sufficient flexibility to provide for expansion and contraction due to temperature fluctuation. Where pipe passes through building structure pipe joints shall not be concealed, but shall be located where they may be readily inspected. Install piping to be insulated with sufficient clearance to permit application of insulation. Install piping as indicated and detailed, to avoid interference with other piping, conduit, or equipment. Except where

specifically indicated otherwise, run piping plumb and straight and parallel to walls and ceilings. Trapping of lines will not be permitted except where indicated. Provide sleeves of suitable size for lines passing through building structure. Braze refrigerant piping with silver solder complying with AWS A5.8/A5.8M. Inside of tubing and fittings shall be free of flux. Clean parts to be jointed with emery cloth and keep hot until solder has penetrated full depth of fitting and extra flux has been expelled. Cool joints in air and remove flame marks and traces of flux. During brazing operation, prevent oxide film from forming on inside of tubing by slowly flowing dry nitrogen through tubing to expel air. Make provisions to automatically return oil on halocarbon systems. Installation of piping shall comply with ASME B31.5.

3.2.3 Returning Oil From Refrigerant System

Install refrigerant lines so that gas velocity in the evaporator suction line is sufficient to move oil along with gas to the compressor. Where equipment location requires vertical risers, line shall be sized to maintain sufficient velocity to lift oil at minimum system loading and corresponding reduction of gas volume. Install a double riser when excess velocity and pressure drop would result from full system loading. Larger riser shall have a trap, of minimum volume, obtained by use of 90- and 45-degree ells. Arrange small riser with inlet close to bottom of horizontal line, and connect to top of upper horizontal line. Do not install valves in risers.

3.2.4 Refrigerant Driers, Sight Glass Indicators, and Strainers

Provide refrigerant driers, sight glass liquid indicators, and strainers in refrigerant piping in accordance with CID A-A-50502 and this section when not furnished by the manufacturer as part of the equipment. Install driers in liquid line with service valves and valved bypass line the same size as liquid line in which dryer is installed. Size of driers shall be determined by piping and installation of the unit on location. Install dryers of 50 cubic inches and larger vertically with the cover for removing cartridge at the bottom. Install moisture indicators in the liquid line downstream of the drier. Indicator connections shall be the same size as the liquid line in which it is installed.

3.2.5 Strainer Locations and Installation

Locate strainers close to equipment they are to protect. Provide a strainer in common refrigerant liquid supply to two or more thermal valves in parallel when each thermal valve has a built-in strainer. Install strainers with screen down and in direction of flow as indicated on strainer's body.

3.2.6 Solenoid Valve Installation

Install solenoid valves in horizontal lines with stem vertical and with flow in direction indicated on valve. If not incorporated as integral part of the valve, provide a strainer upstream of the solenoid valve. Provide service valves upstream of the solenoid valve, upstream of the strainer, and downstream of the solenoid valve. Remove the internal parts of the solenoid valve when brazing the valve.

3.3 AUXILIARY DRAIN PANS, DRAIN CONNECTIONS, AND DRAIN LINES

Provide drain lines full size of drain opening. Indoor drain lines shall

be insulated. Route to building exterior to no more than 6 inches above grade.

3.4 ACCESS PANELS

Provide access panels for concealed valves, controls, dampers, and other fittings requiring inspection and maintenance.

3.5 AIR FILTERS

Allow access space for servicing filters. Install filters with suitable sealing to prevent bypassing of air.

3.6 FLASHING AND PITCH POCKETS

Provide flashing and pitch pockets for equipment supports and roof penetrations and flashing where piping or ductwork passes through exterior walls in accordance with Section 07 60 00 FLASHING AND SHEET METAL.

3.7 IDENTIFICATION TAGS AND PLATES

Provide equipment, gages, thermometers, valves, and controllers with tags numbered and stamped for their use. Provide plates and tags of brass or suitable nonferrous material, securely mounted or attached. Provide minimum letter and numeral size of 1/8 inch high.

3.8 FIELD QUALITY CONTROL

3.8.1 Leak Testing

Upon completion of installation of air conditioning equipment, test factory- and field-installed refrigerant piping with an electronic-type leak detector. Use same type of refrigerant to be provided in the system for leak testing. When nitrogen is used to boost system pressure for testing, ensure that it is eliminated from the system before charging. Minimum refrigerant leak field test pressure shall be as specified in ANSI/ASHRAE 15 & 34, except that test pressure shall not exceed 150 psig on hermetic compressors unless otherwise specified as a low side test pressure on the equipment nameplate. If leaks are detected at time of installation or during warranty period, remove the entire refrigerant charge from the system, correct leaks, and retest system.

3.8.2 Evacuation, Dehydration, and Charging

After field charged refrigerant system is found to be without leaks or after leaks have been repaired on field-charged and factory-charged systems, evacuate the system using a reliable gage and a vacuum pump capable of pulling a vacuum of at least one mm Hg absolute. Evacuate system in accordance with the triple-evacuation and blotter method or in accordance with equipment manufacturer's printed instructions and recharge system.

3.8.3 Start-Up and Initial Operational Tests

Test the air conditioning systems and systems components for proper operation. Adjust safety and automatic control instruments as necessary to ensure proper operation and sequence. Conduct operational tests for not less than 8 hours.

3.8.4 Performance Tests

Upon completion of evacuation, charging, startup, final leak testing, and proper adjustment of controls, test the systems to demonstrate compliance with performance and capacity requirements. Test systems for not less than 8 hours, record readings hourly. At the end of the test period, average the readings, and the average shall be considered to be the system performance. Record the following readings:

Supply Air Temperature
Return Air Temperature

-- End of Section --

SECTION 26 00 00.00 20

BASIC ELECTRICAL MATERIALS AND METHODS

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.

ASTM INTERNATIONAL (ASTM)

ASTM D709	(2013) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013) National Electrical Safety Code
IEEE C57.12.28	(2005; INT 3 2011) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2005) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code

1.2 RELATED REQUIREMENTS

This section applies to certain sections of Division 02, EXISTING CONDITIONS and Divisions 22 and 23, PLUMBING and HEATING VENTILATING AND AIR CONDITIONING. This section applies to all sections of Division 26 and 33, ELECTRICAL and UTILITIES, of this project specification unless specified otherwise in the individual sections. This section has been incorporated into, and thus, does not apply to, and is not referenced in the following sections.

Section 26 12 19.10 THREE-PHASE PAD MOUNTED TRANSFORMERS
Section 26 13 00 SF6/ HIGH-FIREPOINT FLUIDS INSULTAED PAD-MOUNTED SWITCHGEAR
Section 26 27 14.00 20 ELECTRICITY METERING
Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM

Section 26 32 13.00 20 SINGLE OPERATION GENERATOR SETS
Section 26 51 00 INTERIOR LIGHTING
Section 26 36 23.00 20 AUTOMATIC TRANSFER SWITCHES

Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.

c. The technical paragraphs referred to herein are those paragraphs in PART 2 - PRODUCTS and PART 3 - EXECUTION of the technical sections that describe products, systems, installation procedures, equipment, and test methods.

1.4 ELECTRICAL CHARACTERISTICS

Electrical characteristics for this project shall be 4160V primary, three phase, three wire, 60 Hz, and 480Y/277 volts secondary, three phase, four wire. Final connections to the power distribution system at the existing manhole shall be made by the Contractor as directed by the Contracting Officer.

1.5 ADDITIONAL SUBMITTALS INFORMATION

Submittals required in other sections that refer to this section must conform to the following additional requirements as applicable.

1.5.1 Shop Drawings (SD-02)

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.

1.5.2 Product Data (SD-03)

Submittal shall include performance and characteristic curves.

1.6 QUALITY ASSURANCE

1.6.1 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.

1.6.2 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 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 the technical section.

1.6.2.1 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.

1.6.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 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.

1.8 POSTED OPERATING INSTRUCTIONS

Provide for each system and principal item of equipment as specified in the technical sections for use by operation and maintenance personnel. The operating instructions shall include the following:

a. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.

b. Start up, proper adjustment, operating, lubrication, and shutdown procedures.

c. Safety precautions.

d. The procedure in the event of equipment failure.

e. Other items of instruction as recommended by the manufacturer of each system or item of equipment.

Print or engrave 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 shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

1.9 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.

1.10 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified in the technical sections 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 inch 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 inch high normal block style.

1.11 WARNING SIGNS

Provide warning signs for the enclosures of electrical equipment including substations, pad-mounted transformers, pad-mounted switches, generators, and switchgear having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28 or IEEE C57.12.29, such as for pad-mounted transformers and pad-mounted dead-front air insulated switches, provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Sign shall be a decal and shall have nominal dimensions of 7 by 10 inches with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 2 inch high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background. Decal shall be Panduit No. PPSO710D72 or approved equal.

1.12 ELECTRICAL REQUIREMENTS

Electrical installations shall conform to IEEE C2, NFPA 70, and requirements specified herein.

1.13 INSTRUCTION TO GOVERNMENT PERSONNEL

Where specified in the technical sections, furnish the services of competent instructors to give full instruction to designated Government personnel in the adjustment, operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work. Instruction shall 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. The number of man-days (8 hours per day) of instruction furnished shall be as specified

in the individual section.

PART 2 PRODUCTS

2.1 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test and the additional requirements specified in the technical sections.

PART 3 EXECUTION

3.1 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 the section specifying the associated electrical equipment.

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, but space the signs a maximum of 30 feet apart.

-- End of Section --

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SECTION 26 08 00

APPARATUS INSPECTION AND TESTING

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	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

1.2 RELATED REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS 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. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted 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. Perform acceptance tests and inspections on applicable equipment and systems specified in the following sections:

a. Section 26 32 13.00 20 SINGLE OPERATION GENERATOR SETS. 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 PAD-MOUNTED TRANSFORMERS

e. Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION

f. Section 26 13 00 PAD-MOUNTED DEAD-FRONT AIR INSULATED SWITCHGEAR

i. Section 26 36 23.00 20 AUTOMATIC TRANSFER SWITCHES

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.

-- End of Section --

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SECTION 26 12 19.10

THREE-PHASE PAD-MOUNTED TRANSFORMERS

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 CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 318M	(2011; Errata 2013) Building Code Requirements for Structural Concrete & Commentary

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2014) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM D117	(2010) Standard Guide for Sampling, Test Methods, Specifications and Guide for Electrical Insulating Oils of Petroleum Origin
ASTM D1535	(2013) Specifying Color by the Munsell System
ASTM D3487	(2009) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
ASTM D877/D877M	(2013) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D92	(2012b) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2012) Pour Point of Petroleum Products

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

IEEE 386	(2006; INT 1 2011) Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013) National Electrical Safety Code
IEEE C37.47	(2011) Standard for High Voltage Current-Limiting Type Distribution Class Fuses and Fuse Disconnecting Switches
IEEE C57.12.00	(2010) Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.28	(2005; INT 3 2011) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2005) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE C57.12.34	(2009) Standard for Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 5 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below
IEEE C57.12.90	(2010) Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(2008; INT 2009) Standard Requirements for Instrument Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C62.11	(2012) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering
ANSI C12.7	(2005) Requirements for Watthour Meter Sockets
NEMA LI 1	(1998; R 2011) Industrial Laminating

Thermosetting Products

NEMA/ANSI C12.10 (2011) Physical Aspects of Watthour Meters - Safety Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203 (1992) Fish Acute Toxicity Test

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 (2007) 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, shall be 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. The following shall be submitted 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

Pad-mounted transformer design tests; G

Pad-mounted transformerroutine and other tests; G

SD-10 Operation and Maintenance Data

Transformer(s), Data Package 5; G

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein.

SD-11 Closeout Submittals

Transformer test schedule; G

Submit report of test results as specified by paragraph entitled "Field Quality Control."

1.4.1 Government Submittal Review

Code OPHC22, NAVFAC MIDLANT, Naval Facilities Engineering Command will review and approve all submittals in this section requiring Government approval.

1.4.2 Reduced Submittal Requirements

Transformers designed and manufactured by ABB in Jefferson City, MO; by Cooper Power Systems 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, the following items shall be submitted:

a. A certification, signed by the manufacturer, stating that the technical requirements of this specification shall be met.

b. An outline drawing of the transformer with devices identified (paragraph entitled "Pad-Mounted Transformer Drawings", item a).

c. ANSI nameplate data of the transformer (paragraph entitled "Pad-Mounted Transformer Drawings", item b).

d. Manufacturer's published time-current curves (properly overlaid on one full size logarithmic paper) of the transformer high side fuses (paragraph entitled "Pad-Mounted Transformer Drawings", item e) with transformer damage curve, inrush curve, and thru fault current indicated.

e. Routine and other tests (in PART 2, see paragraph entitled "Source Quality Control", subparagraph entitled "Routine and Other Tests"), shall be conducted by the manufacturer and may be witnessed by the government. Provide transformer test schedule required by submittal item "SD-11 Closeout Submittals". Provide certified copies of the tests.

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

Drawings shall indicate, but not be limited to the following:

a. An outline drawing, with front, top, and side views.

b. ANSI nameplate data.

c. Elementary diagrams and wiring diagrams with terminals identified of watthour meter and current transformers.

d. One-line diagram, including switch(es), current transformers, meters, and fuses.

e. Manufacturer's published time-current curves (on full size logarithmic paper) 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, 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.

1.5.3 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. 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.

1.5.3.1 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 shall not be used, unless specified otherwise.

1.6 MAINTENANCE

1.6.1 Additions to Operation and Maintenance Data

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. Information on watthour demand meter, CT's, and fuse block

g. Actual nameplate diagram

h. Date of purchase

1.7 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.

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.

2.2.1 Compartments

The high- and low-voltage compartments shall be 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 shall contain the incoming line, insulated high-voltage load-break connectors, bushing well inserts, feed-thru 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 with insulated standoff bushings, protective caps, and ground pad.

a. Insulated high-voltage load-break connectors: IEEE 386, rated 5 kV, 60 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 shall have a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

b. Bushing well inserts and feed-thru inserts: IEEE 386, 200 amperes, 5 kV Class. Provide a bushing well insert for each bushing well unless indicated otherwise. Provide feed-thru inserts as indicated.

c. Load-break switch

   Radial-feed oil-immersed type rated at 5 kV, 60 kV BIL, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 12,000 rms amperes symmetrical. Locate the switch handle in the high-voltage compartment.

d. Provide bayonet type, oil-immersed, expulsion fuses in series with oil-immersed, partial-range, current-limiting fuses. Bayonet fuse links shall 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. In order to eliminate or minimize oil spills, the bayonet fuse assembly shall include an oil retention valve inside the housing which closes when the fuse holder is removed and an external drip shield. Warning shall be conspicuously displayed within the high-voltage compartment cautioning against removing or inserting fuses unless the load-break switch is in the open position 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 6 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. Provide insulated standoff bushings for parking of energized high-voltage connectors on parking stands.

g. Protective caps: IEEE 386, 200 amperes, 5 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 shall contain low-voltage bushings with NEMA spade terminals, accessories, metering, stainless steel or laser-etched anodized aluminum diagrammatic transformer nameplate, and ground pad.

a. Accessories shall include 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. Biodegradable, lLess-flammable liquid-insulated, two winding, 60 hertz, 65 degrees C rise above a 30 degrees C average ambient, self-cooled type.

b. Transformer shall be rated 225 kVA.

c. Transformer voltage ratings: 4160 V Delta

d. Tap changer shall be 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. Tap changers shall clearly indicate which tap setting is in use.

e. Minimum tested percent impedance at 85 degrees C shall not be less than the following values:

2.87 for units rated 112.5kVA to 300kVA

f. Audible sound levels shall comply with the following:

kVA	DECIBELS (MAX

225	55

g. Transformer shall include lifting lugs and provisions for jacking under base. The transformer base construction shall be suitable for using rollers or skidding in any direction. Provide transformer top with an access handhole. Transformer shall have its kVA rating conspicuously displayed using 3 inch high yellow letters on its enclosure. The transformer shall have an insulated low-voltage neutral bushing with NEMA spade terminal, and with removable ground strap.

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. No-load losses (NLL) shall be referenced at 20 degrees C. Load losses (LL) shall be referenced 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. That table is based on requirements contained within 10 CFR 431, Subpart K.

kVA	EFFICIENCY (percent)
225	99.17

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.

The fluid shall be a biodegradable electrical insulating and cooling liquid classified by UL and approved by FM as "less flammable" fluids. The fluid shall meet the following fluid properties:

1. Pour point: ASTM D97, less than -15 degree C

2. Aquatic biodegradation: EPA 712-C-98-075, 100 percent

3. Trout toxicity: OECD Test 203, zero mortality of EPA 821-R-02-012, pass

2.2.3.1 Liquid-Filled Transformer Nameplates

Distribution transformers shall be provided with nameplate information in accordance with IEEE C57.12.00 and as modified or supplemented by this section.

2.2.4 Corrosion Protection

Bases and cabinets of transformers shall be corrosion resistant and shall be fabricated of stainless steel conforming to ASTM A240/A240M, Type 304 or 304L. Base shall include any part of pad-mounted transformer that is within 3 inches of concrete pad.

Paint entire transformer assembly Munsell 7GY3.29/1.5 green. Paint coating system shall comply 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

Provide warning signs for the enclosures of pad-mounted transformers having a nominal rating exceeding 600 volts.

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 signs on the outside of the high voltage compartment door(s). Sign shall be a decal and shall have nominal dimensions of 7 by 10 inches with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 2 inch high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background. Decal shall be Panduit No. PPSO710D72 or approved equal.

2.4 Arc Flash Warning Label

Provide 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. The label format shall be 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

Concrete associated with electrical work for other than encasement of underground ducts shall be 4000 psi minimum 28-day compressive strength unless specified otherwise. All concrete shall 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. The manufacturer shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

2. The accuracy shall be directly traceable to the National Institute of Standards and Technology.

3. Instrument calibration frequency schedule shall not exceed 12 months for both test floor instruments and leased specialty equipment.

4. Dated calibration labels shall be visible on all test equipment.

5. Calibrating standard shall be of 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 states that "design tests are made only on representative apparatus to substantiate the ratings assigned to all other 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 each of the specified transformer(s). Design tests shall have been performed in accordance with IEEE C57.12.90 prior to the award of this contract.

a. Tests shall be 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 (ONAN), 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 shall include 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 shall be performed in accordance with IEEE C57.12.90 by the manufacturer on each of 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 shall be 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

Electrical installations shall 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 grounding systems shall have a resistance to solid earth ground not exceeding 5 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 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" shall apply.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Exothermic welds and compression connectors shall be installed 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. Unless otherwise indicated, the slab shall be at least 8 inches thick, reinforced with a 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 4 inches from the top of the slab. Slab shall be placed on a 6 inch thick, well-compacted gravel base. Top of concrete slab shall be approximately 4 inches above finished grade with gradual slope for drainage. Edges above grade shall have 1/2 inch chamfer. Slab shall be 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

Cast-in-place concrete work shall conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.5.2 Sealing

When the installation is complete, the Contractor shall seal all entries into the equipment enclosure with an approved sealing method. Seals shall be 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.

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 testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be 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, the Contractor shall 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, the Contracting Officer shall be given 5 working days advance notice of the dates and times of checking and testing.

-- End of Section --

SECTION 26 12 21

SINGLE-PHASE PAD-MOUNTED TRANSFORMERS

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 CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 318	(2011; Errata 1 2011; Errata 2 2012; Errata 3-4 2013) Building Code Requirements for Structural Concrete and Commentary
ACI 318M	(2011; Errata 2013) Building Code Requirements for Structural Concrete & Commentary

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2014) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM D117	(2010) Standard Guide for Sampling, Test Methods, Specifications and Guide for Electrical Insulating Oils of Petroleum Origin
ASTM D1535	(2013) Specifying Color by the Munsell System
ASTM D3487	(2009) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
ASTM D877/D877M	(2013) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D92	(2012b) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2012) Pour Point of Petroleum Products

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2006; INT 1 2011) Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013) National Electrical Safety Code
IEEE C37.47	(2011) Standard for High Voltage Current-Limiting Type Distribution Class Fuses and Fuse Disconnecting Switches
IEEE C57.12.00	(2010) Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.25	(1990) Standard for Transformers - Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers With Separable Insulated High-Voltage Connectors; High Voltage, 34,500 Grdy/ 19,920 Volts and Below; Low Voltage, 240/120 Volts; 167 kVa and Smaller Requirements
IEEE C57.12.28	(2005; INT 3 2011) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2005) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2010) Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(2008; INT 2009) Standard Requirements for Instrument Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C62.11	(2012) 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	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering
ANSI C12.7	(2005) Requirements for Watthour Meter Sockets
NEMA/ANSI C12.10	(2011) Physical Aspects of Watthour Meters - Safety Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

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	(2007) 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. Submit in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Pad-mounted transformer drawings; G

SD-03 Product Data

Single-phase pad-mounted transformers (dead-front); G

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

Submit reports, including 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

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

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein.

SD-11 Closeout Submittals

Transformer test schedule; G

Submit report of test results as specified by paragraph entitled "Source Quality Control."

1.4.1 Reduced Submittal Requirements

Transformers designed and manufactured by ABB in Jefferson City, MO; by Cooper Power Systems 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 entitled "Pad-Mounted Transformer Drawings", item a).

c. ANSI nameplate data of the transformer (paragraph entitled "Pad-Mounted Transformer Drawings", item b).

d. Manufacturer's published time-current curves (properly overlaid on one full size logarithmic paper) of the transformer high side fuses (paragraph entitled "Pad-Mounted Transformer Drawings", item e) with transformer damage curve, inrush curve, and thru fault current indicated.

e. Routine and other tests (in PART 2, see paragraph entitled "Source Quality Control", subparagraph entitled "Routine and Other Tests"), conducted by the manufacturer.These tests may be witnessed by the government. Provide transformer test schedule required by submittal item "SD-11 Closeout Submittals". Provide certified copies of the tests.

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. ANSI nameplate data.

c. Elementary diagrams and wiring diagrams with terminals identified of meter and current transformers.

d. One-line diagram, including switch(es), current transformers, meters, and fuses.

e. Manufacturer's published time-current curves (on full size logarithmic paper) of the transformer high side fuse.

1.5.2 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.

1.5.3 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

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. Information on watthour demand meter, CT's, and fuse block.

g. Actual nameplate diagram.

h. Date of purchase.

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 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS (DEAD-FRONT)

IEEE C57.12.25, IEEE C57.12.28 and as specified herein.

2.2.1 Compartment Construction

a. Two compartment: Provide high- and low-voltage compartments separated by steel isolating barriers extending the full height and depth of the compartments. Compartment doors:

   1. Hinged lift-off type with stop in open position and three-point latching.

   2. High voltage door fastening accessible only after the low voltage door has been opened.

2.2.1.1 High Voltage

High-voltage portion contains: the incoming line, insulated high-voltage load-break connectors, bushing well inserts, four high-voltage bushing wells configured for loop feed application, load-break switch handle(s), access to oil-immersed fuses, dead-front surge arresters, tap changer handle, connector parking stands with insulated standoff bushings, protective caps, and ground pad.

a. Insulated high-voltage load-break connectors: IEEE 386, rated 5 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. Provide connectors and inserts from the same manufacturer. Provide connectors with a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

c. Bushing well inserts: IEEE 386, 200 amperes, 5 kV class. Provide a bushing well insert for each bushing well unless indicated otherwise.

f. 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.

g. Surge arresters: IEEE C62.11, rated 6 kV, fully shielded, dead-front metal-oxide-varistor, elbow type with resistance-graded gap suitable for plugging into inserts as indicated.

h. Parking stands: Provide a parking stand near each bushing well. Provide insulated standoff bushings for parking of energized load-break connectors on parking stands.

i. Protective caps: IEEE 386, 200 amperes, 5 kV class. Provide

insulated protective caps (not shipping caps) for insulating and sealing out moisture from unused bushing well inserts and insulated standoff bushings.

2.2.1.2 Low Voltage

Low-voltage portion 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 plug, fill plug, pressure relief device and a liquid level sight gage.

b. Metering

For two-compartment transformers, provide as specified in Section 26 27 14.00 20 ELECTRICITY METERING.

For two-compartment transformers, provide a transformer-rated meter at the secondary portion of the transformer.

1. NEMA/ANSI C12.10. Provide a socket-mounted electronic programmable outdoor watthour meter, surface mounted flush against the side of the low-voltage compartment as indicated. Program the meter at the factory or in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of project. Coordinate the meter to system requirements.

(a) Design: Provide meter designed for use on a single-phase, three-wire, 240/120 volt system with two current transformers. Include necessary KYZ pulse initiation hardware for energy monitoring and control system (EMCS).

(b) Coordination: Provide meter coordinated with ratios of current transformers and transformer secondary voltage.

(c) Class: 20; Form: 4S, accuracy: plus or minus 1.0 percent Finish: Class II.

(d) Cover: Polycarbonate and lockable to prevent tampering and unauthorized removal.

(e) Kilowatt-hour register: five digit electronic programmable type.

(f) Demand register:

(1) Provide solid state.

(2) Meter reading multiplier: Indicate multiplier on the meter face.

(3) Demand interval length: programmed for 15 minutes with rolling demand up to six subintervals per interval.

(g) Meter fusing: Provide a fully enclosed pullout, deadfront type fuse block mounted in the secondary side containing one fuse per phase to protect the voltage input to the meter. Size fuses

as recommended by the meter manufacturer.

(h) Socket: ANSI C12.7. Provide NEMA Type 3R, box-mounted socket having automatic circuit-closing bypass and having jaws compatible with requirements of the meter. Cover unused hub openings with blank hub plates. Paint box Munsell 7GY3.29/1.5 green to match the pad-mounted transformer to which the box-mounted socket is attached. The Munsell color notation is specified in ASTM D1535.

2. Current transformers IEEE C57.13. Provide butyl-molded window type current transformers with 600-volt insulation, 10 kV BIL and mount on the low-voltage bushings. Route current transformer leads in a location as remote as possible from the power transformer secondary cables to permit current measurements to be taken with hook-on-ammeters. Provide two current transformers per power transformer with characteristics listed in the following table.

2.2.2 Transformer

a. Less-flammable liquid-insulated, two winding, 60 hertz, 65 degrees C rise above a 30 degrees C average ambient, self-cooled type.

b. Rated 150 kVAc. Voltage ratings: V - 240/120 V.

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:

2.50 for units rated 25 kVA and below
2.87 for units rated 37.5 kVA to 100 kVA
4.03 for 167 kVA rated units

f. Comply with the following audible sound level limits:

kVA	DECIBELS (MAX)
10	48
15	48
25	48
37.5	48
50	48

kVA	DECIBELS (MAX)
75	51
100	51
167	55

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.

4. kVA rating conspicuously displayed using 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.

kVA	EFFICIENCY (percent)
10	98.62
15	98.76
25	98.91
37.5	99.01
50	99.08
75	99.17
100	99.23
167	99.25

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, 100 percent.

3. Trout toxicity: OECD Test 203, zero mortality of EPA 821-R-02-012, pass.

2.4 LIQUID-FILLED TRANSFORMER NAMEPLATES

Provide nameplate information in accordance with IEEE C57.12.00 and as modified or supplemented by this section.

2.5 CORROSION PROTECTION

Provide corrosion resistant bases and cabinets of transformers, fabricated of stainless steel conforming to ASTM A240/A240M, Type 304 or 304L. Base includes any part of pad-mounted transformer that is within 3 inches of concrete pad.

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.

2.6 WARNING SIGNS

Provide warning signs for the enclosures of pad-mounted transformers having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28 or IEEE C57.12.29, such as for pad-mounted transformers, provide self-adhesive warning signs (decals, Panduit No. PPSO710D72 or approved equal) on the outside of the high voltage compartment door(s), with nominal dimensions of 7 by 10 inches with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 2 inch high letters. Include the word "DANGER" in white letters on a red background and the words "HIGH VOLTAGE" in black letters on a white background.

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 side warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.

2.7 GROUNDING AND BONDING

UL 467. Provide grounding and bonding as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.8 PADLOCKS

Provide padlocks for pad-mounted equipment, keyed as directed by the Contracting Officer. Comply with Section 08 71 00 DOOR HARDWARE.

2.9 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.

Provide concrete associated with electrical work as follows:

a. Composed of fine aggregate, coarse aggregate, portland cement, and water so proportioned and mixed as to produce a plastic, workable mixture.

b. Fine aggregate: hard, dense, durable, clean, and uncoated sand.

c. Coarse aggregate: reasonably well graded from 3/16 inch to 1 inch.

d. Fine and coarse aggregates: free from injurious amounts of dirt, vegetable matter, soft fragments or other deleterious substances.

e. Water: fresh, clean, and free from salts, alkali, organic matter, and other impurities.

f. Concrete associated with electrical work for other than encasement of underground ducts: 4000 psi minimum 28-day compressive strength unless specified otherwise.

g. Slump: Less than 4 inches. Retempering of concrete will not be permitted.

h. Exposed, unformed concrete surfaces: smooth, wood float finish.

i. Concrete must be cured for a period of not less than 7 days, and concrete made with high early strength portland cement must be repaired by patching honeycombed or otherwise defective areas with cement mortar as directed by the Contracting Officer.

j. Air entrain concrete exposed to weather using an air-entraining admixture conforming to ASTM C260/C260M.

k. Air content: between 4 and 6 percent.

2.10 SOURCE QUALITY CONTROL

2.10.1 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.

2.10.2 Test Instrument 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.

2.10.3 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 (ONAN), 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 C57.12.25.

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.

2.10.4 Routine and Other Tests

IEEE C57.12.00. Routine and other tests: performed 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 include:

a. Polarity.

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 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 four ground rods in the ground ring, one per corner. Install the ground rods at least 10 feetapart 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.

3.3.1 Meters and Current Transformers

ANSI C12.1.

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 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 feet apart.

3.6 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.

3.6.1 Cast-In-Place Concrete

Provide cast-in-place concrete work in accordance with the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.6.2 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.

3.7 FIELD QUALITY CONTROL

3.7.1 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.

3.7.1.1 Pad-Mounted Transformers

a. Visual and mechanical inspection.

1. Compare equipment nameplate information 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.

8. Verify that positive pressure is maintained on gas-blanketed transformers.

9. Perform specific inspections and mechanical tests as recommended by manufacturer.

10. Verify correct equipment grounding.

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. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground. Calculate polarization index.

4. Perform turns-ratio tests at all tap positions.

5. Perform insulation power-factor or dissipation-factor tests on all windings in accordance with test equipment manufacturer’s published data.

6. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests.

7. Measure the resistance of each high-voltage winding in each de-energized tap-changer position. Measure the resistance of each low-voltage winding in each de-energized tap-changer position, if applicable.

8. Remove and test a sample of insulating liquid for the following: Dielectric breakdown voltage, Acid neutralization number, Specific gravity, Interfacial tension, Color, Visual Condition, Water in insulating liquids (Required on 25 kV or higher voltages and on all silicone-filled units.), and Power factor or dissipation factor.

9. Perform dissolved-gas analysis (DGA) on a sample of insulating liquid.

3.7.1.2 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 wiring.

5. Verify the unit is 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 that all required grounding and shorting connections provide good contact.

8. Verify correct operation of transformer withdrawal mechanism and grounding operation.

9. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical tests.

1. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

2. Perform insulation-resistance test.

3. Perform a polarity test.

4. Perform a ratio-verification test.

3.7.1.3 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 testing megger 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.

3.7.1.4 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.

3.7.2 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.

-- End of Section --

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SECTION 26 13 00

SF6/HIGH-FIREPOINT FLUIDS INSULATED PAD-MOUNTED SWITCHGEAR

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 A167	(1999; R 2009) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM D1535	(2013) Specifying Color by the Munsell System
ASTM D2472	(2000; R 2006) Standard Specification for Sulphur Hexafluoride
ASTM D6871	(2003; R 2008) Standard Specification for Natural (Vegetable Oil) Ester Fluids Used in Electrical Apparatus

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2006; INT 1 2011) Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013) National Electrical Safety Code
IEEE C37.60	(2012) Standard Requirements for Overhead, Pad Mounted, Dry Vault and Submersible Automatic Circuit Reclosers and Fault Interrupters for Alternating Current Systems Up to 38 kV
IEEE C37.74	(2003; Int 1 2004) Standard Requirements for Subsurface, Vault, and Pad-Mounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems Up to 38 kV
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 C62.11	(2012) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 61099	(2010; ED 2.0) Insulating Liquids - Specifications for Unused Synthetic Organic Esters for Electrical Purposes
IEC 62271-103	(2013; Corr 1 2013) High-Voltage Switchgear and Controlgear – Part 103: Switches for Rated Voltages Above 1 Kv up to and Including 52 Kv
IEC 62271-111	(2012; ED 2.0) High Voltage Switchgear And Controlgear - Part 111: Automatic Circuit Reclosers and Fault Interrupters for Alternating Current Systems up to 38 kV

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code
NFPA 70B	(2013) Recommended Practice for Electrical Equipment Maintenance

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD 8500.01	(2014) Cybersecurity
DOD 8510.01	(2014) Risk Management Framework (RMF) for DoD Information Technology (IT)

UNDERWRITERS LABORATORIES (UL)

UL 467	(2007) 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

1.3.1 Switched Way

A switched way is considered a three-phase circuit entrance to the bus

through a switch. For single-phase switches, it is a single-phase entrance to the bus through a switch.

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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Switchgear Drawings; G

SD-03 Product Data

Electronic Overcurrent Control Curves; G

SF6/High-Firepoint Fluid Insulated Pad-mounted Switchgear; G

Include data on switches and associated accessories with each submittal. Include manufacturer's information for each component, device and accessory provided with the equipment with each submittal.

Insulated High-Voltage Connectors; G

Surge Arresters; G

SD-06 Test Reports

Acceptance Checks and Tests; G

SD-07 Certificates

Paint Coating System; G

Cybersecurity; G

SD-09 Manufacturer's Field Reports

Switchgear design and production tests; G

SD-10 Operation and Maintenance Data

SF6/High-Firepoint Fluid Insulated Pad-mounted Switchgear, Data Package 5; G

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

1.5 QUALITY ASSURANCE

1.5.1 Switchgear Drawings

Furnish drawings that include, but are not limited to, the following:

a. Overall dimensions, weights, plan view, and front view

b. Ratings

c. Single-line diagram.

1.5.2 Paint Coating System

Submit IEEE C57.12.28 paint coating system performance requirement tests.

1.5.3 Electronic Overcurrent Control Curves

Provide time-current characteristic curves in PDF format and in electronic format suitable for import or updating into the EasyPower SKM PowerTools for Windows computer program).

1.6 MAINTENANCE

1.6.1 SF6/High-Firepoint Fluid Insulated Pad-mounted Switchgear Operation and Maintenance

Submit Operation and Maintenance Manuals in accordance with Section 01 78 23OPERATION AND MAINTENANCE DATA.

PART 2 PRODUCTS

2.1 SF6/HIGH-FIREPOINT FLUID INSULATED PAD-MOUNTED SWITCHGEAR

IEEE C37.74, IEC 62271-103

2.1.1 Ratings and Test Requirements

The voltage rating of the switchgear must be 15.5 kVas indicated. Provide the corresponding ratings associated with the required switchgear voltage rating as follows:

Rated Maximum Voltage, kV	15.5
Rated Withstand Impulse Voltage, kV BIL	95
Continuous and Load Interrupting Current, A	600
Short-Time Current, kA rms Sym	12.5
Short-Circuit interrupting Current,kA rms Sym	12.5

2.1.2 Switchgear Construction

Provide switchgear with switch contacts and cable entrance terminations contained in a sealed, dielectric-filled stainless steel tank. Switchgear must be shipped factory filled with appropriate levels of SF6 gas conforming to ASTM D2472 or less-flammable, high-firepoint biodegradable fluid conforming to ASTM D6871 and IEC 61099. Configure switchgear with load interrupting and fault interrupting switched ways as indicated. Provide switchgear with front accessible terminations suitable for cables

entering from below with manual operating provisions either mounted on the rear or capable of hookstick operation per IEEE C37.74. Switch contact positions for switched ways must be visible through viewing windows in the switchgear tank located adjacent to the manual operating provisions. Provide internal gas pressure gage or fluid level gage in viewable location from switch operating handle. Provide each switched way with three position switch; Open, Closed, Ground.

2.1.2.1 Pad-mounting Provisions

Provide non-enclosed switchgear suitable for installation on a concrete pad. Fabricate switchgear support frame enclosure base enclosure with ASTM A167 type 304 or 304L stainless steel. Enclosure base must include any part of the switchgear enclosure that is within 3 inches of concrete pad. Paint enclosure including base ASTM D1535 Munsell 7GY3.29/1.5 green. Comply with IEEE C57.12.28 for the paint coating system regardless of equipment material.

2.1.3 Load Interrupting Switched Ways

2.1.3.1 Three-Pole Group Operated Switched Ways

Provide three-pole group operated load interrupting switched ways as indicated.

2.1.3.2 Fault Interrupting Switched Ways

IEEE C37.60, IEC 62271-111. Provide non-fused, non-reclosing, manual reset, vacuum interrupters consisting of vacuum interrupter and a spring assisted operating mechanism. Each fault interrupting switched way must utilize internally mounted current transformers and an electronic overcurrent control to provide three-pole ganged tripping as indicated for single-phase and three-phase faults. Provide electronic overcurrent control with provisions for a minimum of ten field changeable overcurrent trip settings.

2.1.4 Automatic Switch Controls

Provide an automatic switch control system to execute Manual , Automatic Source-Transfer operations. Power the switch control system and associated communication port provisions from an integral battery-charger DC supply system. Use motor operators and associated motor operator controllers for switch way operation. Use 120 Vac control power for automatic switch control.

2.1.4.1 Manual Operation

Provide the motor operator controllers with "Close" and "Open" pushbuttons for manual operation.

2.1.4.2 SCADA Operation

The automatic switch control system must execute remote commands received from a SCADA master station and transmit switchgear operation information to a SCADA master station via a DNP 3.0 100Base-FX Ethernet communication port. Include transfer of switch ways to "Close" and "Open" positions for execution of remote commands. Include switch way position status, voltage and current readings, and DC supply system status with communication of switchgear information.

2.1.4.3 Source-Transfer Operation

Provide an automatic switch control system that opens an incoming switch way when voltage is lost and closes the alternate incoming switch way if voltage is present. Include with the Source-Transfer controls an overcurrent-lockout feature that prevents automatic closing of a switch way into a system fault. Include provisions for returning the system to the normal configuration via manual, SCADA, or automatic operations when voltage is restored.

2.1.4.4 Fault Detection Isolation and Restoration Operation

The automatic switch control system must execute circuit fault detection isolation operation for closed and open loop distribution systems. Provide communication via a peer-to-peer fiber optic network for the pad mount switchgear unit automatic switch control systems. Provide an optical fiber cable approved by the automatic switch control system manufacturer.

2.1.5 Low Voltage Test Pins

Provide load interrupting switch ways with internal load side voltage sensors and external test pins that allow for low voltage checks to confirm energized and in-phase conditions using a standard high-impedance voltmeter.

2.1.6 Dead-Front High-Voltage Bushings

IEEE 386. 15 kV, 95 kV BIL. Provide 600 ampere one-piece deadbreak apparatus bushings for each switched way.

a. Parking stands: Provide a parking stand near each dead-front bushing. Provide insulated standoff bushings for parking of energized load-break connectors on each parking stands.

2.2 Insulated High-Voltage Connectors

IEEE 386. Provide corresponding connector for each switched way. Provide a grounding eye and test point on each connector.

a. 600 Ampere deadbreak connector ratings: Voltage: 15 kV, 95 kV BIL. Short time rating: 25,000 rms symmetrical amperes. Provide connectors with 200 ampere bushing interface.

b. Provide one set of three grounding elbows. Deliver grounding elbows to the Contracting Officer.

2.3 Surge Arresters

IEEE C62.11, rated 6 kV, fully shielded, dead-front, metal-oxide-varistor, elbow type with resistance-graded gap, suitable for plugging into inserts. Provide arresters on switched ways as indicated.

2.4 SF6 Refill Cylinders

Provide two SF6 refill cylinders, minimum size of 6 pounds of SF6; include regulator, valves, and hose for connection to the fill valve of the switch.

2.5 SOURCE QUALITY CONTROL

2.5.1 Switchgear Design and Production Tests

Furnish reports which include results of design and production tests performed according to IEEE C37.74, IEC 62271-103 and IEEE C37.60. Perform manufacturer production tests on each switchgear assembly to ensure that design performance is maintained in production.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.2 GROUNDING

NFPA 70 and IEEE C2, except provide grounds and grounding systems with a resistance to solid earth ground not exceeding 5 ohms. 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.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION at each corner of switchgear pad as indicated.

3.2.2 Switchgear Grounding

Connect #4/0 bare copper conductor ground ring, not less than 24 inches below grade, to the upper end of the ground rods by exothermic welds or compression connectors. Provide #4/0 bare copper conductors connecting the switchgear grounding provisions to two different ground rods.

3.2.3 Connections

Make joints in grounding conductors and ground ring 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 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

Mount switch on concrete slab. Provide slab with dimensions at least 12 inches thick, reinforced with a 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 4 inches from the top of the slab. Place slab on a 6 inch thick, well-compacted gravel base. Install top of concrete slab approximately 4 inches above finished grade. Provide edges above grade with 1/2 inch chamfer. Provide slab of adequate size to project at least 8 inches beyond equipment.

Stub up conduits, with bushings, 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with switch cable training areas. Provide concrete work as specified in Section 03 30 00

CAST-IN-PLACE CONCRETE.

3.4 FIELD QUALITY CONTROL

3.4.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, NFPA 70B, NETA ATS and referenced ANSI standards.

Include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.4.1.1 Switchgear

a. Visual and Mechanical Inspection

1. Compare equipment nameplate information with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Check for proper anchorage, alignment, required area clearances, and grounding.

4. Perform mechanical operator tests in accordance with manufacturer's instructions.

5. Verify that insulating SF6 gas pressure or dielectric fluid level is correct.

6. Inspect all indicating devices for proper operation.

b. Electrical Tests

1. Perform contact-resistance tests.

3. Perform insulation-resistance tests.

4. Perform an over-potential test on each switched way pole with the switched way in the open position in accordance with the manufacturer's instructions.

3.4.1.2 Grounding System

a. Visual and Mechanical Inspection

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.

3.4.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that devices are in good operating condition and properly performing the intended function. Perform each test function not less than three times. As an exception to requirements stated elsewhere in the contract, notify the Contracting Officer five working days in advance of the dates and times for checks and tests.

-- End of Section --

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SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM

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.

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D709	(2013) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013) National Electrical Safety Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering
ANSI C12.7	(2005) Requirements for Watthour Meter Sockets
ANSI C80.1	(2005) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2005) American National Standard for Electrical Metallic Tubing (EMT)
ANSI C80.5	(2005) American National Standard for Electrical Rigid Aluminum Conduit

NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA BU 1.1	(2010) General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 V or Less
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2008; E 2010) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 4	(2010) Terminal Blocks
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
NEMA MG 1	(2011; Errata 2012) Motors and Generators
NEMA MG 10	(2013) 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	(1992; R 1997) Standard for Dry-Type Transformers for General Applications
NEMA TC 14	(2002) Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2013) Standard for Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TP 1	(2002) Guide for Determining Energy Efficiency for Distribution Transformers

NEMA VE 1	(2009) Standard for Metal Cable Tray Systems
NEMA WD 1	(1999; R 2005; R 2010) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2012) Wiring Devices Dimensions Specifications
NEMA Z535.4	(2011) American National Standard for Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code
NFPA 70E	(2012; Errata 2012) Standard for Electrical Safety in the Workplace
NFPA 780	(2014) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568-C.1	(2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard
TIA-569	(2012c; Addendum 1 2013; Errata 2013) Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-607	(2011b) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

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

29 CFR 1910.147	Control of Hazardous Energy (Lock Out/Tag Out)

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jul 2012) Standard for Flexible Metal Conduit
UL 1063	(2006; Reprint Jul 2012) Machine-Tool Wires and Cables
UL 1203	(2013) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations
UL 1242	(2006; Reprint Mar 2014) Standard for

	Electrical Intermediate Metal Conduit -- Steel
UL 1283	(2005; Reprint Feb 2013) Electromagnetic Interference Filters
UL 1449	(2006; Reprint Sep 2013) Surge Protective Devices
UL 1561	(2011; Reprint Sep 2012) Dry-Type General Purpose and Power Transformers
UL 1569	(1999; Reprint Jan 2012) Standard for Metal-Clad Cables
UL 1660	(2004; Reprint Apr 2013) Liquid-Tight Flexible Nonmetallic Conduit
UL 1699	(2006; Reprint Nov 2013) Arc-Fault Circuit-Interrupters
UL 198M	(2003; Reprint Feb 2013) Standard for Mine-Duty Fuses
UL 20	(2010; Reprint Feb 2012) General-Use Snap Switches
UL 2043	(2013) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces
UL 360	(2013; Reprint May 2013) Liquid-Tight Flexible Steel Conduit
UL 4	(2004; Reprint Oct 2013) Standard for Armored Cable
UL 4248-1	(2007; Reprint Oct 2013) UL Standard for Safety Fuseholders - Part 1: General Requirements
UL 4248-12	(2007; Reprint Dec 2012) UL Standard for Safety Fuseholders - Part 12: Class R
UL 44	(2014) Thermoset-Insulated Wires and Cables
UL 467	(2007) Grounding and Bonding Equipment
UL 486A-486B	(2013; Reprint Feb 2014) Wire Connectors
UL 486C	(2013; Reprint Feb 2014) Splicing Wire Connectors
UL 489	(2013; Reprint Mar 2014) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 498	(2012; Reprint Feb 2014) Attachment Plugs

	and Receptacles
UL 5	(2011) Surface Metal Raceways and Fittings
UL 50	(2007; Reprint Apr 2012) Enclosures for Electrical Equipment, Non-environmental Considerations
UL 506	(2008; Reprint Oct 2013) Specialty Transformers
UL 508	(1999; Reprint Oct 2013) Industrial Control Equipment
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013) Metallic Outlet Boxes
UL 514B	(2012) Conduit, Tubing and Cable Fittings
UL 514C	(2014) Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 5A	(2003; Reprint Jun 2013) Nonmetallic Surface Raceways and Fittings
UL 6	(2007; reprint Nov 2010) Electrical Rigid Metal Conduit-Steel
UL 651	(2011; Reprint May 2014) Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
UL 67	(2009; Reprint Jan 2013) Standard for Panelboards
UL 674	(2011; Reprint Jul 2013) Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations
UL 6A	(2008; Reprint May 2013) Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel
UL 719	(2006; Reprint Apr 2013) Nonmetallic-Sheathed Cables
UL 797	(2007; Reprint Dec 2012) Electrical Metallic Tubing -- Steel
UL 817	(2001; Reprint Feb 2014) Standard for Cord Sets and Power-Supply Cords
UL 83	(2014) Thermoplastic-Insulated Wires and Cables
UL 845	(2005; Reprint Jul 2011) Motor Control

	Centers
UL 854	(2004; Reprint Sep 2011) Standard for Service-Entrance Cables
UL 857	(2009; Reprint Dec 2011) Busways
UL 869A	(2006) Reference Standard for Service Equipment
UL 870	(2008; Reprint Feb 2013) Standard for Wireways, Auxiliary Gutters, and Associated Fittings
UL 943	(2006; Reprint Jun 2012) Ground-Fault Circuit-Interrupters
UL 984	(1996; Reprint Sep 2005) Hermetic Refrigerant Motor-Compressors

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. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Panelboards; G

Transformers; G

SD-03 Product Data

Receptacles; G

Circuit breakers; G

Switches; G

Transformers; G

Enclosed circuit breakers; G

Motor controllers; G

Combination motor controllers; G

Manual motor starters; G

Metering; G

Telecommunications Grounding Busbar; G

Surge protective devices; G

Include performance and characteristic curves.

SD-06 Test Reports

600-volt wiring test; G

Grounding system test; G

Transformer tests; G

Ground-fault receptacle test; G

SD-07 Certificates

Fuses; G

SD-09 Manufacturer's Field Reports

Transformer factory tests

SD-10 Operation and Maintenance Data

Electrical Systems, Data Package 5; G

Metering, Data Package 5; G

Submit operation and maintenance data in accordance with Section 01 78 23, OPERATION AND MAINTENANCE DATA and as specified herein.

1.4 QUALITY ASSURANCE

1.4.1 Fuses

Submit coordination data as specified in paragraph, FUSES of this section.

1.4.2 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.

1.4.3 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.

1.4.3.1 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.

1.4.3.2 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 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 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 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

Steelcompression type.

2.2.8 Fittings for Rigid Nonmetallic Conduit

NEMA TC 3 for PVC, and UL 514B.

2.3 CABINETS, JUNCTION BOXES, AND PULL BOXES

Volume greater than 100 cubic inches, UL 50, hot-dip, zinc-coated, if sheet steel.

2.4 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.

2.4.1 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.

e. All conductors: copper.

2.4.1.1 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.

2.4.2 Color Coding

Provide color coding for service, feeder, branch, control, and signaling circuit conductors.

2.4.2.1 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.

2.4.2.2 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

2.4.3 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 or Type XHHW or RHW conforming to UL 44, except that grounding wire may be type TW 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.

2.4.4 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.

2.4.5 Service Entrance Cables

Service Entrance (SE) and Underground Service Entrance (USE) Cables, UL 854.

2.5 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.

2.6 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: zinc-coated sheet steel or cast metal having round or beveled edges.

c. For nonmetallic boxes and fittings, other suitable plates may be provided.

d. Plates on finished walls: nylon or lexan, minimum 0.03 inch wall thickness and same color as receptacle or toggle switch with which they are mounted.

e. Plates on finished walls: satin finish stainless steel or brushed-finish aluminum, minimum 0.03 inch thick.

f. Screws: machine-type with countersunk heads in color to match finish of plate.

g. Sectional type device plates are not be permitted.

h. Plates installed in wet locations: gasketed and UL listed for "wet locations."

2.7 SWITCHES

2.7.1 Toggle Switches

NEMA WD 1, UL 20, single pole, double pole, three-way, and four-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.

2.7.2 Breakers Used as Switches

For 120- and 277-Volt fluorescent fixtures, mark breakers "SWD" in accordance with UL 489.

2.7.3 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. Utilize Class R fuseholders and fuses for fused switches, unless indicated otherwise. Provide horsepower rated for switches serving as the motor-disconnect means. Provide switches in NEMA enclosure as indicated per NEMA ICS 6.

2.8 FUSES

NEMA FU 1. Provide complete set of fuses for each fusible switch panel and control center. Coordinate time-current characteristics curves of fuses serving motors or connected in series with circuit breakers for proper operation. Submit coordination data for approval. Provide fuses with a voltage rating not less than circuit voltage.

2.8.1 Fuseholders

Provide in accordance with UL 4248-1.

2.8.2 Cartridge Fuses, Current Limiting Type (Class R)

UL 198M, Class RK-1 RK-5 time-delay type. Provide only Class R associated fuseholders in accordance with UL 4248-12.

2.8.3 Cartridge Fuses, High-Interrupting Capacity, Current Limiting Type (Classes J, L, and CC)

UL 198M, Class J for zero to 600 amperes, Class L for 601 to 6,000 amperes, and Class CC for zero to 30 amperes.

2.9 RECEPTACLES

Provide the following:

a. UL 498, hard use (also designated heavy-duty), grounding-type.

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.

2.9.1 Switched Duplex Receptacles

Provide separate terminals for each ungrounded pole. Top receptacle: switched when installed.

2.9.2 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.

2.9.3 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak of 6 milliamperes or greater 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.

2.9.4 Special Purpose Receptacles

Provide in ratings indicated. Furnish one matching plug with each

receptacle.

2.10 PANELBOARDS

Provide panelboards in accordance with the following:

a. UL 67 and UL 50 having a short-circuit current rating as indicated of 10,000 amperes symmetrical minimum.

b. Panelboards for use as service disconnecting means: additionally conform to UL 869A.

c. Panelboards: circuit breaker-equipped.

d. 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.

e. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings.

f. Use of "Subfeed Breakers" is not acceptable unless specifically indicated otherwise.

g. Main breaker: "separately" mounted "above" or "below" branch breakers.

h. Where "space only" is indicated, make provisions for future installation of breakers.

i. Directories: indicate load served by each circuit in panelboard.

j. Directories: indicate source of service to panelboard (e.g., Panel PA served from Panel MDP).

k. Provide new directories for existing panels modified by this project as indicated.

l. Type directories and mount in holder behind transparent protective covering.

m. Panelboards: listed and labeled for their intended use.

n. Panelboard nameplates: provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

2.10.1 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. Outdoor cabinets: NEMA 3R raintight with conduit hubs welded to the cabinet.

e. Front edges of cabinets: form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front.

f. 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.

g. 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.

h. Flush doors: mounted on hinges that expose only the hinge roll to view when the door is closed.

i. Each door: fitted with a combined catch and lock, except that doors over 24 inches long provided with a three-point latch having a knob with a T-handle, and a cylinder lock.

j. Keys: two provided with each lock, with all locks keyed alike.

k. Finished-head cap screws: provided for mounting the panelboard fronts on the cabinets.

2.10.2 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 busses shall be copper.

2.10.2.1 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.

2.10.3 Circuit Breakers

UL 489, thermal magnetic-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.

2.10.3.1 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.

2.10.3.2 Circuit Breakers for HVAC Equipment

Provide circuit breakers for HVAC equipment having motors (group or individual) marked for use with HACR type and UL listed as HACR type.

2.11 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.

2.12 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. Transformer insulation system:

(1) 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding 150 degrees C under full-rated load in maximum ambient of 40 degrees C.

(2) 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 150 degrees C under full-rated load in maximum ambient of 40 degrees C.

d. Transformer of 150 degrees C temperature rise: capable of carrying continuously 100 percent of nameplate kVA without exceeding insulation rating.

g. Transformers: quiet type with maximum sound level at least 3 decibels less than NEMA standard level for transformer ratings indicated.

2.12.1 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. Minimum efficiency, based on factory test results: not be less than NEMA Class 1 efficiency as defined by NEMA TP 1.

2.13 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.

2.13.1 High Efficiency Single-Phase Motors

Single-phase fractional-horsepower alternating-current motors: high efficiency types corresponding to the applications listed in NEMA MG 11. 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.

2.13.2 Premium Efficiency Polyphase Motors

Select polyphase motors based on high efficiency characteristics relative to typical characteristics and applications as listed in NEMA MG 10. 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.

2.13.3 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.

2.13.4 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, and motor control equipment forming part of motor control centers or switchgear assemblies, the conduit and wiring connecting such centers, 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.

2.14 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 selector switch with the means for locking in any position.

j. 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.

l. 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.

m. 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.

2.14.1 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.

2.14.2 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 (4) 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.

2.14.2.1 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 eEach connected terminal with the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.14.3 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. Provide fuses in each ungrounded primary feeder. Provide one fused secondary lead with the other lead grounded.

2.14.4 Enclosures for Motor Controllers

NEMA ICS 6.

2.15 LOCKOUT REQUIREMENTS

Provide disconnecting means 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. Comply with requirements of Division 23, "Mechanical" for mechanical isolation of machines and other equipment.

2.16 GROUNDING AND BONDING EQUIPMENT

2.16.1 Ground Rods

UL 467. Ground rods: copper-clad steel, with minimum diameter of 3/4 inch and minimum length 10 feet. Sectional ground rods are permitted.

2.16.2 Ground Bus

Copper ground bus: provided in the electrical equipment rooms as

indicated.

2.17 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.

2.18 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.

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.

2.19 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.

2.20 FIRESTOPPING MATERIALS

Provide firestopping around electrical penetrations in accordance with Section 07 84 00, FIRESTOPPING .

2.21 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entrance, panelboards and airfield lighting control panels. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker.

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).

Provide SPDs. Maximum L-N, L-G, and N-G Voltage Protection Rating:

700V for 208Y/120V, three phase system
1,200V for 480Y/277V, three phase system

Maximum L-L Voltage Protection Rating:

1,200V for 208Y/120V, three phase system
2,000V for 480Y/277V, three phase system

The minimum MCOV (Maximum Continuous Operating Voltage) rating for L-N and L-G modes of operation: 120% of nominal voltage for 240 volts and below; 115% of nominal voltage above 240 volts to 480 volts.

Provide EMI/RFI filtering per UL 1283 for each mode with the capability to attenuate high frequency noise. Minimum attenuation: 20db.

2.22 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 Dark Gray.

g. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

2.23 SOURCE QUALITY CONTROL

2.23.1 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

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 severe 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 and PVC Schedule 80

(1) Do not use in areas where subject to severe physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, hospitals, power plants, missile magazines, and other such areas.

(2) Do not use in hazardous (classified) areas.

(3) Do not use in fire pump rooms.

(4) Do not use in penetrating fire-rated walls or partitions, or fire-rated floors.

(5) Do not use above grade, except where allowed in this section for rising through floor slab or indicated otherwise.

(6) Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

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 for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.1.4.6 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.

3.1.4.7 Conduit Through Floor Slabs

Where conduits rise through floor slabs, do not allow curved portion of bends to be visible above finished slab.

3.1.4.8 Conduit Installed in Concrete Floor Slabs

PVC, Type EPC-40, unless indicated otherwise. Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends must not be visible above finish slab. Increase slab thickness as necessary to provide minimum one inch cover over conduit. Where embedded conduits cross building and/or expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings must allow horizontal and vertical movement of raceway. Conduit larger than one inch trade size: installed parallel with or at right angles to main reinforcement; when at right angles to reinforcement, install conduit close to one of supports of slab. Where nonmetallic conduit is used, convert raceway to plastic coated rigid steel or plastic coated steel IMC before rising above floor, unless specifically indicated.

3.1.4.9 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.

3.1.4.10 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 installationwith 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. 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.

3.1.4.11 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.

3.1.4.12 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.

3.1.4.13 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 liquidtight 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, except that aluminum boxes may be used with aluminum conduit, and nonmetallic boxes may be used with nonmetallic conduit system. 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 fixturesfor 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. 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, and compatible with nonmetallic raceway systems, 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.

3.1.6 Mounting Heights

Mount panelboards, enclosed circuit breakers, motor controller 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 18 inches above finished floor, unless otherwise indicated. Mount other devices as indicated. Measure mounting heights of wiring devices and outletsto center of device or outlet.

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 withmanufacturer's recommendations

3.1.7.1 Marking Strips

Provide marking strips 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.

3.1.9 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. Make ground connection to driven ground rods on exterior of building. 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. 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 cone pointed ground rods. 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,2 additional rods, spaced on center, not less than twice the distance of the length of the rod may be coupled and driven with the first rod. 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 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 compression connections using a hydraulic 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 Repair of Existing Work

Perform repair of existing work, demolition, and modification of existing electrical distribution systems as follows:

3.1.13.1 Workmanship

Lay out work in advance. Exercise care where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces is necessary for proper installation, support, or anchorage of conduit, raceways, or other electrical work. Repair damage to buildings, piping, and equipment using skilled craftsmen of trades involved.

3.1.13.2 Existing Concealed Wiring to be Removed

Disconnect existing concealed wiring to be removed from its source. Remove conductors; cut conduit flush with floor, underside of floor, and through walls; and seal openings.

3.1.13.3 Removal of Existing Electrical Distribution System

Removal of existing electrical distribution system equipment includes equipment's associated wiring, including conductors, cables, exposed conduit, surface metal raceways, boxes, and fittings, back to equipment's power source as indicated.

3.1.13.4 Continuation of Service

Maintain continuity of existing circuits of equipment to remain. Maintain existing circuits of equipment energized. Restore circuits wiring and power which are to remain but were disturbed during demolition back to original condition.

3.1.14 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.

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. Where field painting of enclosures for panelboards, load centers or the like is specified to match adjacent surfaces, to correct damage to the manufacturer's factory applied coatings, or to meet the indicated or specified safety criteria, provide manufacturer's recommended coatings and apply in accordance to manufacturer's instructions.

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 s.

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 approximately 500 volts to provide direct reading of resistance. Minimum resistance: 250,000 ohms.

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.

3.5.5 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.

-- End of Section --

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SECTION 26 27 14.00 20

ELECTRICITY METERING

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	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013) National Electrical Safety Code
IEEE C37.90.1	(2012) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.13	(2008; INT 2009) Standard Requirements for Instrument Transformers
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60687	(1992) Alternating Current Static Watt-Hour Meters for Active Energy (Classes 0,2 S and 0,5 S)
IEC 62053-22	(2003; ED 1.0) Electricity Metering Equipment (a.c.) - Particular Requirements - Part 22: Static Meters for Active Energy (Classes 0,2 S and 0,5 S)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering
ANSI C12.18	(2006) Protocol Specification for ANSI Type 2 Optical Port
ANSI C12.20	(2010) Electricity Meters - 0.2 and 0.5 Accuracy Classes
ANSI C12.7	(2005) Requirements for Watthour Meter

Sockets

NEMA C12.19 (2008) Utility Industry End Device Data Tables

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be 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.

Technical data packages consisting of technical data and computer software (meaning technical data which relates to computer software) which are specifically identified in this project and which may be defined/required in other specifications shall be delivered strictly in accordance with the CONTRACT CLAUSES and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. All submittals not specified as technical data packages are considered 'shop drawings' under the Federal Acquisition Regulation Supplement (FARS) and shall contain no proprietary information and be delivered with unrestricted rights.

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

The most recent meter product data shall be submitted as a Technical Data Package and shall be licensed to the project site. Any software shall be submitted on CD-ROM and 6 hard copies of the software user manual shall be submitted for each piece of software provided.

Current transformer; G

Potential transformer; G

External communications devices; G

Configuration Software; G

The most recent version of the configuration software for each type (manufacturer and model) shall be submitted as a Technical Data Package and shall be licensed to the project site. Software shall be submitted on CD-ROM and 6 hard copies of the software user manual shall be submitted for each piece of software provided.

SD-06 Test Reports

Acceptance checks and tests; G

System functional verification; G

Building meter installation sheet, per building; G

Completed meter installation schedule; G

Completed meter data schedule; G

Meter configuration template; G

Contractor shall fill in the meter configuration template and submit to the Activity for concurrence.

Meter configuration report; G

The meter configuration report shall be submitted as a Technical Data Package.

SD-10 Operation and Maintenance Data

Electricity Meters and Accessories, Data Package 5; G

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein.

SD-11 Closeout Submittals

System functional verification; G

1.4 QUALITY ASSURANCE

1.4.1 Installation Drawings

Drawings shall be provided in hard-copy and electronic format, and shall include but not be limited to the following:

a. Wiring diagrams with terminals identified of kilowattadvanced meter, current transformers, potential transformers, protocol modules, communications interfaces, Ethernet connections, telephone lines. For each typical meter installation, provide a diagram.

b. One-line diagram, including meters, switch(es), current transformers, potential transformers, protocol modules, communications interfaces, Ethernet connections, telephone outlets, and fuses. 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 shall have been in satisfactory commercial or industrial use for 1 year prior to bid opening. The 1-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product, or an earlier release of the product, shall 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 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.

1.4.3 Material and Equipment Manufacturing Data

Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

1.5 MAINTENANCE

1.5.1 Additions to Operation and Maintenance Data

In addition to requirements of Data Package 5, include the following on the actual electricity meters and accessories provided:

a. A condensed description of how the system operates

b. Block diagram indicating major assemblies

c. Troubleshooting information

d. Preventive maintenance

e. Prices for spare parts and supply list

1.6 WARRANTY

The equipment items and software shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment and software on a regular and emergency basis during the warranty period of the contract.

1.7 SYSTEM DESCRIPTION

1.7.1 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. Communication system requirements are contained in a separate specification section as identified in paragraph entitled "Communications Interfaces".

1.7.2 Selection Criteria

Metering components and software are part of a system that includes the physical meter, data recorder function and communications method. Every building site identified shall include sufficient metering components to measure the electrical parameters identified and to store and communicate the values as required.

Contractor shall verify that the electricity meter installed on any building site is compatible with the base-wide metering system with respect to the types of meters selected and the method used to program the meters for initial use. Software and meter programming tools are necessary to set up the meters described by this specification. New software tools different from the meter programming methods currently used by base personnel will require separate approval for use.

PART 2 PRODUCTS

2.1 ELECTRICITY METERS AND ACCESSORIES

2.1.1 Physical and Common Requirements

a. Provide metering system components in accordance with the Metering System Schedule shown in this specification. Provide Meter configuration template.

b. Replace all existing meter bases. For socket arrangements, use meter and base form of 9S unless installation-specific limitations require the use of a different form type. For panelboards, switchboards, and switchgear, match the existing installation with the new meter base.

c. Meter shall have NEMA 3R enclosure for surface mounting with bottom or rear penetrations.

d. Surge withstand capability shall conform to IEEE C37.90.1.

e. Use #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 shall 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 shall be optically isolated to 2500 volts DC from signal and communications outputs. Components shall 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 shall 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 shall be rated indoor or outdoor, as required for the specific application. Voltage rating shall provide 120 volts, wye-connected, 3 phase, 4 wire, 60 Hz, insulation class, 600 volts. Potential transformers BIL shall be 10 kV and shall have an accuracy class of 0.3 at burdens w, x, and y. Thermal rating shall be 500 VA.

e. The Contractor shall be responsible for determining the actual voltage ratio of each potential transformer for medium voltage applications. Transformer shall 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 shall be rated for interior use. Voltage rating shall provide 120 volts, wye-connected, 3 phase, 4 wire, 60 Hz, insulation class, 600 volts. Potential transformers BIL shall 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 shall have an accuracy class of 0.3 at burdens w, x, and y. Thermal rating shall be 500 VA. Potential transformers shall be accessed from the front and mounted in a metering section.

2.1.3 Current Transformer Requirements

a. Current transformer shall be installed with a rating as shown in the schedule.

b. Current transformers shall have an Accuracy Class of 0.3 (with a maximum error of plus/minus 0.3 percent at 5.0 amperes) when operating within the specified rating factor.

c. Current transformers shall be solid-core, bracket-mounted for new installations using ring-tongue lugs for electrical connections. Current transformers shall be accessible and the associated wiring shall 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 shall have:

(1) Insulation Class: All 600 volt and below current transformers shall be rated 10 KV BIL. Current transformers for 2400 and 4160 volt service shall be rated 25 KV BIL.

(2) Frequency: Nominal 60 Hz.

(3) Burden: Burden class shall be selected for the load.

(4) Phase Angle Range: 0 to 60 degrees.

e. Meter shall accept current input from standard instrument transformers (5A secondary current transformers).

f. Current inputs shall 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
225	480Y/277	200/5	2.0	0.3 thru B0.1

2.1.4 Meter Requirements

Electricity meters shall include the following features:

a. Meter shall comply with ANSI C12.1, NEMA C12.19, and ANSI C12.20.

b. Meter sockets shall comply with ANSI C12.7.

e. Provide socket-mounted or panel mounted meters as indicated on the meter schedule.

(1) Panel-mounted meters shall be semi-flush, back-connected, dustproof, draw-out switchboard type. Cases shall have window removable covers capable of being sealed against tampering. Meters shall be of a type that can be withdrawn through approved sliding contacts from fronts of panels or doors without opening current-transformer secondary circuits, disturbing external circuits, or requiring disconnection of any meter leads. Necessary test devices shall be incorporated within each meter and shall provide means for testing either from an external source of electric power or from associated instrument transformers or bus voltage.

f. Meter shall be a Class 20, transformer rated design.

g. Use Class 200 meters for direct current reading without current transformers for applications with an expected load less than 200

amperes, where indicated.

h. Meter shall be rated for use at temperature from minus 40 degrees Centigrade to plus 70 degrees Centigrade.

i. The meters shall have an electronic demand recording register and shall be secondary reading as indicated. The register shall be used to indicate maximum kilowatt demand as well as cumulative or continuously cumulative demand. Demand shall be measured on a block-interval basis and shall be capable of a 5 to 60 minute interval and initially set to a 15-minute interval. It shall have provisions to be programmed to calculate demand on a rolling interval basis. Meter readings shall be true RMS.

j. The meter electronic register shall be of modular design with non-volatile data storage. Downloading meter stored data shall be capable via an optical port. Recording capability of data storage with a minimum capability of 89 days of 15 minute, 2 channel interval data. The meter shall be capable of providing at least 2 KYZ pulse outputs (dry contacts). Default initial configuration (unless identified otherwise by base personnel) shall be:

(1) First channel - kWh
(2) Second channel - kVARh
(3) KYZ output #1 - kWh
(4) KYZ output #2 - kVARh

k. All meters shall have identical features available in accordance with this specification. The meter schedule identifies which features shall be activated at each meter location.

l. Enable switches for Time of Use (TOU), pulse and load profile measurement module at the factory.

m. Meter shall have an optical port on front of meter capable of speeds from 9600 to a minimum of 19.2k baud, and shall be initially set at 9600 baud. Optical device shall be compatible with ANSI C12.18.

n. Meters shall be 120-480 volts auto ranging.

o. 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 shall 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.

p. On switchboard style installations, provide switchboard case with disconnect means for meter removal incorporating short-circuiting of current transformer circuits.

q. Meter covers shall be polycarbonate resins with an optical port and

reset. Backup battery shall be easily accessible for change-out after removing the meter cover.

r. The normal billing data scroll shall be fully programmable. Data scroll display shall include the following.

(1) Number of demand resets.
(2) End-of-interval indication.
(3) Maximum demand.
(4) New maximum demand indication.
(5) Cumulative or continuously cumulative.
(6) Time remaining in interval.
(7) Kilowatt hours.

s. The register shall incorporate a built-in test mode that allows it to be tested without the loss of any data or parameters. The following quantities shall be available for display in the test mode:

(1) Present interval's accumulating demand.
(2) Maximum demand.
(3) Number of impulses being received by the register.

t. Pulse module simple I/O board with programmable ratio selection.

u. Meters shall be programmed after installation via an optical port. Optical display shall show TOU data, peak kWh, semi-peak kWh, off peak kWh, and phase angles.

v. Self-monitoring to provide for:

(1) Unprogrammed register.
(2) RAM checksum error.
(3) ROM checksum error.
(4) Hardware failure.
(5) Memory failure.
(6) EPROM error.
(7) Battery status (fault, condition, or time in service).

w. Liquid crystal alphanumeric displays, 9 digits, blinking squares confirm register operation. 6 Large digits for data and smaller digits for display identifier.

x. Display operations, programmable sequence with display identifiers. Display identifiers shall be selectable for each item. Continually sequence with time selectable for each item.

y. The meters shall support three modes of registers: Normal Mode, Alternate Mode, and Test Mode. The meter also shall support a "Toolbox" or "Service Information" (accessible in the field) through an optocom port to a separate computer using the supplied software to allow access to instantaneous service information such as voltage, current, power factor, load demand, and the phase angle for individual phases.

z. Meter shall have a standard 5-year warranty.

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 shall be provided between the current transformer and the meter. A shorting mechanism shall be built into the wiring block to allow the current transformer wiring to be changed without removing power to the transformer. The wiring blocks shall be located where they are accessible without the necessity of disconnecting power to the transformer.

c. Voltage monitoring circuits shall be equipped with disconnect switches to isolate the meter base or socket from the voltage source. Provide fuse protection in accordance with paragraph entitled "Voltage Requirements"

2.1.6 Installation Methods

a. Transformer Mounted ("XFMR" in Metering Systems Schedule). Meter base shall be located outside on the secondary side of the pad-mounted transformer.

b. Stand Mounted Adjacent to Transformer ("STAND" in Metering Systems Schedule). Meter base shall 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.

c. Building Mounted ("BLDG" in Metering Systems Schedule). Meter base shall be mounted on the side of the existing building near the service entrance.

d. Panel Mounted. ("PNL" in Metering Systems Schedule). Meter shall be mounted where directed.

e. Commercial meter pedestal ("PED" in Metering Systems Schedule).

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall 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 Existing Condition Survey

The Contractor shall perform a field survey, including inspection of all existing equipment, resulting clearances, and new equipment locations intended to be incorporated into the system and furnish an existing conditions report to the Government. The report shall identify those items that are non-workable as defined in the contract documents. The Contractor shall be held responsible for repairs and modifications necessary to make the system perform as required.

3.1.1.1 Existing Meter Sockets

In some cases, the existing meter sockets will have to be replaced to accommodate the new electrical meters. An existing socket is considered unacceptable for any of the following conditions:

a. It is a non-ANSI form factor meter socket.

b. It is weathered beyond the point of being safe to reuse.

c. It is installed incorrectly, such as a non-weather resistant enclosure installed outdoors.

d. It is not the correct form factor for the existing electrical service.

3.1.1.2 Existing Installations

As part of the existing condition survey, the following applies for installations with existing meters:

a. Replace any meters that do not comply with this section.

b. If CTs are installed, verify that they comply with this section. If they do not comply, replace them with CTs that comply with this section. One CT per phase is required for wye-connected systems.

c. If potential transformers are installed on low-voltage systems, remove the PTs as part of the installation.

d. Install disconnect switches as specified in this section.

3.1.2 Scheduling of Work and Outages

The Contract Clauses shall govern regarding permission for power outages, scheduling of work, coordination with Government personnel, and special working conditions.

3.1.3 Configuration Software

The standard meter shall include the latest available version of firmware and software. Meter shall either be programmed at the factory or shall be programmed in the field. Meters shall have a password that shall be provided to the contracting officer upon project completion. When field programming is performed, turn field programming device over to the Contracting Officer at completion of project. When interfacing software is used for a meter that is different than the existing meters in use at the Activity, turn the software over to the Contracting Officer at completion of the project.

3.2 FIELD QUALITY CONTROL

Perform the following acceptance checks and tests on a random sample of 10 percent of the installed meters as designated by the Contracting Officer .

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 and mechanical 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) Record password and user log-in for each meter.

(g) Verify grounding of metering enclosure.

(h) Set all required parameters including instrument transformer ratios, system type, frequency, power demand methods/intervals, and communications requirements. Verify that the CT ratio and the PT ratio are properly included in the meter multiplier or the programming of the meter. Confirm that the multiplier is provided on the meter face or on the meter.

(i) Provide building meter installation sheet, per building for each facility.

(j) Provide the completed meter installation schedule for the installation.

(k) Provide the completed meter data schedule for the installation.

(2) Electrical tests.

(a) Apply voltage or current as appropriate to each analog input and verify correct measurement and indication.

(b) Confirm correct operation and setting of each auxiliary input/output feature including mechanical relay, digital, and analog.

(c) After initial system energization, confirm measurements and indications are consistent with loads present.

(d) Make note of, and report, any "Error-Code" or "Caution-Code" on the meter's display.

(3) Provide meter configuration report.

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.

(2) Electrical Tests.

Verify proper operation by reviewing the meter configuration report.

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.

(2) Electrical Tests.

(a) Verify by the meter configuration report that the polarity and phasing are correct.

3.2.2 System Functional Verification

Verify that the installed meters are working correctly in accordance with the meter configuration report:

a. The correct meter form is installed.

b. All voltage phases are present.

c. Phase rotation is correct.

d. Phase angles are correct.

e. The new meter accurately measures power magnitude and direction, and can communicate as required by paragraph entitled "Communications Interfaces".

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SECTION 26 32 13.00 20

SINGLE OPERATION GENERATOR SETS

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.

ASME INTERNATIONAL (ASME)

ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2012) Standard for Factory-Made Wrought Steel Buttwelding Fittings

ASTM INTERNATIONAL (ASTM)

ASTM A126	(2004; R 2014) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A181/A181M	(2013) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A193/A193M	(2012a) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2013) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A234/A234M	(2013; E 2014) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM D975 (2014) Standard Specification for Diesel Fuel Oils

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

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 C2 (2012; Errata 2012; INT 1-4 2012; INT 5-7 2013) 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

INTERNATIONAL CODE COUNCIL (ICC)

ICC UBC (1997; Erratas Vol 1, 2 & 3 01/2001; Vol 1 & 2 03/2001; Vol 2 10/2001) Uniform Building Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60034-2A (1974; ED 1.0) Rotating Electrical Machines Part 2: Methods for Determining Losses and Efficiency of Rotating Electrical Machinery from Tests (Excluding Machines for Traction Vehicles) Measurement of Losses by the Calorimetric Method

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 3046 (1986; Am. 1) Reciprocating Internal Combustion Engines - Performance

ISO 8528 (1993; R 2005) Reciprocating Internal Combustion Engine Driven Alternating Current Generator Sets

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58 (2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

MSS SP-69 (2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI

Approved American National Standard)

MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2011; Errata 2013) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-80	(2013) 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 C50.10	(1990) Rotating Electrical Machinery - Synchronous Machines
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA MG 1	(2011; Errata 2012) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2012; Errata 2011; Errata 2011) Flammable and Combustible Liquids Code
NFPA 37	(2010; TIA 10-1; TIA 13-2; TIA 13-3) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-DTL-16884	(2014; Rev N) Fuel, Naval Distillate
MIL-DTL-5624	(2013; Rev V) Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-STD-461	(2007; Rev F) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-52557	(Rev A; Notice 1) Fuel Oil, Diesel; for Posts, Camps and Stations

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

40 CFR 60	Standards of Performance for New Stationary Sources

UNDERWRITERS LABORATORIES (UL)

UL 1236	(2006; Reprint Jul 2011) Standard for Battery Chargers for Charging Engine-Starter Batteries
UL 142	(2006; Reprint Jul 2013) Steel Aboveground Tanks for Flammable and Combustible Liquids
UL 429	(2013) Electrically Operated Valves
UL 467	(2007) Grounding and Bonding Equipment
UL 489	(2013; Reprint Mar 2014) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

1.2 RELATED REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS, and Section 26 08 00 APPARATUS INSPECTION AND TESTING apply to this section except as modified herein.

1.3 SYSTEM DESCRIPTION

1.3.1 Engine-Generator Set Data

Submit data pertaining to the diesel engine-generator set and to the auxiliary equipment including but not limited to the following:

a. Make of engine.

b. Type or model of engine.

c. Gross bhp rating of engine shall be the total rated power output before deducting power requirements of electric motor-driven equipment or engine driven radiator fan.

d. Net brake power rating of engine shall include deductions for the total power requirements of electric motor-driven or engine-driven accessories as defined in ISO 3046. Net ratings shall include a deduction in power output for cooling media system power requirements including radiator fans and any other power consuming devices required to provide cooling as specified.

e. Strokes per cycle.

f. Number of cylinders.

g. Bore and stroke, inches.

h. Engine speed, rpm.

i. Piston speed, fpm.

j. kW power rating of engine-generator set as defined in the paragraph entitled "Engine-Generator Set Ratings and Performance."

k. Induction method (naturally aspirated, turbocharged).

l. Intercooler type (air-to-air or jacket water).

m. Governor type, make, and model.

n. Make and model of turbochargers.

1.3.2 Engine-Generator Set Efficiencies

Submit data pertaining to the diesel engine-generator set including but not limited to the following: Loads shall be calculated on basis of rated engine-generator set power.

a. Fuel consumption at 0.80 power factor, gallons per hr.

1. 1/2 load

2. 3/4 load

3. Full load

b. Generator efficiency at 0.80 power factor (percent).

1. 1/2 load

2. 3/4 load

3. Full load

c. Radiator capacity at design conditions.

1. Coolant shall be antifreeze mixture as specified under paragraph entitled "Cooling System."

2. gpm of coolant

3. cfm of air through radiator

4. Btu per hr of heat exchange based on optimum coolant temperature to and from engine.

1.3.3 Diesel Engine Data

Submit data certified by the engine manufacturer including but not limited to the following: Loads shall be calculated on basis of rated engine-generator set power.

a. Approximate exhaust temperature degrees F at full load

b. Weight of exhaust gas at full load lb per hr

c. Weight of intake air at full load lb per hr

d. Total heat rejected at full load Btu per hr

1. To jacket coolant system

2. To fuel oil cooling system

e. Emissions (Lbs/hr)(kg/hr) at full load

1. Total Suspended Particulate

2. Particulate matter with an average aerodynamic diameter of 10 microns (PM-10)

3. Sulfur dioxides

4. Nitrogen Oxides (as N02)

5. Carbon Monoxide

6. Volatile Organic Compounds

f. Visible Emissions (percent opacity) at full load

1.3.4 Generator and Exciter Data

Submit data certified by the generator manufacturer including but not limited to the following:

a. Make and model number of generator

b. kW rating of generator

c. Generator reactances

1. Synchronous reactance, Xd

2. Transient reactance, X'd

3. Subtransient reactance, X"d

4. Negative sequence reactance, X2

5. Zero sequence reactance, Xo

1.3.5 Capacity Calculations for Engine-Generator Set

Calculations shall verify that the engine-generator set power rating is adequate for the load described in the paragraph entitled "Load Profile."

1.3.6 Calculations for Brake Mean Effective Pressure (BMEP)

Calculation shall verify that the diesel engine meets the specified maximum BMEP as follows:

a. kW: Minimum power rating of engine-generator set as defined in the paragraph entitled "Engine-Generator Set Ratings and Performance."

b. rpm: Engine revolutions per minute.

c. cu. in.: Total engine piston displacement in cubic inches.

d. GEN.EFF.: Generator efficiency.

e. x: Multiplication sign.

f. bhp': Brake horsepower required from diesel engine by generator loaded to full power rating.

g. bhp': kW/(GEN.EFF. times 0.746).

h. bhp": Brake horsepower required by diesel engine driven fan for cooling radiator or motor driven fan for cooling radiator.

i. bhp: bhp' plus bhp".

j. BMEP psi: (792,000 times bhp) /(rpm times cu. in.).

1.3.7 Torsional Vibration Stress Analysis Computations

Torsional vibrational stresses in the crankshaft and generator shaft of assembled diesel engine and driven generator shall not exceed 5000 psi when engine is driving generator at rated speed while assembled unit is loaded to rated engine-generator set power. Computations shall 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 shall 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.

1.3.8 Capacity Calculations for Batteries

Calculation shall verify that the engine starting battery capacity exceeds dc power requirements.

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. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Engine-Generator set and auxiliary equipment; G

Auxiliary systems; G

SD-03 Product Data

Engine-generator set data; G

Engine-generator set efficiencies; G

Diesel engine data; G

Generator and exciter data; G

Diesel engine-generator set; G

Auxiliary systems and equipment; G

Remote alarm annunciator; G

SD-05 Design Data

Capacity calculations for engine-generator set; G

Calculations for brake mean effective pressure; G

Torsional vibration stress analysis computations; G

Capacity calculations for batteries; G

SD-06 Test Reports

Acceptance checks and tests; G

Functional acceptance tests; G

Functional acceptance test procedure; G

SD-07 Certificates

Vibration isolation system certification; G

Fuel system certification; G

Start-up engineer qualification resume; G

Instructor's qualification resume; G

SD-09 Manufacturer's Field Reports

Engine tests; G

Generator tests; G

Assembled engine-generator set tests; G

SD-10 Operation and Maintenance Data

Diesel engine-generator set, Data Package 4; G

Auxiliary systems and equipment, Data Package 4; G

Preliminary assembled operation and maintenance manuals; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and the paragraph entitled "Assembled Operation and Maintenance Manuals."

SD-11 Closeout Submittals

Posted operating instructions; G

Training plan; G

1.5 QUALITY ASSURANCE

1.5.1 Drawing Requirements

1.5.1.1 Engine-Generator Set and Auxiliary Equipment

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 subbase.

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 diesel 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, diesel fuel day tanks, fuel oil cooler, valves and pumps, intake filters, vibration isolators, and other auxiliary equipment not integral with the engine-generator set.

1.5.2 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 entitled "Vibration Isolation System."

1.5.3 Fuel System Certification

When the diesel fuel system requires a fuel oil cooler as described in the paragraph entitled "Fuel Oil Cooler," submit certification from the engine manufacturer that the fuel system design is satisfactory.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver equipment on pallets or blocking wrapped in heavy-duty plastic,

sealed to protect parts and assemblies from moisture and dirt. Plug piping, conduit, exhaust, and air intake openings. 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.

1.7 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: NAS Oceana, Virginia Beach, VA

b. Site Elevation: 22 feet above mean sea level

c. Ambient Temperatures:

1. Maximum 100 degrees F dry bulb.

2. Minimum 10 degrees F dry bulb.

f. Seismic Zone: Zone 1 as defined by ICC UBC.

1.8 MAINTENANCE

1.8.1 Extra Materials

1.8.1.1 Paint

Furnish one gallon of identical paint used on engine-generator set in manufacturer's sealed container with each engine-generator set.

1.8.1.2 Filters

Furnish four spare replacement elements in their original containers for each filter with each unit.

1.8.2 Posted Operating Instructions

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.

PART 2 PRODUCTS

2.1 DIESEL ENGINE-GENERATOR SET

Provide diesel engine-generator sets consisting of a water cooled diesel engine direct connected to an ac generator with a brushless excitation system and accessories. Equipment and materials shall be the manufacturer's standard products offered in catalogs for commercial or industrial use.

2.1.1 Engine-Generator Set Ratings and Performance

ISO 8528. Each engine-generator set shall have a power rating of not less than 200 kW at 0.8 power factor and supply 480Y/277-volt, three-phase, 60 -Hz ac output. Coordinate the engine-generator set to ensure an installed rating in the environment described in paragraph entitled "Site Conditions." The power of the engine-generator set is defined as the power output available at the generator terminals excluding the electrical power absorbed by the essential independent auxiliaries. Essential independent auxiliaries are items of equipment which are essential for the continued or repeated operation of the engine which uses power supplied from a source other than the engine.

2.1.1.1 Diesel Engine Capacity

The diesel engine shall meet the specified maximum BMEP requirements at rated speed as calculated in accordance with the paragraph entitled "Calculations for BMEP." The engine capacity shall 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.

b. Engine cooled by a radiator fan mechanically driven by the diesel engine or remote with a motor driven fan.

c. Engine cooled by coolant mixture of water and ethylene glycol, 50 percent by volume of each.

2.1.1.2 Performance Class

The voltage and frequency behavior of the generator set shall be in accordance with ISO 8528 operating limit values for performance Class G2 as follows.

2.1.1.3 Load Profile

The diesel engine-generator set shall be of adequate capacity necessary for the following load profile:

a. Lighting 1 kW

b. Receptacle 3 kW

c. Airfield lighting kW

2.1.2 Diesel Engines and Accessories

ISO 3046. Diesel engines shall be four-cycle naturally aspirated, or turbocharged, or turbocharged and intercooled; vertical in-line or vertical Vee type; designed for stationary service. Engines shall be capable of immediate acceleration from rest to normal speed without intermediate idle/warm up period or prelubrication to provide essential electrical power. Two-cycle engines are not acceptable.

2.1.2.1 Subbase Mounting

Mount each engine-generator set on a structural steel subbase 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 subbase to properly support the equipment and maintain proper alignment of the engine-generator set in the specified seismic zone. In addition, provide subbase with both lifting rings and jacking pads properly located to facilitate shipping and installation of the unit. Factory align engine and generator on the subbase and securely bolt into place in accordance with the manufacturer's standard practice. Crankshaft shall have rigid coupling for connection to the generator.

2.1.2.2 Assembly

Completely shop assemble each engine-generator set on its structural steel subbase. 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.

2.1.2.3 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.

2.1.2.4 Intercooler

Provide manufacturer's standard intercooler for engine size specified.

2.1.2.5 Crankcase Protection

Provide manufacturer's standard method of preventing crankcase explosions and standard method of crankcase ventilation.

2.1.2.6 Engine Lubricating Oil System

Provide each engine with the manufacturer's standard full pressure lubricating oil system arranged to cool the pistons and to distribute oil to moving parts of the engine. Provide oil type and oil filters as recommended by the engine manufacturer.

2.1.2.7 Engine Cooling System

Provide each engine with the manufacturer's standard jacket water pump. Provide a thermostatic control valve in the jacket coolant system for each engine-generator set to maintain a constant jacket coolant temperature to the engine.

2.1.2.8 Engine Fuel System

Provide each engine with the manufacturer's standard fuel system integral with the engine, complete with necessary piping, fittings, and valves for connecting items of equipment which are a part of the system. Provide engine manufacturer's standard hand priming pump. Provide manufacturer's standard simplex filter for each engine, of the throwaway filter element type, consisting of shell filter elements, drains, and necessary

connections and fittings.

2.1.2.9 Engine Intake Filter

Provide intake filter assemblies for each engine of the oil bath or dry type, as standard with the manufacturer. Filters shall 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.

2.1.2.10 Engine Starting System

Starting shall 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.

2.1.2.11 Jacket Coolant Heating System

Provide a factory-installed, 280 volts ac, single phase, jacket coolant heating system to ensure rapid starting. Thermostatically control heater at the temperature recommended by engine manufacturer. Include necessary equipment, piping, controls, wiring, and accessories.

2.1.2.12 Engine Protective (Shutdown) Devices

Equip each engine with devices to shut down the engine by shutting off the fuel supply to the engine via a fuel shutoff solenoid. Auxiliary contacts shall be suitable for activating a remote alarm system. Shutdown shall open the associated generator circuit breaker. Provide the following shutdown devices:

a. Overspeed device which operates when engine speed exceeds normal synchronous speed by 18 percent or as recommended by manufacturer. Device shall require manual reset.

b. Pressure switch which operates when lubricating oil pressure to engine drops below a preset value.

c. Temperature switch which operates when jacket coolant temperature exceeds a preset value.

d. Device which operates when the coolant level in the radiator drops below a preset level.

e. Other shutdown devices as recommended by the engine manufacturer.

2.1.2.13 Engine Alarm Devices

Equip each engine with alarm devices. Auxiliary contacts shall be suitable for activating a remote alarm system. Alarm devices shall have factory-fixed set points. Provide the following alarm contact devices:

a. Pressure switch which operates when lubricating oil pressure drops below a preset value.

b. Temperature switch which operates when jacket coolant temperature exceeds a preset value.

c. Temperature switch which operates when jacket coolant temperature is

too low.

d. Other alarm devices as recommended by the engine manufacturer.

2.1.2.14 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 subbase 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 subbase on the foundation.

e. Removable guard, around fan. Support guard, on engine subbase, to suit manufacturer's standard.

2.1.2.15 Engine Speed Governor System

Provide a forward acting type engine speed governor system. Steady-state frequency band and frequency regulation (droop) shall be in accordance with the operating limit values of the performance class specified in the paragraph entitled "Performance Class."

2.1.3 Generator and Excitation System

2.1.3.1 Generator

Provide salient-pole type, ac, brushless-excited, revolving field, air-cooled, self-ventilated, dripproof guarded, coupled type, synchronous generator conforming to NEMA MG 1, Part 16, NEMA C50.10, and IEEE C50.12. Generator shall be rated for continuous duty at 100 percent of the power rating of the engine-generator set as specified in paragraph entitled "Engine-Generator Set Ratings and Performance." Temperature rise of each of the various parts of the generator shall not exceed 130 degrees C as measured by resistance, based on a maximum ambient temperature of 40 degrees C. Winding insulation shall be Class H.

a. Stator: Stator windings shall be 2/3 pitch design.

b. Rotor: The rotor shall have connected amortiser windings.

c. Generator Space Heater: Provide 120 volt ac heaters. Heater capacity shall be as recommended by the generator manufacturer to aid in keeping the generator insulation dry.

d. Grounding: Provide non-corrosive steel grounding pads located at two opposite mounting legs.

e. Filters: Provide manufacturer's standard generator cooling air filter assembly.

2.1.3.2 Excitation System

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 shall be as specified in paragraph entitled "Generator." System shall provide a minimum short circuit of 300 percent rated engine-generator set current for at least 10 seconds. Steady state voltage regulation shall be in accordance with the operating limit values of the performance class specified in the paragraph entitled "Performance Class."

a. Exciter and Rotating Rectifier Assembly: Rectifiers shall 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 shall be solid state or digital, automatic, three-phase sensing, volts per hertz type regulator. Voltage variation for any 40 degree C change over the operating temperature range shall be less than plus or minus 1.0 percent. Operating temperature shall be minus 40 degree C to plus 70 degree C. Voltage adjust range shall be plus to minus 5.0 percent of nominal. Inherent regulator features shall include overexcitation shutdown.

2.1.3.3 Electromagnetic Interference (EMI) Suppression

Provide as an integral part of the generator and excitation system, EMI suppression complying with MIL-STD-461.

2.2 ENGINE-GENERATOR SET AUXILIARY SYSTEMS AND EQUIPMENT

Provide auxiliary systems and equipment designed for continuous duty at 100 percent of the power rating of the engine-generator set as specified in the paragraph entitled "Engine-Generator Set Ratings and Performance."

2.2.1 Vibration Isolation System

Install the subbase on vibration isolators that are secured to a suitable concrete foundation. Provide isolators as recommended by the engine-generator set and isolator manufacturers and provide integral or external lateral support to limit lateral movement and overturning moments. The isolation system shall reduce the vibration transmitted to the adjacent floor slab to a maximum of 0.0015 inch total amplitude throughout the frequency range down to 65 Hz.

2.2.2 Exhaust System

Provide exhaust systems for each engine.

2.2.2.1 Exhaust Silencers

A critical class silencer shall 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 shall 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

2.2.3 Cooling System

Provide the specified cooling water system. Properly size equipment to handle the flow rate and pressure losses of the coolant mixture specified in the paragraph entitled "Diesel Engine Capacity," and at the site elevation specified in the paragraph entitled "Site Conditions."

2.2.3.1 Radiators

Provide for each engine-generator set, as standard with the manufacturer.

a. Design Conditions: Each radiator unit shall 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 shall 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 100 degrees F maximum, and 0 degrees F minimum at the site elevation specified in the paragraph entitled "Site Conditions," and with the coolant mixture specified in the paragraph entitled "Diesel Engine Capacity." Pressure drop through the radiator shall not exceed 6 psi when circulating the maximum required coolant flow. Radiator air velocity shall be a maximum of 1500 feet per minute.

0 d. Coolant solution shall be a mixture of clean water and ethylene glycol, 50 percent by volume each. Provide an anti-freeze solution tester suitable for the mixture.

2.2.4 Diesel Fuel System

NFPA 30 and NFPA 37 and the requirements herein.

2.2.4.1 Diesel Fuel Piping System

Factory installed piping shall conform to the engine manufacturer's standard. Provide flange connections in accordance with ASME B16.1 Class 125 flanges.

2.2.4.2 Diesel Fuel Day Tank System

Provide 120 volt ac diesel fuel day tank system. Include necessary equipment, piping, controls, wiring, and accessories.

a. Day Tanks: UL 142. Provide integral in skid double wall (110 percent containment) diesel fuel day tanks with a minimum capacity of 24 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 and provide an access opening with dustproof, removable 24 inch cover. Provide 4 1/2 inch square inspection port. Provide proper venting of both inner and outer containment.

b. Float Switches: Provide tank-top mounted or external float cage, single-pole, single-throw type designed for use on fuel oil tanks. Arrange high level float switches to close on rise of liquid level, and low level float switches to close on fall of liquid level. Mount float cage units with isolating and drain valves. Contacts shall be suitable for the station battery voltage.

    1. Critical low level float switch which shall activate at 5 percent of normal liquid level shall shut engine off.

    2. Low-low level float switch which shall activate alarm at 30 percent of normal liquid level.

    3. Low level float switch which shall open the fuel oil solenoid valve and start the fuel transfer pump at 75 percent of normal liquid level.

    4. High level float switch which shall close the fuel oil solenoid valve and stop the fuel transfer pump at 90 percent of normal liquid level.

    5. Critical high level float switch which shall activate alarm at 95 percent of normal liquid level.

c. Leak Detector Switch: Actuates when fuel is detected in containment basin, stops fuel transfer pump, and closes the fuel oil solenoid valve.

d. Control Panel: Provide NEMA ICS 6, Type4X, enclosed control panel for each day tank. Control panel shall include the following accessories.

    1. Power available LED (green).

    2. Critical low fuel alarm contacts for shut down of engine.

    3. Low-low level fuel alarm LED.

    4. Low-low level fuel alarm contacts for remote annunciator.

    5. Critical high level fuel alarm LED.

    6. Leak detecting alarm LED.

    7. Alarm horn.

e. Tank Gages: Provide buoyant force type gages for diesel fuel day 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.

2.2.4.3 Fuel Transfer Pumps

Fuel transfer pumps may be day tank or base mounted. Pumps shall be duplex, 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. Provide motor and controller in accordance with paragraph entitled "Electrical Support Equipment."

2.2.4.4 Fuel Oil Solenoid Valve

UL 429. Provide electric solenoid type control valve for each day tank. Solenoid shall be rated for starting battery voltage. Valve body shall have a minimum working pressure rating of 150psig at 200 degrees F. Valve shall be capable of passing 0 to 10 gpm of fuel oil. Valves shall be two-way, direct acting, normally closed (open when energized, closed when de-energized), with brass body and resilient seat material. Solenoid enclosures shall be NEMA ICS 6, Type 1. Body connections shall be same size as connecting piping. Valve shall be in line before the fuel pump.

2.2.4.5 Fuel Oil Cooler

Provide an air cooled fuel oil cooler if the temperature of the fuel returned to the tank from the engine will cause overheating of the tank fuel above the maximum fuel temperature allowed by the engine manufacturer when operating at maximum rated generator power output and low fuel level in the tank. The fuel oil cooler shall be furnished by the engine manufacturer for the application and the installation shall be complete including piping and power requirements.

2.2.5 Starting Battery System

Provide a 24-volt dc starting battery installation for starting of each engine-generator set utilizing an electric cranking system.

2.2.5.1 Engine Starting Battery

Provide maintenance free, sealed, lead-acid, SAE Type D diesel engine starting batteries. Batteries shall have sufficient capacity to provide 60 seconds of continuous cranking of the engine in an ambient temperature of 0 degrees F.

2.2.5.2 Starting Battery Charger

UL 1236. Provide 120 volt ac, enclosed, automatic equalizing, dual-rate, solid-state, constant voltage type battery charger with automatic ac line compensation. Dc output shall be voltage regulated and current limited. Charger shall have two ranges, float and equalize, and shall provide continuous taper charging. The charger shall have a continuous output rating of not less than 10 amperes and shall be sized to recharge the engine starting batteries in a minimum of 8 hours while providing the control power needs of the engine-generator set. Enclosure shall be NEMA ICS 6, Type4X. The following accessories shall be included:

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

2.2.6 Engine-Generator Control Panel

Provide NEMA ICS 6, Type4X, enclosed control panel mounted on the engine-generator set with vibration isolators. Provide the following control panel mounted devices and control features.

2.2.6.1 Control Panel Mounted Devices

a. Engine Control Switch (ECS): Provide a three position control switch with "MANUAL START" - "OFF/RESET" - "AUTO START" positions.

b. Emergency Stop Push Button (ESPB): Provide a red, mushroom head, twist-to-reset, maintained contact type push button.

c. Generator Metering: Provide ac metering package that displays ac voltage, current, and frequency of one phase of the generator output simultaneously. Metering package shall include a voltmeter/ammeter phase selector switch to allow viewing of each phase.

d. Generator Voltage Adjust Potentiometer (VAP): Provide a potentiometer, locking screwdriver type, to adjust generator voltage.

e. Engine Instrumentation: Provide instrumentation package that displays the following engine information:

    1. Engine oil pressure

    2. Engine coolant temperature

    3. Engine speed (rpm)

    4. Engine running hours

f. Indicating Lamps: Provide LED type indicating lamps and a lamp test switch. Lamps shall indicate the following alarm and shutdown conditions:

    1. Low engine lubricating oil pressure alarm

    2. Low engine lubricating oil pressure shutdown

3. High engine coolant temperature alarm

4. High engine coolant temperature shutdown

5. Engine overcrank shutdown

6. Engine overspeed shutdown

7. Emergency stop shutdown

8. Starting battery system trouble alarm

9. Day tank low fuel shutdown

10. Low engine coolant temperature alarm

11. Low coolant level shutdown

g. Alarm Horn: Provide an alarm horn and a horn silence switch.

h. Panel Lamp: Provide a panel lamp and lamp "ON-OFF" switch.

2.2.6.2 Crank Cycle/Terminate Relay

Provide crank cycle/terminate relay with adjustable crank/rest periods of 1 to 60 seconds (initially set for 15 seconds) and adjustable total crank time of 30 seconds to 10 minutes (initially set for 75 seconds).

2.2.6.3 Engine Cooldown Relay

Provide cooldown relay with adjustable cool down time of 0 to 30 minutes (initially set at engine manufacturer's recommended time).

2.2.7 Remote Alarm Annunciator

Provide NEMA ICS 6, Type4X, enclosed remote alarm annunciator. The annunciator shall have a lamp test switch and LED type indicating lamps. The annunciator shall give visual and audible warnings for the following operating and alarm conditions:

a. Provide lamps for the following operating conditions:

1. Operating power source, normal or emergency

2. Starting battery system trouble

b. Provide lamps and an audible signal for the following alarm conditions:

1. Low engine lubricating oil pressure

2. Low engine coolant temperature

3. High engine coolant temperature

4. Low fuel

5. Engine overcrank shutdown

6. Engine overspeed shutdown

2.2.7.1 Storage Battery

Provide storage batteries of suitable rating and capacity to supply and maintain power for the remote alarm annunciator for a period of 90 minutes minimum without the voltage applied falling below 87.5 percent of normal. Provide a 120 volt ac automatic battery charger.

2.2.8 Generator Circuit Breaker

UL 489, molded case, adjustable thermal magnetic trip type circuit breaker. The circuit breaker continuous current rating shall be adequate for the power rating of the engine-generator set and the circuit breaker shall be rated to withstand the short circuit current provided by the generator set. Provide circuit breaker in a NEMA ICS 6, Type4X enclosure mounted on the engine-generator set.

2.2.9 Electrical Support Equipment

Furnish with respective pieces of equipment. Motors, controllers, contactors, and disconnects shall 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 shall be included under this section.

2.2.10 Weatherproof Enclosure

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 shall 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 shall 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.

2.2.11 Generator Enclosure Platform

Provide a platform around the generator enclosure as follows to facilitate maintenance and repair.

a. The platform shall be cantilever supported off of the engine generator sub-base with formed aluminum frame, structural members, and toe plates, railing posts, rails, stairs and floor assemblies. Platform shall be of the U construction with 2 "walk" assemblies (outside of all generator set service doors), connected together with a "rear" platform at the control panel end.

b. Two stairs with abrasive, anti-slip tape offering heavy-duty, high-traction surface shall be used to access the platform.

c. Design of platform shall permit inspection of all serviceable components including visual inspection of any radiator discharge plenum to confirm that radiator is "free" of any foreign obstructions.

d. Platform height shall be no greater than 1.5 inch above the bottom of the generator base frame.

e. The platform frame shall be of .125 gauge formed aluminum.

f. Frame design shall be pre-drilled to accept handrail mounting vertical supports. Structural frame members shall serve as the walkway toe-board supports. Vertical railing supports shall be secured to the toe-plates and horizontal structural members using 5/16 inch bolts on 6 inch centers.

g. All pieces shall be cut and formed using computer assisted design software for accuracy.

h. All bolts shall be 5/16 inch minimum.

i. Compression members shall be predrilled to connect the stairs assembly and frame to the tank and utilize ¼ inch formed aluminum construction.

j. No connection to the sub-base tank is permitted but rather all connections shall be through the engine base.

k. The walkway tread shall utilize .125" inch aluminum tread plate 1 inch thick minimum to provide sufficient cross section to resist vertically applied loads.

l. Platform shall provide for 180 degree "full swing opening" of all side service doors and at least 135 degree opening of the rear control panel door.

m. Handrails shall be a nominal 42 inch from the walkway surface.

n. All hand rails are to be .125 gauge formed aluminum, at a 2 inch angle. The walkway (stairs and platform) shall meet standards of OSHA 3124 - Stairways and Ladders and OSHA 1910.24 - Fixed Industrial Stairs.

2.3 SPECIAL WRENCHES AND TOOLS

Wrenches and tools specifically designed and required to work on the new equipment, which are not commercially available as standard mechanic's tools, shall be furnished to the Contracting Officer.

2.4 IDENTIFICATION OF EQUIPMENT

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 shall be normal block lettering, a minimum of 0.25 inch high.

2.4.1 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 diesel engine of laminated plastic, 0.125 inch thick, matte white finish with black center core, with lettering accurately aligned and engraved into the core.

2.4.2 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 shall be minimum of 0.5 inch high and 2 inches long and shall indicate component system and component function.

2.4.3 Equipment

Provide ID plates of a minimum size of 3 inches high and 5 inches long on provided equipment indicating the following information:

a. Manufacturer's name, address, type and model number, and serial number;

b. Contract number and accepted date;

c. Capacity or size;

d. System in which installed; and

e. System which it controls.

2.5 ASSEMBLED OPERATION AND MAINTENANCE MANUALS

The contents of the assembled operation and maintenance manuals shall include the manufacturer's O&M information required by the paragraph entitled "SD-10, Operation and Maintenance Data" and the manufacturer's O&M information specified in Section 26 36 23.00 20 AUTOMATIC TRANSFER SWITCHES.

a. Manuals shall 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) shall be made part of the assembled O&M. The manual shall be assembled in the order noted in table of contents.

c. The cover sheet or binder on each volume of the manuals shall be identified and marked with the words, "Operation and Maintenance Manual."

2.6 SOURCE QUALITY CONTROL

Perform and report on factory tests and inspections prior to shipment. Provide certified copies of manufacturer's test data and results. Test procedures shall conform to ASME, IEEE, IEC, and ANSI standards, and to ISO requirements on testing, as appropriate and applicable. The manufacturer performing the tests shall provide equipment, labor, and consumables necessary for tests and measuring and indicating devices shall

be certified to be within calibration. Tests shall indicate satisfactory operation and attainment of specified performance. If satisfactory, equipment tested will be given a tentative approval. Equipment shall not be shipped before approval of the factory test reports for the following tests.

2.6.1 Engine Tests

Perform customary commercial factory tests in accordance with ISO 3046 on each engine and associated engine protective device, including, but not limited to the following:

a. Perform dynamometer test at rated power. Record horsepower at rated speed and nominal characteristics such as lubricating oil pressure, jacket water temperature, and ambient temperature.

b. Test and record the values that the low oil pressure alarm and protective shutdown devices actuate prior to assembly on the engine.

c. Test and record values that the high jacket water temperature alarm and protective shutdown devices actuate prior to assembly on the engine.

2.6.2 Generator Tests

Tests shall be performed on the complete factory assembled generator prior to shipment. Conduct tests in accordance with IEEE 115, NEMA C50.10, and NEMA MG 1.

2.6.2.1 Routine Tests

Perform the following routine tests on the generators and their exciters:

a. Resistance of armature and field windings

b. Mechanical balance

c. Phases sequence

d. Open circuit saturation curve and phase (voltage) balance test

e. Insulation resistance of armature and field windings

f. High potential test

2.6.2.2 Design Tests

Submit the following design tests made on prototype machines that are physically and electrically identical to the generators specified.

a. Temperature rise test

b. Short circuit saturation curve and current balance test

2.6.3 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.

2.6.3.1 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 shall be recorded on the data sheet at the time of adjustment. Stabilization shall 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.

2.6.3.2 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 undervoltage protection device. The data sheets shall indicate the voltage regulation as a percent of rated voltage and the maximum and minimum voltages attainable. Voltage regulation shall be defined as follows:

$$\text{Percent Regulation} = \frac{((\text{No-Load Voltage}) - (\text{Rated-Load Voltage})) \times 100}{(\text{Rated-Load Voltage})}$$

2.6.3.3 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 shall show the maximum and minimum frequencies attained at rated load, and at no load.

2.6.3.4 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 shall 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.

PART 3 EXECUTION

3.1 INSTALLATION

Installation shall conform to the applicable requirements of IEEE C2 NFPA 30, NFPA 37, and NFPA 70.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounding systems shall have a resistance to solid earth ground not exceeding 5 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 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" shall apply.

3.2.3 Connections

Make joints in grounding conductors by exothermic weld or compression connector. Exothermic welds and compression connectors shall be installed as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION paragraph regarding "Grounding."

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 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 shall include conducting preliminary operations and functional acceptance tests. The start-up engineer shall be present at the engine generator set installation site, full-time, while preliminary operations and functional acceptance tests are being conducted.

3.4 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.

3.4.1 Performance of Acceptance Checks and Tests

The acceptance checks and tests shall be accomplished by the testing organization as described in Section 26 08 00 APPARATUS INSPECTION AND TESTING.

3.4.1.1 Generator Sets

Complete as specified in the paragraph entitled "Acceptance Checks and Tests."

3.4.1.2 Automatic Transfer Switches

Complete acceptance checks and tests as specified in Section 26 36 23.00 20 AUTOMATIC TRANSFER SWITCHES.

3.4.2 Preliminary Operations

The start-up engineer shall 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.

3.4.3 Preliminary Assembled Operation and Maintenance Manuals

Preliminary assembled operation and maintenance manuals shall have been submitted to and approved by the Contracting Officer. Manuals shall be prepared as specified in the paragraph entitled "Assembled Operation and Maintenance Manuals."

3.4.4 Functional Acceptance Test Procedure

Test procedure shall be prepared by the start-up engineer specifically for the engine-generator set and auxiliary equipment. The test agenda shall cover the requirements specified in the paragraph entitled "Functional Acceptance Tests." The test procedure shall 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 shall also be included in the test procedure.

3.4.5 Test Equipment

Test equipment and instruments shall be on hand prior to scheduling field tests or, subject to Contracting Officer approval, evidence shall be provided to show that arrangements have been made to have the necessary equipment and instruments on site prior to field testing.

3.5 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 shall 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 shall provide labor, equipment, diesel fuel, test load, and consumables required for the specified tests. The test load shall be a cataloged product. Calibration of measuring devices and indicating devices shall be certified. Refer to Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS, for requirements for a cataloged product. Perform the following field tests.

3.5.1 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.

3.5.1.1 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. Thermographic 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.

3.5.1.2 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. Thermographic 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.

3.5.1.3 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 watthour meters according to manufacturer's published data.

3. Verify all instrument multipliers.

4. Electrically confirm that current transformer secondary circuits are intact.

3.5.1.4 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. Thermographic 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.

3.5.1.5 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.

3.5.1.6 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. 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 testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be 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.

3.5.2 Functional Acceptance Tests

The tests shall be performed by the start-up engineer. Upon successful test completion, the start-up engineer shall 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 shall 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 shall be dated and signed by the start-up engineer, and submitted for approval by the Contracting Officer. The Contracting Officer and NAVFAC MIDLANT, will witness final acceptance tests. Testing shall include but not be limited to:

a. Verify proper functioning of each engine protective shutdown device and pre-shutdown alarm device. Testing of the devices shall be accomplished by simulating device actuation and observing proper alarm and engine shutdown operation.

b. Verify proper functioning of the engine overspeed trip device. Testing of the overspeed trip device shall be accomplished by raising the speed of the engine-generator set until an overspeed trip is experienced.

c. Verify proper functioning of the crank cycle/terminate relay. Testing of the relay shall 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 entitled "Crank Cycle/Terminate Relay."

d. Verify proper functioning of the following automatic and manual operations. Testing shall include but not be limited to:

    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 cooldown 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.

3.6 DEMONSTRATION

Upon completion of the work and at a time approved by the Contracting Officer, the Contractor shall provide instructions by a qualified instructor to the Government personnel in the proper operation and maintenance of the equipment. Two Government personnel shall receive

training comparable to the equipment manufacturer's factory training. The duration of instruction shall 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.

3.6.1 Instructor's Qualification Resume

Instructors shall be regular employees of the engine-generator set manufacturer. The instruction personnel provided to satisfy the requirements above shall 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.

3.6.2 Training Plan

Submit training plan 30 calendar days prior to training sessions. Training plan shall include scheduling, content, outline, and training material (handouts). Content shall include but not limited to the following:

3.6.2.1 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.

3.6.2.2 Maintenance Personnel Training

Shall include mechanical, hydraulic, electrical, and electronic instructions for the engine-generator set and auxiliary equipment including automatic transfer switches.

a. Mechanical Training: Shall 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: Shall 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.

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SECTION 26 33 53.00 20

UNINTERRUPTIBLE POWER SUPPLY (UPS)

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.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S1.4	(1983; Amendment 1985; R 2006) Specification for Sound Level Meters (ASA 47)

ASTM INTERNATIONAL (ASTM)

ASTM B173	(2010) Standard Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors
ASTM D709	(2013) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 450	(2010) Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013) National Electrical Safety Code
IEEE C57.110	(2008) Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer Capability When Supplying Nonsinusoidal Load Currents
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	(2013) Standard for Acceptance Testing

Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 9001 (2008; Corr 1 2009) Quality Management Systems- Requirements

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2008) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA PE 1 (2003) Uninterruptible Power Systems (UPS) Specification and Performance Verification

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1449 (2006; Reprint Sep 2013) Surge Protective Devices

UL 1778 (2005; Reprint Oct 2011) Uninterruptible Power Systems

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, shall be 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. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

UPS Drawings; G

UPS Installation; G

SD-03 Product Data

UPS Module; G

Submittal shall include manufacturer's information for each

component, device, and accessory provided with the transformer.

Factory Testing

UPS System

UPS Spare Parts; G

SD-06 Test Reports

Work Plan; G

Factory Test Plan; G

Performance Test Plan; G

Factory Tests; G

Performance Tests Report; G

Factory Tests Report; G

SD-09 Manufacturer's Field Reports

Initial Inspection and Tests; G

Performance Tests; G

SD-10 Operation and Maintenance Data

UPS Operation and Maintenance, Data Package 5; G

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein.

SD-11 Closeout Submittals

Installation

1.5 PERFORMANCE REQUIREMENTS

1.5.1 Normal Operation

The UPS module rectifier/charger shall convert the incoming ac input power to dc power for the inverter and for float charging the battery. The inverter shall supply ac power to the critical load continuously. Inverter output shall be synchronized with the bypass ac power source, provided that the bypass ac power source is within the specified voltage and frequency range.

1.5.2 Emergency Operation (Loss or deviation of AC Input Power)

Whenever the ac input power source deviates from the specified tolerances or fails completely, the inverter shall draw its power from the battery system and shall supply AC power to the critical load without any interruption or switching. The battery shall continue to supply power to the inverter for the specified protection time or until return of ac input source. At the same time, an alarm shall sound to alert operating personnel and a trouble signal shall be sent over the communication

network, allowing startup of a secondary power source or orderly shutdown of the critical load.

1.5.3 Return of AC Input Power Source

When stable ac input power source returns the rectifier/charger shall resume operation and shall simultaneously supply the inverter with dc power and recharge the battery. This shall be an automatic function and shall cause no disturbance to the critical load.

1.5.4 Failure of AC Input Power to Return

Should the ac input power fail to return before the battery voltage reaches the discharge limit, the UPS system shall disconnect from the critical load to safeguard the battery.

1.5.5 Transfer to Bypass AC Power Source

When the UPS controller senses an overload or degradation of the inverter output, the bypass switch shall automatically transfer the critical load from the inverter output to the bypass ac power source without an interruption of power. If the bypass ac power source is outside of specified tolerance limits, the UPS and the critical load shall shut down.

1.5.6 Retransfer to Inverter

The static bypass switch shall be capable of automatically retransferring the load back to the inverter output after the inverter output has returned to normal conditions. Retransfer shall only occur if the two sources are synchronized.

1.5.7 UPS Bypass Maintenance

Manual closure of the maintenance bypass switch shall transfer the critical load from the inverter output to the bypass ac power source without disturbing the critical load bus. UPS module shall be capable of manual return to normal operation after completion of maintenance.

1.5.8 Battery Maintenance

The battery protective device shall provide the means of disconnecting the battery from the rectifier/charger and inverter for maintenance. The UPS module shall continue to function and meet the performance criteria specified except for the battery back-up time function.

1.6 QUALITY ASSURANCE

The manufacturer shall have a documented quality assurance program including:

a. Inspections of incoming parts, modular assemblies and final product.

b. Final test procedure for the product including proof of performance specifications.

c. On-site test procedure shall include an inspection of controls and indicators after installation of the equipment.

d. ISO 9001 quality certification.

1.6.1 UPS Drawings

Detail drawings consisting of a complete list of equipment and materials, manufacturer's descriptive and technical literature, battery sizing calculations per IEEE 485, installation instructions, single-line diagrams, ladder-type schematic diagrams, elevations, layout drawings, and details required to demonstrate that the system has been coordinated and will function properly as a unit.

1.6.2 UPS Installation

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.

1.6.3 Work Plan

Submit 6 copies of schedules of dates for factory tests, installation, field tests, and operator training for the UPS system. Furnish a list of instrumentation equipment for factory and field test reports.

1.6.4 Factory Test Plan

Submit 6 copies of factory test plans and procedures at least 21 calendar days prior to the tests being conducted. Provide detailed description of test procedures, including test equipment and setups, to be used to ensure the UPS meets the performance specification and explain the test methods to be used. As a minimum, the test procedures shall include the test required under the paragraph entitled "Factory Testing."

1.6.5 Performance Test Plan

Submit 6 copies of test plans and procedures at least 15 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 (list make and model and provide functional description of the test instruments and accessories) and setups of the tests to be conducted to ensure the UPS meets the performance specification. Explain the test methods to be used. As a minimum, the test procedures shall include the tests required under the paragraph entitled "Performance Tests."

1.6.6 Factory Tests Report

Submit 6 copies of factory test report within 45 calendar days after completion of tests. Receive approval of test prior to shipping unit. Factory test reports shall be signed by an official authorized to certify on behalf of the UPS manufacturer of that the system meets specified requirements in accordance with the requirements set forth in paragraph entitled "Factory Testing". Test reports in shall be in booklet form tabulating factory tests and measurements performed, upon completion and

testing of the installed system. Reports shall state the Contractor's name and address, the name of the project and location, and list the specific requirements which are being certified.

1.6.7 Performance Tests Report

Submit report of test results as specified by paragraph entitled "Performance Tests" within 15 calendar days after completion of tests. Field test reports shall be signed by an official authorized to certify on behalf of the UPS manufacturer that the system meets specified requirements in accordance with the requirements set forth in paragraph entitled "Performance Tests". Test reports in shall be in booklet form tabulating factory tests and measurements performed, upon completion and testing of the installed system. Reports shall state the Contractor's name and address, the name of the project and location, and list the specific requirements which are being certified.

1.6.8 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.

1.6.8.1 Reference Standard Compliance

Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations such as American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM), National Electrical Manufacturers Association (NEMA), Underwriters Laboratories (UL), and Association of Edison Illuminating Companies (AEIC), submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance.

1.6.8.2 Independent Testing Organization Certificate

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.

1.6.9 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. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

1.6.9.1 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.

1.6.9.2 Material and Equipment Manufacturing Date

Products manufactured more than 2 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 DELIVERY AND STORAGE

Equipment placed in storage shall be protected 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, the equipment storage facility shall be environmentally controlled to ensure temperature parameters are within equipment specification. Documentation of same shall be provided to the Government when storage is implemented.

1.8 PROJECT/SITE CONDITIONS

1.8.1 Environmental Conditions

The UPS and battery system shall be capable of withstanding any combination of the following external environmental conditions without mechanical or electrical damage or degradation of operating characteristics.

a. Operating altitude: Sea level to 3,300 ft. (Systems applied at higher altitudes shall be derated in accordance with the manufacturer's instructions).

b. Non-operating altitude: Sea level to 36,000 ft.

c. Operating ambient temperature range: 32 to 104 degrees F. Range for batteries is 50 to 86 degrees F.

d. Non-operating and storage ambient temperature range: Minus 4 to plus 122 degrees F.

e. Operating relative humidity: 0 to 95 percent, without condensation.

1.8.2 Sound Pressure Levels

Sound pressure levels produced by the UPS, when operating under full rated load, at a distance of 5 feet in any direction from the perimeter of the unit, shall not exceed 65 dB as measured on the A scale of a Type 1 sound level meter at slow response conforming to ASA S1.4.

1.8.3 Verification of Dimensions

The Contractor shall become familiar with details of the work, verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

1.9 SPECIAL TOOLS

Provide one set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment.

1.10 OPERATION AND MAINTENANCE MANUALS

1.10.1 Additions to UPS Operation and Maintenance Manuals

In addition to requirements of Data Package 5, include the followings on the actual UPS system provided:

a. An outline drawing, front, top, and side views.

b. Prices for spare parts and supply list.

c. Routine and field acceptance test reports.

d. Date of Purchase.

e. Corrective maintenance procedures.

f. Test measurement levels with specific test points.

1.10.2 Spare Parts

Furnish the following spare parts, of the same material and workmanship, meeting the same requirements, and interchangeable with the corresponding original parts.

a. Fuses: Two of each type and rating.

b. Circuit boards: One circuit board for each critical circuit.

c. Air Filters: One set of filters.

1.11 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.

PART 2 PRODUCTS

2.1 UPS SYSTEM DESCRIPTION

The UPS system shall conform to UL 1778 and shall consist of UPS module, battery system, battery protective device, static bypass transfer switch, controls and monitoring. Input ac power shall be connected to the normal source ac input of the UPS module. Alternate power source shall be connected to bypass/maintenance bypass. The battery shall be connected to

the dc input of the UPS module through the battery protective device. The ac output of the UPS system shall be connected to the critical loads.

2.1.1 Semiconductor Fusing

Power semiconductors shall be fused with fast-acting fuses to prevent cascaded or sequential semiconductor failures. Indicator lamp or display panel denoting blown fuse conditions shall be readily observable by the operator without removing panels or opening cabinet doors.

2.1.2 Control Power

Provide dual control power supplies. The control power circuit shall have suitable protection, appropriately marked and located in the immediate vicinity of the input protective device.

2.1.3 EMI/RFI Protection

The components and the system shall be designed to minimize the emission of electromagnetic waves that may cause interference with other equipment.

2.1.4 Internal Wiring

Wiring practices, materials, and coding shall be in accordance with the requirements of NFPA 70, OSHA, and other applicable standards. Wire runs shall be protected in a manner which separates power and control wiring. Control wiring shall be minimum No. 16 AWG extra-flexible stranded copper. Logic-circuit wiring may be smaller. Ribbon cables shall be minimum No. 22 AWG. Control wiring shall have permanently attached wire numbers.

2.1.5 Internal Assembly

The printed circuit board (PCB) subassemblies shall be mounted in pull-out and/or swing-out trays where feasible. Cable connections to the trays shall be sufficiently long to allow easy access to all components. Where not feasible to mount PCB subassemblies in pull-out or swing-out trays, they shall be firmly mounted inside the enclosure. Every PCB subassembly shall be monitored. Self-test and diagnostic circuitry shall be included in the logic circuits such that a fault can be isolated down to the PCB subassembly level.

2.1.6 Cabinets

UPS system shall be installed in cabinets of heavy-duty structure meeting the NEMA PE 1 standards for floor mounting. UPS module cabinet shall be structurally adequate for forklift handling or lifting. Removable lifting eyes shall be provided on top of each cabinet. UPS module cabinet shall have hinged and lockable doors on the front only, with assemblies and components accessible from the front. Doors shall be key lockable. Operating controls shall be located outside the locked doors. Input, output, and battery cables shall be installed through the top or bottom of the cabinet.

2.1.6.1 Cabinet Finish

Equipment cabinet shall be cleaned, primed and painted in the manufacturer's standard colors, in accordance with accepted industry standards. Cabinets shall be labeled in accordance with NFPA 70 for arc flash hazard with warning sign reading: "Warning-Potential Arc Flash

Hazard. Appropriate PPE and Tools Required when working on this equipment" or similar wording.

2.1.6.2 Live Parts (300 Volts and Above)

Live parts (300 volts and above) that are exposed when front access doors are open shall be adequately protected or covered to minimize the chance of accidental contact.

2.1.6.3 Drawout Assemblies

Drawout assemblies weighing 50 lbsor more shall be provided with a means of lifting, either an overhead device or a hoisting device.

2.1.7 Safety

UPS shall be equipped with instruction plates including warnings and cautions, suitably located, and describing any special or important procedures to be followed in operating and servicing the equipment. The control panel display shall also provide warning messages prior to performing a critical function.

2.2 UPS SYSTEM RATINGS

Unless stated otherwise, the parameters listed are under full output load at 0.8 power factor, with batteries fully charged and floating on the dc bus and with nominal input voltage.

2.2.1 System Capacity

15 kVA, 12 kW.

2.2.2 Battery Capacity

Discharge time to end voltage: 15 minutes, at 77 degrees F. End voltage at full discharge shall be 1.67 volts per cell. Battery shall be capable of delivering 150 percent of full rated UPS load at initial start-up.

2.2.3 Static Switch

10,000 amperes symmetrical interrupting capacity.

2.2.4 Module Bus Bracing

Braced for 10,000 amperes symmetrical interrupting capacity.

2.2.5 AC Input

a. Voltage 208 volts line-to-line.

b. Number of phases: 3-phase, 3 4-wire, plus ground.

c. Voltage Range: Plus 10 percent, minus 20 percent, without affecting battery float voltage or output voltage.

d. Frequency: 60 Hz, plus or minus 5 percent.

e. Power walk-in: 20 percent to 100 percent over 10 to 20 seconds.

f. Total harmonic current distortion (THD) reflected into the primary line: 5 percent maximum.

g. Input surge protection: per IEEE C62.41.1 and IEEE C62.41.2.

h. Input power factor: Lagging from 1-100 percent load.

2.2.6 AC Output

a. Voltage 208 volts line-to-line, 120 volts line-to-neutral.

b. Number of phases: 3-phase, 4-wire, plus ground.

c. Voltage regulation:

(1) Balanced load: Plus or minus 1.0 percent.

(2) 50 percent load imbalance, phase-to-phase: Plus or minus 2 percent.

(3) No-load voltage modulation: Plus or minus 1 percent.

(4) Voltage drift: Plus or minus 1 percent over any 30 day interval (or length of test) at stated ambient conditions.

d. Voltage adjustment: Plus or minus 5 percent manually.

e. Frequency: 60 Hz.

f. Frequency regulation: Plus or minus 0.1 percent.

g. Frequency drift: Plus or minus 0.1 percent over any 24 hour interval (or length of test) at stated ambient conditions when on internal oscillator.

h. Harmonic content (RMS voltage): Voltage THD shall be a maximum of 2 percent with 100 percent linear load and 5 percent with 100 percent nonlinear load and a crest factor of less than 3 to 1.

i. Load power factor operating range: 1.0 to 0.8 lagging.

j. Phase displacement:

(1) Balanced load: Plus or minus 1 degree of bypass input.

(2) 50 percent load imbalance phase-to-phase: Plus or minus 3 degrees of bypass input.

k. Wave-form deviation factor: 5 percent at no load.

l. Overload capability (at full voltage) (excluding battery):

(1) 125 percent load for 10 minutes.

(2) 150 percent load for 60 seconds.

(3) 300 percent load for one cycle after which it shall be current limited to 150 percent until fault is cleared or UPS goes to bypass.

2.2.7 Transient Response

2.2.7.1 Voltage Transients

a. 100 percent load step: Plus or minus 5 percent.

b. Loss or return of ac input: Plus or minus 1 percent.

c. Automatic transfer of load from UPS to bypass: Plus or minus 4 percent.

d. Manual retransfer of load from bypass to UPS: Plus or minus 4 percent.

e. Response time: Recovery to 99 percent steady-state condition within 20 milliseconds after any of the above transients.

2.2.7.2 Frequency

a. Transients: Plus or minus 0.6 Hz maximum.

b. Slew Rate: 1.0 Hz maximum per second.

2.2.8 Efficiency

Minimum Efficiency: 90 percent at full load kW and 90 percent at 50 percent load.

2.3 UPS MODULE

2.3.1 General Description

UPS module shall consist of a rectifier/charger unit and a 3-phase inverter unit with their associated transformers, synchronizing equipment, protective devices, surge suppression, input isolation transformer, and accessories as required for operation.

2.3.1.1 Interchangeability

The subassemblies in one UPS module shall be interchangeable with the corresponding modules within the same UPS, and from one UPS system to another of identical systems.

2.3.2 Rectifier/Charger Unit

Rectifier/charger unit shall be solid state and shall provide regulated direct current to the dc bus, supplying power to the inverter and charging the battery plant.

2.3.2.1 Input Protective Device

Rectifier/charger unit shall be provided with an input protective device. The protective device shall be sized to accept simultaneously the full-rated load and the battery recharge current. The protective device shall be capable of shunt tripping and shall have 10,000 amperes symmetrical interrupting rating. The protective device shall have provision for locking in the "off" position.

2.3.2.2 Surge Protection

A surge suppression device shall be installed at the UPS input to protect against lightning and switching surges. Internal components shall be protected from surges that enter at each ac input connection including main input, static bypass transfer switch, and maintenance bypass/isolation switch. Surge suppressors shall protect internal components according to IEEE C62.41.1 and IEEE C62.41.2, Category B. Surge suppressors shall be UL 1449 approved to fail in "safe" mode.

2.3.2.3 Input Isolation Transformer

A dry-type, isolated-winding power transformer shall be used for the rectifier unit. The transformer's hottest spot winding temperature shall not exceed the temperature limit of the transformer insulation material when operating at full load. The transformer insulation shall be Class H, 150 degrees C rise. Transformer connections shall be accessible from the front. Transformer cabinet, if required, shall match the UPS cabinet and attach to it.

2.3.2.4 Power Walk-In

Rectifier/charger unit shall be protected by a power walk-in feature such that when ac power is returned to the ac input bus, the total initial power requirement will not exceed 20 percent of the rated full load current. This demand shall increase gradually to 100 percent of the rated full load current plus the battery charging current over the specified time interval.

2.3.2.5 Sizing

Rectifier/charger unit shall be sized for the following two simultaneous operating conditions:

a. Supplying the full rated load current to the inverter.

b. Recharging a fully-discharged battery to 95 percent of rated ampere-hour capacity within ten times the discharge time after normal ac power is restored.

2.3.2.6 Battery Charging Current

a. Primary current limiting: Battery-charging current shall be voltage regulated and current limited. The battery-charging current limit shall be separately adjustable from 2 percent to 25 percent of the maximum discharge current. After the battery is recharged, the rectifier/charger unit shall maintain the battery at full float charge until the next operation under input power failure. Battery charger shall be capable of providing equalizing charge to the battery.

2.3.2.7 DC Ripple

Rectifier/charger unit shall minimize ripple current and voltage supplied to the battery; the ripple current into the battery shall not exceed 3 percent RMS of the inverter input rated current; the ripple voltage into the battery shall not exceed 2 percent RMS of the float voltage.

2.3.2.8 DC Voltage Adjustment

Rectifier/charger unit shall have manual means for adjusting dc voltage for battery equalization, to provide voltage within plus 10 percent of nominal float voltage.

2.3.2.9 Battery Isolation Protective Device

Module shall have a dc protective device to isolate the module from the battery system. The protective device size and interrupting rating shall be as required by system capacity and shall incorporate a shunt trip as required by circuit design. The protective device shall have provision for locking in the "off" position.

2.3.3 Inverter Unit

Inverter unit shall be a solid-state device deriving its power from the dc bus (rectifier or battery source) and providing ac power within specified limits to the critical load. Inverter shall utilize microprocessor controlled solid state Pulse Width Modulation (PWM) controlled IGBT power transistor technology to shape the ac output.

2.3.3.1 Output Overload

The inverter shall be able to sustain an overload as specified across its output terminals. The inverter shall not shut off, but shall continue to operate within rated parameters, with inverse-time overload shutdown protection. If the overload condition persists beyond the rated parameters of the inverter, the inverter shall current limit, load shall be transferred to the bypass source, and the inverter shall disconnect automatically from the critical load bus.

If the bypass source is not available and the overload/fault condition continues, the inverter shall current limit for a limited time as determined by the manufacturer and shall shut down to protect the internal components.

2.3.3.2 Output Frequency Control

The inverter shall normally operate in phase-lock and synchronism with the bypass source. When the bypass source frequency deviates by more than ±0.5 Hz, the internal frequency oscillator shall automatically take control and become the new frequency reference. Upon restoration of the bypass source within the required tolerance, the inverter shall synchronize back with that source at a slew rate not exceeding the specified rate. The oscillator shall be temperature compensated and shall be manually adjustable.

2.3.3.3 Output Protective Device

The output protective device shall be capable of shunt tripping or opening on an applied control signal and shall have the proper frame size and trip rating to supply overload current as specified. External output protective device shall have provision for locking in the "off" position. The inverter output protective device shall work in conjunction with the bypass protective device for both manual and automatic load transfers to and from bypass power.

2.3.3.4 Output Transformer

The inverter output transformer shall be similar to the input transformer and shall be capable of handling up to K-13 nonlinear loads as described in IEEE C57.110.

2.3.4 External Protection

UPS module shall have built-in self-protection against undervoltage, overvoltage, overcurrent and surges introduced on the ac input source and/or the bypass source. The UPS shall also have built-in self-protection against overvoltage and voltage surges introduced at the output terminals by paralleled sources, load switching, or circuit breaker operation in the critical load distribution system.

2.3.5 Internal Protection

UPS module shall be self-protected against overcurrent, sudden changes in output load and short circuits at the output terminals. UPS module shall be provided with output reverse power detection which shall cause the module to be disconnected from the critical load bus when output reverse power is present. UPS module shall have built-in protection against permanent damage to itself and the connected load for predictable types of failure within itself and the connected load. At the end of battery discharge limit, the module shall shut down without damage to internal components.

2.4 STATIC BYPASS TRANSFER CIRCUIT

A static bypass transfer circuit shall be provided as an integral part of the UPS and shall consist of a static switch, made up of two reverse-paralleled SCRs (silicon-controlled rectifiers) per phase conductor, and a bypass protective device or bypass switch, made up of a contactor or motor operated circuit breaker. The bypass protective device shall be in parallel with the static switch. The inverter output protective device shall disconnect and isolate the inverter from the bypass transfer circuit.

The control logic shall contain an automatic transfer circuit that senses the status of the inverter logic signals and alarm conditions and provides an uninterrupted transfer of the load to the bypass ac power source, without exceeding the transient limits specified herein, when a malfunction occurs in the UPS or when an external overload condition occurs. The power section of the static bypass transfer circuit shall be provided as a plug-in type assembly to facilitate maintenance. The static bypass transfer circuit shall be used to connect the input bypass ac power source to the critical load when required, and shall have the following features:

2.4.1 Uninterrupted Transfer

The static bypass transfer switch shall automatically cause the bypass ac power source to assume the critical load without interruption when the bypass control logic senses one of the following conditions and the UPS inverter output is synchronized to the bypass ac power source:

a. Inverter overload exceeds unit's rating.

b. Battery protection period is expired and bypass is available.

c. System failure.

d. Inverter output undervoltage or overvoltage.

2.4.2 Interrupted Transfer

If an overload occurs and the UPS inverter output is not synchronized to the bypass ac power source, the UPS inverter output shall current-limit for 200 milliseconds minimum. The inverter shall then turn off and an interrupted transfer to the bypass ac power source shall be made.

If the bypass ac power source is beyond the conditions stated below, an interrupted transfer shall be made upon detection of a fault condition:

a. Bypass voltage greater than plus or minus 10 percent from the UPS rated output voltage.

b. Bypass frequency greater than plus or minus 0.5 Hz from the UPS rated output frequency.

c. Phase differential of ac bypass voltage to UPS output voltage greater than plus or minus 3 degrees.

2.4.3 Manual Transfer

It shall be possible to make a manually-initiated static transfer from the system status and control panel. The transfer shall be make-before-break utilizing the bypass switch.

2.4.4 Automatic Uninterrupted Forward Transfer

The static bypass transfer switch shall automatically forward transfer, without interruption after the UPS inverter is turned "on", or after an instantaneous overload-induced reverse transfer has occurred and the load current has returned to less than the unit's 100 percent rating.

2.4.5 Forced Transfer

The control logic circuitry shall provide the means of making a forced or reverse transfer of the static bypass transfer circuit on an interrupted basis. Minimum interruption shall be 200 milliseconds when the UPS inverter is not synchronized to the bypass ac power source.

2.4.6 Overload Ratings

The static bypass transfer switch shall withstand the following overload conditions:

a. 1000 percent of UPS output rating for one cycle.

b. 150 percent of UPS output rating for 30 seconds.

c. 125 percent of UPS output rating for 10 minutes.

2.4.7 Static Switch Disconnect

A static switch disconnect shall be incorporated to isolate the static bypass transfer switch assembly so it can be removed for servicing. The

switch shall be equipped with auxiliary contacts.

2.5 MAINTENANCE BYPASS SWITCH

2.5.1 General

A maintenance bypass switch shall be provided as an integral part of the UPS and located within the UPS module or in a matching cabinet adjacent to the UPS cabinet. The maintenance bypass switch shall provide the capability to continuously support the critical load from the bypass AC power source while the UPS is isolated for maintenance. The maintenance bypass switch shall be housed in an isolated compartment inside the UPS cabinet in such a way that service personnel will not be exposed to electrically live parts while maintaining the equipment. Switch shall contain a maintenance bypass protective device and a module isolation protective device.

2.5.2 Load Transfer

The maintenance bypass switch shall provide the capability of transferring the critical load from the UPS static bypass transfer switch to maintenance bypass and then back to the UPS static bypass transfer switch with no interruption to the critical load.

2.6 MODULE CONTROL PANEL

The UPS module shall be provided with a control/indicator display panel. The display panel shall be on the front of the UPS module. Controls, meters, alarms and indicators for operation of the UPS module shall be on this panel. The display panel shall be menu driven for browsing all the screens.

2.6.1 Module Meters

2.6.1.1 Monitored Functions

The following functions shall be monitored and displayed:

a. Input voltage, phase-to-phase (all three phases).

b. Input current, all three phases.

c. Input frequency.

d. Battery voltage.

e. Battery current (charge/discharge).

f. Output voltage, phase-to-phase and phase-to-neutral (all three phases).

g. Output current, all three phases.

h. Output frequency.

i. Output kilowatts.

j. Elapsed time meter to indicate hours of operation, 6 digits.

k. Bypass voltage, phase-to-phase and phase-to-neutral (all three phases).

l. Output kilovars.

m. Output kilowatt hours, with 15-minute demand attachment.

n. Battery temperature.

o. Output Percentage load.

p. Remaining battery time.

2.6.1.2 Meter Construction

The display panel shall display alphanumeric parameters based on true RMS metering with 1 percent accuracy (minimum 4 significant digits).

2.6.2 Module Controls

Module shall have the following controls:

a. Lamp test/reset pushbutton.

b. Alarm test/reset pushbutton.

c. Module input protective device trip pushbutton, with guard.

d. Module output protective device trip pushbutton, with guard.

e. Battery protective device trip pushbutton, with guard.

f. Emergency off pushbutton, with guard.

g. DC voltage adjustment potentiometer, with locking guard.

h. Control power off switch.

i. UPS/bypass transfer selector switch.

j. Static bypass transfer switch enable/disable selector switch.

2.6.3 Module Alarm Indicators

Module shall have indicators for the following alarm items. Any one of these conditions shall turn on an audible alarm and the appropriate summary indicator. Each new alarm shall register without affecting any previous alarm.

a. Input ac power source failure.

b. Input protective device open.

c. Input power out of tolerance.

d. Overload.

e. Overload shutdown.

f. DC overvoltage/shutdown.

g. DC ground fault.

h. Low battery.

i. Battery discharged.

j. Battery protective device open.

k. Blower fan failure.

l. Input transformer overtemperature.

m. Low battery shutdown.

n. UPS on battery.

o. Equipment overtemperature.

p. Fuse blown (with indication where).

q. Control power failure.

r. Charger off/problem.

s. Inverter fault/off.

t. Emergency power off.

u. External shutdown (remote EPO activated).

v. Critical load on static bypass.

w. Static bypass transfer switch disabled/failure.

x. Inverter output overvoltage.

y. Inverter output undervoltage.

z. Inverter output overfrequency.

aa. Inverter output underfrequency.

bb. Bypass source voltage outside limits.

cc. Bypass frequency out of range.

dd. Bypass source to inverter out of synchronization.

ee. Overtemperature shutdown.

ff. Hardware shutdown.

2.6.4 Module Emergency OFF Button

Pressing the emergency off button shall cause the module to be disconnected from the system, via its input protective device, output protective device, and battery protective device. The button shall include a protective cover to prevent unintentional activation.

2.7 SELF-DIAGNOSTIC CIRCUITS

The control logic shall include status indicators for trouble-shooting the control circuits. These indicators shall be mounted on the circuit card edge or face such that they will be visible without repositioning the card, and shall be labeled with the function name.

2.8 REMOTE MONITORING PANEL

A remote monitoring panel shall be provided to monitor system status. The panel shall be designed for wall mounting near the critical load.

2.8.1 Indicators

Minimum display shall include the following indicators:

a. Load on UPS.

b. Load on battery.

c. Load on bypass.

d. Low battery.

e. Summary alarm.

f. New alarm (to alert the operator that a second summary alarm condition has occurred).

2.8.2 Audible Alarm

Any single indicator shall also turn on the audible alarm. An audible alarm test/reset button and lamp test/reset button shall be included. This reset button shall not affect nor reset the alarm on the module.

2.9 COMMUNICATIONS AND DATA ACQUISITION

An RS 485 communications and data acquisition port shall be provided. This port shall allow the system parameters, status, alarm indication and control panel functions specified to be remotely monitored and controlled.

Additionally, a second communication port shall be provided for use with the following:

a. A set of six Form C remote alarm contacts rated at 120V, 0.5A, shall be provided for remote alarm monitoring.

b. Auto-dial modem communication shall be provided to communicate with a remote modem in case an alarm function is active.

c. A SNMP (Simple Network Management Protocol) adapter shall be provided to communicate UPS monitoring via a network or direct connection to a PC.

d. A standard Web Browser adapter shall be provided to remotely view and monitor UPS functions over the Internet.

All the communication ports and contacts shall be capable of simultaneous

communication.

2.9.1 Emergency Control Contacts

Provide normally open contacts to signal when power is supplied to the UPS from emergency engine generators or alternate source.

2.10 TEMPERATURE CONTROL

2.10.1 General

Cabinet and enclosure ventilation shall be adequate to ensure that components are operated within their ratings. Forced-air cooled rectifier, inverter, and control unit will be acceptable. The cooling fans shall continue operation if UPS input power is lost. Redundancy shall be provided so that failure of one fan or associated circuit breaker will not cause an overheat condition. Cooling air shall enter the lower front of the cabinets and exhaust at the top. Blower power failure shall be indicated as a visual and audible alarm on the control panel. Air inlets shall have replaceable filters that may be located on the inside of the cabinet doors and shall be easily accessible for replacement.

2.10.2 Blower Power Source

Blower power source shall be internally derived from the output side of UPS module, with automatic transfer arrangement.

2.10.3 Temperature Sensors

Temperature sensors shall be provided to monitor the air temperature. Separate sensors shall monitor the temperature of rectifier and inverter heat sinks. Separate sensors shall also monitor the transformer temperature. Critical equipment over-temperature indication shall start a timer that shall shut down the UPS system if the temperature does not return below the setpoint level recommended by the UPS manufacturer.

2.11 BATTERY SYSTEM

2.11.1 General

Battery system shall contain the battery cells, racks, battery disconnect, battery monitor and cabinet, if required. A storage battery with sufficient ampere-hour rating to maintain UPS output at full capacity for the specified duration shall be provided for each UPS module. The battery shall be of heavy-duty, industrial design suitable for UPS service. The cells shall be provided with flame arrestor vents, intercell connectors and cables, cell-lifting straps, cell-numbering sets, and terminal grease. Intercell connectors shall be sized to maintain terminal voltage within voltage window limits when supplying full load under power failure conditions. Cell and connector hardware shall be stainless steel of a type capable of resisting corrosion from the electrolyte used.

2.11.2 Battery Ratings

a. Type: nickel cadmium.

b. Specific gravity when fully charged: 1.215.

c. End voltage 1.67 volts per cell.

d. Float voltage: 2.17 to 2.26 volts per cell.

e. Equalizing voltage: 2.33 to 2.38 volts per cell.

2.11.3 Battery Construction

The battery shall be of the valve-regulated, sealed, non-gassing, recombinant type.

2.11.4 Battery Cabinet

The battery pack assembly shall be furnished in a battery cabinet matching the UPS cabinet. The battery cabinet shall be designed to allow for checking the torque on the connections in the battery system and to provide adequate access for annual housekeeping chores. External wiring interface shall be through the bottom or top of the assembly. A smoke and high temperature alarm shall annunciate detection of either smoke or high temperature within the battery cabinet.

2.11.5 Cell-Terminal Covers

Acid-resistant transparent cell-terminal covers not exceeding 6 feet in length and with vent holes drilled on top where needed shall be provided.

2.11.6 Battery Disconnect

Each battery pack assembly shall have a fused disconnect switch provided in a NEMA 1 enclosure, finished with acid-resistant paint and located in line with the assembly. Switch shall be complete with line side and load side bus bars for connection to battery cells.

2.11.7 Battery Monitor

A battery monitor shall be provided for each battery pack assembly. At a minimum, this device shall monitor the following parameters:

a. Total system voltage.

b. Ambient room temperature.

c. Total battery discharge cycles with a duration of 30 seconds or less.

The monitor shall also record the total accumulated discharge minutes and accumulated battery system discharge kW hours.

2.12 FACTORY TESTING

The UPS system shall be factory tested to meet the requirements specified using a test battery (not the battery to be supplied with the system). UPS module shall be factory load tested as an independent assembly with 3-phase ac input power and with battery power for a minimum of 8 hours, with meter readings taken every 30 minutes. Load shall be balanced at rated kVA and rated power factor. Factory tests for the UPS module shall be run under full load, and will be witnessed by the Government. Should a malfunction occur, the problem shall be corrected and the test shall be repeated. As a
minimum, the factory tests shall include the parameters described in paragraphs ac Input, ac Output, Transient Response and Efficiency. The

tests shall encompass all aspects of operation, such as module failure, static bypass operation, battery failure, input power failure and overload ratings. The Contracting Officer shall be notified in writing at least 2 weeks before testing. Factory-test time shall not be used for system debugging and/or checkout. Such work shall be done prior to notifying the Government that the system is ready for testing. Factory tests shall be performed during normal business hours. The system shall be interconnected and tested for an additional 8 hours to ensure proper wiring and performance.

2.12.1 Transient Tests

Transient tests shall be conducted using high-speed oscillograph type recorders to demonstrate the operation of the components to the satisfaction of the Government. These tests shall include 50 percent to 100 percent load changes, manual transfer, manual retransfer, low dc bus initiated transfer and low ac output bus transfer. A recording instrument equipped with an event marker shall be used.

2.12.2 Efficiency Tests

Testing for efficiency shall be performed at zero output up to 100 percent of stated kVA output in 25 percent steps, 0.8 power factor, with battery fully charged and floating on the dc bus, with nominal input voltage, and with module connected to represent actual operating conditions.

2.13 CABLE LUGS AND TERMINATIONS

2.13.1 Cable Lugs

Provide appropriate compression type lugs on all ac and dc power connections to the UPS system and battery as required. Aluminum or bare copper cable lugs are not suitable.

2.13.2 Terminations

Terminals shall be supplied for making power and control connections. Terminal blocks shall be provided for field wiring terminals. Terminal blocks shall be heavy-duty, strap-screw type. Terminal blocks for field wiring shall be located in one place in each module. Control wiring shall be extended to the terminal block location. No more than two wires shall land on any terminal point. Where control wiring is attached to the same point as power wiring, a separate terminal shall be provided. If bus duct is used, bus stubs shall be provided where bus duct enters cabinets.

2.14 INSPECTION

Inspection before shipment is required. The manufacturer shall notify the Government at least 2 weeks before shipping date so that an inspection can be made.

2.15 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 inch 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 1.0 by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

2.16 MANUFACTURER'S NAMEPLATES

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.

2.17 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.1.1 Control Cable

UPS control wiring shall be installed in individual separate rigid steel conduits, unless connections are made between side by side matching cabinets of UPS. Tag control wires with numeric identification tags corresponding to the terminal strip location to where the wires are connected. In addition to manufacturer's requirements, provide four additional spare conductors between UPS module and remote alarm panel in same conduit. When routing control cables inside UPS module, maintain a minimum 6 inches separation from power cables.

3.1.2 Grounding Conductor

Provide an insulated equipment grounding conductor in feeder and branch circuits. Conductor shall be separate from the electrical system neutral conductor. Ground battery racks and battery breaker cabinets with a separate equipment grounding conductor to the UPS cabinet.

3.1.3 UPS Output Conductors

Isolate the UPS output conductors from the UPS cabinet to the critical load panels and from other conductors by installing in separate conduit. Isolation shall prevent inductive coupling from other conductors.

3.1.4 DC Power Conductors

When installed in conduits, place dc power conductors from the UPS cabinet to the battery circuit breaker such that each conduit contains an equal number of positive and negative conductors, for example, two positive and two negative conductors in each conduit.

3.1.5 Conduit Entries

Conduit entries shall use the available conduit areas shown on manufacturer's installation drawings. Conduit entries shall not be made

through the front, side or rear panels of the UPS or Maintenance Bypass Cabinet.

3.1.6 Battery Rack Assembly

Battery racks are typically shipped dismantled in separate rail, frame, and brace packages. Ensure that manufacturer furnished assembly hardware is used to assemble battery racks. Installation of battery racks shall conform to the manufacturer's instructions.

3.1.7 Battery Cabinet Assembly

Battery cabinets are typically factory assembled for up to 100 KVA UPS systems. Battery cabinets for larger units typically require assembly at the site. Installation of battery cabinets shall conform to the manufacturer's instructions.

3.1.8 Battery Installation

Installation of batteries shall conform to the manufacturer's instructions.

3.2 FIELD QUALITY CONTROL

Contractor shall notify Contracting Officer in writing at least 45 calendar days prior to completion of the UPS system installation. At this time the Contractor, will schedule the UPS manufacturer's technical representative to inspect the completed installation. The UPS technical representative shall provide instruction for activity personnel as specified in paragraph titled "DEMONSTRATION".

3.2.1 Installation Preparation

The following items shall be completely installed by the Contractor and be operational prior to the arrival of the UPS representative for inspection, unit start-up and testing:

a. Ventilation equipment in the UPS and battery rooms.

b. Battery cabinets and cells. This is not applicable for maintenance-free battery.

c. Battery connections including cell-to-cell, tier-to-tier, and rack-to-rack connections, with correct polarity;

d. DC power and control connections between UPS and battery circuit breaker, with correct polarity;

e. DC power connection between battery circuit breaker and battery, with correct polarity;

f. Clockwise phase rotation of ac power connections;

g. AC power to rectifier input bus;

h. AC power to UPS bypass input bus;

i. AC power to UPS maintenance bypass circuit breaker;

j. AC power from UPS output to UPS maintenance bypass output circuit

breaker;

k. Remote monitors and control wiring;

l. UPS system and battery system properly grounded;

m. Emergency shower and eye wash;

o. Control connections between UPS module and UPS maintenance bypass cabinet;

p. Clean and vacuum UPS and battery room floors, battery cells, and UPS equipment, both inside and outside.

q. Ensure that shipping members have been removed.

r. Provide IEEE 450 battery installation certification.

3.2.2 Initial Inspection and Tests

The UPS technical representative and the Contracting Officer, in the presence of the Contractor, will inspect the completed installation. The Contractor shall correct construction or installation deficiencies as directed. Perform acceptance checks in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections, performed in accordance with NETA ATS.

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with drawings, specifications and approved shop drawings.

(2) Inspect physical and mechanical condition. Inspect doors, panels, and sections for paint, dents, scratches, fit, and missing hardware. Inspect the displays for scratches, dark pixels or uneven brightness.

(3) Inspect anchorage, alignment, grounding, and required clearances.

(4) Verify that fuse sizes and types correspond to drawings.

(5) Verify the unit is clean inside and out.

(6) Test all electrical and mechanical interlock systems for correct operation and sequencing.

(7) Inspect bolted electrical connections for high resistance using one of the following methods:

(a) Use a low-resistance ohmmeter.

(b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

(c) Perform thermographic survey.

(8) Verify operation of forced ventilation.

(9) Verify that vents are clear and new clean filters are installed.

3.2.3 Performance Tests

Provide equipment, test instruments, power, load bank, materials and labor required for tests. Contracting Officer will witness all tests and the tests shall be subject to his approval. Perform tests in accordance with the manufacturer's recommendations and include the following electrical tests.

3.2.3.1 UPS Unit Performance Tests

Upon completion of battery activation procedures, Contractor shall connect load bank to UPS output. Load bank required shall be determined by the following:

UPS KVA RATING X 0.8 = KW of LOAD BANK

Performance test is to be run under the supervision of the UPS technical representative. UPS unit shall be operated under full load for a minimum of one hour. Contractor shall be required to operate feeder and bypass power feeder breakers during testing of the UPS.

a. Electrical Tests

(1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

(2) Test static transfer from inverter to bypass and back. Use normal load, if possible.

(3) Set free running frequency of oscillator.

(4) Test dc undervoltage trip level on inverter input breaker. Set according to manufacturer's published data.

(5) Test alarm circuits.

(6) Verify synchronizing indicators for static switch and bypass switches.

(7) Perform electrical tests for UPS system breakers.

(8) Perform electrical tests for UPS system batteries.

b. Test Values

(1) Compare bolted connection resistances to values of similar connections.

(2) Verify bolt-torque levels.

(3) Micro-ohm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate any values which deviate from similar connections by more than 50 percent of the lowest value.

c. Load Test

The installed system shall be load tested for a continuous 24 hour period by means of resistive load banks. The system shall be continuously tested at 1/2 load for 8 hours, 3/4 load for 8 hours and full load for 8 hours. Provide resistive load banks of total kW load of equipment to facilitate startup under load conditions, and to conduct load tests described above. Instrument readings shall be recorded every half hour for the following:

(1) Input voltage (all three phases).

(2) Input current (all three phases).

(3) Input frequency.

(4) Battery voltage.

(5) Output voltage (all three phases).

(6) Output current (all three phases).

(7) Output kilowatts.

(8) Output frequency.

d. Battery Discharge Test

With the battery fully charged, the system shall undergo a complete battery discharge test to full depletion and a recharge to nominal conditions.
Instrument readings shall be recorded every minute during discharge for the following:

(1) Battery voltage.

(2) Battery current.

(3) Output voltage (all three phases).

(4) Output current (all three phases).

(5) Output kilowatts.

(6) Output frequency.

3.2.3.2 Battery Performance Test (Constant KW)

Furnish all labor, material and test equipment necessary to conduct performance test under the direction of UPS technical representative. The following shall be accomplished:

a. Install a calibrated voltmeter across the battery terminals to measure voltage, and install a calibrated voltmeter across the UPS dc shunt to read charging current. UPS technical representative will advise connection to dc shunt.

b. Record temperature of pilot cells in battery immediately prior to start of discharge performance test.

c. Read and record total battery voltage and battery current at start of discharge and every minute during discharge test.

d. Record minutes and seconds when battery voltage drops below minimum discharge voltage of 291 volts dc. On initial discharge test, a battery may be expected to deliver 95 percent of its rated capacity. This will increase to 100 percent after several complete discharge cycles or after 12 months of float charge service.

e. Should battery fail to meet the requirements of the first discharge performance test, open the inverted output breaker. Then put battery on equalizing charge, with rectifier adjusted to normal equalizing voltage . Equalize for a minimum of 100 hours. Measure and record time and battery voltage. Run a second discharge performance test.

3.3 DEMONSTRATION

3.3.1 Instructing Government Personnel

Furnish the services of competent instructors to give full instruction to designated Government personnel in the adjustment, operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work. Instruction shall 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 8 hours of instruction for 8 personnel. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with equipment or system. When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instructions to acquaint the operating personnel with the changes or modifications. Field training shall be videotaped and the tape shall be left with the Contracting Officer. A factory training videotape shall be provided as part of the training materials.

3.4 FINAL ADJUSTMENTS

a. Remove load bank and reconnect system for normal operation.

b. Equalize battery at required volts for a period of 72 hours.

e. Check battery connections are properly torqued to manufacturer's specifications. Take and record, for cell-to-cell and terminal connections, detailed micro-ohm resistance readings. Remake connections having a resistance of more than 10 percent above the average.

f. All manufacturer's data and operation manuals, which are an integral part of, and shipped with UPS, shall be delivered to Contracting Officer.

3.5 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 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.

3.7 DISPOSAL

Upon completion of UPS installation and testing, Contractor shall remove and dispose of empty, partially full and excess acid drums, including shipping containers, obsolete batteries, and obsolete UPS modules. Removal shall be accomplished off-base and in conformance with local laws and regulations regarding disposal of hazardous material.

-- End of Section --

SECTION 26 36 23.00 20

AUTOMATIC TRANSFER SWITCHES

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	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1008	(2012; Reprint Apr 2013) Transfer Switch Equipment
UL 508	(1999; Reprint Oct 2013) Industrial Control Equipment

1.2 RELATED REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS, and Section 26 08 00 APPARATUS INSPECTION AND TESTING, apply 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. The following shall be submitted 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

SD-06 Test Reports

Acceptance Checks and Tests; G

Functional Acceptance Tests; G

SD-07 Certificates

Proof of Listing; G

SD-10 Operation and Maintenance Data

Automatic Transfer Switches, Data Package 5; G

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

1.4 QUALITY ASSURANCE

1.4.1 Proof of Listing

Submit proof of listing by UL 1008.

1.4.2 Automatic Transfer Switch Drawings

Drawings shall include outline, arrangement, and detail drawings. Detail drawings shall 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.

PART 2 PRODUCTS

2.1 AUTOMATIC TRANSFER SWITCHES

Provide four-pole, automatic transfer switches for use in emergency systems in accordance with UL 1008. Each automatic transfer switch shall be rated for total system transfer and have the current and voltage ratings as indicated. The rating of the switch shall be adequate for withstanding the effects of the indicated RMS symmetrical fault current when protected by the indicated overcurrent device without contact welding. The switch operating mechanism shall be electrically operated from the source to which it is transferring, shall have quick-make, quick-break, load break contacts, and shall be mechanically held in both positions. Switches utilizing circuit breakers are not acceptable. Non-fire pump service transfer switches shall have manual operating means provided for maintenance and servicing accessible only by opening the enclosure. The manual operating means shall affect the opening and closing of the switch contacts at the same rate of speed as that caused by the automatic operation of the switch. Automatic transfer switches provided with by-pass/isolation switches shall be mounted on a drawout mechanism so that the automatic transfer switch can be removed from the enclosure. The switch enclosure shall comply with UL 508, NEMA Type 1, and shall be equipped with an equipment ground lug.

2.1.1 By-Pass/Isolation Switches

Include by-pass/isolation switches for the indicated automatic transfer switches. Provide by-pass/isolation switches in accordance with UL 1008 that can be used to manually select an available power source to feed load

circuits and to permit total isolation of the automatic transfer switch. The by-pass/isolation switch shall be rated for total system transfer and have the same current rating, voltage rating, number of poles, and withstand and closing rating as the associated automatic transfer switch.

2.1.2 Automatic Transfer Switch Controls

2.1.2.1 Controls for Utility-Generator Automatic Transfer Switch

Provide all necessary controls to start the generator set upon loss of the normal (utility) source, transfer the load to the generator set upon reaching rated voltage and frequency, re-transfer the load when the normal (utility) source returns, and stop the generator set.

The switch shall include the following control features.

a. Three-phase normal source voltage sensing circuit with adjustable dropout, 75-93 percent of nominal, and pickup, 85-100 percent of nominal.

b. Engine starting control contacts with adjustable commit-to-start delay circuit, 0.5-6.0 seconds.

c. Voltage/frequency sensing circuit, set for 80 percent of nominal, for enabling load transfer to emergency source.

d. Transfer to emergency source time delay for transfer switches as indicated, adjustable 0-5 minutes.

e. Re-transfer to normal source time delay, adjustable 1-30 minutes.

f. Programmable exerciser to allow automatic starting of the generator set and subsequent load transfer. Exercise periods shall be selectable for 1 to 24 hours per day for 0 to 7 days a week.

2.1.3 Front Panel Devices

Provide devices mounted on cabinet front consisting of:

a. Mode selector switch with the following positions and associated functions;

    1. TEST - Simulates loss of normal/preferred source system operation.

    2. NORMAL - Transfers system to normal/preferred source bypassing re-transfer time delay.

b. Lamps for indicating connected source and normal/preferred source is available.

c. Auxiliary contacts for indicating connected source and normal/preferred source available.

e. Lamps for indicating that the by-pass/isolation switch is in the "normal by-pass", "alternate by-pass", or "isolated" position.

PART 3 EXECUTION

3.1 INSTALLATION

Installation shall 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 shall 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", shall have been submitted to and approved by the Contracting Officer.

3.2.3 Test Equipment

All test equipment and instruments shall be on hand prior to scheduling field tests, or subject to Contracting Officer's approval, evidence shall 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 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 shall 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 shall provide labor, equipment, apparatus, including test load, and consumables required for the specified tests. Calibration of all measuring devices and indicating devices shall be certified. The test load shall be a cataloged product in accordance with Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS. 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.

3.3.1 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.

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.

3.3.2 Functional Acceptance Tests

Functional Acceptance Tests shall be coordinated with Section 26 32 13.00 20 SINGLE OPERATION GENERATOR SETS and shall include simulating power failure and demonstrating the following operations for each automatic transfer switch. Contractor shall show by demonstration 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 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.

-- End of Section --

SECTION 26 41 00

LIGHTNING PROTECTION SYSTEM

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	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code
NFPA 780	(2014) Standard for the Installation of Lightning Protection Systems

U.S. AIR FORCE (USAF)

AFI 32-1065	(1998) Grounding Systems

UNDERWRITERS LABORATORIES (UL)

UL 467	(2007) Grounding and Bonding Equipment
UL 96	(2005; Reprint Sep 2013) Standard for Lightning Protection Components
UL Electrical Constructn	(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. 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 Constructn, 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.

2.2 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, and grounding electrodes and ground ring electrode conductor. Expose conductors on the structures except where conductors are required to be in protective sleeves. 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. Roof conductors are to be concealed within the ceiling cavities as much as practicable.

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.

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.

3.2 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 RESTORATION

Where sod has been removed, place sod as soon as possible after completing the backfilling. Restore, to original condition, the areas disturbed by trenching, storing of dirt, cable laying, and other work. Overfill to accommodate for settling. Include necessary topsoil, fertilizing, liming, seeding, sodding, sprigging or mulching in any restoration. Maintain disturbed surfaces and replacements until final acceptance.

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.

-- End of Section --

SECTION 26 51 00

INTERIOR LIGHTING

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.

ASTM INTERNATIONAL (ASTM)

ASTM A1008/A1008M	(2013) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardened
ASTM A580/A580M	(2013b) Standard Specification for Stainless Steel Wire
ASTM A641/A641M	(2009a) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B164	(2003; R 2008) Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B633	(2013) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM E2129	(2010) Standard Practice for Data Collection for Sustainability Assessment of Building Products

CALIFORNIA ENERGY COMMISSION (CEC)

CEC Title 24	(2008; Effective Jan 2010) California's Energy Efficiency Standards for Residential and Nonresidential Buildings

GREEN SEAL (GS)

GS-12	(1997) Occupancy Sensors

ILLUMINATING ENGINEERING SOCIETY OF NORTH AMERICA (IES)

IES HB-10	(2011) IES Lighting Handbook

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013) 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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI ANSLG C78.41	(2006) For Electric Lamps--Guidelines for Low-Pressure Sodium Lamps
ANSI ANSLG C78.42	(2009) For Electric Lamps: High-Pressure Sodium Lamps
ANSI C78.1381	(1998) American National Standard for Electric Lamps - 250-Watt, 70 Watt, M85 Metal-Halide Lamps
ANSI C78.901	(2005) American National Standard for Electric Lamps - Single Base Fluorescent Lamps--Dimensional and Electrical Characteristics
ANSI C82.1	(2004) American National Standard for Electric Lamp Ballasts - Line Frequency Fluorescent Lamp Ballasts
ANSI C82.2	(2002) American National Standard for Lamp Ballasts--Methods of Measurement of Fluorescent Lamp Ballasts
ANSI C82.4	(2002) American National Standard for Ballasts for High-Intensity-Discharge and Low-Pressure Sodium (LPS) Lamps (Multiple-Supply Type)
ANSI/ANSLG C78.43	(2013) American National Standard for Electric Lamps - Single-Ended Metal-Halide Lamps
NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ANSLG C78.81	(2013) American National Standard for Electric Lamps--Double-Capped Fluorescent Lamps--Dimensional and Electrical Characteristics
NEMA ANSLG C82.11	(2011) Lamp Ballasts - High-Frequency

	Fluorescent Lamp Ballasts
NEMA C136.10	(2010) American National Standard for Roadway and Area Lighting Equipment-Locking-Type Photocontrol Devices and Mating Receptacles--Physical and Electrical Interchangeability and Testing
NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA LL 1	(1997; R 2002) Procedures for Linear Fluorescent Lamp Sample Preparation and the TCLP Extraction

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2012; Amendment 1 2012) Life Safety Code
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code
NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

UNDERWRITERS LABORATORIES (UL)

UL 1029	(1994; Reprint Dec 2013) High-Intensity-Discharge Lamp Ballasts
UL 1598	(2008; Reprint Oct 2012) Luminaires
UL 20	(2010; Reprint Feb 2012) General-Use Snap Switches
UL 595	(1985) Marine-Type Electric Lighting Fixtures
UL 773	(1995; Reprint Mar 2002) Standard for Plug-In, Locking Type Photocontrols for Use with Area Lighting
UL 773A	(2006; Reprint Nov 2013) Standard for Nonindustrial Photoelectric Switches for Lighting Control
UL 844	(2012) Standard for Luminaires for Use in Hazardous (Classified) Locations

UL 924	(2006; Reprint Apr 2014) Standard for Emergency Lighting and Power Equipment
UL 935	(2001; Reprint Dec 2013) Standard for Fluorescent-Lamp Ballasts

1.2 RELATED REQUIREMENTS

Materials not considered to be lighting equipment or lighting fixture accessories are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Lighting fixtures and accessories mounted on exterior surfaces of buildings are specified in this section.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

b. Average life is the time after which 50 percent will have failed and 50 percent will have survived under normal conditions.

c. Total harmonic distortion (THD) is the root mean square (RMS) of all the harmonic components divided by the total fundamental current.

1.4 SYSTEM DESCRIPTION

1.4.1 Lighting Control System

Provide lighting control system as indicated. Lighting control equipment shall include, if indicated: control modules, power packs, dimming ballasts, occupancy sensors, and light level sensors.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

Data, drawings, and reports shall employ the terminology, classifications, and methods prescribed by the IES HB-10, as applicable, for the lighting system specified.

SD-03 Product Data

Fluorescent lighting fixtures; G

Fluorescent electronic ballasts; G

Fluorescent lamps; G

Photocell switch; G

Power hook fixture hangers; G

Exit signs; G

Emergency lighting equipment; G

Occupancy sensors; G

Energy Efficiency

SD-06 Test Reports

Operating test

Submit test results as stated in paragraph entitled "Field Quality Control."

SD-10 Operation and Maintenance Data

Lighting Control System, Data Package 5; G

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein, showing all light fixtures, control modules, control zones, occupancy sensors, light level sensors, power packs, dimming ballasts, schematic diagrams and all interconnecting control wire, conduit, and associated hardware.

Operational Service

Submit documentation that includes contact information, summary of procedures, and the limitations and conditions applicable to the project. Indicate manufacturer's commitment to reclaim materials for recycling and/or reuse.

1.6 QUALITY ASSURANCE

1.6.1 Fluorescent Electronic Ballasts

Submit ballast catalog data as required in the paragraph entitled "Fluorescent Lamp Electronic Ballasts" contained herein. As an option, submit the fluorescent fixture manufacturer's electronic ballast specification information in lieu of the actual ballast manufacturer's catalog data. This information shall include published specifications and sketches, which covers the information required by the paragraph entitled "Fluorescent Lamp Electronic Ballasts" herein. This information may be supplemented by catalog data if required, and shall contain a list of vendors with vendor part numbers.

1.6.2 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.

1.6.3 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. 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.

1.6.3.1 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.

1.6.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6.3.3 Energy Efficiency

Comply with National Energy Policy Act and Energy Star requirements for lighting products. Submit data indicating lumens per watt efficiency and color rendition index of light source.

1.7 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.

1.7.1 Electronic Ballast Warranty

Furnish the electronic ballast manufacturer's warranty. The warranty period shall not be less than 5 years from the date of manufacture of the electronic ballast. Ballast assembly in the lighting fixture, transportation, and on-site storage shall not exceed 12 months, thereby permitting 4 years of the ballast 5 year warranty to be in service and energized. The warranty shall state that the malfunctioning ballast shall be exchanged by the manufacturer and promptly shipped to the using Government facility. The replacement ballast shall be identical to, or an improvement upon, the original design of the malfunctioning ballast.

1.8 OPERATIONAL SERVICE

Coordinate with manufacturer for maintenance agreement. Collect information from the manufacturer about maintenance agreement options, and submit to Contracting Officer. Services shall reclaim materials for recycling and/or reuse. Services shall not landfill or burn reclaimed materials. Indicate procedures for compliance with regulations governing disposal of mercury. When such a service is not available, local recyclers shall be sought after to reclaim the materials.

PART 2 PRODUCTS

2.1 FLUORESCENT LIGHTING FIXTURES

UL 1598. Fluorescent fixtures shall have electronic ballasts unless specifically indicated otherwise.

2.1.1 Fluorescent Lamp Electronic Ballasts

The electronic ballast shall as a minimum meet the following characteristics:

a. Ballast shall comply with UL 935, NEMA ANSLG C82.11, NFPA 70, and CEC Title 24 unless specified otherwise. Ballast shall be 100 percent electronic high frequency type with no magnetic core and coil components. Ballast shall provide transient immunity as recommended by IEEE C62.41.1 and IEEE C62.41.2. Ballast shall be designed for the wattage of the lamps used in the indicated application. Ballasts shall be designed to operate on the voltage system to which they are connected.

b. Power factor shall be 0.95 (minimum).

c. Ballast shall operate at a frequency of 20,000 Hertz (minimum). Ballast shall be compatible with and not cause interference with the operation of occupancy sensors or other infrared control systems. Provide ballasts operating at or above 40,000 Hertz where available.

d. Ballast shall have light regulation of plus or minus 10 percent lumen output with a plus or minus 10 percent input voltage regulation. Ballast shall have 10 percent flicker (maximum) using any compatible lamp.

e. Ballast factor shall be between 0.85 (minimum) and 1.00 (maximum). Current crest factor shall be 1.7 (maximum).

f. Ballast shall be UL listed Class P with a sound rating of "A."

g. Ballast shall have circuit diagrams and lamp connections displayed on the ballast.

h. Ballasts shall be instant start unless otherwise indicated. Ballasts shall be programmed start where indicated. Instant start ballasts shall operate lamps in a parallel circuit configuration that permits the operation of remaining lamps if one or more lamps fail or are removed. Programmed start ballasts may operate lamps in a series circuit configuration. Provide series/parallel wiring for programmed start ballasts where available.

i. Ballasts for compact fluorescent fixtures shall be programmed start.

j. Ballasts for T-5 and smaller lamps shall have end-of-life protection circuits as required by NEMA ANSLG C78.81 and ANSI C78.901 as applicable.

k. Ballast shall be capable of starting and maintaining operation at a minimum of 0 degrees F unless otherwise indicated.

l. Electronic ballast shall have a full replacement warranty of 5 years from date of manufacture as specified in paragraph entitled "Electronic Ballast Warranty" herein.

2.1.1.1 T-8 Lamp Ballast

a. Total harmonic distortion (THD): Shall be 20 percent (maximum).

b. Input wattage.

1. 32 watts (maximum) when operating one F32T8 lamp

2. 62 watts (maximum) when operating two F32T8 lamps

2.1.2 Fluorescent Lamps

a. T-8 rapid start low mercury lamps shall be rated 32 watts (maximum), 2800 initial lumens (minimum), CRI of 75 (minimum), color temperature of 3500 K, and an average rated life of 20,000 hours. Low mercury lamps shall have passed the EPA Toxicity Characteristic Leachate Procedure (TCLP) for mercury by using the lamp sample preparation procedure described in NEMA LL 1.

g. Compact fluorescent lamps shall be: CRI 80, minimum, 3500 K, 10,000 hours average rated life, and as follows:

2. T-4, double twin tube, rated 26 watts, 1800 initial lumens (minimum),.

Average rated life is based on 3 hours operating per start.

2.2 SUSPENDED FIXTURES

Provide hangers capable of supporting twice the combined weight of fixtures supported by hangers. Provide with swivel hangers to ensure a plumb installation. Hangers shall be cadmium-plated steel with a swivel-ball tapped for the conduit size indicated. Hangers shall allow fixtures to swing within an angle of 45 degrees. Brace pendants 4 feet or longer to limit swinging. Single-unit suspended fluorescent fixtures shall have twin-stem hangers. Multiple-unit or continuous row fluorescent fixtures shall have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end. Rods shall be a minimum 0.18 inch diameter.

2.3 SWITCHES

2.3.1 Toggle Switches

Provide toggle switches as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.4 PHOTOCELL SWITCH

UL 773 or UL 773A, hermetically sealed cadmium-sulfide or silicon diode type cell rated 120 volts ac, 60 Hz with single-throw contacts. Switch shall turn on at or below 3 footcandles and off at 2 to 10 footcandles. A time delay shall prevent accidental switching from transient light sources. Provide switch:

a. Integral to the luminaire, rated 1000W minimum.

2.5 EXIT SIGNS

UL 924, NFPA 70, and NFPA 101. Exit signs shall be self-powered type. Exit signs shall use no more than 5 watts.

2.5.1 Self-Powered LED Type Exit Signs (Battery Backup)

Provide with automatic power failure device, test switch, pilot light, and fully automatic high/low trickle charger in a self-contained power pack. Battery shall be sealed electrolyte type, shall operate unattended, and require no maintenance, including no additional water, for a period of not less than 5 years. LED exit sign shall have emergency run time of 1 1/2 hours (minimum). The light emitting diodes shall have rated lamp life of 70,000 hours (minimum).

2.6 EMERGENCY LIGHTING EQUIPMENT

UL 924, NFPA 70, and NFPA 101. Provide lamps in wattage indicated.

2.6.1 Emergency Lighting Unit

Provide as indicated. Emergency lighting units shall be rated for 12 volts, except units having no remote-mounted lamps and having no more than two unit-mounted lamps may be rated 6 volts. Equip units with brown-out sensitive circuit to activate battery when ac input falls to 75 percent of normal voltage. Provide integral self-testing module.

2.7 OCCUPANCY SENSORS

UL listed. Comply with GS-12. Occupancy sensors and power packs shall be designed to operate on the voltage indicated. Sensors and power packs shall have circuitry that only allows load switching at or near zero current crossing of supply voltage. Occupancy sensor mounting as indicated. Sensor shall have an LED occupant detection indicator. Sensor shall have adjustable sensitivity and adjustable delayed-off time range of 5 minutes to 15 minutes. Wall mounted sensors shall match the color of adjacent wall plates as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, ceiling mounted sensors shall be white. Ceiling mounted sensors shall have 360 degree coverage unless otherwise indicated.

b. Infrared sensors shall have a daylight filter. Sensor shall have a fresnel lens that is applicable to space to be controlled.

2.8 EQUIPMENT IDENTIFICATION

2.8.1 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.

2.8.2 Labels

Provide labeled luminaires in accordance with UL 1598 requirements. All luminaires shall be clearly marked for operation of specific lamps and ballasts according to proper lamp type. The following lamp characteristics shall be noted in the format "Use Only _____":

a. Lamp diameter code (T-4, T-5, T-8, T-12), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.

c. Start type (preheat, rapid start, instant start) for fluorescent and compact fluorescent luminaires.

e. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.

All markings related to lamp type shall be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when lamps are in place. Ballasts shall have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.

2.9 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.1.1 Lamps

Lamps of the type, wattage, and voltage rating indicated shall be delivered to the project in the original cartons and installed just prior to project completion. Lamps installed and used for working light during construction shall be replaced prior to turnover to the Government if more than 15 percent of their rated life has been used. Lamps shall be tested

for proper operation prior to turn-over and shall be replaced if necessary with new lamps from the original manufacturer. Provide 10 percent spare lamps of each type from the original manufacturer.

3.1.2 Lighting Fixtures

Set lighting fixtures plumb, square, and level with ceiling and walls, in alignment with adjacent lighting fixtures, and secure in accordance with manufacturers' directions and approved drawings. Installation shall meet requirements of NFPA 70. Mounting heights specified or indicated shall be to the bottom of fixture for ceiling-mounted fixtures and to center of fixture for wall-mounted fixtures. Obtain approval of the exact mounting for lighting fixtures on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed.

3.1.3 Suspended Fixtures

Suspended fixtures shall be provided with 45 degree swivel hangers so that they hang plumb and shall be located with no obstructions within the 45 degree range in all directions. The stem, canopy and fixture shall be capable of 45 degree swing. Pendants, rods, or chains 4 feet or longer excluding fixture shall be braced to prevent swaying using three cables at 120 degree separation. Suspended fixtures in continuous rows shall have internal wireway systems for end to end wiring and shall be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces. Aligning splines shall be used on extruded aluminum fixtures to assure hairline joints. Steel fixtures shall be supported to prevent "oil-canning" effects. Fixture finishes shall be free of scratches, nicks, dents, and warps, and shall match the color and gloss specified. Pendants shall be finished to match fixtures. Aircraft cable shall be stainless steel. Canopies shall be finished to match the ceiling and shall be low profile unless otherwise shown. Maximum distance between suspension points shall be 10 feet or as recommended by the manufacturer, whichever is less.

3.1.4 Exit Signs and Emergency Lighting Units

Wire exit signs and emergency lighting units ahead of the switch to the normal lighting circuit located in the same room or area.

3.1.5 Photocell Switch Aiming

Aim switch according to manufacturer's recommendations.

3.1.6 Occupancy Sensor

Provide quantity of sensor units indicated as a minimum. Provide additional units to give full coverage over controlled area. Full coverage shall provide hand and arm motion detection for office and administration type areas and walking motion for industrial areas, warehouses, storage rooms and hallways. Locate the sensor(s) as indicated and in accordance with the manufacturer's recommendations to maximize energy savings and to avoid nuisance activation and deactivation due to sudden temperature or airflow changes and usage. Set sensor "on" duration to 15 minutes.

3.2 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.

3.3 FIELD QUALITY CONTROL

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test to show that equipment operates in accordance with requirements of this section.

3.3.1 Occupancy Sensor

Test sensors for proper operation. Observe for light control over entire area being covered.

-- End of Section --

SECTION 27 10 00

BUILDING TELECOMMUNICATIONS CABLING SYSTEM

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	(2013) Laminated Thermosetting Materials

ELECTRONIC COMPONENTS ASSOCIATION (ECA)

ECA EIA/ECA 310	(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	(2011) 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	(2013) Performance Standard for Category 6 and Category 7 100 Ohm Shielded and Unshielded Twisted Pairs

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-1152	(2009) Requirements for Field Test Instruments and Measurements for Balanced

	Twisted-Pair Cabling
TIA-455-21	(1988a; R 2012) FOTP-21 - Mating Durability of Fiber Optic Interconnecting Devices
TIA-526-14	(2010b) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
TIA-526-7	(2002; R 2008) OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode 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) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568-C.3	(2008; Add 1 2011) Optical Fiber Cabling Components Standard
TIA-569	(2012c; Addendum 1 2013; Errata 2013) Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-570	(2012c) Residential Telecommunications Infrastructure Standard
TIA-606	(2012b) Administration Standard for the Telecommunications Infrastructure
TIA-607	(2011b) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA/EIA-598	(2005c) Optical Fiber Cable Color Coding
TIA/EIA-604-10	(2002a) FOCIS 10 Fiber Optic Connector Intermateability Standard - Type LC
TIA/EIA-604-12	(2000) FOCIS 12 Fiber Optic Connector Intermateability Standard Type MT-RJ
TIA/EIA-604-2	(2004b; R 2014) FOCIS 2 Fiber Optic Connector Intermateability Standard
TIA/EIA-604-3	(2004b; R 2014) Fiber Optic Connector Intermateability Standard (FOCIS), Type SC and SC-APC, FOCIS-3

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 68	Connection of Terminal Equipment to the Telephone Network (47 CFR 68)

UNDERWRITERS LABORATORIES (UL)

UL 1286	(2008; Reprint Sep 2013) 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 Nov 2012) Communication Circuit Accessories
UL 444	(2008; Reprint Apr 2010) Communications Cables
UL 467	(2007) Grounding and Bonding Equipment
UL 50	(2007; Reprint Apr 2012) Enclosures for Electrical Equipment, Non-environmental Considerations
UL 514C	(1996; Reprint Nov 2011) Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 723	(2008; Reprint Aug 2013) Test for Surface Burning Characteristics of Building Materials
UL 969	(1995; Reprint Nov 2008) Standard for Marking and Labeling Systems

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 The following shall be submitted 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.

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

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, and FD's to the telecommunications work area outlets. 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.

1.6.2 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 of 32 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 in hard copy format on electronic media using Windows based computer cable management software. 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 only the required data fieldsin 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.

2.3 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.

2.3.1 Horizontal Cabling

Provide horizontal cable in compliance with NFPA 70 and performance

characteristics in accordance with TIA-568-C.1.

2.3.1.1 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 . Provide four each individually twisted pair, minimum size 24 AWG conductors, Category 6, with a blue thermoplastic jacket. 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 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. Cables installed in conduit within and under slabs shall be UL listed and labeled for wet locations in accordance with NFPA 70.

2.3.1.2 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.

2.4 TELECOMMUNICATIONS SPACES

Provide connecting hardware and termination equipment in the telecommunications entrance facility and telecommunication equipment rooms 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.

2.4.1 Patch Panels

Provide ports for the number of horizontal and backbone cables terminated on the panel plus 25 percent spare. Provide pre-connectorized optical fiber and copper patch cords for patch panels. Provide patch cords, as complete assemblies, with matching connectors as specified. Provide fiber optic patch cables with crossover orientation in accordance with TIA-568-C.3. 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.

2.4.1.1 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 EIA/TIACategory 6 requirements. Panel shall be constructed of 0.09 inches minimum aluminum and shall be rack mounted and compatible with an ECA EIA/ECA 310 19 inches equipment cabinet. Panel shall provide 48 non-keyed, 8-pin modular ports, wired to T568AT568B. Patch panels shall terminate the building cabling on Type 110

IDCs and shall utilize a printed circuit board interface. The rear of each panel shall have incoming cable strain-relief and routing guides. Panels shall have each port factory numbered and be equipped with laminated plastic nameplates above each port.

2.4.1.2 Fiber Optic Patch Panel

Provide panel for maintenance and cross-connecting of optical fiber cables. Panel shall be constructed of 16 gauge steel minimum and shall be rack mounted and compatible with a ECA EIA/ECA 310 19 inches equipment rack. Each panel shall provide 12 single-mode adapters as duplex SC in accordance with TIA/EIA-604-3 with zirconia ceramic alignment sleeves. 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 and routing guides. Panels shall have each adapter factory numbered and be equipped with laminated plastic nameplates above each adapter.

2.5 TELECOMMUNICATIONS OUTLET/CONNECTOR ASSEMBLIES

2.5.1 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, 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 6 requirements. Outlet/connectors provided for 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 for 200 mating cycles.

2.5.2 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.

2.5.3 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 with8/125 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.

2.5.4 Cover Plates

Telecommunications cover plates shall comply with UL 514C, and TIA-568-C.1, , ; 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.

2.6 GROUNDING AND BONDING PRODUCTS

Provide in accordance with UL 467, TIA-607, and NFPA 70. Components shall be identified as required by TIA-606. Provide ground rods, bonding

conductors, and grounding busbars as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.7 FIRESTOPPING MATERIAL

Provide as specified in Section 07 84 00 FIRESTOPPING.

2.8 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.

2.9 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.

2.10 TESTS, INSPECTIONS, AND VERIFICATIONS

2.10.1 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

Install telecommunications cabling and pathway systems, including the horizontal and backbone cable, pathway systems, telecommunications outlet/connector assemblies, and associated hardware in accordance with NECA/BICSI 568, TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, TIA-569, NFPA 70, and UL standards as applicable. Provide cabling in a star topology network. Pathways and outlet boxes shall be installed as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Install telecommunications cabling with copper media in accordance with the following criteria to avoid potential electromagnetic interference between power and telecommunications equipment. The interference ceiling shall not exceed 3.0 volts per meter measured over the usable bandwidth of the telecommunications cabling.

3.1.1 Cabling

Install UTP, and optical fiber telecommunications cabling system as detailed in TIA-568-C.1, TIA-568-C.2, TIA-568-C.3. Screw terminals shall not be used except where specifically indicated on plans. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations. Do not exceed manufacturers' cable pull tensions for copper and optical fiber cables. Provide a device to monitor cable pull tensions. Do not exceed 25 pounds 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 crush cables with staples. For UTP cable, bend radii shall not be less than four times the cable diameter. Cables shall be terminated; no cable shall contain unterminated elements. Cables shall not be spliced. Label cabling in accordance with paragraph LABELING in this section.

3.1.1.1 Horizontal Cabling

Install horizontal cabling as indicated on drawings Do not untwist Category 6 UTP cables more than one half inch from the point of termination to maintain cable geometry. Provide slack cable in the form of a figure eight (not a service loop) on each end of the cable, 10 feet in the telecommunications room, and 12 inches in 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.

3.1.3 Work Area Outlets

3.1.3.1 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

3.1.3.2 Cover Plates

As a minimum, each outlet/connector shall be labeled as to its function and a unique number to identify cable link in accordance with the paragraph LABELING in this section.

3.1.3.3 Cables

Unshielded twisted pair and fiber optic cables shall have a minimum of 12 inches of slack cable loosely coiled into the telecommunications outlet boxes. Minimum manufacturer's bend radius for each type of cable shall not be exceeded.

3.1.3.4 Pull Cords

Pull cords shall be installed in conduit serving telecommunications outlets that do not have cable installed.

3.1.4 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings as specified in Section 07 84 00 FIRESTOPPING.

3.1.5 Grounding and Bonding

Provide in accordance with TIA-607, NFPA 70 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.2 LABELING

3.2.1 Labels

Provide labeling in accordance with TIA-606. Handwritten labeling is unacceptable. Stenciled lettering for voice and data circuits shall be provided using thermal ink transfer process .

3.2.2 Cable

Cables shall be labeled using color labels on both ends 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.

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, TIA-568-C.3. Test equipment shall conform to TIA-1152. 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.

3.5.1.1 Inspection

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 T568A or T568B pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, . Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, 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 prior to being cross-connected.

For single-mode optical fiber, perform optical fiber end-to-end attenuation tests in accordance with TIA-568-C.3 and TIA-526-7 using Method A, Optical Power Meter and Light Source for single-mode optical fiber. Perform verification acceptance tests.

3.5.1.3 Performance Tests

Perform testing for each outlet and MUTOA as follows:

a. Perform Category 6 link tests in accordance with TIA-568-C.1 and TIA-568-C.2. Tests shall include wire map, length, insertion loss, NEXT, PSNEXT, ELFEXT, PSELFEXT, return loss, propagation delay, and delay skew.

. Optical fiber Links. Perform optical fiber end-to-end link tests in accordance with TIA-568-C.3.

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.

a. Voice Tests. These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and DSN telephone call.

b. Data Tests. These tests assume the Information Technology Staff has a network installed and are available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

-- End of Section --

SECTION 31 23 00.00 20

EXCAVATION AND FILL

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.

ASTM INTERNATIONAL (ASTM)

ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM D1140	(2000; R 2006) Amount of Material in Soils Finer than the No. 200 Sieve
ASTM D1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3)
ASTM D1883	(2007; E 2009; E 2009) CBR (California Bearing Ratio) of Laboratory-Compacted Soils
ASTM D2434	(1968; R 2006) Permeability of Granular Soils (Constant Head)
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D3786/D3786M	(2013) Hydraulic Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method
ASTM D422	(1963; R 2007; E 2014; E 2014) Particle-Size Analysis of Soils
ASTM D4318	(2010; E 2014) Liquid Limit, Plastic

	Limit, and Plasticity Index of Soils
ASTM D4355	(2007) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4491	(1999a; R 2014; E 2014) Water Permeability of Geotextiles by Permittivity
ASTM D4533	(2011) Trapezoid Tearing Strength of Geotextiles
ASTM D4632/D4632M	(2008; R 2013; E 2013; E 2014) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2012) Determining Apparent Opening Size of a Geotextile
ASTM D4759	(2011) Determining the Specification Conformance of Geosynthetics
ASTM D4833/D4833M	(2007; E 2013; R 2013) Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
ASTM D6938	(2010) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D698	(2012; E 2014) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft.

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA SW-846.3-3	(1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-203	(Rev C; Notice 3) Paper, Kraft, Untreated

1.2 DEFINITIONS

1.2.1 Degree of Compaction

Degree of compaction is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557, for general soil types, abbreviated as percent laboratory maximum density.

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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Shoring and Sheeting Plan

Dewatering work plan

Submit 15 days prior to starting work.

SD-06 Test Reports

Borrow Site Testing; G

Fill and backfill test

Select material test

Density tests

Moisture Content Tests

Copies of all laboratory and field test reports within 24 hours of the completion of the test.

1.4 DELIVERY, STORAGE, AND HANDLING

Perform in a manner to prevent contamination or segregation of materials.

1.5 CRITERIA FOR BIDDING

Base bids on the following criteria:

a. Surface elevations are as indicated.

b. Pipes or other artificial obstructions, except those indicated, will not be encountered.

c. Ground water elevations indicated by the boring log were those existing at the time subsurface investigations were made and do not necessarily represent ground water elevation at the time of construction.

e. Material character is indicated by the boring logs.

f. Hard materials and rock will not be encountered .

g. Borrow material Suitable backfill and bedding material in the quantities required are not available at the project site

h. Blasting will not be permitted. Remove material in an approved manner.

1.6 REQUIREMENTS FOR OFF SITE SOIL

Soils brought in from off site for use as backfill shall be tested for petroleum hydrocarbons, BTEX, PCBs and HW characteristics (including toxicity, ignitability, corrosivity, and reactivity). Backfill shall not

contain concentrations of these analytes above the appropriate State and/or EPA criteria, and shall pass the tests for HW characteristics. Determine petroleum hydrocarbon concentrations by using appropriate State protocols. Determine BTEX concentrations by using EPA SW-846.3-3 Method 5035/8260B. Perform complete TCLP in accordance with EPA SW-846.3-3 Method 1311. Perform HW characteristic tests for ignitability, corrosivity, and reactivity in accordance with accepted standard methods. Perform PCB testing in accordance with accepted standard methods for sampling and analysis of bulk solid samples. Provide borrow site testing for petroleum hydrocarbons and BTEX from a grab sample of material from the area most likely to be contaminated at the borrow site (as indicated by visual or olfactory evidence), with at least one test from each borrow site. For each borrow site, provide borrow site testing for HW characteristics from a composite sample of material, collected in accordance with standard soil sampling techniques. Do not bring material onsite until tests results have been received and approved by the Contracting Officer.

1.7 QUALITY ASSURANCE

1.7.1 Shoring and Sheeting Plan

Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations. Drawings shall include material sizes and types, arrangement of members, and the sequence and method of installation and removal. Calculations shall include data and references used.

The Contractor is required to hire a Professional Geotechnical Engineer to provide inspection of excavations and soil/groundwater conditions throughout construction. The Geotechnical Engineer shall be responsible for performing pre-construction and periodic site visits throughout construction to assess site conditions. The Geotechnical Engineer shall update the excavation, sheeting and dewatering plans as construction progresses to reflect changing conditions and shall submit an updated plan if necessary. A written report shall be submitted, at least monthly, informing the Contractor and Contracting Officer of the status of the plan and an accounting of the Contractor's adherence to the plan addressing any present or potential problems. The Geotechnical Engineer shall be available to meet with the Contracting Officer at any time throughout the contract duration.

1.7.2 Dewatering Work Plan

Submit procedures for accomplishing dewatering work.

1.7.3 Utilities

Movement of construction machinery and equipment over pipes and utilities during construction shall be at the Contractor's risk. Perform work adjacent to non-Government utilities as indicated in accordance with procedures outlined by utility company. Excavation made with power-driven equipment is not permitted within two feet of known Government-owned utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted

by the Contracting Officer. Report damage to utility lines or subsurface construction immediately to the Contracting Officer.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

2.1.1 Satisfactory Materials

Any materials classified by ASTM D2487 as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, SM, SW-SM, SC, free of debris, roots, wood, scrap material, vegetation, refuse, soft unsound particles, and frozen, deleterious, or objectionable materials. Unless specified otherwise, the maximum particle diameter shall be one-half the lift thickness at the intended location.

2.1.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials. Unsatisfactory materials also include man-made fills, trash, refuse, or backfills from previous construction. Unsatisfactory material also includes material classified as satisfactory which contains root and other organic matter, frozen material . The Contracting Officer shall be notified of any contaminated materials.

2.1.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in ASTM D2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM, and SM shall be identified as cohesionless only when the fines are nonplastic (plasticity index equals zero). Materials classified as GM and SM will be identified as cohesive only when the fines have a plasticity index greater than zero.

2.1.4 Common Fill

Approved, unclassified soil material with the characteristics required to compact to the soil density specified for the intended location.

2.1.5 Backfill and Fill Material

ASTM D2487, classification GW, GP, GM, SW, SP, SM, with a maximum ASTM D4318 liquid limit of 20 , maximum ASTM D4318 plasticity index of 6 , and a maximum of 25 percent by weight passing ASTM D1140, No. 200 sieve.

2.1.6 Topsoil

Natural, friable soil representative of productive, well-drained soils in the area, free of subsoil, stumps, rocks larger than one inch diameter, brush, weeds, toxic substances, and other material detrimental to plant growth. Amend topsoil pH range to obtain a pH of 5.5 to 7.

2.2 UTILITY BEDDING MATERIAL

Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Backfill to top of pipe shall be compacted to 95

percent of ASTM D698 maximum density. Plastic piping shall have bedding to spring line of pipe. Provide ASTM D2321 materials as follows:

a. Class I: Angular, 0.25 to 1.5 inches, graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.

b. Class II: Coarse sands and gravels with maximum particle size of 1.5 inches, including various graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class as specified in ASTM D2487.

2.2.1 Sand

Clean, coarse-grained sand classified as or SW or SP by ASTM D2487 for bedding and backfill as indicated.

2.2.2 Gravel

Clean, coarsely graded natural gravel, crushed stone or a combination thereof or having a classification of GW or GP in accordance with ASTM D2487 for bedding and backfill as indicated. Maximum particle size shall not exceed 3 inches.

2.3 BORROW

Obtain borrow materials required in excess of those furnished from excavations from sources outside of Government property.

2.4 BACKFILL FOR UNDERDRAINAGE SYSTEMS

Clean sand, crushed rock, or gravel meeting the following requirements:

a. Perforated or Slotted-Wall Pipe: Backfill meeting requirements of Type I material as specified in Table 1.

d. Any Type Drain Used With Filter Fabric: Clean gravel or crushed stone or gravel conforming to ASTM C33 coarse aggregate grading size 57, 67, or 7 Type II material as specified in Table 1.

TABLE 1			
		Type II Gradation 57 ASTM C33/C33M	
ASTM D422 Sieve Size		Percent Passing	
1.5 inches		100	
1 inch		90 - 100	
3/8 inch		25 - 60	
No. 4		5 - 40	
No. 8		0 - 20	

2.5 FILTER FABRIC

Provide a pervious sheet of polyester, nylon, glass or polypropylene , ultraviolet resistant filaments woven, spun bonded, fused, or otherwise manufactured into a nonraveling fabric with uniform thickness and strength. Fabric shall have the following manufacturer certified minimum average roll properties as determined by ASTM D4759:

	Class A	
a. Grab tensile strength (ASTM D4632/) machine and transversed direction	min. 180	
b. Grab elongation (ASTM D4632/) machine and transverse direction	min. 15	

	Class A	
c. Puncture resistance (ASTM D4833/)	min. 80	
d. Mullen burst strength (ASTM D3786/D3786M)	min. 290	
e. Trapezoidal Tear (ASTM D4533)	min. 50	
f. Apparent Opening Size (ASTM D4751)	min. 40	
g. Permeability (ASTM D4491)	Bedding material, filter fabric, and rock	
h. Ultraviolet Degradation (ASTM D4355)	70 percent Strength retained at 150 hours	

2.6 MATERIAL FOR PIPE CASING

2.6.1 Casing Pipe

ASTM A139/A139M, Grade B, or ASTM A252, Grade 2, smooth wall pipe. Casing size shall be of the outside diameter and wall thickness as indicated. Protective coating is not required on casing pipe.

2.7 MATERIAL FOR RIP-RAP

Bedding material Filter fabric and rock conforming to DOT or State Standard for construction indicated.

2.7.1 Bedding Material

Consisting of sand, gravel, or crushed rock, well graded, with a maximum particle size of 2 inches. Material shall be composed of tough, durable particles. Fines passing the No. 200 standard sieve shall have a plasticity index less than six.

2.7.2 Grout

Composed of cement, water, an air-entraining admixture, and sand mixed in proportions of one part portland cement to two parts of sand, sufficient water to produce a workable mixture, and an amount of admixture which will entrain sufficient air to produce durable grout, as determined by the Contracting Officer. Mix grout in a concrete mixer. Mixing time shall be

sufficient to produce a mixture having a consistency permitting gravity flow into the interstices of the rip-rap with limited spading and brooming.

2.7.3 Rock

Rock fragments sufficiently durable to ensure permanence in the structure and the environment in which it is to be used. Rock fragments shall be free from cracks, seams, and other defects that would increase the risk of deterioration from natural causes. The size of the fragments shall be such that no individual fragment exceeds a weight of 150 pounds and that no more than 10 percent of the mixture, by weight, consists of fragments weighing 2 pounds or less each. Specific gravity of the rock shall be a minimum of 2.50 . The inclusion of more than trace quantities of dirt, sand, clay, and rock fines will not be permitted.

2.8 BURIED WARNING AND IDENTIFICATION TAPE

Polyethylene plastic and metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inch minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Color and printing shall be permanent, unaffected by moisture or soil.

Warning Tape Color Codes	
Red:	Electric
Yellow:	Gas, Oil; Dangerous Materials
Orange:	Telephone and Other Communications
Blue:	Potable Water Systems
Green:	Sewer Systems
White:	Steam Systems
Gray:	Compressed Air

2.8.1 Warning Tape for Metallic Piping

Acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above. Minimum thickness of tape shall be 0.003 inch. Tape shall have a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.8.2 Detectable Warning Tape for Non-Metallic Piping

Polyethylene plastic tape conforming to the width, color, and printing

requirements specified above. Minimum thickness of the tape shall be 0.004 inch. Tape shall have a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Tape shall be manufactured with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.9 DETECTION WIRE FOR NON-METALLIC PIPING

Detection wire shall be insulated single strand, solid copper with a minimum of 12 AWG.

PART 3 EXECUTION

3.1 PROTECTION

3.1.1 Shoring and Sheeting

Provide shoring bracing cribbing trench boxes underpinning and/or sheeting . In addition to Section 25 A and B of EM 385-1-1 and other requirements set forth in this contract, include provisions in the shoring and sheeting plan that will accomplish the following:

a. Prevent undermining of pavements, foundations and slabs.

b. Prevent slippage or movement in banks or slopes adjacent to the excavation.

c. Allow for the abandonment of shoring and sheeting materials in place in critical areas as the work is completed. In these areas, backfill the excavation to the elevation indicated and remove the remaining exposed portion of the shoring before completing the backfill.

3.1.2 Drainage and Dewatering

Provide for the collection and disposal of surface and subsurface water encountered during construction.

3.1.2.1 Drainage

So that construction operations progress successfully, completely drain construction site during periods of construction to keep soil materials sufficiently dry. The Contractor shall establish/construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and/or provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils, prevent erosion and undermining of foundations. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed. Excavated slopes and backfill surfaces shall be protected to prevent erosion and sloughing. Excavation shall be performed so that the site, the area immediately surrounding the site, and the area affecting operations at the site shall be continually and effectively drained.

3.1.2.2 Dewatering

Groundwater flowing toward or into excavations shall be controlled to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. French drains, sumps, ditches or trenches will not be permitted within 3 feet of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Control measures shall be taken by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, the water level shall be maintained continuously, at least 1 foot below the working level.

Operate dewatering system continuously until construction work below existing water levels is complete. Submit performance records weekly. Measure and record performance of dewatering system at same time each day by use of observation wells or piezometers installed in conjunction with the dewatering system.

3.1.3 Underground Utilities

Location of the existing utilities indicated is approximate. The Contractor shall physically verify the location and elevation of the existing utilities indicated prior to starting construction. The Contractor shall scan the construction site with electromagnetic and sonic equipment and mark the surface of the ground where existing underground utilities are discovered.

3.1.4 Machinery and Equipment

Movement of construction machinery and equipment over pipes during construction shall be at the Contractor's risk. Repair, or remove and provide new pipe for existing or newly installed pipe that has been displaced or damaged.

3.2 SURFACE PREPARATION

3.2.1 Clearing and Grubbing

Unless indicated otherwise, remove trees, stumps, logs, shrubs, brush and vegetation and other items that would interfere with construction operations within the clearing limits . Remove stumps entirely. Grub out matted roots and roots over 2 inches in diameter to at least 18 inches below existing surface.

3.2.2 Stripping

Strip suitable soil from the site where excavation or grading is indicated and stockpile separately from other excavated material. Material unsuitable for use as topsoil shall be wasted . Locate topsoil so that the material can be used readily for the finished grading. Where sufficient existing topsoil conforming to the material requirements is not available on site, provide borrow materials suitable for use as topsoil. Protect topsoil and keep in segregated piles until needed.

3.2.3 Unsuitable Material

Remove vegetation, debris, decayed vegetable matter, sod, mulch, and

rubbish underneath paved areas or concrete slabs.

3.3 EXCAVATION

Excavate to contours, elevation, and dimensions indicated. Reuse excavated materials that meet the specified requirements for the material type required at the intended location. Keep excavations free from water. Excavate soil disturbed or weakened by Contractor's operations, soils softened or made unsuitable for subsequent construction due to exposure to weather. Excavations below indicated depths will not be permitted except to remove unsatisfactory material. Unsatisfactory material encountered below the grades shown shall be removed as directed. Refill with backfill and fill material and compact to 95 percent of ASTM D698 or ASTM D1557 maximum density. Satisfactory material removed below the depths indicated, without specific direction of the Contracting Officer, shall be replaced with satisfactory materials to the indicated excavation grade; except as specified for spread footings. Determination of elevations and measurements of approved overdepth excavation of unsatisfactory material below grades indicated shall be done under the direction of the Contracting Officer.

3.3.1 Pipe Trenches

Excavate to the dimension indicated. Grade bottom of trenches to provide uniform support for each section of pipe after pipe bedding placement. Tamp if necessary to provide a firm pipe bed. Recesses shall be excavated to accommodate bells and joints so that pipe will be uniformly supported for the entire length. Rock, where encountered, shall be excavated to a depth of at least 6 inches below the bottom of the pipe.

3.3.2 Hard Material Excavation

Remove hard material to elevations indicated in a manner that will leave foundation material in an unshattered and solid condition. Roughen level surfaces and cut sloped surfaces into benches for bond with concrete. Removal of hard material beyond lines and grades indicated will not be grounds for a claim for additional payment unless previously authorized by the Contracting Officer. Excavation of the material claimed as rock shall not be performed until the material has been cross sectioned by the Contractor and approved by the Contracting Officer. Common excavation shall consist of all excavation not classified as rock excavation.

3.3.3 Excavated Materials

Satisfactory excavated material required for fill or backfill shall be placed in the proper section of the permanent work required or shall be separately stockpiled if it cannot be readily placed. Satisfactory material in excess of that required for the permanent work and all unsatisfactory material shall be disposed of as specified in Paragraph "DISPOSITION OF SURPLUS MATERIAL."

3.3.4 Final Grade of Surfaces to Support Concrete

Excavation to final grade shall not be made until just before concrete is to be placed.

3.4 SUBGRADE PREPARATION

Unsatisfactory material in surfaces to receive fill or in excavated areas

shall be removed and replaced with satisfactory materials as directed by the Contracting Officer. The surface shall be scarified to a depth of 6 inches before the fill is started. Sloped surfaces steeper than 1 vertical to 4 horizontal shall be plowed, stepped, benched, or broken up so that the fill material will bond with the existing material. When subgrades are less than the specified density, the ground surface shall be broken up to a minimum depth of 6 inches, pulverized, and compacted to the specified density. When the subgrade is part fill and part excavation or natural ground, the excavated or natural ground portion shall be scarified to a depth of 12 inches and compacted as specified for the adjacent fill. Material shall not be placed on surfaces that are muddy, frozen, or contain frost. Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Material shall be moistened or aerated as necessary to plus or minus 3 percent of to provide the moisture. Minimum subgrade density shall be as specified herein.

3.4.1 Proof Rolling

Proof rolling shall be done on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. After stripping, proof roll the existing subgrade of the airfield pavement area with six passes of a dump truck loaded with 212 cubic feet of soil. Operate the truck in a systematic manner to ensure the number of passes over all areas, and at speeds between 2 1/2 to 3 1/2 miles per hour. Notify the Contracting Officer a minimum of 3 days prior to proof rolling. Proof rolling shall be performed in the presence of the Contracting Officer or his designated representative. Rutting or pumping of material shall be undercut as directed by the Contracting Officer and replaced with suitable material in accordance with the established Contract Unit Prices.

3.5 SUBGRADE FILTER FABRIC

Place synthetic fiber filter fabric as indicated directly on prepared subgrade free of vegetation, stumps, rocks larger than 2 inches diameter and other debris which may puncture or otherwise damage the fabric. Repair damaged fabric by placing an additional layer of fabric to cover the damaged area a minimum of 3 feet overlap in all directions. Overlap fabric at joints a minimum of 3 feet. Obtain approval of filter fabric installation before placing fill or backfill. Place fill or backfill on fabric in the direction of overlaps and compact as specified herein. Follow manufacturer's recommended installation procedures.

3.6 FILLING AND BACKFILLING

Fill and backfill to contours, elevations, and dimensions indicated. Compact each lift before placing overlaying lift.

3.6.1 Common Fill Placement

Provide for general site .Use satisfactory materials. Place in 6 inch lifts. Compact areas not accessible to rollers or compactors with mechanical hand tampers. Aerate material excessively moistened by rain to a satisfactory moisture content. Finish to a smooth surface by blading, rolling with a smooth roller, or both.

3.6.2 Backfill and Fill Material Placement

Provide for paved areas and under concrete slabs, except where select material is provided. Place in 6 inch lifts. Do not place over wet or frozen areas. Place backfill material adjacent to structures as the structural elements are completed and accepted. Backfill against concrete only when approved. Place and compact material to avoid loading upon or against the structure.

3.6.3 Select Material Placement

Place in 6 inch lifts. Do not place over wet or frozen areas. Backfill adjacent to structures shall be placed as structural elements are completed and accepted. Backfill against concrete only when approved. Place and compact material to avoid loading upon or against structure.

3.6.4 Backfill and Fill Material Placement Over Pipes and at Walls

Backfilling shall not begin until construction below finish grade has been approved, underground utilities systems have been inspected, tested and approved, forms removed, and the excavation cleaned of trash and debris. Backfill shall be brought to indicated finish grade . . Heavy equipment for spreading and compacting backfill shall not be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; the area remaining shall be compacted in layers not more than 4 inches in compacted thickness with power-driven hand tampers suitable for the material being compacted. Backfill shall be placed carefully around pipes or tanks to avoid damage to coatings, wrappings, or tanks. Backfill shall not be placed against foundation walls prior to 7 days after completion of the walls. As far as practicable, backfill shall be brought up evenly on each side of the wall and sloped to drain away from the wall.

3.6.5 Trench Backfilling

Backfill as rapidly as construction, testing, and acceptance of work permits. Place and compact backfill under structures and paved areas in 6 inch lifts to top of trench and in 6 inch lifts to one foot over pipe outside structures and paved areas.

3.7 BORROW

Where satisfactory materials are not available in sufficient quantity from required excavations, approved borrow materials shall be obtained as specified herein.

3.8 BURIED WARNING AND IDENTIFICATION TAPE

Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade.

3.9 BURIED DETECTION WIRE

Bury detection wire directly above non-metallic piping at a distance not to exceed 12 inches above the top of pipe. The wire shall extend continuously and unbroken, from manhole to manhole. The ends of the wire shall terminate inside the manholes at each end of the pipe, with a minimum of 3 feet of wire, coiled, remaining accessible in each manhole.

The wire shall remain insulated over it's entire length. The wire shall enter manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, the wire shall terminate in the valve pit at the pump station end of the pipe.

3.10 COMPACTION

Determine in-place density of existing subgrade; if required density exists, no compaction of existing subgrade will be required. Density requirements specified herein are for cohesionless materials. When cohesive materials are encountered or used, density requirements may be reduced by 5 percent.

3.10.1 General Site

Compact underneath areas designated for vegetation and areas outside the 5 foot line of the paved area or structure to 90 percent of ASTM D1557.

3.10.2 Structures, Spread Footings, and Concrete Slabs

Compact top 12 inches of subgrades to 95 percent of ASTM D1557. Compact fill and backfill material select material to 95 percent of ASTM D1557.

3.10.3 Paved Areas

Compact top 12 inches of subgrades to 95 percent of ASTM D1557. Compact fill and backfill materials to 95 percent of ASTM D1557.

3.10.4 Airfield Pavements

Compact top 24 inches below finished pavement or top 12 inches of subgrades, whichever is greater, to 100 percent of ASTM D1557; compact fill and backfill material to 100 percent of ASTM D1557.

3.11 PIPELINE CASING UNDER PAVEMENT

Provide new smooth wall steel pipeline casing under existing pavement by the boring and jacking method of installation. Provide each new pipeline casing, where indicated and to the lengths and dimensions shown, complete and suitable for use with the new piped utility as indicated.

3.11.1 Earthwork for Pipeline Casings

Provide excavation, sheet piling, shoring, dewatering, and backfilling for pipeline casings under this section.

3.11.2 Steel Cased Pipelines

Install pipeline casing by dry boring and jacking method as follows:

3.11.2.1 Hole for Pipeline Casing

Mechanically bore holes and case through the soil with a cutting head on a continuous auger mounted inside the casing pipe. Weld lengths of pipe together in accordance with AWS D1.1/D1.1M. Do not use water or other fluids in connection with the boring operation.

3.11.2.2 Cleaning

Clean inside of the pipeline casing of dirt, weld splatters, and other foreign matter which would interfere with insertion of the piped utilities by attaching a pipe cleaning plug to the boring rig and passing it through the pipe.

3.11.2.3 Piped Utilities

Provide in casing using wood supports adjusted to obtained grades and elevations indicated.

3.11.2.4 End Seals

After installation of piped utilities in pipeline casing, provide watertight end seals at each end of pipeline casing between pipeline casing and piping utilities. P

3.12 SPECIAL EARTHWORK REQUIREMENTS FOR SUBSURFACE DRAINS

Excavate to dimensions indicated. Provide a bedding surface of no more than one inch of sandor gravel and place on compacted native soil as indicated. Backfill around and over the pipes after pipe installation has been approved. Place special granular filter material in 6 inch lifts and compact with mechanical, vibrating plate tampers or rammers until no further consolidation can be achieved. Compact backfill overlying the special granular filter material as specified for adjacent or overlying work.

3.12.1 Granular Backfill Using Filter Fabric

3.12.1.1 Perforated or Slotted Wall Pipes

Wrap one layer of filter fabric around pipe in such a manner that longitudinal overlaps are in unperforated or unslotted quadrants of the pipe. Overlap fabric a minimum of 2 inches. Secure fabric to pipe so that backfill material does not infiltrate through overlaps. Place granular material and extend it for one pipe diameter, minimum of 6 inches on each side of and 18 inches above top of pipe. Place a layer of filter fabric on top of granular filter before continuing with backfill.

3.13 RIP-RAP CONSTRUCTION

Construct rip-rap on filter fabric in accordance with State Standard, in the areas indicated.

3.13.1 Preparation

Trim and dress indicated areas to conform to cross sections, lines and grades shown within a tolerance of 0.1 foot.

3.13.2 Bedding Placement

Spread filter fabric on prepared subgrade as indicated.

3.13.3 Stone Placement

Place rock for filter fabric on prepared bedding material to produce a well graded mass with the minimum practicable percentage of voids in

conformance with lines and grades indicated. Distribute larger rock fragments, with dimensions extending the full depth of the rip-rap throughout the entire mass and eliminate "pockets" of small rock fragments. Rearrange individual pieces by mechanical equipment or by hand as necessary to obtain the distribution of fragment sizes specified above.

3.14 FINISH OPERATIONS

3.14.1 Grading

Finish grades as indicated within one-tenth of one foot. Grade areas to drain water away from structures. Maintain areas free of trash and debris. For existing grades that will remain but which were disturbed by Contractor's operations, grade as directed.

3.14.2 Topsoil and Seed

Scarify existing subgrade. Provide 4 inches of topsoil for newly graded finish earth surfaces and areas disturbed by the Contractor. Topsoil shall not be placed when the subgrade is frozen, excessively wet, extremely dry, or in a condition otherwise detrimental to seeding, planting, or proper grading. If there is insufficient on-site topsoil meeting specified requirements for topsoil, provide topsoil required in excess of that available. Seed shall match existing vegetation. Provide seed at 5 pounds per 1000 square feet. Provide as follows:

Fertilzer (CID-A-A-1909), Type I, Class 2, 10-10-10 at 25 pounds per sq. ft.
Commercial agriculture limestone of 94-80-14 analysis at 70 pounds per 1000 sq. ft.

Provide mulch and water to establish an acceptable stand of grass.

3.14.3 Protection of Surfaces

Protect newly backfilled, graded, and topsoiled areas from traffic, erosion, and settlements that may occur. Repair or reestablish damaged grades, elevations, or slopes.

3.15 DISPOSITION OF SURPLUS MATERIAL

Remove from Government property surplus or other soil material not required or suitable for filling or backfilling, and brush, refuse, stumps, roots, and timber.

3.16 FIELD QUALITY CONTROL

3.16.1 Sampling

Take the number and size of samples required to perform the following tests.

3.16.2 Testing

Perform one of each of the following tests for each material used. Provide additional tests for each source change.

3.16.2.1 Fill and Backfill Material Testing

Test fill and backfill material in accordance with ASTM C136 for conformance to ASTM D2487 gradation limits; ASTM D1140 for material finer than the No. 200 sieve; ASTM D4318 for liquid limit and for plastic limit; ASTM D698 or ASTM D1557 for moisture density relations, as applicable.

3.16.2.2 Select Material Testing

Test select material in accordance with ASTM C136 for conformance to ASTM D2487 gradation limits; ASTM D1140 for material finer than the No. 200 sieve; ASTM D698 or ASTM D1557 for moisture density relations, as applicable.

3.16.2.3 Density Tests

Test density in accordance with ASTM D1556, or ASTM D6938. When ASTM D6938 density tests are used, verify density test results by performing an ASTM D1556 density test at a location already ASTM D6938 tested as specified herein. Perform an ASTM D1556 density test at the start of the job, and for every 10 ASTM D6938 density tests thereafter. Test each lift at randomly selected locations every 2000 square feet of existing grade in fills for structures and concrete slabs, and every 2500 square feet for other fill areas and every 2000 square feet of subgrade in cut. Include density test results in daily report.

Bedding and backfill in trenches: One test per 100 linear feet in each lift.

3.16.2.4 Moisture Content Tests

In the stockpile, excavation or borrow areas, a minimum of two tests per day per type of material or source of materials being placed is required during stable weather conditions. During unstable weather, tests shall be made as dictated by local conditions and approved moisture content shall be tested in accordance with ASTM D2216. Include moisture content test results in daily report.

-- End of Section --

SECTION 32 01 11.51

RUBBER AND PAINT REMOVAL FROM AIRFIELD PAVEMENTS

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. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910 Occupational Safety and Health Standards

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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

paint removal samples

SD-07 Certificates

Schedule of work

High-pressure rubber and paint removal equipment

1.3 RADIO COMMUNICATION

No personnel or equipment will be allowed on the runway until radio contact has been made with the Control Tower and permission is granted by the Control Tower. A radio for this purpose will be required of the Contractor and approved by the Contracting Officer. The Contractor shall be in contact with the Control Tower at all times during the removal work.

1.4 EMERGENCY LANDINGS AND TAKEOFF

Emergencies shall take precedence over all Contractor operations. Upon notification from the Control Tower of emergency landing or imminent takeoff, all operations shall be stopped immediately and all personnel and equipment evacuated to an area not utilized for aircraft traffic which is at least 200 feet measured perpendicular to and away from the near edge of the runway. Equipment shall be able to clear the work area within 3 minutes.

1.5 ENVIRONMENTAL CONDITIONS

Do not perform work when the temperature is below 40 degrees F, during lightning storms, or when the pavement is covered with snow or ice.

1.6 SAFETY

Comply with OSHA 29 CFR 1910.

1.7 SCHEDULE

1.7.1 Schedule of Work

Submit a schedule of work to the Contracting Officer for transmittal to the Operations Officer. Describe the work to be accomplished; noting the location of work, distances from the ends of runways, taxiways, buildings, and other structures; and indicating dates and hours during which the work will be accomplished. Schedule the work to conform to aircraft operating schedules. The Government will try to schedule aircraft operations so as to permit the maximum amount of time for the Contractor's work. However, in the event of any emergency, intense operational demands, adverse wind conditions, and other unforeseen difficulties, discontinue all work at locations in the aircraft operational area. Keep the approved schedule of work current and notify the Contracting Officer of any changes prior to beginning each day's work.

1.8 EQUIPMENT

1.8.1 Equipment Data

Submit descriptive data of removal equipment including area of coverage per pass, range of water pressures, and water tank capacity.

1.9 QUALITY ASSURANCE

1.9.1 Required Samples

Prior to the start of work, remove paint on designated test areas not less than 50 feet in length. Use procedures, water pressures, nozzle height, nozzle spacings, nozzle angle, and equipment movement rate to achieve the required degree of paint removal in accordance with the paragraph entitled "Execution." Submit the test results before any further removal work will be allowed.

PART 2 PRODUCTS

2.1 MATERIALS

Water to be used for high-pressure water equipment will be made available from Government hydrants as shown on the drawings, at the prevailing rates. Furnish all equipment and labor for delivery of water from the hydrant to the job site. Notify the Contracting Officer on location of fire hydrants to be used and the respective times of use. Connections to a fire hydrant will be subject to the Contracting Officer's inspection and approval.

2.2 EQUIPMENT

Vehicular-mounted hydraulic system capable of delivering high-pressure water impact upon the pavement surface less or greater than 8,000 pounds per square inch. If high-pressure water is delivered from a spray bar, the nozzles shall be spaced to provide total coverage of the area being treated. The nozzle line shall have adjustable pressure regulators or relief valves and gauges measuring actual line pressure. Equipment shall be supported on pneumatic tires. Provide equipment, tools, and machinery

which are safe and in satisfactory condition at all times.

PART 3 EXECUTION

3.1 DEGREE OF REMOVAL

Remove percent of 80 loose, flaking paint. Hard, firm paint that has the surface chalk removed may remain.

3.2 RATE OF REMOVAL

Remove rubber at a minimum rate of 10,000 square feet per hour. Do not permit high-pressure water application to remove the existing pavement surface.

3.3 WATER PRESSURE

Provide water pressure impact upon the indicated pavement areas sufficient to remove the designated paint to the required degree of removal without damaging the existing pavement joint sealant, and other airfield appurtenances. Contractor shall be responsible for repairing any damage caused by the removal work.

3.4 REMOVAL OF RESIDUE

Remove all residue from the pavement. Obtain the approval of residue removal and disposal method from the Contracting Officer prior to beginning work.

-- End of Section --

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SECTION 32 01 13

BITUMINOUS SEAL AND FOG COATS

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 226	(1980; R 2008) Standard Specification for Viscosity-Graded Asphalt Cement
AASHTO M 81	(1992; R 2008) Standard Specification for Cutback Asphalt (Rapid-Curing Type)
AASHTO M 82	(1975; R 2008) Standard Specification for Cutback Asphalt (Medium-Curing Type)
AASHTO T 40	(2002; R 2006) Sampling Bituminous Materials

ASTM INTERNATIONAL (ASTM)

ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C142/C142M	(2010) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM D1250	(2008) Standard Guide for Use of the Petroleum Measurement Tables
ASTM D140/D140M	(2009) Standard Practice for Sampling Bituminous Materials
ASTM D2027/D2027M	(2013) Cutback Asphalt (Medium-Curing Type)
ASTM D2028/D2028M	(2010) Cutback Asphalt (Rapid-Curing Type)
ASTM D2397/D2397M	(2013) Standard Specification for Cationic Emulsified Asphalt

ASTM D2995	(1999; R 2009) Determining Application Rate of Bituminous Distributors
ASTM D3381/D3381M	(2013) Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D3625/D3625M	(2012) Standard Practice for Effect of Water on Bituminous-Coated Aggregate Using Boiling Water
ASTM D4791	(2010) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D490	(1992; R 2011) Road Tar
ASTM D633	(2011) Volume Correction Table for Road Tar
ASTM D75/D75M	(2013) Standard Practice for Sampling Aggregates
ASTM D946/D946M	(2009a) Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D977	(2013; E 2014) Emulsified Asphalt

U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)

MUTCD	(2009) Manual on Uniform Traffic Control Devices

1.2 SYSTEM DESCRIPTION

1.2.1 Equipment, Plant and Tools

Equipment, plant and tools used in the work are subject to approval and shall be maintained in a satisfactory working condition at all times. Provide equipment which is adequate and has the capability of producing the results specified. Provide calibrated equipment, such as asphalt distributors, scales, batching equipment, spreaders and similar equipment, that has been recalibrated by an approved calibration laboratory within 12 months prior to commencing work and every 6 months thereafter, by such laboratory from the date of recalibration, during the term of the contract. Submit an equipment list with calibration reports.

1.2.2 Bituminous Distributors

Provide distributors that have pneumatic tires of sufficient size and number to prevent rutting, shoving, or otherwise damaging any part of the pavement structure. Design and equip the distributor to distribute the bituminous material in a uniform double or triple lap at the specified temperature, at readily determined and controlled rates from 0.05 to 2.0 gallons/square yard, with a pressure range of 25 to 75 psi with an allowable variation from the specified rate of not more than plus or minus 5 percent, and at variable widths. Include in the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a

thermometer for reading the temperature of tank contents, and a hand-held hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. Equip the distributor to circulate and agitate the bituminous material during the heating process. Provide distributor with an adjustable, both horizontally and vertically, spray nozzle bar. Make normal width of bar application at least 12 feet, with provisions for lesser or larger width when necessary. Equip distributor with a meter having a dial registering feet of travel/min. Make both dials visible to the distributor driver. Provide a thermometer and well, not in contact with any heating tubes, for accurately indicating temperature of asphalt emulsion.

1.2.3 Aggregate Spreader

The aggregate-spreading equipment shall be adjustable and capable of uniformly spreading aggregate at the specified rate in a single-pass operation over the surface to be sealed.

1.2.4 Pneumatic-Tired Roller

Provide a pneumatic-tired roller of sufficient size to seat the cover aggregate into the bituminous material without fracturing the aggregate particles. The rollers shall have a total compacting width of not less than 5 feet. The gross weight shall be adjustable within 200 to 350 psi of compacting width.

1.2.5 Power Brooms and Power Blowers

Provide power brooms and power blowers suitable for cleaning surfaces to be treated .

1.2.6 Storage Tanks

Provide tanks capable of heating the bituminous material, under effective and positive control at all times, to the required temperature. Accomplish heating by steam coils, hot oil, or electricity. Affix to the tank an armored thermometer with a range from 100 to 300 degrees F so that the temperature of the bituminous material may be read at all times.

1.2.7 Power Rollers

Provide self-propelled tandem and three-wheel type rollers, weighing not less than 5 tons and suitable for rolling bituminous pavements. The wheels of the rollers shall be equipped with adjustable scrapers. Equip the rollers with water tanks and sprinkling apparatus for keeping the wheels wet in order to prevent adherence of the bituminous material to the wheels.

1.2.8 Single-Pass, Surface-Treatment Machines

Provide machines capable of spraying bituminous material and spreading aggregate in one pass; of distributing the bituminous material uniformly, at even heat, and in controlled amounts; and immediately spreading aggregates uniformly, in controlled amounts, over the surface to be sealed.

1.2.9 Vacuum Sweepers for Fog Seal

Provide self-propelled, vacuum pickup sweeper capable of removing loose sand, water, and debris from pavement surface.

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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Waybills and Delivery Tickets
Equipment List
Inspection Reports

SD-04 Samples

Bituminous Materials
Aggregates
Fog Seal; G

SD-06 Test Reports

Tests

1.4 QUALITY ASSURANCE

Perform sampling and testing using an approved commercial testing laboratory or facilities furnished by the Contractor. No work requiring testing will be permitted until the facilities have been inspected and approved. The first inspection will be at the expense of the Government. Costs incurred for any subsequent inspection will be charged to the Contractor. Perform tests in sufficient numbers, and at the location and times directed, to ensure that the materials meet specified requirements.

1.4.1 Samples

Take aggregate samples for laboratory tests in accordance with ASTM D75/D75M. Take samples of bituminous material in accordance with AASHTO T 40 or ASTM D140/D140M.

1.4.2 Aggregates Source

Select sources from which aggregates are to be obtained and notify the Contracting Officer within 15 days after the award of the Contract. Submit a 50 pound sample of aggregate for each aggregate size. Perform tests for the evaluation of aggregates by using an approved commercial laboratory at no expense to the Government. Tests for determining the suitability of aggregate shall include, but not limited to: gradation in accordance with ASTM C136, abrasion resistance in accordance with ASTM C131, clay lumps and friable particles in accordance with ASTM C142/C142M, unit weight and voids in accordance with ASTM C29/C29M, and flat and elongated particles in accordance with ASTM D4791. The use of an antistripping agent is subject to approval by the Contracting Officer.

1.4.3 Bituminous Material Source

Select sources from which bituminous materials are to be obtained and notify the Contracting Officer within 15 days after the award of the contract. From each source of supply, submit a one gallon sample of

bituminous material.

1.4.4 Equipment Calibration

Furnish all equipment, materials and labor necessary to calibrate the bituminous distributor and the aggregate spreader. Perform all calibrations with the approved job materials and prior to applying the specified coatings to the prepared surface. Perform calibration of the bituminous distributor in accordance with ASTM D2995. Inspect all equipment prior to application of fog seal. Perform work to calibrate tank and measuring devices of the distributor. Perform inspection and calibration at the beginning of the work and at least once a day during construction.

1.5 DELIVERY, STORAGE, AND HANDLING

Deliver emulsified asphalt (fog seal) to the site in a homogenous and undamaged condition. Inspect the materials for contamination and damage. Unload and store the materials with a minimum of handling. Protect stored aggregate from contamination and segregation. Replace defective or damaged materials.

1.6 ENVIRONMENTAL REQUIREMENTS

Apply the coating when the existing surface is dry, and when the weather is not foggy, rainy, or when the wind velocity will prevent the uniform application of the bitumen or aggregates. Apply fog seal when atmospheric temperature is above 50 degrees F and rising or when pavement temperature is above 60 degrees F, unless otherwise directed.

PART 2 PRODUCTS

2.1 EMULSIFIED ASPHALT FOR FOG SEAL

Emulsified asphalt for Fog Seal shall conform to ASTM D977, SS-1h for anionic and ASTM D2397/D2397M CSS-1h for cationic materials. Submit in accordance with paragraph titled "Sample Application", for approval and selection of one of the trial application rates.

2.2 WATER

Provide fresh, clean, and potable water.

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Repair damaged surface and fill cracks before starting work. Immediately before starting work, remove all loose material, dirt, clay, or other objectionable material from the surface to be treated with power brooms or power blowers, if needed. Paint firmly bonded to the surface that has the chalk removed may remain. Material removed from the surface shall not be mixed with the cover aggregate. When necessary to achieve a clean surface for fog application, flushing with water will be permitted.

3.2 FIELD QUALITY CONTROL - SEAL COAT

3.2.1 Tests

Perform field tests in sufficient numbers to assure that the specifications are being met. Submit copies of the test results, within 24 hours of the completion of the test. Submit certified copies of the aggregate test results, not less than 30 days before the material is required in the work and certified copies of the bituminous materials test reports indicating compliance with applicable specified requirements, not less than 30 days before the material is required in the work. A copy of the calibration test results, before the bituminous distributor and aggregate spreader are used on the job. Testing is the responsibility of the Contractor and shall be performed by an approved commercial laboratory. The following number of tests, if performed at the appropriate time, will be the minimum acceptable for each type of operation.

3.2.1.1 Gradation

Perform gradation tests in accordance with ASTM C136. Perform a minimum of one gradation for every 80 tons of aggregate to be placed, with a minimum of three gradations for each day's run. When the source of materials is changed or deficiencies are found, the gradation shall be repeated and the material already placed shall be retested to determine the extent of the unacceptable material. Replace all in-place unacceptable material at no additional expense to the Government.

3.2.1.2 Abrasion Resistance

Perform abrasion resistance tests in accordance with ASTM C131. Perform one test for every 80 tons of aggregate placed.

3.2.1.3 Stripping

Perform stripping test on aggregate from each source, in accordance with ASTM D3625/D3625M, prior to incorporation into the work and when the source is changed.

3.2.2 Bituminous Material Sample

Obtain a sample of the bituminous material used under the supervision of the Contracting Officer. The sample will be retained by the Government.

3.3 TRIAL APPLICATION - SEAL COAT

Prior to applying the seal coat, place a test section at least 100 feet long by 20 feet wide using the approved job materials and roll them in accordance with the specified requirements. Perform tests to determine the application rates of the bitumen and aggregate. If the tests indicate that the seal coat test section does not conform to the specification requirements, make necessary adjustments to the application equipment and to the spreading and rolling procedures, and construct additional test sections for conformance to the specifications. Where test sections do not conform to specification requirements, remove seal coat at no expense to the Government; no separate payment will be made for seal coat materials and labor, either in placement or removal of any test section. Perform quality control sampling and testing during construction as required in paragraph FIELD QUALITY CONTROL above.

3.4 FOG SEAL APPLICATION

3.4.1 Sample Application

Determine the required application rate from a sample installation. Select an area of the prepared pavement at least 300 feet long and as wide as the distributor spray bar. Dilute emulsified asphalt with an equal part of water or as recommended by the manufacturer. Apply the water diluted asphalt emulsion in at least three test sections; each a minimum of 100 feet long. The trial applications shall be made at the rates of 0.08 , 0.14 , and 0.20 gallons/square yard. The trial application rates may be modified if approved by the Contracting Officer. Additional trial applications may be made if warranted by pavement surface conditions. Use the rate which has been satisfactorily applied without leaving an excess of asphalt residue on the surface and has been approved, for the fog seal.

3.4.2 Application Inspection

Inspect application of fog seal for uniformity. During application, take 2 samples for each 500 square yards of surface area to receive emulsified asphalt. Weigh samples to determine conformance with application rate.

3.4.3 Inspection Reports

Furnish a written report citing climatic temperature during application of fog seal, emulsion temperature during application, and rate of emulsion application.

3.4.4 Application

Following preparation of the surface, apply the water diluted asphalt emulsion at the rate determined from the trial application. Maintain application temperature of emulsified asphalt between 75 and 160 degrees F. To obtain uniform application of the fog seal at the junction of previous and subsequent applications, spread building paper on the surface of the applied material for a sufficient distance back from the ends of each application so that flow from the spray bar may be started and stopped on the paper, and so that all sprayers will operate at full force. Immediately after application, remove and properly dispose of the building paper. Treat spots unavoidably missed with the hand spray equipment. Base bids on application of diluted emulsion at 0.14 gsy. If the actual amount required is more or less than 0.14 gsy, an adjustment in the contract price will be made as provided by the contract.

3.5 SITE PROTECTION

During applications, protect adjacent buildings, structures, vehicles, manhole covers, inlet grates, and trees to prevent being spattered or marred.

3.6 TRAFFIC CONTROL

Protect freshly placed coatings from damage by traffic. Provide sufficient warning signs and barricades to prevent traffic over freshly treated surfaces. Protect treated areas from traffic for at least 24 hours after final application of coatings, or for such time as necessary to prevent picking up. Immediately prior to opening to traffic, roll the entire treated area with a self-propelled pneumatic-tired roller. Provide

warning signs and barricades for proper traffic control, in accordance with MUTCD.

-- End of Section --

SECTION 32 01 16.17

COLD MILLING OF BITUMINOUS PAVEMENTS

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 C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

1.2 QUALITY ASSURANCE

1.2.1 Grade

Conform the finished milled surfaces to the lines, grades, and cross sections indicated. The finished milled-pavement surfaces shall vary not more than 1/4 inch from the established plan grade line and elevation. Finished surfaces at a juncture with other pavements shall coincide with the finished surfaces of the abutting pavements. The deviations from the plan grade line and elevation will not be permitted in areas of pavements where closer conformance with planned grade and elevation is required for the proper functioning of appurtenant structures involved.

1.2.2 Surface Smoothness

Finished surfaces shall not deviate from the testing edge of a straightedge more than 1/4 inch in the transverse or longitudinal direction.

1.2.3 Traffic Control

Provide all necessary traffic controls during milling operations.

1.3 ENVIRONMENTAL REQUIREMENTS

Milling shall not be performed when there is accumulation of snow or ice on the pavement surface.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 EXECUTING EQUIPMENT

3.1.1 Cold-Milling Machine

Provide a cold-milling machine which is self-propelled, capable of milling

the pavement to a specified depth and smoothness and of establishing grade control; with means of controlling transverse slope and dust produced during the pavement milling operation. The machine shall have the ability to remove the millings or cuttings from the pavement and load them into a truck. The milling machine shall not cause damage to any part of the pavement structure that is not to be removed.

3.1.2 Cleaning Equipment

Provide cleaning equipment suitable for removing and cleaning loose material from the pavement surface.

3.1.3 Straightedge

Furnish and maintain at the site, in good condition, one 12 foot straightedge or other suitable device for each milling machine, for testing the finished surface. Make straightedge available for Government use. Straightedges shall be constructed of aluminum or other lightweight metal, with blades of box or box-girder cross section with flat bottom reinforced to insure rigidity and accuracy. Straightedges shall have handles to facilitate movement on the pavement.

3.2 PREPARATION OF SURFACE

Clean the pavement surface of excessive dirt, clay, or other foreign material immediately prior to milling the pavement.

3.3 MILLING OPERATION

A minimum of seven days notice is required, prior to start work, for the Contracting Officer to coordinate the milling operation with other activities at the site. Make sufficient passes so that the designated area is milled to the grades and cross sections indicated. The milling shall proceed with care and in depth increments that will not damage the pavement below the designated finished grade. Repair or replace, as directed, items damaged during milling such as manholes, valve boxes, utility lines, pavement that is torn, cracked, gouged, broken, or undercut. The milled material shall be removed from the pavement and loaded into trucks. Removed material shall have a minimum of 95 percent by weight passing a sieve when tested in accordance with ASTM C136.

3.4 GRADE AND SURFACE-SMOOTHNESS TESTING

3.4.1 Grade-Conformance Tests

Test the finished milled surface of the pavement for conformance with the plan-grade requirements and for acceptance by the Contracting Officer by running lines of levels at intervals of 25 feet longitudinally and 25 feet transversely to determine the elevation of the completed pavement. Correct variations from the designated grade line and elevation in excess of the plan-grade requirements as directed. Skin patching for correcting low areas will not be permitted. Remove and replace the deficient low area. Remove sufficient material to allow at least 1 inch of asphalt concrete to be placed.

3.4.2 Surface-Smoothness Tests

After completion of the final milling, the finished milled surface will be tested by the Government with a straightedge. Other approved devices may

be used, provided that when satisfactorily and properly operated, such devices reveal all surface irregularities exceeding the tolerances specified. Correct surface irregularities that depart from the testing edge by more than 1/4 inch. Skin patching for correcting low areas will not be permitted. Remove and replace the deficient low area. Remove sufficient material to allow at least 1 inch of asphalt concrete to be placed.

3.5 REMOVAL OF MILLED MATERIAL

Material that is removed shall be stockpiled as specified and in such a manner to prevent segregation or contamination .

-- End of Section --

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SECTION 32 01 17.16

SEALING OF CRACKS IN BITUMINOUS PAVEMENTS

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 C509	(2006; R 2011) Elastomeric Cellular Preformed Gasket and Sealing Material
ASTM D6690	(2012) Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
ASTM D789	(2007; E 2010) Determination of Relative Viscosity and Moisture Content of Polyamide (PA)

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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Installation of Sealant

SD-04 Samples

Materials; G

SD-06 Test Reports

Test Requirements

1.3 QUALITY ASSURANCE

Test the crack sealant and backup material, when required, for conformance with the referenced applicable material specification. Furnish samples of materials, in sufficient quantity to be tested upon request. Conformance with the test requirements of the laboratory tests specified will not constitute final acceptance of the materials. Submit reports of all tests. Perform testing of the materials in an approved, independent laboratory; submit certified copies of the test reports for approval 30 days prior to the use of the materials at the job site. Samples will be retained by the Government for possible future testing, should the materials appear defective during or after application. Final acceptance

will be based on the performance of the in-place materials.

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the job site for defects; unload, and store them with a minimum of handling to avoid damage. Provide storage facilities at the job site to protect materials from weather and to maintain them at the temperatures recommended by the manufacturer.

1.5 ENVIRONMENTAL REQUIREMENTS

The ambient air temperature and the pavement temperature within the joint wall shall be a minimum of 50 degrees F and rising at the time of application of the materials. Do not apply sealant if moisture is observed in the crack.

PART 2 PRODUCTS

2.1 SEALANTS

Provide sealants conforming to ASTM D6690, Type II or ASTM D6690, Type I.

2.2 BACKUP MATERIALS

Provide backup material that is a compressible, nonshrinking, nonstaining, nonabsorptive material and nonreactive with the crack sealant. The melting point of the backing material shall be at least 5 degrees F greater than the maximum pouring temperature of the sealant being used, when tested in accordance with ASTM D789. The material shall have a water absorption of not more than 5 percent by weight when tested in accordance with ASTM C509. The backup material shall be 25 percent (plus or minus 5 percent) larger in diameter than the nominal width of the crack.

PART 3 EXECUTION

3.1 EXECUTING EQUIPMENT

Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started and shall be maintained in satisfactory condition at all times.

3.1.1 Routing Equipment

Provide routing equipment which is a self-powered machine operating a power driven tool or bit specifically designed for routing bituminous pavements. The bit shall rotate about a vertical axis at sufficient speed to cut a smooth vertical-walled reservoir in the pavement surface and shall maintain accurate cutting without damaging the sides or top edges of the reservoir. Provide a router capable of following the trace of the crack without deviation. The use of rotary impact routing devices will not be permitted for cleaning cracks.

3.1.2 Concrete Saw

Provide a self-propelled power saw with small diameter (6 inches or less) water-cooled diamond or abrasive saw blades for cutting cracks to the depths and widths specified and for removing filler that is embedded in the cracks or adhered to the crack faces. The diameter of the saw blade shall be small enough to allow the saw to closely follow the trace of the crack.

3.1.3 Sandblasting Equipment

Include in the sandblasting equipment an air compressor, hose, and long-wearing venturi-type nozzle of proper size, shape and opening. The maximum nozzle opening shall not exceed 1/4 inch. The air compressor shall be portable; and shall be capable of furnishing not less than 150 cfm and maintaining a line pressure of not less than 90 psi at the nozzle while in use. Demonstrate compressor capability under job conditions before approval. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the crack about 1 inch above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to secure satisfactory results.

3.1.4 Waterblasting Equipment

Include with the waterblasting equipment a trailer-mounted water tank, pumps, high-pressure hose, wand with safety release cutoff control, nozzle, and auxiliary water resupply equipment. The water tank and auxiliary resupply equipment shall be of sufficient capacity to permit continuous operations. The hose, wand, and nozzle shall be capable of cleaning the crack faces and the pavement surface on both sides of the crack for a width of at least 1/2 inch. A pressure gauge mounted at the pump shall show at all times the pressure in psi at which the equipment is operating.

3.1.5 Hand Tools

Hand tools may be used, when approved, for removing defective sealant from cracks and repairing or cleaning the crack faces.

3.1.6 Crack Sealing Equipment

Provide unit applicators, used for heating and installing the hot-poured crack sealant materials, that are mobile and equipped with a double-boiler, agitator-type kettle with an oil medium in the outer space for heat transfer; a direct-connected pressure-type extruding device with a nozzle shaped for inserting in the crack to be filled; positive temperature devices for controlling the temperature of the transfer oil and sealant; and a recording type thermometer for indicating the temperature of the sealant. Allow the sealant to circulate through the delivery hose and return to the inner kettle when not in use, due to the applicator unit design.

3.2 PREPARATION OF CRACKS

Immediately before the installation of the crack sealant, thoroughly clean the cracks to remove oxidized pavement, loose aggregate and foreign

debris. The preparation shall be as follows:

3.2.1 Cracks

3.2.1.1 Hairline Cracks

Cracks that are less than 1/4 inch wide do not need to be sealed .

3.2.1.2 Small Cracks

Cracks that are 1/4 to 3/4 inch wide shall be routed to a nominal width 1/8 inch greater than the existing nominal width and to a depth not less than 3/4 inch, sandblastedor waterblasted and cleaned using compressed air.

3.2.1.3 Medium Cracks

Cracks that are 3/4 to 2 inches wide shall be sandblastedor waterblasted and cleaned using compressed air.

3.2.1.4 Large Cracks

Cracks that are greater than 2 inches wide shall be repaired using pothole repair techniques instead of sealing.

3.2.2 Existing Sealant Removal

Cut loose the in-place sealant from both crack faces and to a depth shown on the drawings, using a concrete saw or hand tools as specified in paragraph EQUIPMENT. Depth shall be sufficient to accommodate any backup material that is required to maintain the depth of new sealant to be installed. Prior to further cleaning operations, remove all old loose sealant remaining in the crack opening by blowing with compressed air.

3.2.3 Routing

Perform routing of the cracks using a rotary router with a bit that is at least 1/8 inch wider than the nominal width of the crack to remove all residual old sealant (resealing), oxidized pavement and any loose aggregate in the crack wall.

3.2.4 Sawing

Perform sawing of the cracks using a power-driving concrete saw as specified in paragraph EQUIPMENT. Stiffen the blade as necessary with suitable dummy (or used) blades or washers. Immediately following the sawing operation, clean the crack opening using a water jet to remove all saw cuttings and debris.

3.2.5 Sandblasting

Sandblast clean the crack faces and the pavement surfaces extending a minimum of 1/2 inch from the crack edges. Use a multiple-pass technique until the surfaces are free of dust, dirt, old sealant residue, or foreign debris that might prevent the sealant material from bonding to the asphalt pavement. After final cleaning and immediately prior to sealing, blow out the cracks with compressed air and leave them completely free of debris and water. Ensure that sandblasting does not damage the pavement.

3.2.6 Backup Material

Use backup material on all cracks that have a depth greater than 3/4 inch. Insert the backup material into the lower portion of the crack as shown on the drawings. Ensure that the backup material is placed at the specified depth and is not stretched or twisted during installation.

3.2.7 Rate of Progress of Crack Preparation

Limit the stages of crack preparation, which include routing, sandblasting of the crack faces, air pressure cleaning and placing of the backup material, to only that linear footage that can be sealed during the same day.

3.3 PREPARATION OF SEALANT

Do not heat hot-poured sealants in excess of the safe heating temperature recommended by the manufacturer, as shown on the sealant containers. Withdraw and waste sealant that has been overheated or subjected to application temperatures for over 4 hours or that has remained in the applicator at the end of the day's operation.

3.4 INSTALLATION OF SEALANT

Submit manufacturer's instructions 30 days prior to the use of the material on the project. Installation of the material will not be allowed until the instructions are received.

3.4.1 Time of Application

Seal cracks immediately following final cleaning of the crack walls and following the placement of the backup material (when required). Cracks that cannot be sealed under the conditions specified, or when rain interrupts sealing operations, shall be recleaned and allowed to dry prior to installing the sealant.

3.4.2 Sealing the Crack

Immediately preceding, but not more than 50 feet ahead of the crack sealing operations, perform a final cleaning with compressed air. Fill the cracks from the bottom up to 1/8 inch below the pavement surface. Remove excess or spilled sealant from the pavement by approved methods and discard it. Install the sealant in a manner which prevents the formation of voids and entrapped air. Several passes with the applicator wand may be necessary to obtain the specified sealant depth from the pavement surface. Do not use gravity methods or pouring pots to install the sealant material. Traffic shall not be permitted over newly sealed pavement until authorized by the Contracting Officer. Cracks shall be checked frequently to ensure that the newly installed sealant is cured to a tack-free condition within 3 hours.

3.5 CRACK SEALANT INSTALLATION TEST SECTION

Prior to the cleaning and sealing of the cracks for the entire project, construct a test section at least 200 feet long using the specified materials and approved equipment, to demonstrate the proposed sealing of all cracks of the project. Following the completion of the test section and before any other crack is sealed, inspect the test section to determine that the materials and installation meet the requirements

specified. If materials or installation do not meet requirements, remove the materials and reclean and reseal the cracks at no cost to the Government. When the test section meets the requirements, it may be incorporated into the permanent work and paid for at the contract unit price per linear foot for sealing items scheduled. Seal all other cracks in the manner approved for sealing the test section.

3.6 CLEANUP

Upon completion of the project, remove unused materials from the site and leave the pavement in a clean condition.

3.7 QUALITY CONTROL PROVISIONS

3.7.1 Crack Cleaning

Provide quality control provisions during the crack cleaning process to correct improper equipment and cleaning techniques that damage the bituminous pavement in any manner. Cleaned cracks shall be approved prior to installation of the crack sealant.

3.7.2 Crack Seal Application Equipment

Inspect the application equipment to ensure conformance to temperature requirements and proper installation. Evidences of bubbling, improper installing, and failing to cure or set will cause to suspend operations until causes of the deficiencies are determined and corrected.

3.7.3 Crack Sealant

Inspect the crack sealant for proper cure and set rating, bonding to the bituminous pavement, cohesive separation within the sealant, reversion to liquid, and entrapped air and voids. Sealants exhibiting any of these deficiencies, at any time prior to the final acceptance of the project, shall be removed from the crack, wasted, and replaced as specified herein at no additional cost to the Government.

-- End of Section --

SECTION 32 01 19

FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS

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 C1016	(2014) Standard Test Method for Determination of Water Absorption of Sealant Backing (Joint Filler) Material
ASTM D5893/D5893M	(2010) Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements
ASTM D6690	(2012) Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
ASTM D7116	(2005) Standard Specification for Joint Sealants, Hot Applied, Jet Fuel Resistant Types, for Portland Cement Concrete Pavement
ASTM D789	(2007; E 2010) Determination of Relative Viscosity and Moisture Content of Polyamide (PA)

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 525	(1989) Corps of Engineers Test Method for Evaluation of Hot-Applied Joint Sealants for Bubbling Due to Heating

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS SS-S-200	(Rev E; Am 1; Notice 1) Sealant, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied, for Portland Cement Concrete Pavement

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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Manufacturer's Recommendations; G.
Equipment.

SD-04 Samples

Materials; G.

SD-06 Test Reports

Certified copies of the test reports; G.

1.3 QUALITY ASSURANCE

1.3.1 Test Requirements

Test the joint sealant and backup or separating material for conformance with the referenced applicable material specification. The materials will be tested by the Government. No material shall be used at the project prior to receipt of written notice that the materials meet the laboratory requirements. The cost of the first test of samples will be borne by the Government. If the samples fail to meet specification requirements, replace the materials represented by the sample and test the new materials at the Contractor's expense. Conformance with the requirements of the laboratory tests specified will not constitute final acceptance of the materials. Final acceptance will be based on the performance of the in-place materials. Submit samples of the materials (sealant, primer if required, and backup material), in sufficient quantity for testing and approval 10 days prior to the beginning of work. No material will be allowed to be used until it has been approved.

1.3.2 Trial Joint Sealant Installation

Prior to the cleaning and sealing of the joints for the entire project, prepare a test section at least 200 feet long using the specified materials and approved equipment, so as to demonstrate the proposed joint preparation and sealing of all types of joints in the project. Following the completion of the test section and before any other joint is sealed, inspect the test section to determine that the materials and installation meet the requirements specified. If it is determined that the materials or installation do not meet the requirements, remove the materials, and reclean and reseal the joints at no cost to the Government. When the test section meets the requirements, it may be incorporated into the permanent work and paid for at the contract unit price per linear foot for sealing items scheduled. Prepare and seal all other joints in the manner approved for sealing the test section.

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the job site for defects, unload, and store them with a minimum of handling to avoid damage. Provide storage facilities at the job site for maintaining materials at the temperatures and conditions recommended by the manufacturer.

1.5 ENVIRONMENTAL REQUIREMENTS

The ambient air temperature and the pavement temperature within the joint wall shall be a minimum of 50 degrees F and rising at the time of application of the materials. Do not apply sealant if moisture is

observed in the joint.

PART 2 PRODUCTS

2.1 SEALANTS

Materials for sealing cracks in the various paved areas indicated on the drawings shall be as follows:

Area	Sealing Material
Joint Sealing for first 500' of Runway 14L, 32R Ends, All Blast Pads	FS SS-S-200 Type M
Concrete repairs at Runway 32 Hold Apron	FS SS-S-200 Type H
Runway 14L-32R Station 15+00 to 85+00 ;Runway 15K-23R, Runway 15R-23L Taxiways A and P	ASTM D5893/D5893M

2.2 PRIMERS

When primers are recommended by the manufacturer of the sealant, use them in accordance with the recommendation of the manufacturer.

2.3 BACKUP MATERIALS

Provide backup material that is a compressible, nonshrinking, nonstaining, nonabsorbing material, nonreactive with the joint sealant. The material shall have a melting point at least 5 degrees F greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. The material shall have a water absorption of not more than 5 percent of the sample weight when tested in accordance with ASTM C1016. Use backup material that is 25 plus or minus 5 percent larger in diameter than the nominal width of the crack.

2.4 BOND BREAKING TAPES

Provide a bond breaking tape or separating material that is a flexible, nonshrinkable, nonabsorbing, nonstaining, and nonreacting adhesive-backed tape. The material shall have a melting point at least 5 degrees F greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. The bond breaker tape shall be approximately 1/8 inch wider than the nominal width of the joint and shall not bond to the joint sealant.

PART 3 EXECUTION

3.1 EXECUTING EQUIPMENT

Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started maintained in satisfactory condition at all times. Submit a list of proposed equipment to be used in performance of construction work including descriptive data, 14 days prior to use on the project.

3.1.1 Joint Cleaning Equipment

3.1.1.1 Tractor-Mounted Routing Tool

Provide a routing tool, used for removing old sealant from the joints, of such shape and dimensions and so mounted on the tractor that it will not damage the sides of the joints. The tool shall be designed so that it can be adjusted to remove the old material to varying depths as required. The use of V-shaped tools or rotary impact routing devices will not be permitted. Hand-operated spindle routing devices may be used to clean and enlarge random cracks.

3.1.1.2 Concrete Saw

Provide a self-propelled power saw, with water-cooled diamond or abrasive saw blades, for cutting joints to the depths and widths specified or for refacing joints or cleaning sawed joints where sandblasting does not provide a clean joint.

3.1.1.3 Sandblasting Equipment

Include with the sandblasting equipment an air compressor, hose, and long-wearing venturi-type nozzle of proper size, shape and opening. The maximum nozzle opening should not exceed 1/4 inch. The air compressor shall be portable and capable of furnishing not less than 150 cfm and maintaining a line pressure of not less than 90 psi at the nozzle while in use. Demonstrate compressor capability, under job conditions, before approval. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint approximately 1 inch above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to secure satisfactory results.

3.1.1.4 Waterblasting Equipment

Include with the waterblasting equipment a trailer-mounted water tank, pumps, high-pressure hose, wand with safety release cutoff control, nozzle, and auxiliary water resupply equipment. Provide water tank and auxiliary resupply equipment of sufficient capacity to permit continuous operations. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint approximately 1 inch above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to obtain satisfactory results. A pressure gauge mounted at the pump shall show at all times the pressure in psi at which the equipment is operating.

3.1.1.5 Hand Tools

Hand tools may be used, when approved, for removing defective sealant from a crack and repairing or cleaning the crack faces.

3.1.2 Sealing Equipment

3.1.2.1 Two-Component, Cold-Applied, Machine Mix Sealing Equipment

Provide equipment used for proportioning, mixing, and installing FS SS-S-200 Type M joint sealants designed to deliver two semifluid components through hoses to a portable mixer at a preset ratio of 1 to 1 by volume using pumps with an accuracy of plus or minus 5 percent for the quantity of each component. The reservoir for each component shall be equipped with mechanical agitation devices that will maintain the components in a uniform condition without entrapping air. Incorporate provisions to permit thermostatically controlled indirect heating of the components, when required. However, immediately prior to proportioning and mixing, the temperature of either component shall not exceed 90 degrees F. Provide screens near the top of each reservoir to remove any foreign particles or partially polymerized material that could clog fluid lines or otherwise cause misproportioning or improper mixing of the two components. Provide equipment capable of thoroughly mixing the two components through a range of application rates of 10 to 60 gallons per hour and through a range of application pressures from 50 to 1500 psi as required by material, climatic, or operating conditions. Design the mixer for the easy removal of the supply lines for cleaning and proportioning of the components. The mixing head shall accommodate nozzles of different types and sizes as may be required by various operations. The dimensions of the nozzle shall be such that the nozzle tip will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval.

3.1.2.2 Two-Component, Cold-Applied, Hand-Mix Sealing Equipment

Mixing equipment for FS SS-S-200 Type H sealants shall consist of a slow-speed electric drill or air-driven mixer with a stirrer in accordance with the manufacturer's recommendations. Submit printed copies of manufacturer's recommendations, 14 days prior to use on the project, where installation procedures, or any part thereof, are required to be in accordance with those recommendations. Installation of the material will not be allowed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

3.1.2.3 Cold-Applied, Single-Component Sealing Equipment

The equipment for installing ASTM D5893/D5893M single component joint sealants shall consist of an extrusion pump, air compressor, following plate, hoses, and nozzle for transferring the sealant from the storage container into the joint opening. The dimension of the nozzle shall be such that the tip of the nozzle will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval. Small hand-held air-powered equipment (i.e., caulking guns) may be used for small applications.

3.2 PREPARATION OF JOINTS

Immediately before the installation of the sealant, thoroughly clean the joints to remove all laitance, curing compound, filler, protrusions of hardened concrete, and old sealant from the sides and upper edges of the joint space to be sealed.

3.2.1 Existing Sealant Removal

Cut loose the in-place sealant from both joint faces and to the depth shown on the drawings, using the tractor-mounted routing equipment concrete saw, or waterblaster as specified in paragraph EQUIPMENT. Depth shall be sufficient to accommodate any separating or backup material that is required to maintain the depth of new sealant to be installed. Prior to further cleaning operations, remove all loose old sealant remaining in the joint opening by blowing with compressed air. Hand tools may be required to remove sealant from random cracks. Chipping, spalling, or otherwise damaging the concrete will not be allowed.

3.2.2 Sawing

3.2.2.1 Facing and Refacing of Joints

Accomplish refacing or facing of joints using a concrete saw as specified in paragraph EQUIPMENT to remove all residual old sealant and a minimum of concrete from the joint face to provide exposure of newly cleaned concrete, and, if required, to enlarge the joint opening to the width and depth shown on the drawings. Stiffen the blade with a sufficient number of suitable dummy (used) blades or washers. Thoroughly clean, immediately following the sawing operation, the joint opening using a water jet to remove all saw cuttings and debris.

3.2.2.2 Refacing of Random Cracks

Accomplish sawing of the cracks using a power-driven concrete saw as specified in paragraph EQUIPMENT. The saw blade shall be 6 inches or less in diameter to enable the saw to follow the trace of the crack. Stiffen the blade, as necessary, with suitable dummy (or used) blades or washers. Immediately following the sawing operation, thoroughly clean the crack opening using a water jet to remove all saw cuttings and debris.

3.2.3 Sandblasting

The newly exposed concrete joint faces and the pavement surfaces extending a minimum of 1/2 inch from the joint edges shall be sandblasted or waterblasted clean. use a multiple-pass technique until the surfaces are free of dust, dirt, curing compound, filler, old sealant residue, or any foreign debris that might prevent the bonding of the sealant to the concrete. After final cleaning and immediately prior to sealing, blow out the joints with compressed air and leave them completely free of debris and water.

3.2.4 Back-Up Material

When the joint opening is of a greater depth than indicated for the sealant depth, plug or seal off the lower portion of the joint opening using a back-up material to prevent the entrance of the sealant below the specified depth. Take care to ensure that the backup material is placed at the specified depth and is not stretched or twisted during installation.

3.2.5 Bond Breaking Tape

Where inserts or filler materials contain bitumen, or the depth of the joint opening does not allow for the use of a backup material, insert a bond breaker separating tape to prevent incompatibility with the filler materials and three-sided adhesion of the sealant. Securely bond the tape to the bottom of the joint opening so it will not float up into the new sealant.

3.2.6 Rate of Progress of Joint Preparation

Limit the stages of joint preparation, which include sandblasting, air pressure cleaning and placing of the back-up material to only that lineal footage that can be sealed during the same day.

3.3 PREPARATION OF SEALANT

3.3.1 Type M Sealants

Inspect the FS SS-S-200 Type M sealant components and containers prior to use. Reject any materials that contain water, hard caking of any separated constituents, nonreversible jell, or materials that are otherwise unsatisfactory. Settlement of constituents in a soft mass that can be readily and uniformly remixed in the field with simple tools will not be cause for rejection. Prior to transfer of the components from the shipping containers to the appropriate reservoir of the application equipment, thoroughly mix the materials to ensure homogeneity of the components and incorporation of all constituents at the time of transfer. When necessary for remixing prior to transfer to the application equipment reservoirs, warm the components to a temperature not to exceed 90 degrees F by placing the components in heated storage or by other approved methods but in no case shall the components be heated by direct flame, or in a single walled kettle, or a kettle without an oil bath.

3.3.2 Type H Sealants

Mix the FS SS-S-200 Type H sealant components either in the container furnished by the manufacturer or a cylindrical metal container of volume approximately 50 percent greater than the package volume. Thoroughly mix the base material in accordance with the manufacturer's instructions. The cure component shall then be slowly added during continued mixing until a uniform consistency is obtained.

3.3.3 Single-Component, Cold-Applied Sealants

Inspect the ASTM D5893/D5893M sealant and containers prior to use. Reject any materials that contain water, hard caking of any separated constituents, nonreversible jell, or materials that are otherwise unsatisfactory. Settlement of constituents in a soft mass that can be readily and uniformly remixed in the field with simple tools will not be cause for rejection.

3.4 INSTALLATION OF SEALANT

3.4.1 Time of Application

Seal joints immediately following final cleaning of the joint walls and following the placement of the separating or backup material. Open

joints, that cannot be sealed under the conditions specified, or when rain interrupts sealing operations shall be recleaned and allowed to dry prior to installing the sealant.

3.4.2 Sealing Joints

Immediately preceding, but not more than 50 feet ahead of the joint sealing operations, perform a final cleaning with compressed air. Fill the joints from the bottom up to 1/4 inch plus or minus 1/16 inch below the pavement surface. Remove and discard excess or spilled sealant from the pavement by approved methods. Install the sealant in such a manner as to prevent the formation of voids and entrapped air. In no case shall gravity methods or pouring pots be used to install the sealant material. Traffic shall not be permitted over newly sealed pavement until authorized by the Contracting Officer. When a primer is recommended by the manufacturer, apply it evenly to the joint faces in accordance with the manufacturer's instructions. Check the joints frequently to ensure that the newly installed sealant is cured to a tack-free condition within the time specified.

3.5 INSPECTION

3.5.1 Joint Cleaning

Inspect joints during the cleaning process to correct improper equipment and cleaning techniques that damage the concrete pavement in any manner. Cleaned joints will be approved prior to installation of the separating or back-up material and joint sealant.

3.5.2 Joint Sealant Application Equipment

Inspect the application equipment to ensure conformance to temperature requirements, proper proportioning and mixing (if two-component sealant) and proper installation. Evidences of bubbling, improper installation, failure to cure or set will be cause to suspend operations until causes of the deficiencies are determined and corrected.

3.5.3 Joint Sealant

Inspect the joint sealant for proper rate of cure and set, bonding to the joint walls, cohesive separation within the sealant, reversion to liquid, entrapped air and voids. Sealants exhibiting any of these deficiencies at any time prior to the final acceptance of the project shall be removed from the joint, wasted, and replaced as specified herein at no additional cost to the Government.

3.6 CLEAN-UP

Upon completion of the project, remove all unused materials from the site and leave the pavement in a clean condition.

-- End of Section --

SECTION 32 01 26.71

GROOVING FOR AIRFIELD PAVEMENTS

PART 1 GENERAL

1.1 SUBMITTALS

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

SD-03 Product Data

Equipment; G
Procedures; G

1.2 ENVIRONMENTAL REQUIREMENTS

Grooving operations will not be permitted when freezing conditions prevent the immediate removal of debris and/or drainage of water from the grooved area. Discharge and disposal of waste slurry shall be the Contractor's responsibility. Waste slurry discharge pits may be constructed alongside the pavement to be grooved, as directed by the Contracting Officer. Provide and maintain temporary storm drainage, pollution control, and erosion control features at each discharge pit in accordance with base environmental regulations. After the waste slurry has been dewatered, the hardened slurry shall be excavated and disposed off base . All disposal pit areas shall be regraded and restored to original condition.

PART 2 PRODUCTS

2.1 GROOVING MACHINE

Provide a grooving machine that is power driven, self-propelled, specifically designed and manufactured for pavement grooving, and has a self contained and integrated continuous slurry vacuum system as the primary method for removing waste slurry. The grooving machine shall be equipped with diamond-saw cutting blades, and capable of making at least 18 inches in width of multiple parallel grooves in one pass of the machine. Thickness of the cutting blades shall be capable of making the required width and depth of grooves in one pass of the machine. The cutting head shall not contain a mixture of new and worn blades or blades of unequal wear or diameter. Match the blade type and configuration with the hardness of the existing airfield pavement. The wheels on the grooving machine shall be of a design that will not scar or spall the pavement. Provide the machine with devices to control depth of groove and alignment within the specified tolerances.

Submit a list of proposed equipment to be used in performance of this work, including descriptive data and safety precautions required for the equipment operation.

2.2 WATER SUPPLY

The Government will provide water for the grooving operation.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Existing Pavements

Bumps, depressed areas, bad or faulted joints, and badly cracked and/or spalled areas in the pavement shall not be grooved until such areas are adequately repaired or replaced. If the existing pavement is not suitable because of its strength, an overlay, flexible or rigid, will be required using the procedures specified in Section 32 12 15.13 Hot-Mix Ashpalt for Airfield Paving .

3.1.2 New Pavements

Allow new asphalt concrete pavements to cure for a minimum of 30 days before grooving, to allow the material to become stable enough to prevent closing of the grooves under normal use. Permit new portland cement concrete pavements to cure for a minimum of 28 days before grooving.

3.2 GROOVING

3.2.1 Procedures

Submit grooving sequence and method of placing guide lines to control grooving operation. Cut grooves in the portland cement areas as indicated on the drawings. Begin the grooving at one side of the usable runway and continue for the full width of the area. Take all reasonable precautions to prevent damage to or roughening of the pavement between grooves. Spalling along or tearing or raveling of the groove edges shall not be allowed. The grooves shall be 1/4 inch, plus 1/16 inch, minus 0 inch wide by 1/4 inch, plus or minus 1/16 inch deep and 1-1/2 inches, plus 0 inches, minus 1/8 inch center to center spacing. The groove length shall be 130 feet plus or minus 3 inches long and normal to the longitudinal axis of the centerline of the runway . The transverse alignment of the grooves shall not vary more than 3 inches plus or minus on a 75 foot length of grooving. Do not groove within 6 inches plus or minus 3 inches of the runway centerline. Do not groove within 6 inches of transverse joints or working cracks, through compression seals, in-runway lighting fixtures or similar items, the first 10 feet either side of an arresting barrier cable or the first and last 10 feet of the runway.

3.2.2 Clean-Up

Clean-up shall be continuous. Flush debris produced by the equipment to the edge of the grooved area or pick it up before it dries and hardens. The dust coating remaining shall be flushed to the edge of the area if the resultant accumulation is not detrimental to the vegetation or storm drainage system. Accomplish all flushing operations in a manner to prevent erosion on the shoulders, damage to vegetation, or plugging of storm drainage.

3.2.3 Repair of Damaged Pavement

Repair at the Contractor's expense, as specified in Section 32 13 11 , any damage, which in the opinion of the Contracting Officer will be detrimental to aircraft operations and/or pavement performance, occurring to the pavement as a result of the grooving operations.

3.3 CONTRACTOR QUALITY CONTROL

3.3.1 Test Section

Groove a test section in an area of the pavement outside of the trafficked area, as approved by the Contracting Officer. The area shall be 100 feet long by two lanes wide. Demonstrate the setup and alignment process, the grooving operation, and the waste slurry disposal.

3.3.2 Inspections

At the beginning of each work shift, furnish a full complement of grooving blades with each saw that are capable of cutting grooves of the specified width, depth, and spacing. If during the work, a single grooving blade on a machine becomes incapable of cutting a groove, continue work for the remainder of the work shift. The Contractor is not required to cut the groove omitted because of the failed blade. Should two or more grooving blades on a machine become incapable of cutting grooves, cease operating the machine until it is repaired.

-- End of Section --

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SECTION 32 11 23

AGGREGATE AND/OR GRADED-CRUSHED AGGREGATE BASE COURSE

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 basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180	(2010) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
AASHTO T 224	(2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C127	(2012) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	(2012) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	(2013) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method

ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2167	(2008) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D422	(1963; R 2007; E 2014) Particle-Size Analysis of Soils
ASTM D4318	(2010; E 2014) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D5821	(2013) Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6938	(2010) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D75/D75M	(2013) Standard Practice for Sampling Aggregates
ASTM E11	(2013) Wire Cloth and Sieves for Testing Purposes

1.2 DEFINITIONS

For the purposes of this specification, the following definitions apply.

1.2.1 Aggregate Base Course

Aggregate base course (ABC) is well graded, durable aggregate uniformly moistened and mechanically stabilized by compaction.

1.2.2 Graded-Crushed Aggregate Base Course

Graded-crushed aggregate (GCA) base course is well graded, crushed, durable aggregate uniformly moistened and mechanically stabilized by compaction. GCA is similar to ABC, but it has more stringent requirements and it produces a base course with higher strength and stability.

1.2.3 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum dry density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve are expressed as a percentage of the laboratory maximum dry density in

accordance with AASHTO T 180 Method D and corrected with AASHTO T 224.

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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Plant, Equipment, and Tools
Waybills and Delivery Tickets

SD-06 Test Reports

Sampling and Testing; G
Field Density Tests; G

1.4 QUALITY ASSURANCE

Sampling and testing are the responsibility of the Contractor and performed by a testing laboratory approved in accordance with Section QUALITY CONTROL. Work requiring testing will not be permitted until the testing laboratory has been inspected and approved. Test the materials to establish compliance with the specified requirements; perform testing at the specified frequency. The Contracting Officer may specify the time and location of the tests. Furnish copies of test results to the Contracting Officer within 24 hours of completion of the tests.

1.4.1 Sampling

Take samples for laboratory testing in conformance with ASTM D75/D75M. When deemed necessary, the sampling will be observed by the Contracting Officer.

1.4.2 Tests

Perform the following tests in conformance with the applicable standards listed.

1.4.2.1 Sieve Analysis

Make sieve analysis in conformance with ASTM C117 and ASTM C136. Sieves shall conform to ASTM E11. Particle-size analysis of the soils shall also be completed in conformance with ASTM D422.

1.4.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D4318.

1.4.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture content in accordance with AASHTO T 180, Method D and corrected with AASHTO T 224.

1.4.2.4 Field Density Tests

Measure field density in accordance with ASTM D1556, ASTM D2167 or ASTM D6938. For the method presented in ASTM D1556 use the base plate as shown in the drawing. For the method presented in ASTM D6938 check the calibration curves and adjust them, if necessary, using only the sand cone method as described in paragraph Calibration, of the ASTM publication. Tests performed in accordance with ASTM D6938 result in a wet unit weight of soil, and ASTM D6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall also be checked along with density calibration checks as described in ASTM D6938. The calibration checks of both the density and moisture gauges shall be made by the prepared containers of material method, as described in paragraph Calibration of ASTM D6938, on each different type of material being tested at the beginning of a job and at intervals as directed.

a. Submit certified copies of test results for approval not less than 30 days before material is required for the work.

b. Submit calibration curves and related test results prior to using the device or equipment being calibrated.

c. Submit copies of field test results within 24 hours after the tests are performed.

1.4.2.5 Wear Test

Perform wear tests on ABC and GCA course material in conformance with ASTM C131.

1.4.2.6 Soundness

Perform soundness tests on GCA in accordance with ASTM C88.

1.4.3 Testing Frequency

1.4.3.1 Initial Tests

Perform one of each of the following tests, on the proposed material prior to commencing construction, to demonstrate that the proposed material meets all specified requirements when furnished. If materials from more than one source are going to be utilized, this testing shall be completed for each source.

a. Sieve Analysis including the 0.02mm sieve.

b. Liquid limit and plasticity index.

c. Moisture-density relationship.

d. Wear.

e. Soundness.

1.4.3.2 In Place Tests

Perform each of the following tests on samples taken from the placed and compacted ABC and GCA. Samples shall be taken and tested at the rates indicated. Perform sampling and testing of recycled concrete aggregate at twice the specified frequency until the material uniformity is established.

a. Perform density tests on every lift of material placed and at a frequency of one set of tests for every 250 square yards , or portion thereof, of completed area.

b. Perform sieve analysis on every lift of material placed and at a frequency of one sieve analysis for every 500 square yards , or portion thereof, of material placed.

c. Perform liquid limit and plasticity index tests at the same frequency as the sieve analysis.

d. Measure the total thickness of the base course at intervals, in such a manner as to ensure one measurement for each 500 square yards of base course. Measurements shall be made in 3 inch diameter test holes penetrating the base course.

1.4.4 Approval of Material

Select the source of the material 30 days prior to the time the material will be required in the work. Tentative approval of material will be based on initial test results. Final approval of the materials will be based on sieve analysis, liquid limit, and plasticity index tests performed on samples taken from the completed and fully compacted course(s).

1.5 ENVIRONMENTAL REQUIREMENTS

Perform construction when the atmospheric temperature is above 35 degrees F. When the temperature falls below 35 degrees F, protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements.

PART 2 PRODUCTS

2.1 PLANT, EQUIPMENT, AND TOOLS

All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Provide adequate equipment having the capability of producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

2.2 AGGREGATES

Provide ABC and GCA consisting of clean, sound, durable particles of crushed stone, crushed slag, crushed gravel, crushed recycled concrete (for ABC only), angular sand, or other approved material. ABC shall be free of lumps of clay, organic matter, and other objectionable materials or coatings. GCA shall be free of silt and clay as defined by ASTM D2487,

organic matter, and other objectionable materials or coatings. The portion retained on the No. 4 sieve is known as coarse aggregate; that portion passing the No. 4 sieve is known as fine aggregate.

2.2.1 Coarse Aggregate

Provide coarse aggregates with angular particles of uniform density. When the coarse aggregate is supplied from more than one source, aggregate from each source shall meet the specified requirements and shall be stockpiled separately.

a. Crushed Gravel: Crushed gravel manufactured by crushing gravels, and meets all the requirements specified below.

b. Crushed Stone: Provide crushed stone consisting of freshly mined quarry rock, meeting all the requirements specified below.

c. Crushed Recycled Concrete: Provide crushed recycled concrete consisting of previously hardened portland cement concrete or other concrete containing pozzolanic binder material. The recycled material shall be free of all reinforcing steel, bituminous concrete surfacing, and any other foreign material and shall be crushed and processed to meet the required gradations for coarse aggregate. Reject recycled concrete aggregate exceeding this value. Crushed recycled concrete must meet all other applicable requirements specified below. Crushed recycled concrete cannot be used for GCA.

2.2.1.1 Aggregate Base Course

ABC coarse aggregate shall not show more than 50 percent loss when subjected to the Los Angeles abrasion test in accordance with ASTM C131. The amount of flat and elongated particles shall not exceed 30 percent. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. In the portion retained on each sieve specified, the crushed aggregates shall contain at least 50 percent by weight of crushed pieces having two or more freshly fractured faces determined in accordance with ASTM D5821. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractured faces. Crushed gravel shall be manufactured from gravel particles 50 percent of which, by weight, are retained on the maximum size sieve listed in TABLE 1.

2.2.1.2 Graded-Crushed Aggregate Base Course

GCA coarse aggregate shall not show more than 40 percent loss when subjected to the Los Angeles abrasion test in accordance with ASTM C131. GCA coarse aggregate shall not exhibit a loss greater than 18 percent weighted average, at five cycles, when tested for soundness in magnesium sulfate, or 12 percent weighted average, at five cycles, when tested in sodium sulfate in accordance with ASTM C88. The amount of flat and elongated particles shall not exceed 20 percent for the fraction retained on the 1/2 inch sieve nor 20 percent for the fraction passing the 1/2 inch sieve. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. In the portion retained on each sieve specified, the crushed aggregate shall contain at least 90 percent by weight of

crushed pieces having two or more freshly fractured faces determined in accordance with ASTM D5821. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractured faces. Crushed gravel shall be manufactured from gravel particles 90 percent of which by weight are retained on the maximum size sieve listed in TABLE 1.

2.2.2 Fine Aggregate

Fine aggregates shall be angular particles of uniform density. When the fine aggregate is supplied from more than one source, aggregate from each source shall meet the specified requirements.

2.2.2.1 Aggregate Base Course

ABC fine aggregate shall consist of screenings, angular sand, crushed recycled concrete fines, or other finely divided mineral matter processed or naturally combined with the coarse aggregate.

2.2.2.2 Graded-Crushed Aggregate Base Course

Provide GCA fine aggregate consisting of angular particles produced by crushing stone, or gravel that meets the requirements for wear and soundness specified for GCA coarse aggregate. Fine aggregate shall be produced by crushing only particles larger than No. 4 sieve in size. The fine aggregate shall contain at least 90 percent by weight of particles having two or more freshly fractured faces in the portion passing the No. 4 sieve and retained on the No. 10 sieve, and in the portion passing the No. 10 sieve and retained on the No. 40 sieve.

2.2.3 Gradation Requirements

Apply the specified gradation requirements to the completed base course. The aggregates shall be continuously well graded within the limits specified in TABLE 1. Sieves shall conform to ASTM E11.

TABLE 1. GRADATION OF AGGREGATES			
Percentage by Weight Passing Square-Mesh Sieve			
Sieve Designation	No. 1 GCA	No. 2 ABC	
2 inch	100	---	
1-1/2 inch	70-100	100	
1 inch	45-80	60-100	
1/2 inch	30-60	30-65	
No. 4	20-50	20-50	
No. 10	15-40	15-40	
No. 40	5-25	5-25	

TABLE 1. GRADATION OF AGGREGATES			
Percentage by Weight Passing Square-Mesh Sieve			
Sieve Designation	No. 1 GCA	No. 2 ABC	
No. 200	0-8	0-8	
NOTE 1: Particles having diameters less than 0.02mm No. 635 shall not be in excess of 3 percent by weight of the total sample tested.			
NOTE 2: The values are based on aggregates of uniform specific gravity. If materials from different sources are used for the coarse and fine aggregates, they shall be tested in accordance with ASTM C127 and ASTM C128 to determine their specific gravities. If the specific gravities vary by more than 10 percent, the percentages passing the various sieves shall be corrected as directed by the Contracting Officer.			

2.3 LIQUID LIMIT AND PLASTICITY INDEX

Apply liquid limit and plasticity index requirements to the completed course and to any component that is blended to meet the required gradation. The portion of any component or of the completed course passing the No. 40 sieve shall be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 5.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

When the ABC or GCA is constructed in more than one layer, clean the previously constructed layer of loose and foreign matter by sweeping with power sweepers or power brooms, except that hand brooms may be used in areas where power cleaning is not practicable. Provide adequate drainage during the entire period of construction to prevent water from collecting or standing on the working area. Provide line and grade stakes as necessary for control. Grade stakes shall be in lines parallel to the centerline of the area under construction and suitably spaced for string lining.

3.2 OPERATION OF AGGREGATE SOURCES

Clearing, stripping, and excavating are the responsibility of the Contractor. Operate the aggregate sources to produce the quantity and quality of materials meeting the specified requirements in the specified time limit. Aggregate sources on private lands shall be conditioned in agreement with local laws or authorities.

3.3 STOCKPILING MATERIAL

Clear and level storage sites prior to stockpiling of material. Stockpile all materials, including approved material available from excavation and grading, in the manner and at the locations designated. Aggregates shall be stockpiled on the cleared and leveled areas designated by the Contracting Officer to prevent segregation. Materials obtained from different sources shall be stockpiled separately.

3.4 PREPARATION OF UNDERLYING COURSE

Prior to constructing the base course(s), the underlying course or subgrade shall be cleaned of all foreign substances. At the time of construction of the base course(s), the underlying course shall contain no frozen material. The surface of the underlying course or subgrade shall meet specified compaction and surface tolerances. The underlying course shall conform to Section 31 23 00.00 20 Exvacation and Fill . Ruts or soft yielding spots in the underlying courses, areas having inadequate compaction, and deviations of the surface from the requirements set forth herein shall be corrected by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses containing sands or gravels, as defined in ASTM D2487, the surface shall be stabilized prior to placement of the base course(s). Stabilization shall be accomplished by mixing ABC or GCA into the underlying course and compacting by approved methods. The stabilized material shall be considered as part of the underlying course and shall meet all requirements of the underlying course. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained in a satisfactory condition until the base course is placed.

3.5 INSTALLATION

3.5.1 Mixing the Materials

Mix the coarse and fine aggregates in a stationary plant, or in a traveling plant or bucket loader on an approved paved working area. Make adjustments in mixing procedures or in equipment, as directed, to obtain true grades, to minimize segregation or degradation, to obtain the required water content, and to insure a satisfactory base course meeting all requirements of this specification.

3.5.2 Placing

Place the mixed material on the prepared subgrade or subbase in layers of uniform thickness with an approved spreader. When a compacted layer 6 inches or less in thickness is required, place the material in a single layer. When a compacted layer in excess of 6 inches is required, place the material in layers of equal thickness. No layer shall be thicker than 6 inches or thinner than 4 inches when compacted. The layers shall be so placed that when compacted they will be true to the grades or levels required with the least possible surface disturbance. Where the base course is placed in more than one layer, the previously constructed layers shall be cleaned of loose and foreign matter by sweeping with power sweepers, power brooms, or hand brooms, as directed. Such adjustments in placing procedures or equipment shall be made as may be directed to obtain true grades, to minimize segregation and degradation, to adjust the water content, and to insure an acceptable base course.

3.5.3 Grade Control

The finished and completed base course shall conform to the lines, grades, and cross sections shown. Underlying material(s) shall be excavated and prepared at sufficient depth for the required base course thickness so that the finished base course and the subsequent surface course will meet the designated grades.

3.5.4 Edges of Base Course

The base course(s) shall be placed so that the completed section will be a minimum of 2 feet wider, on all sides, than the next layer that will be placed above it. Additionally, place approved fill material along the outer edges of the base course in sufficient quantities to compact to the thickness of the course being constructed, or to the thickness of each layer in a multiple layer course, allowing in each operation at least a 2 foot width of this material to be rolled and compacted simultaneously with rolling and compacting of each layer of base course. If this base course material is to be placed adjacent to another pavement section, then the layers for both of these sections shall be placed and compacted along this edge at the same time.

3.5.5 Compaction

Compact each layer of the base course, as specified, with approved compaction equipment. Maintain water content during the compaction procedure to within plus 2 percent of the optimum water content determined from laboratory tests as specified in this Section. Begin rolling at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half the width of the roller. Alternate trips of the roller shall be slightly different lengths. Speed of the roller shall be such that displacement of the aggregate does not occur. In all places not accessible to the rollers, the mixture shall be compacted with hand-operated power tampers. Continue compaction until each layer has a degree of compaction that is at least 100 percent of laboratory maximum density through the full depth of the layer. Make such adjustments in compacting or finishing procedures as may be directed to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to ensure a satisfactory base course. Any materials that are found to be unsatisfactory shall be removed and replaced with satisfactory material or reworked, as directed, to meet the requirements of this specification.

3.5.6 Thickness

Construct the compacted thickness of the base course as indicated. No individual layer shall be thicker than 6 inches nor be thinner than 4 inches in compacted thickness. The total compacted thickness of the base course(s) shall be within 1/2 inch of the thickness indicated. Where the measured thickness is more than 1/2 inch deficient, correct such areas by scarifying, adding new material of proper gradation, reblading, and recompacting as directed. Where the measured thickness is more than 1/2 inch thicker than indicated, the course shall be considered as conforming to the specified thickness requirements. Average job thickness shall be the average of all thickness measurements taken for the job, but shall be within 1/4 inch of the thickness indicated. The total thickness of the base course shall be measured at intervals in such a manner as to ensure one measurement for each 500 square yards of base course. Measurements shall be made in 3 inch diameter test holes penetrating the base course.

3.5.7 Proof Rolling

Proof rolling of the areas indicated shall be in addition to the compaction specified and shall consist of the application of 4 coverages with a heavy pneumatic-tired roller having four or more tires, each loaded to a minimum of 30,000 pounds and inflated to a minimum of 125 psi. In areas designated, apply proof rolling to the top of the underlying

material on which the base course is laid and to each layer of base course top of the completed ABC GCA course. Maintain water content of the underlying material at optimum or at the percentage directed from start of compaction to completion of proof rolling of that layer. Water content of each layer of the base course shall be maintained at the optimum percentage directed from start of compaction to completion of proof rolling. Any base course materials or any underlying materials that produce unsatisfactory results by proof rolling shall be removed and replaced with satisfactory materials, recompacted and proof rolled to meet these specifications.

3.5.8 Finishing

The surface of the top layer of base course shall be finished after final compaction and proof rollingby cutting any overbuild to grade and rolling with a steel-wheeled roller. Thin layers of material shall not be added to the top layer of base course to meet grade. If the elevation of the top layer of base course is 1/2 inch or more below grade, then the top layer should be scarified to a depth of at least 3 inches and new material shall be blended in and compacted , compacted and proof rolled to bring to grade. Adjustments to rolling and finishing procedures shall be made as directed to minimize segregation and degradation, obtain grades, maintain moisture content, and insure an acceptable base course. Should the surface become rough, corrugated, uneven in texture, or traffic marked prior to completion, the unsatisfactory portion shall be scarified, reworked and recompacted or it shall be replaced as directed.

3.5.9 Smoothness

The surface of the top layer shall show no deviations in excess of 3/8 inch when tested with a 12 foot straightedge. Take measurements in successive positions parallel to the centerline of the area to be paved. Measurements shall also be taken perpendicular to the centerline at 50 foot intervals. Deviations exceeding this amount shall be corrected by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

3.6 TRAFFIC

Do not allow traffic on the completed base course.

3.7 MAINTENANCE

Maintain the base course in a satisfactory condition until the full pavement section is completed and accepted. Maintenance shall include immediate repairs to any defects and shall be repeated as often as necessary to keep the area intact. Any base course that is not paved over prior to the onset of winter, shall be retested to verify that it still complies with the requirements of this specification. Any area of base course that is damaged shall be reworked or replaced as necessary to comply with this specification.

3.8 DISPOSAL OF UNSATISFACTORY MATERIALS

Dispose of any unsuitable materials that must be removed outside the limits of Government-controlled land . No additional payments will be made for materials that must be replaced.

-- End of Section --

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SECTION 32 11 33

CEMENT STABILIZED BASE COURSE AT AIRFIELDS

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 140	(2013) Standard Specification for Emulsified Asphalt
AASHTO M 208	(2001; R 2009) Standard Specification for Cationic Emulsified Asphalt
AASHTO M 81	(1992; R 2008) Standard Specification for Cutback Asphalt (Rapid-Curing Type)
AASHTO M 82	(1975; R 2008) Standard Specification for Cutback Asphalt (Medium-Curing Type)

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C171	(2007) Standard Specification for Sheet Materials for Curing Concrete
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C595/C595M	(2013) Standard Specification for Blended Hydraulic Cements
ASTM D1140	(2000; R 2006) Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve

ASTM D1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1632	(2007) Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory
ASTM D1633	(2000; R 2007) Compressive Strength of Molded Soil-Cement Cylinders
ASTM D2027/D2027M	(2013) Cutback Asphalt (Medium-Curing Type)
ASTM D2028/D2028M	(2010) Cutback Asphalt (Rapid-Curing Type)
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D420	(1998; R 2003) Site Characterization for Engineering Design, and Construction Purposes
ASTM D4318	(2010; E 2014) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D558	(2011) Moisture-Density (Unit Weight) Relations of Soil-Cement Mixtures
ASTM D559	(2003) Wetting and Drying Compacted Soil-Cement Mixtures
ASTM D560	(2003) Freezing and Thawing Compacted Soil-Cement Mixtures
ASTM D6938	(2010) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D75/D75M	(2013) Standard Practice for Sampling Aggregates
ASTM D977	(2013; E 2014) Emulsified Asphalt

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

NIOSH 81-123	(1981) Occupational Health Guideline for Chemical Hazards, (Vols. 1, 2, and 3)

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS CCC-C-467	(Rev C; Notice 1) Cloth, Burlap, Jute (or Kenaf)

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. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

Base course aggregate

Rigid pavement base course

Submit duplicate samples of material to be subjected to field testing, as required in paragraph entitled "Field Sampling and Testing." Select the source(s) and provide sample of the aggregate listed above before the materials are required for mix design. Submit duplicate samples for approval at least 30 days prior to start of work. Do not use aggregate prior to receiving written approval of the samples. Investigate new sources in accordance with ASTM D420. Take samples from pits, borrow areas, stockpiles or other locations in conformance with ASTM D75/D75M and test. For determining optimum moisture content and maximum density, samples of the blended mixture(s) shall be representative of the processing area before addition of cement.

SD-05 Design Data

Mix design

Job-mix formula

Submit a contractor-furnished mix design thirty days prior to commencement of work. After receiving approval of the mix design, submit a job-mix formula.

SD-06 Test Reports

Aggregate plasticity index

Sieve analysis of aggregate

Compressive strength

Soil-cement weight loss

Aggregate percentage of wear

Existing soil moisture-density

Liquid limit of aggregates

Plasticity index of aggregates

Sieve analysis of combined material

Compressive strength of soil aggregate material

Optimum moisture content and maximum density

Submit results of ASTM C136 sieve analysis and ASTM D1633 compressive strength testing.

SD-07 Certificates

Portland cement

Location of aggregate source

Method of installation

Construction equipment list

1.3 DELIVERY AND STORAGE

1.3.1 Cement

Store cement immediately upon receipt. Store cement in bags on pallets in an airtight and weatherproof structure. Elevate pallets above surface a distance sufficient to prevent the absorption of moisture. Stack bags close together to reduce circulation of air, but do not stack against outside walls. The manner of storage shall permit easy access for inspection and identification of each shipment. Transfer bulk cement to elevated airtight and weatherproof bins. Cement shall be free-flowing and free of lumps. Test cement that has been in storage longer than 6 months by standard mortar tests or loss on ignition test and use such cement only with approval of the Contracting Officer. Show the date of receipt of shipment on each bag of cement.

1.3.2 Aggregates

Store aggregates in a manner to minimize segregation and contamination. To prevent the inclusion of contaminants, store aggregates on surfaces covered with tightly laid wooden planks, sheet metal, or other hard and clean material. Store aggregates of different sizes in separate piles. Form stockpiles of coarse aggregates by spreading the materials in horizontal layers not exceeding 5 feet in depth. Stockpiling may be the single-core type, cast and spread type or truck-dumped type. Should the coarse aggregates become segregated, re-mix the stockpile to conform to specified grading requirements. Aggregate obtained from below existing watertable shall be drained before use.

1.3.3 Curing Materials

Deliver curing materials in original sealed containers showing trade name, specification number and manufacturer's name. Store in a manner that will prevent damage and contamination.

1.4 ENVIRONMENTAL CONDITIONS

Do not construct base when weather conditions will detrimentally affect quality of the finished course. Apply cement when the ambient temperature is a minimum of 40 degrees F and rising. Do not apply cement to aggregate materials that are frozen or contain frost. If ambient temperature falls below 40 degrees F, protect completed cement-treated areas against freezing. Reprocess, reshape, and recompact damaged material. Provide drainage to prevent water from collecting or standing on stabilized areas, and on the pulverized, mixed, or partially mixed materials.

1.5 QUALITY ASSURANCE

1.5.1 Required Data

Submit location of aggregate source in writing. Do not construe Government approval of samples as approval of the source of the samples. Submit a construction equipment list, and method of proportioning, spreading, compacting and curing to be used, thirty days prior to commencement of work.

PART 2 PRODUCTS

2.1 CEMENT

ASTM C150/C150M, Type II, low alkali or ASTM C595/C595M Type IP Type I PM.

2.2 AGGREGATE MATERIALS

2.2.1 Base Course Aggregate

Crushed and uncrushed coarse and fine aggregate. Sample materials in accordance with ASTM D75/D75M. Material passing the No. 40 sieve shall have a maximum liquid limit of 25 and a maximum plasticity index of 12 in accordance with ASTM D4318. The aggregate sand equivalent is to exceed 18. Perform sieve analysis in accordance with ASTM C117 and ASTM C136.

2.2.1.1 Rigid Pavement Base Course

Plasticity index of less than 8 and liquid limit less than 25 in accordance with ASTM D4318.

2.2.1.2 Gradation of Aggregate

Conform to the following:

TABLE I			
Sieve Designation	Percent by Weight Passing		
	(1)	(2)	
3 inch		100	
2 1/2 inch		90-100	
2 inch			
1 1/2 inch			
1 inch	100		
3/4 inch	0-100		
1/2 inch			

TABLE I			
Sieve Designation	Percent by Weight Passing		
	(1)	(2)	
No. 4	5-70	55-70	
No. 10			
No. 30	2-55		
No. 40			
No. 200	3-15	3-20	

2.3 WATER

Provide potable, clean, fresh and free from injurious amounts of oils, acid, salt, alkali, organic matter and other substances deleterious to the hardening of soil-cement.

2.4 CEMENT-TREATED BASE

Uniformly blend aggregates and cement together, mixed with water. Provide cement treated base produced with the following characteristics:

2.4.1 Compressive Strength

Unconfined compressive strength at optimum moisture content a minimum of 650 psi at 7 days when tested in accordance with ASTM D1633.

2.4.2 Weight Loss of Specimens

Less than 14 percent when subjected to 12 cycles of wet-dry tests in accordance with ASTM D559.

Less than 14 percent when subjected to 12 cycles of freeze-thaw tests in accordance with ASTM D560.

2.5 MIX DESIGN

Provide a mix design and job-mix formula for plant mix material for base prepared by an approved laboratory. Show amount of cement needed and the moisture-densityrelations of the composite aggregate mixture in accordance with ASTM D558. Mix design shall include certified test reports showing results of tests and results of 7-day compressive tests and the freezing and thawing tests. . Mold a minimum of four cylinders of each cement mixture in accordance with ASTM D1632, except that test specimen molds shall be 4 inches in diameter by 4.6 inches high. Cure and test specimens in accordance with ASTM D1633 with the following exceptions: (1) cure specimens in moist room at 100 percent relative humidity for 7 days; and (2) after curing, cap specimens and immerse in water at room temperature for a period of 4 hours prior to testing. Before or during construction, if the source of any materials is changed, or if there is any variation in quality of materials furnished, conduct additional tests and adjust amount of cement as required to obtain the specified results.

2.6 CURING MATERIALS

2.6.1 Bituminous Material

2.6.1.1 Liquid Asphalt

ASTM D2027/D2027M or AASHTO M 82, Type MC-70 for medium-curing asphalt; ASTM D2028/D2028M or AASHTO M 81, type RC-70 for rapid-curing asphalt.

2.6.1.2 Emulsified Asphalt

ASTM D977 or AASHTO M 140, Type RS-1 or AASHTO M 208CRS-1 .

2.6.2 Burlap

FS CCC-C-467.

2.6.3 Polyethylene Sheeting

White, opaque, free of defects, uniform in appearance, a minimum 4 mils thick. Water retention requirements shall be in accordance with ASTM C171.

2.6.4 Polyethylene-Coated Burlap

White, opaque, 4 mil thick film, impregnated into, extruded on, or permanently affixed to surface of one side of burlap weighing not less than 9 ounces per square yard prior to coating. Water retention requirements shall be in accordance with ASTM C171.

2.6.5 Waterproof Paper

White topside. Water retention requirements shall be in accordance with ASTM C171.

PART 3 EXECUTION

3.1 SITE PREPARATION

3.1.1 Cleaning and Grading

Clean debris from the area to be stabilized. Inspect subbase (GCA) for capability to withstand without displacement, compaction specified for the aggregate-cement mixture. Correct ruts, soft or yielding areas in subbase by removing or adding material or aerating or wetting materials as required. Grade proof roll and shape the area to be stabilized to conform to lines, grades, and cross sections prior to placing cement-treated course according to Section 31 23 00.00 20 EXCAVATION AND BACKFILL The surface shall be approved by the Contracting Officer prior to base course placement. Determine moisture-density relationship of existing soils in accordance with ASTM D1557. Perform laboratory tests on existing materials prior to initial construction.

3.1.2 Grade Control

Maintain lines and grades indicated. When the stabilized course is part of a pavement which is to meet a fixed grade, construct a transition of sufficient length to minimize abrupt or noticeable grade changes.

3.1.3 Operation of Government Borrow Pits

Perform cleaning, stripping, and excavating in opening or operation of pits or quarries. Open pits in a manner that will expose vertical faces of the deposit for suitable working depths. Obtain materials excavated from pits in successive vertical cuts extending through exposed strata. Waste pockets or strata of unsuitable materials overlying or occurring in the deposit. Methods of operating pits and processing and blending of materials may be changed or modified by the Contracting Officer without adjustments in the contract price when such action is necessary to obtain material conforming to specified requirements.

3.2 MIXING AND PLACING

3.2.1 Mixing

Mix cement and aggregate in a central mixing plant . Proportion aggregate by weight or by volume in such quantities that specified gradation, bearing ratio, liquid limit, and plasticity index requirements are met after base has been placed and compacted. Proportion cement by weight in accordance with job-mix formula. Provide necessary moisture content for specified compaction by addition of water by weight or by volume. Mixing operations shall produce uniform blending and the method of discharging shall not produce segregation.

3.2.2 Plant Mix Materials

Materials from several sources which are blended and mixed or processed in a central mixing plant or in a traveling mixing plant. Prepare base course materials for airfield portland cement concrete pavement in a central mixing plant. Add cement in accordance with job-mix formula. Uniformly mix materials with required amount of water. After mixing is completed, transport the materials to, and spread on, prepared underlying course without undue loss of the moisture content.

3.2.3 Placing

Loose thickness of individual layers shall not exceed 8 inches . When stabilized course is constructed in more than one layer, clean previously constructed layers of loose and foreign matter by sweeping with power sweepers or power brooms, except that hand brooms may be used where permitted by the Contracting Officer. Not more than 60 minutes shall elapse between start of moist mixing and start of compaction of treated layer. Not more than 30 minutes shall elapse between placement of cement-treated aggregates in adjacent lanes. If elapsed time exceeds 30 minutes, provide construction joint. Layers are to be uniform in thickness.

3.2.4 Compaction

With the exception of materials placed by traveling-plant method, thoroughly loosen blended materials to full depth by disks or scarifiers and determine moisture content of mixture and compare with laboratory optimum moisture content. Begin rolling and compaction when moisture content is within plus or minus 2 percentage points of optimum moisture content. Compact layers of base course materials. Continue compaction until layer or layers are compacted through full depth of base . Begin rolling at outside edge of a minimum one half the width of the roller. Subsequent rolled trips shall be slightly different lengths. In places

not accessible to rolling equipment, compact the material by mechanical tamping. Continue blading, rolling and tamping until surface is smooth and free from waves and irregularities. Determine in-place density of compacted cement-aggregate mixture in accordance with ASTM D1556 with minimum compaction of 100 percent of maximum density in accordance with ASTM D558.

3.3 FINISHING

3.3.1 Finishing

After compaction, moisten surface if necessary, and shape to required lines, grades and cross section. Lightly scarify surface to eliminate imprints made by the compacting or shaping equipment. Thoroughly compact surface to specified density with rubbertired rollers and smooth-wheel tandem rollers to provide a smooth, dense, uniform surface free of surface checking, ridges or loose material and conforming to crown, grade and line indicated. Complete finishing operations within 2 hours after completion of mixing operations. In places not accessible to finishing and shaping equipment, compact mixture with mechanical tampers to density specified; shape and finish by hand methods. Reprocess with additional cement, the portion of the compacted mix with density less than that specified, or that has not properly hardened, or that is improperly finished.

3.3.2 Edges of Stabilized Course

Place material along edges of the stabilized course in a quantity that will compact to thickness of course being constructed. If constructed in two or more layers, place in a quantity that will compact to thickness of each layer. Allow in each operation, a minimum width of one foot of the shoulder to be rolled and compacted simultaneously with each layer of the stabilized course.

3.3.3 Thickness Control

Where average measured thickness of stabilized course is more than 1/2 inch deficient in thickness, conduct additional tests and correct deficiencies as directed by the Contracting Officer. Correct excesses in thickness if so directed by the Contracting Officer. Average job thickness is the average of the job measurements determined as specified in paragraph entitled "Thickness Test," in this section, but within 1/2 inch of the thickness indicated. Replace material removed for test holes or for deficient thickness reconstruction and compact with new soil-cement mixture.

3.3.4 Construction Joints

At the end of each work day, form a straight transverse construction joint by cutting back into completed work to form a true vertical face free of loose or shattered material. Remove improperly compacted material along construction joints and replace with soil-cement that is mixed, moistened, and compacted in accordance with this specification.

3.4 CURING AND PROTECTION

3.4.1 Curing, Protection and Cover

Immediately after completion of finishing operations, but no later than the end of each days stabilization work, protect the surface against rapid

drying for seven days by one of the methods specified. In addition, protect the stabilized area from freezing during the curing period or until hardened, whichever period is longer.

3.4.2 Bituminous Material

Immediately after finishing, clean surface of loose and foreign matter. Ensure that surface contains sufficient moisture, by applying water in a fine spray as required, to prevent penetration of bituminous material. Using a distributor, apply bituminous material at a temperature between 20 and 185 (degrees F and at a rate between 0.20 and 0.25 gallons per square yard. Treat areas inaccessible to, or missed by distributor using manually operated hose attachment. Apply sand at 1/4 inch depth (pounds per square yard to treated surfaces requiring protection from traffic.

3.4.3 Burlap or Cotton Mats

Burlap covers consisting of two or more layers of burlap having a combined weight of 14 ounces or more per square yard in a dry condition. Burlap may be either new or have been used only for curing concrete. Cotton mats and burlap strips shall have a length, after shrinkage, at least one foot greater than required to cover the entire width and edges of finished stabilized area. Mats shall overlap each other at least 6 inches. Thoroughly wet mats before placing and keep them continuously wet and in intimate contact with surface and edges of finished stabilized area during entire curing period.

3.4.4 Waterproof Paper, Blankets, or Impermeable Sheets

Moisten surface with a fine spray of water, then cover with waterproof-paper, waterproof-paper blankets, polyethylene-coated burlap blankets, or polyethylene sheeting. Thoroughly saturate polyethylene-coated burlap with water before placing. Place waterproof-paper blankets, polyethylene-coated burlap blankets, or polyethylene sheeting with the light-colored side up. Extend sheets over the edges of stabilized area and secure in place during the curing period. Overlap edges of sheets a minimum of one foot and securely cement or tape to form continuous closed joints. Immediately repair tears and holes in sheets. Reject curing material that does not provide a continuous cover.

3.4.5 Moist Curing

Apply a 2 inch covering of soil or minimum 4 pounds per square yard of straw. Moisten material initially and keep moistened throughout curing period.

3.5 MAINTENANCE AND TRAFFIC CONTROL

3.5.1 Maintenance

After stabilization is completed, maintain base except where succeeding course is under construction. Maintenance shall include drainage and watering as required to maintain course in proper condition. Correct deficiencies in thickness, composition, construction, smoothness or density which develop during maintenance to conform to requirements specified. Maintain surface moisture by lightly sprinkling with water to prevent dust.

3.5.2 Traffic Control

Completed portions of the cement-stabilized area may be opened to light, local traffic provided the curing process is not impaired and to other traffic after curing period has elapsed, provided that the cement-stabilized course has hardened sufficiently to prevent surface marring or distortion by equipment or traffic. Do not permit heavy equipment on the area during protection and curing periods. Necessary cement and water may be hauled over the area with pneumatic-tired equipment on approval of the Contracting Officer. Protect finished portions of cement stabilized base from traffic of equipment used in constructing adjoining sections in a manner to prevent marring or damaging completed work.

3.6 SAFETY REQUIREMENTS

In addition to Safety Requirements contained within the Contract Clauses; prevent employee respiratory, eye or skin contact with Portland Cement during wet or dry mixing or of cutback asphalts during transport or application. Provide and require employee to use and dispose or clean the following in accordance with the pertinent provisions of NIOSH 81-123:

a. Impervious: Clothing, boots and gloves.

b. Splash-proof safety goggles and face shields.

c. Respiratory protection equipment.

3.6.1 Additional Safety Requirements for Cutback Asphalts

Application temperatures of asphalt cutbacks specified usually exceed flash point of the material. Take suitable safety precautions to prevent flashing of asphalt. Exercise the following minimum safety precautions:

a. Do not permit open flames or sparks close to the cutback asphalts. Apply controlled heat in heating kettles, mixers, distributors, or other equipment designed and approved for the purpose.

b. Do not use open flames to examine drums, tank cars, or other containers or cutback asphalts.

c. Properly and fully vent vehicles transporting cutback asphalts.

d. Permit only experienced personnel to supervise the handling of cutback asphalt materials.

e. Comply with all applicable intrastate and interstate commerce regulations for transporting cutback asphalts.

3.7 FIELD SAMPLING AND TESTING

In addition to provisions set forth elsewhere in this contract, specified sampling and testing shall be conducted by an approved laboratory. Provide duplicate samples to the Contracting Officer on the average of 3samples a week . Take duplicate samples at the same time and in the same manner as the original.

3.7.1 Sampling

3.7.1.1 Aggregates at Source

Collect samples by taking three incremental specimens at random from source material to make a composite sample a minimum of 150 pounds. Thereafter, during the course of the project, take one random sample from each 4000 tons of material or a day's run, whichever is less. Take the samples at random to make a composite sample of not less than 50 pounds. Repeat the sampling when source of material is changed or when unacceptable deficiencies or variations from specified grading of materials are found in testing.

3.7.1.2 Cement-Treated Materials

After cement and water have been added to the aggregates, thoroughly blend the mixture. Place a sample in a closed and insulated container, before cement hydration is completed, and promptly transport to the laboratory.

3.7.1.3 Sample Identification

Place each sample in a clean container and securely close. Identify each sample with a tag containing the following information:

Contract No.:

Sample No.: Quantity:

Date of Sample:

Sampler:

Source:

Intended Use:

For Testing:

3.7.2 Testing

3.7.2.1 Aggregate Testing

Perform the following tests on each sample of the specified aggregate and existing soil-aggregate materials:

a. Sieve analysis of combined material: ASTM C136 and ASTM D1140.

b. Liquid limit: ASTM D4318.

c. Plasticity index: ASTM D4318.

Perform other specified tests when there is a change of aggregate source. Material shall conform to approved test results developed for the mix design.

3.7.2.2 Compressive Tests

Test composite sample of cement treated materials for compressive strength. Mold specimens in accordance with ASTM D558, Method A or B (as

appropriate), cure and test according to ASTM D1632 and ASTM D1633. Test specimens for compressive strength at 7 days, and submit results to the Contracting Officer.

3.7.2.3 Smoothness Test

Test compacted surface with a 10 foot straightedge applied parallel with, and at right angles to center line of paved area, and correct deviations in excess of 1/2 inch. When base course is to be constructed in more than one layer, specified smoothness requirements apply only to the top layer.

3.7.2.4 Thickness Test

Measure thickness of the base course using 3 inch diameter test holes through the full depth for each 500 square yards of completed course. Refill holes with cement treated material and compact.

3.7.2.5 Field Density Tests

Perform field density tests in accordance with ASTM D1556 or ASTM D6938. Perform one field density test for each 2000 square yards for each layer of base material placed.

3.7.2.6 Laboratory Test

Determine optimum moisture content and maximum density relationship in accordance with ASTM D558.

-- End of Section --

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SECTION 32 12 10

BITUMINOUS TACK AND PRIME COATS

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 226	(1980; R 2008) Standard Specification for Viscosity-Graded Asphalt Cement
AASHTO M 81	(1992; R 2008) Standard Specification for Cutback Asphalt (Rapid-Curing Type)
AASHTO M 82	(1975; R 2008) Standard Specification for Cutback Asphalt (Medium-Curing Type)
AASHTO T 102	(2009) Standard Method of Test for Spot Test of Asphaltic Materials
AASHTO T 40	(2002; R 2006) Sampling Bituminous Materials

ASTM INTERNATIONAL (ASTM)

ASTM D1250	(2008) Standard Guide for Use of the Petroleum Measurement Tables
ASTM D140/D140M	(2009) Standard Practice for Sampling Bituminous Materials
ASTM D2026/D2026M	(1997; E 2010; R 2010) Cutback Asphalt (Slow-Curing Type)
ASTM D2027/D2027M	(2013) Cutback Asphalt (Medium-Curing Type)
ASTM D2028/D2028M	(2010) Cutback Asphalt (Rapid-Curing Type)
ASTM D2397/D2397M	(2013) Standard Specification for Cationic Emulsified Asphalt
ASTM D2995	(1999; R 2009) Determining Application Rate of Bituminous Distributors
ASTM D3381/D3381M	(2013) Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D946/D946M	(2009a) Penetration-Graded Asphalt Cement for Use in Pavement Construction

ASTM D977 (2013; E 2014) Emulsified Asphalt

U.S. GREEN BUILDING COUNCIL (USGBC)

LEED NC (2009) Leadership in Energy and Environmental Design(tm) New Construction Rating System

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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Waybills and Delivery Tickets

Local/Regional Materials

SD-06 Test Reports

Sampling and Testing

1.3 QUALITY ASSURANCE

Use Local/Regional Materials or products extracted, harvested, or recovered, as well as manufactured, within a 500 mile radius from the project site, if available from a minimum of three sources. Tack and prime coat materials may be locally available.

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect the materials delivered to the site for contamination and damage. Unload and store the materials with a minimum of handling.

1.5 ENVIRONMENTAL REQUIREMENTS

Apply bituminous coat only when the surface to receive the bituminous coat is dry. Apply bituminous coat only when the atmospheric temperature in the shade is 50 degrees F or above and when the temperature has not been below 35 degrees F for the 12 hours prior to application, unless otherwise directed.

PART 2 PRODUCTS

2.1 PLANT, EQUIPMENT, MACHINES AND TOOLS

Plant, equipment, machines and tools used in the work are subject to approval and must be maintained in a satisfactory working condition at all times. Calibrated equipment such as asphalt distributors, scales, batching equipment, spreaders and similar equipment, must have been recalibrated by a calibration laboratory within 12 months prior to commencing work and every 2 months thereafter, by such laboratory from the date of recalibration, during the term of the contract.

2.1.1 Bituminous Distributor

Provide a distributor with pneumatic tires of such size and number that the load produced on the base surface does not exceed 650 psi of tire width to prevent rutting, shoving or otherwise damaging the base surface or other layers in the pavement structure. Design and equip the distributor to spray the bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled rates from 0.05 to 2.0 gallons per square yard, with a pressure range of 25 to 75 psi and with an allowable variation from the specified rate of not more than plus or minus 5 percent, and at variable widths. Include with the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. Equip the distributor to circulate and agitate the bituminous material during the heating process.

2.1.2 Heating Equipment for Storage Tanks

The equipment for heating the bituminous material shall be steam, electric, or hot oil heaters. Provide steam heaters consisting of steam coils and equipment for producing steam, so designed that the steam cannot get into the material. Fix an armored thermometer to the tank with a temperature range from 40 to 400 degrees F so that the temperature of the bituminous material may be determined at all times.

2.1.3 Power Brooms and Power Blowers

Use power brooms and power blowers suitable for cleaning the surfaces to which the bituminous coat is to be applied.

2.2 PRIME COAT

Provide asphalt conforming to AASHTO M 82, and specified in the following two subparagraphs.

2.2.1 Cutback Asphalt

Provide cutback asphalt conforming to ASTM D2027/D2027M, Grade MC-70 .

2.2.2 Emulsified Asphalt

Provide emulsified asphalt conforming to ASTM D2397/D2397M, Type CSS-1h.

2.3 TACK COAT

Provide asphalt conforming to ASTM D2397/D2397M or .

2.3.1 Cutback Asphalt

Provide cutback asphalt conforming to ASTM D2027/D2027M, Grade MC-70 .

2.3.2 Emulsified Asphalt

Provide emulsified asphalt conforming to ASTM D2397/D2397M, Type CSS-1h. Dilute the emulsified asphalt with equal parts of water. The base asphalt

used to manufacture the emulsion shall show a negative spot when tested in accordance with AASHTO T 102 using standard naphtha.

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Immediately before applying the bituminous coat, remove all loose material, dirt, clay, or other objectionable material from the surface to be treated by means of a power broom or blower supplemented with hand brooms. The surface shall be dry and clean at the time of treatment.

3.2 APPLICATION RATE

The exact quantities within the range specified, which may be varied to suit field conditions, will be determined by the Contracting Officer.

3.2.1 Tack Coat

Apply bituminous material for the tack coat in quantities of not less than 0.05 gallon nor more than 0.15 gallon per square yard of pavement surface.

3.2.2 Prime Coat

Apply bituminous material for the prime coat in quantities of not less than 0.18 gallon nor more than 0.35 gallon per square yard of pavement surface.

3.3 APPLICATION TEMPERATURE

3.3.1 Viscosity Relationship

Asphalt application temperature shall provide an application viscosity between 10 and 60 seconds, Saybolt Furol, or between 20 and 120 centistokes, kinematic. Furnish the temperature viscosity relation to the Contracting Officer.

3.3.2 Temperature Ranges

The viscosity requirements determine the application temperature to be used. The following is a normal range of application temperatures:

	Degrees F
Liquid Asphalts	
MC-70	120-225

	Degrees F
Paving Grade Asphalts	
Viscosity Grades	
AR 4000	plus 290
Emulsions	
CSS-1h	70-160
*These temperature ranges exceed the flash point of the material and care should be taken in their heating.	

3.4 APPLICATION

3.4.1 General

Following preparation and subsequent inspection of the surface, apply the bituminous prime or tack coat with the Bituminous Distributor at the specified rate with uniform distribution over the surface to be treated. Properly treat all areas and spots missed by the distributor with the hand spray. Until the succeeding layer of pavement is placed, maintain the surface by protecting the surface against damage and by repairing deficient areas at no additional cost to the Government. If required, spread clean dry sand to effectively blot up any excess bituminous material. No smoking, fires, or flames other than those from the heaters that are a part of the equipment are permitted within 25 feet of heating, distributing, and transferring operations of bituminous material other than bituminous emulsions. Prevent all traffic, except for paving equipment used in constructing the surfacing, from using the underlying material, whether primed or not, until the surfacing is completed. The bituminous coat shall conform to all requirements as described herein.

3.4.2 Prime Coat

Apply a prime coat at locations shown on the Drawings. The prime coat is required if it will be at least 7 days before the surfacing (Asphalt cement hot mix concrete) layer is constructed on the underlying (base course, etc.) compacted material. The type of liquid asphalt and application rate will be as specified herein. Protect the underlying from any damage (water, traffic, etc.) until the surfacing is placed. If the Contractor places the surfacing within seven days, the choice of protection measures or actions to be taken is at the Contractor's option. Repair (recompact or replace) damage to the underlying material caused by lack of, or inadequate, protection by approved methods at no additional cost to the Government. If the Contractor opts to use the prime coat, apply as soon as possible after consolidation of the underlying material. Apply the bituminous material uniformly over the surface to be treated at a pressure range of 25 to 75 psi; the rate shall be as specified above in paragraph APPLICATION RATE. To obtain uniform application of the prime coat on the surface treated at the junction of previous and subsequent applications, spread building paper on the surface for a sufficient distance back from the ends of each application to start and stop the prime coat on the paper and to ensure that all sprayers will operate at full force on the surface to be treated. Immediately after application remove and destroy the building paper.

3.4.3 Tack Coat

Apply tack coat at the locations shown on the drawings. Apply the tack coat when the surface to be treated is dry. Immediately following the preparation of the surface for treatment, apply the bituminous material by means of the bituminous distributor, within the limits of temperature specified herein and at a rate as specified above in paragraph APPLICATION RATE. Apply the bituminous material so that uniform distribution is obtained over the entire surface to be treated. Treat lightly coated areas and spots missed by the distributor with the bituminous material. Following the application of bituminous material, allow the surface to cure without being disturbed for period of time necessary to permit setting of the tack coat. Apply the bituminous tack coat only as far in advance of the placing of the overlying layer as required for that day's operation. Maintain and protect the treated surface from damage until the

succeeding course of pavement is placed.

3.5 CURING PERIOD

Following application of the bituminous material and prior to application of the succeeding layer of pavement, allow the bituminous coat to cure and to obtain evaporation of any volatiles or moisture. Maintain the coated surface until the succeeding layer of pavement is placed, by protecting the surface against damage and by repairing and recoating deficient areas. Allow the prime coat to cure without being disturbed for a period of at least 48 hours or longer, as may be necessary to attain penetration into the treated course. Furnish and spread enough sand to effectively blot up and cure excess bituminous material.

3.6 FIELD QUALITY CONTROL

Samples of the bituminous material shall be tested for compliance with the applicable specified requirements. A sample shall be obtained and tested by the Contractor for every 800 tons of bituminous material used. Samples shall be obtained by the Contractor as directed, under the supervision of the Contracting Officer. The sample may be retained and tested by the Government at no cost to the Contractor.

3.7 SAMPLING AND TESTING

Submit copies of all test results for emulsified asphalt, and bituminous materials, within 24 hours of completion of tests. Furnish certified copies of the manufacturer's test reports indicating temperature viscosity relationship for cutback asphalt, compliance with applicable specified requirements, not less than 30 days before the material is required in the work. Perform sampling and testing by an approved commercial testing laboratory or by facilities furnished by the Contractor. No work requiring testing will be permitted until the facilities have been inspected and approved.

3.7.1 Sampling

The samples of bituminous material, unless otherwise specified, shall be in accordance with ASTM D140/D140M or AASHTO T 40. Sources from which bituminous materials are to be obtained shall be selected and notification furnished the Contracting Officer within 15 days after the award of the contract.

3.7.2 Calibration Test

Furnish all equipment, materials, and labor necessary to calibrate the bituminous distributor. Calibration shall be made with the approved job material and prior to applying the bituminous coat material to the prepared surface. Calibrate the bituminous distributor in accordance with ASTM D2995.

3.7.3 Trial Applications

Before providing the complete bituminous coat, apply three lengths of at least 100 feet for the full width of the distributor bar to evaluate the amount of bituminous material that can be satisfactorily applied.

3.7.3.1 Tack Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of bituminous tack coat materials in the amount of 0.05 gallons per square yard. Other trial applications shall be made using various amounts of material as may be deemed necessary.

3.7.3.2 Prime Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of bituminous materials in the amount of 0.25 gallon per square yard. Other trial applications shall be made using various amounts of material as may be deemed necessary.

3.7.4 Sampling and Testing During Construction

Perform quality control sampling and testing as required in paragraph FIELD QUALITY CONTROL.

3.8 TRAFFIC CONTROLS

Keep traffic off surfaces freshly treated with bituminous material. Provide sufficient warning signs and barricades so that traffic will not travel over freshly treated surfaces.

-- End of Section --

SECTION 32 12 15.13

HOT-MIX ASPHALT AIRFIELD PAVING

PART 1 GENERAL

1.1 FULL PAYMENT

1.1.1 Method of Measurement

Measurement of the quantity of hot-mix asphalt, per ton placed and accepted, shall be made for the purposes of assessing the pay factors stipulated below.

1.1.2 Basis of Payment

The measured quantity of hot-mixed asphalt will be paid for and included in the lump-sum contract price. If less than 100 percent payment is due based on the pay factors stipulated in paragraph QUALITY ASSURANCE, a unit price of 102 per ton will be used for purposes of calculating the payment reduction.

1.2 PERCENT PAYMENT

When a lot of material fails to meet the specification requirements for 100 percent pay as outlined in the following paragraphs, that lot shall be removed and replaced, or accepted at a reduced price which will be computed by multiplying the unit price by the lot's pay factor. The lot pay factor is determined by taking the lowest computed pay factor based on either laboratory air voids, in-place density, grade or smoothness (each discussed below). Pay factors based on different criteria (i.e., laboratory air voids and in-place density) of the same lot will not be multiplied together to get a lower lot pay factor. At the end of the project, an average of all lot pay factors will be calculated. If this average lot pay factor exceeds 95.0 percent and no individual lot has a pay factor less than 75.1 percent, then the percent payment for the entire project will be 100 percent of the unit bid price. If the average lot pay factor is less than 95.0 percent, then each lot will be paid for at the unit price multiplied by the lot's pay factor. For any lots which are less than 2000 short tons, a weighted lot pay factor will be used to calculate the average lot pay factor.

1.2.1 Mat and Joint Densities

The average in-place mat and joint densities are expressed as a percentage of the average theoretical maximum density (TMD) for the lot. The average TMD for each lot will be determined as the average TMD of the two random samples per lot. The average in-place mat density and joint density for a lot are determined and compared with Table 1 to calculate a single pay factor per lot based on in-place density, as described below. First, a pay factor for both mat density and joint density are determined from Table 1. The area associated with the joint is then determined and will be considered to be 10 feet wide times the length of completed longitudinal construction joint in the lot. This area will not exceed the total lot size. The length of joint to be considered will be that length where a new lane has been placed against an adjacent lane of hot-mix

asphalt pavement, either an adjacent freshly paved lane or one paved at any time previously. The area associated with the joint is expressed as a percentage of the total lot area. A weighted pay factor for the joint is determined based on this percentage (see example below). The pay factor for mat density and the weighted pay factor for joint density is compared and the lowest selected. This selected pay factor is the pay factor based on density for the lot. When the TMD on both sides of a longitudinal joint is different, the average of these two TMD will be used as the TMD needed to calculate the percent joint density. Rejected lots shall be removed and replaced. Rejected areas adjacent to longitudinal joints shall be removed 4 inches into the cold (existing) lane. All density results for a lot will be completed and reported within 24 hours after the construction of that lot.

Table 1. Pay Factor Based on In-place Density

Average Mat Density (4 cores)	Pay Factor, percent	Average Joint Density (4 cores)
94.0 - 96.0	100.0	Above 92.5
93.9	100.0	92.4
93.8 or 96.1	99.9	92.3
93.7	99.8	92.2
93.6 or 96.2	99.6	92.1
93.5	99.4	92.0
93.4 or 96.3	99.1	91.9
93.3	98.7	91.8
93.2 or 96.4	98.3	91.7
93.1	97.8	91.6
93.0 or 96.5	97.3	91.5
92.9	96.3	91.4
92.8 or 96.6	94.1	91.3
92.7	92.2	91.2
92.6 or 96.7	90.3	91.1
92.5	87.9	91.0
92.4 or 96.8	85.7	90.9
92.3	83.3	90.8

Table 1. Pay Factor Based on In-place Density		
Average Mat Density (4 cores)	Pay Factor, percent	Average Joint Density (4 cores)
92.2 or 96.9	80.6	90.7
92.1	78.0	90.6
92.0 or 97.0	75.0	90.5
below 92.0, above 97.0	0.0 (reject)	below 90.5

1.2.2 Pay Factor Based on In-place Density

An example of the computation of a pay factor (in I-P units only) based on in-place density, is as follows: Assume the following test results for field density made on the lot: (1) Average mat density = 93.2 percent (of lab TMD). (2) Average joint density = 91.5 percent (of lab TMD). (3) Total area of lot = 30,000 square feet. (4) Length of completed longitudinal construction joint = 2000 feet.

a. Step 1: Determine pay factor based on mat density and on joint density, using Table 1:

   Mat density of 93.2 percent = 98.3 pay factor.

   Joint density of 91.5 percent = 97.3 pay factor.

b. Step 2: Determine ratio of joint area (length of longitudinal joint x 10 ft) to mat area (total paved area in the lot): Multiply the length of completed longitudinal construction joint by the specified 10 ft. width and divide by the mat area (total paved area in the lot).

   (2000 ft. x 10 ft.)/30000 sq.ft. = 0.6667 ratio of joint area to mat area (ratio).

c. Step 3: Weighted pay factor (wpf) for joint is determined as indicated below:

   wpf = joint pay factor + (100 - joint pay factor) (1 - ratio) wpf = 97.3 + (100-97.3) (1-.6667) = 98.2 percent

d. Step 4: Compare weighted pay factor for joint density to pay factor for mat density and select the smaller:

   Pay factor for mat density: 98.3 percent. Weighted pay factor for joint density: 98.2 percent

   Select the smaller of the two values as pay factor based on density: 98.2 percent

1.2.3 Payment Adjustment for Smoothness

a. Straightedge Testing. Location and deviation from straightedge for all measurements shall be recorded. When between 5.0 and 10.0 percent of all measurements made within a lot exceed the tolerance specified

in paragraph Smoothness Requirements below, after any reduction of high spots or removal and replacement, the computed pay factor for that lot based on surface smoothness, will be 95 percent. When more than 10.0 percent of all measurements exceed the tolerance, the computed pay factor will be 90 percent. When between 15.0 and 20.0 percent of all measurements exceed the tolerance, the computed pay factor will be 75 percent. When 20.0 percent or more of the measurements exceed the tolerance, the lot shall be removed and replaced at no additional cost to the Government . Regardless of the above, any small individual area with surface deviation which exceeds the tolerance given above by more than 50 percent, shall be corrected by diamond grinding to meet the specification requirements above or shall be removed and replaced at no additional cost to the Government .

b. Profilograph Testing. Location and data from all profilograph measurements shall be recorded. When the Profile Index of a lot exceeds the tolerance specified in paragraph Smoothness Requirements by 1.0 inch/mile, but less than 2.0 inches/mile, after any reduction of high spots or removal and replacement, the computed pay factor for that lot based on surface smoothness will be 95 percent. When the Profile Index exceeds the tolerance by 2.0 inches/mile, but less than 3.0 inches/mile, the computed pay factor will be 90 percent. When the Profile Index exceeds the tolerance by 3.0 inches/mile, but less than 4.0 inches/mile, the computed pay factor will be 75 percent. When the Profile Index exceeds the tolerance by 4.0 inches/mile or more, the lot shall be removed and replaced at no additional cost to the . Regardless of the above, any small individual area with surface deviation which exceeds the tolerance given above by more than 5.0 inches/mile or more, shall be corrected by grinding to meet the specification requirements above or shall be removed and replaced at no additional cost to the Government.

1.2.4 Laboratory Air Voids and Theoretical Maximum Density

Laboratory air voids will be calculated in accordance with ASTM D3203/D3203M by determining the Marshall density of each lab compacted specimen using the laboratory-prepared, thoroughly dry method in ASTM D2726/D2726M and determining the theoretical maximum density (TMD) of two of the sublots using ASTM D2041/D2041M. Laboratory air void calculations for each lot will use the average theoretical maximum density values obtained for the lot. The mean absolute deviation of the four laboratory air void contents (one from each sublot) from the JMF air void content will be evaluated and a pay factor determined from Table 2. All laboratory air void tests will be completed and reported within 24 hours after completion of construction of each lot. The TMD is also used for computation of compaction, as required in paragraph: Mat and Joint Densities above.

1.2.5 Mean Absolute Deviation

An example of the computation of mean absolute deviation for laboratory air voids is as follows: Assume that the laboratory air voids are determined from 4 random samples of a lot (where 3 specimens were compacted from each sample). The average laboratory air voids for each sublot sample 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

= (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 from Table 2 that the lot's pay factor based on laboratory air voids, is 100 percent.

Table 2. Pay Factor Based on Laboratory Air Voids

Mean Absolute Deviation of Lab Air Voids from JMF	Pay Factor, Percent
0.60 or less	100
0.61 - 0.80	98
0.81 - 1.00	95
1.01 - 1.20	90
Above 1.20	reject (0)

1.2.6 Pay Adjustment Based on Grade

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. All testing shall be performed in the presence of the Contracting Officer . The final wearing surface of pavement shall conform to the elevations and cross sections shown and shall vary not more than 0.03 foot for runways or 0.05 foot for taxiways and aprons from the plan grade established and approved at site of work. Finished surfaces at juncture with other pavements shall coincide 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. Detailed notes of the results of the testing shall be kept and a copy furnished to the Contracting Officer immediately after each day's testing. When more than 5 percent of all measurements made within a lot are outside the 0.03 or 0.05 foot tolerance, the pay factor based on grade for that lot will be 95 percent. In areas where the grade exceeds the tolerance by more than 50 percent, remove the surface lift full depth; and replace the lift with hot-mix asphalt to meet specification requirements, at no additional cost to the. Diamond grinding may 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.

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.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 156	(2013) Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
AASHTO M 320	(2010) Standard Specification for Performance-Graded Asphalt Binder
AASHTO T 308	(2010) Standard Method of Test for Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
AASHTO T 329	(2013) Standard Test Method for Moisture Content of Hot Mix Asphalt (HMA) by Oven Method

ASPHALT INSTITUTE (AI)

AI MS-2	(1997 6th Ed) Mix Design Methods

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C1252	(2006) Standard Test Methods for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading)
ASTM C127	(2012) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	(2012) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C142/C142M	(2010) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C566	(2013) Standard Test Method for Total

	Evaporable Moisture Content of Aggregate by Drying
ASTM C88	(2013) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D140/D140M	(2009) Standard Practice for Sampling Bituminous Materials
ASTM D1461	(2011) Moisture or Volatile Distillates in Bituminous Paving Mixtures
ASTM D2041/D2041M	(2011) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D2172/D2172M	(2011) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D2419	(2009) Sand Equivalent Value of Soils and Fine Aggregate
ASTM D242/D242M	(2009) Mineral Filler for Bituminous Paving Mixtures
ASTM D2489/D2489M	(2008) Estimating Degree of Particle Coating of Bituminous-Aggregate Mixtures
ASTM D2726/D2726M	(2013) Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D3203/D3203M	(2011) Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
ASTM D3381/D3381M	(2013) Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D3665	(2012) Random Sampling of Construction Materials
ASTM D3666	(2013) Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D4125/D4125M	(2010) Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D4791	(2010) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D4867/D4867M	(2009) Effect of Moisture on Asphalt Concrete Paving Mixtures
ASTM D5444	(2008) Mechanical Size Analysis of Extracted Aggregate

ASTM D6307	(2010) Asphalt Content of Hot Mix Asphalt by Ignition Method
ASTM D6925	(2009) Standard Test Method for Preparation and Determination of the Relative Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
ASTM D6926	(2010) Standard Practice for Preparation of Bituminous Specimens Using Marshall Apparatus
ASTM D6927	(2006) Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures
ASTM D946/D946M	(2009a) Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D979/D979M	(2012) Sampling Bituminous Paving Mixtures
ASTM E1274	(2003; R 2012) Standard Test Method for Measuring Pavement Roughness Using a Profilograph

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 171	(1995) Standard Test Method for Determining Percentage of Crushed Particles in Aggregate

1.4 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. Hot-mix asphalt (HMA) designed and constructed in accordance with this section shall conform 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, longitudinal joints, and transverse joints for each course or lift.

1.4.1 Asphalt Mixing Plant

Plants used for the preparation of hot-mix asphalt shall conform to the requirements of AASHTO M 156 with the following changes:

a. Truck Scales. Weigh the asphalt mixture on approved scales furnished by the Contractor, or on certified public scales at the Contractor's expense. Scales shall be inspected and sealed at least annually by an approved calibration laboratory.

b. Testing Facilities. Provide laboratory facilities at the plant for the use of the acceptance testing and the Contractor's quality control testing.

c. Inspection of Plant. The shall have access 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 to procure any desired samples.

d. Storage Bins. The asphalt mixture may be stored in non-insulated storage bins for a period of time not exceeding 3 hours. The asphalt mixture may be stored in insulated storage bins for a period of time not exceeding 8 hours. The mix drawn from bins shall meet the same requirements as mix loaded directly into trucks.

1.4.2 Hauling Equipment

Trucks used for hauling hot-mix asphalt shall have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Petroleum based products shall not be used as a release agent. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers (tarps) shall be securely fastened.

1.4.3 Material Transfer Vehicle (MTV)

Material transfer Vehicles shall be required due to the improvement in smoothness and decrease in both physical and thermal segregation. To transfer the material from the hauling equipment to the paver, use a self-propelled, material transfer vehicle with a swing conveyor that can deliver material to the paver without making contact with the paver. The MTV shall be able to move back and forth between the hauling equipment and the paver providing material transfer to the paver, while allowing the paver to operate at a constant speed. The Material Transfer Vehicle will have remixing and storage capability to prevent physical and thermal segregation.

1.4.4 Asphalt Pavers

Mechanical spreading and finishing equipment shall consist of a self-powered paver, capable of spreading and finishing the mixture to the specified line, grade, and cross section. The screed of the paver shall be capable of laying a uniform mixture to meet the specified thickness, smoothness, and grade without physical or temperature segregation, for the full width of the material being placed. The screed will be equipped with a compaction device and it will be used during all placement.

1.4.4.1 Receiving Hopper

The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

1.4.4.2 Automatic Grade Controls

If an automatic grade control device is used, the paver shall be equipped with a control system capable of automatically maintaining the specified

screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. A transverse slope controller shall not be used to control grade. The controls shall be capable of working in conjunction with any of the following attachments:

a. Ski-type device of not less than 30 feet in length.

b. Taut stringline set to grade.

c. Short ski or shoe for joint matching.

d. Laser control.

1.4.5 Rollers

Rollers shall be in good condition and shall be operated at slow speeds to avoid displacement of the asphalt mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. Equipment which causes excessive crushing of the aggregate shall not be used.

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. 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-04 Samples

Asphalt Cement Binder
Aggregates

SD-06 Test Reports

Aggregates; G
QC Monitoring

SD-07 Certificates

Asphalt Cement Binder; G
Testing Laboratory

1.6 QUALITY ASSURANCE

The quality assurance (QA) program for this project is separate and distinct from the Contractor's quality control (QC) program specified in Part 3. Testing for acceptability of work will be performed by the Contractor or by an independent laboratory hired by the Contractor , except for grade and smoothness testing which shall be performed by the Contractor. Acceptance of the plant produced mix and in-place requirements will be on a lot to lot basis. A standard lot for all requirements will be equal to 2000 short tons. Where appropriate, adjustment in payment for individual lots of hot-mix asphalt will be made based on in-place density, laboratory air voids, grade and smoothness in accordance with the following paragraphs. Grade and surface smoothness 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 grade and smoothness measurements for the entire lot cannot be made. In order to evaluate laboratory air voids and in-place (field) density, each lot will be divided into four equal sublots.

1.6.1 Sublot Sampling

One random mixture sample for determining laboratory air voids, theoretical maximum density, and for any additional testing the Contracting Officer desires, will be taken from a loaded truck delivering mixture to each sublot, or other appropriate location for each sublot. 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. Laboratory air voids will be determined from three laboratory compacted specimens of each sublot sample in accordance with ASTM D6926. The specimens will be compacted within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Samples will not be reheated prior to compaction and insulated containers will be used as necessary to maintain the temperature.

1.6.2 Additional Sampling and Testing

The Contracting Officer 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 Contractor. Testing in these areas will be treated as a separate lot. Payment will be made for the quantity of HMA represented by these tests in accordance with the provisions of this section.

1.6.3 In-place Density

For determining in-place density, one random core (4 inches or 6 inches in diameter) will be taken at locations identified by the Contracting Officer from the mat (interior of the lane) of each sublot, and one random core will be taken from the joint (immediately over joint) of each sublot, in accordance with ASTM D979/D979M. Fill all core holes with hot-mix. The core holes shall be dry and tack coated before filling. Each random core will be full thickness of the layer being placed. When the random core is less than 1 inch thick, it will not be included in the analysis. In this case, another random core will be taken. After air drying to meet the requirements for laboratory-prepared, thoroughly dry specimens, cores obtained from the mat and from the joints will be used for in-place density determination in accordance with ASTM D2726/D2726M.

1.6.4 Surface Smoothness

Use both of the following methods to test and evaluate surface smoothness of the finished surface of the pavement final grade. All testing shall be performed in the presence of the Contracting Officer . Detailed notes of the results of the testing shall be kept and a copy furnished to the Contracting Officer immediately after each day's testing. The profilograph method shall be used for all longitudinal and transverse testing, except where the runs would be less than 200 feet in length and the ends where the straightedge shall be used. Where drawings show required deviations from a plane surface (crowns, drainage inlets, etc.), the surface shall be finished to meet the approval of the Contracting Officer .

1.6.4.1 Smoothness Requirements

a. Straightedge Testing: The finished surfaces of the pavements shall have no abrupt change of 1/8 inch or more, and all pavements shall be within the tolerances specified in Table 3 when checked with an approved 12 foot straightedge.

Table 3. Straightedge Surface Smoothness--Pavements

Pavement Category	Direction of Testing	Tolerance, inches
Runways and taxiway	Longitudinal	1/8
	Transverse	1/4
Shoulders (outside edge stripe)	Transverse	1/4
	Longitudinal	Not Required
Calibration hardstands and compass swinging bases	Longitudinal	1/8
	Transverse	1/8
All other airfields and helicopter paved areas	Longitudinal	1/4
	Transverse	1/4

b. Profilograph Testing: The finished surfaces of the pavements shall have no abrupt change of 1/8 inch or more, and all pavement shall have a Profile Index not greater than specified in Table 4 when tested with an approved California-type profilograph. If the extent of the pavement in either direction is less than 200 feet, that direction shall be tested by the straightedge method and shall meet requirements specified above.

Table 4. Profilograph Surface Smoothness--Pavements		
Pavement Category	Direction of Testing	Maximum Specified Profile Index (inch/mile)
Runways	Longitudinal	7
	Transverse	(Use Straightedge)
Taxiways	Longitudinal	9
	Transverse	(Use Straightedge)
Shoulders (outside edge stripe)	Transverse	(Use Straightedge)
	Longitudinal	Not Required
Calibration Hardstands and Compass Swinging Bases		(Use Straightedge)
All Other Airfield and Helicopter Paved Areas	Longitudinal	9
	Transverse	9

1.6.4.2 Testing Method

After the final rolling, but not later than 24 hours after placement, the surface of the pavement in each entire lot shall be tested in such a manner as to reveal all surface irregularities exceeding the tolerances specified above. Separate testing of individual sublots is not required. If any pavement areas are diamond ground, these areas shall be retested immediately after grinding. The area corrected by grinding shall not exceed 10 percent of the total area of the lot. The entire area of the pavement shall be tested in both a longitudinal and a transverse direction on parallel lines. The transverse lines shall be 15 feet or less apart, as directed. The longitudinal lines shall be at the centerline of each paving lane for lines less than 20 feet and at the third points for lanes 20 feet or greater. Other areas having obvious deviations shall also be tested. Longitudinal testing lines shall be continuous across all joints.

a. Straightedge Testing. The straightedge shall be held in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. The amount of surface irregularity shall be determined 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.

b. Profilograph Testing. Profilograph testing shall be performed using an approved California profilograph and procedures described in ASTM E1274. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate "must-grind"

bumps and the Profile Index for the pavement. The "blanking band" shall be 0.2 inches wide and the "bump template" shall span 1 inch with an offset of 0.4 inch. The profilograph shall be operated by an approved, factory-trained operator on the alignments specified above. A copy of the reduced tapes shall be furnished to the Contracting Officer at the end of each day's testing.

c. Bumps ("Must Grind" Areas). Any bumps ("must grind" areas) shown on the profilograph trace which exceed 0.4 inch in height shall be reduced by diamond grinding until they do not exceed 0.3 inch when retested. Such grinding shall be tapered in all directions to provide smooth transitions to areas not requiring grinding. The following will not be permitted: (1) skin patching for correcting low areas, (2) planing or milling for correcting high areas. At the Contractor's option, pavement areas, including ground areas, may be rechecked with the profilograph in order to record a lower Profile Index.

1.7 ENVIRONMENTAL REQUIREMENTS

The hot-mix asphalt shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 5. The temperature requirements may be waived by the , if requested; however, all other requirements, including compaction, shall be met.

Table 5. Surface Temperature Limitations of Underlying Course

Mat Thickness, inches	Degrees F
3 or greater	40
Less than 3	45

PART 2 PRODUCTS

2.1 AGGREGATES

Aggregates shall consist of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. The 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 sufficient materials to produce 200 lb of blended mixture for mix design verification. All aggregate test results and samples shall be submitted to the Contracting Officer at least 14 days prior to start of construction. Aggregate testing shall have been performed within 90 days of performing the mix design.

2.1.1 Coarse Aggregate

Coarse aggregate shall consist of sound, tough, durable particles, free from films or material that would prevent thorough coating and bonding with the asphalt material and free from organic matter and other deleterious substances. The coarse aggregate particles shall meet the following requirements:

a. The percentage of loss shall not be greater than 40 percent after 500 revolutions when tested in accordance with ASTM C131.

b. The sodium sulfate soundness loss shall not exceed 12 percent, or the magnesium sulfate soundness loss shall not exceed 18 percent after five cycles when tested in accordance with ASTM C88.

c. At least 75 percent by weight of coarse aggregate shall have at least two or more fractured faces when tested in accordance with COE CRD-C 171. Fractured faces shall be produced by crushing.

d. The particle shape shall be essentially cubical and the aggregate shall not contain more than 20 percent, by weight, of flat and elongated particles (3:1 ratio of maximum to minimum) when tested in accordance with ASTM D4791.

e. Slag shall be air-cooled, blast furnace slag, and shall have a compacted weight of not less than 75 lb/cu ft when tested in accordance with ASTM C29/C29M.

f. Clay lumps and friable particles shall not exceed 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

2.1.2 Fine Aggregate

Fine aggregate shall consist of clean, sound, tough, durable particles. The aggregate particles shall be free from coatings of clay, silt, or any objectionable material and shall contain no clay balls. The fine aggregate particles shall meet the following requirements:

a. The quantity of natural sand (noncrushed material) added to the aggregate blend shall not exceed 15 percent by weight of total aggregate.

b. The individual fine aggregate sources shall have a sand equivalent value greater than 45 when tested in accordance with ASTM D2419.

c. The fine aggregate portion of the blended aggregate shall have an uncompacted void content greater than 45.0 percent when tested in accordance with ASTM C1252 Method A.

d. Clay lumps and friable particles shall not exceed 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

2.1.3 Mineral Filler

Mineral filler shall be nonplastic material meeting the requirements of ASTM D242/D242M.

2.1.4 Aggregate Gradation

The combined aggregate gradation shall conform to gradations specified in Table 6, when tested in accordance with ASTM C136 and ASTM C117, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but grade uniformly from coarse to fine. The JMF shall be within the specification limits; however, the gradation can exceed the limits when the allowable deviation from the JMF shown in Tables 9 and 10 are applied.

Table 6. Aggregate Gradations

	Gradation 1	Gradation 2	Gradation 3
Sieve Size, inch	Percent Passing by Mass	Percent Passing by Mass	Percent Passing by Mass
1	100	---	---
3/4	90-100	100	---
1/2	68-88	90-100	100
3/8	60-82	69-89	90-100
No. 4	45-67	53-73	58-78
No. 8	32-54	38-60	40-60
No. 16	22-44	26-48	28-48
No. 30	15-35	18-38	18-38
No. 50	9-25	11-27	11-27
No. 100	6-18	6-18	6-18
No. 200	3-6	3-6	3-6

2.2 ASPHALT CEMENT BINDER

Asphalt cement binder shall conform to AASHTO M 320 Performance Grade (PG) 70-22. . Test data indicating grade certification shall be provided by the supplier at the time of delivery of each load to the mix plant. Copies of these certifications shall be submitted to the Contracting Officer. The supplier is defined as the last source of any modification to the binder. The Contracting Officer may sample and test the binder at the mix plant at any time before or during mix production. Samples for this verification testing shall be obtained in accordance with ASTM D140/D140M and in the presence of the Contracting Officer . These samples shall be furnished to the Contracting Officer for the verification testing, which shall be at no cost to the Contractor. Submit 5 gallon sample of the asphalt cement specified for mix design verification and approval not less than 14 days before start of the test section.

2.3 MIX DESIGN

Develop the mix design. The Job Mix formula (JMF)shall have been developed and aggregates tested no earlier than 6 months before contract award. The asphalt mix shall be composed of a mixture of well-graded aggregate, mineral filler if required, and asphalt material. The aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of Table 6. No hot-mix asphalt for payment shall be produced until a JMF has been approved. Laboratory compaction temperatures for

Polymer Modified Asphalts shall be as recommended by the asphalt cement manufacturer. If the Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D4867/D4867M is less than 75, the aggregates shall be rejected or the asphalt mixture treated with an anti-stripping agent. The amount of anti-stripping agent added shall be sufficient to produce a TSR of not less than 75. If an antistrip agent is required, it shall be provided at no additional cost to the Government. Sufficient materials to produce 200 pound of blended mixture shall be provided to the Contracting Officer for verification of mix design at least 14 days prior to construction of test section.

2.3.1 JMF Requirements

Submit the proposed JMF in writing, for approval, at least 14 days prior to the start of the test section, 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 viscosity grade, penetration grade, or performance grade.

e. Number of blows of hammer per side of molded specimen.

f. Laboratory mixing temperature.

g. Lab compaction temperature.

h. Temperature-viscosity relationship of the asphalt cement.

i. Plot of the combined gradation on the 0.45 power gradation chart, stating the nominal maximum size.

j. Graphical plots and summary tabulation of air voids, voids in the mineral aggregate, and unit weight versus asphalt content as shown in AI MS-2. Summary tabulation shall include individual specimen data for each specimen tested.

k. Specific gravity and absorption of each aggregate.

l. Percent natural sand.

m. Percent particles with two or more fractured faces (in coarse aggregate).

n. Fine aggregate angularity.

o. Percent flat or elongated particles (in coarse aggregate).

p. Tensile Strength Ratio and wet/dry specimen test results.

q. Antistrip agent (if required).

r. List of all modifiers.

s. Percentage and properties (asphalt content, binder properties, and aggregate properties) of RAP in accordance with paragraph RECYCLED

HOT-MIX ASPHALT, if RAP is used.

Table 8. Minimum Percent Voids in Mineral Aggregate (VMA)(1)	
Aggregate (See Table 6)	Minimum VMA, percent
Gradation 1	13
Gradation 2	14
Gradation 3	15
(1) Calculate VMA in accordance with AI MS-2, based on ASTM D2726/D2726M bulk specific gravity for the aggregate.	

2.3.2 Adjustments to JMF

The JMF for each mixture shall be in effect until a new formula is approved in writing by the Contracting Officer . Should a change in sources of any materials be made, a new mix design shall be performed and a new JMF approved before the new material is used. The Contractor will be allowed to make minor adjustments within the specification limits to the JMF to optimize mix volumetric properties. Adjustments to the original JMF shall be 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. Adjustments to the JMF shall be limited to plus or minus 1.0 percent on the No. 200 sieve. Asphalt content adjustments shall be limited to plus or minus 0.40 from the original JMF. If adjustments are needed that exceed these limits, a new mix design shall be developed.

2.4 RECYCLED HOT MIX ASPHALT

Recycled HMA shall consist of reclaimed asphalt pavement (RAP), coarse aggregate, fine aggregate, mineral filler, and asphalt cement. The RAP shall be of a consistent gradation and asphalt content and properties. RAP stockpiles shall be free from contamination, including coal-tar sealers. When RAP is fed into the plant, the maximum RAP chunk size shall not exceed 2 inches. The individual aggregates in a RAP chunk shall not exceed the maximum size aggregate of the gradation specified in Table 6. The recycled HMA mix shall be designed using procedures contained in AI MS-2. The job mix shall meet the requirements of paragraph MIX DESIGN. RAP shall only be used for shoulder surface course mixes and for any intermediate courses. The amount of RAP shall be limited so the asphalt binder from the RAP does not exceed 30 percent of the total asphalt content.

2.4.1 RAP Aggregates and Asphalt Cement

The blend of aggregates used in the recycled mix shall meet the requirements of paragraph AGGREGATES. The percentage of asphalt in the RAP shall be established for the mixture design according to ASTM D2172/D2172M using the appropriate dust correction procedure.

2.4.2 RAP Mix

The blend of new asphalt cement and the RAP asphalt binder shall meet the

penetration requirements in paragraph ASPHALT CEMENT BINDER. For PG graded asphalt binders adjust as follows:

a. For 0-20 percent recycled binder content - no change in virgin binder selection.

b. For 20+ to 30 percent recycled binder content - select virgin binder one grade softer than normal.

PART 3 EXECUTION

3.1 CONTRACTOR QUALITY CONTROL

3.1.1 General Quality Control Requirements

Submit the approved Quality Control Plan. Hot-mix asphalt for payment shall not be produced until the quality control plan has been approved. The plan shall 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. Correlation of mechanical hammer to hand hammer. Determine the number of blows of the mechanical hammer required to provide the same density of the JMF as provided by the hand hammer. Use the average of three specimens per trial blow application.

h. Mixture Volumetrics

i. Moisture Content of Mixtures

j. Placing and Finishing

k. Joints

l. Compaction, including HMA-PCC joints

m. Surface Smoothness

n. Truck bed release agent

3.1.2 Testing Laboratory

Provide a fully equipped asphalt laboratory located at the plant or job site. It shall be equipped with heating and air conditioning units to maintain a temperature of 75 plus or minus 5 degrees F. Laboratory facilities shall be kept clean and all equipment shall be maintained in proper working condition. The Contracting Officer shall be permitted unrestricted access to inspect the Contractor's laboratory facility, to

witness quality control activities, and to perform any check testing desired. The Contracting Officer will advise the Contractor 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, the incorporation of the materials into the work shall be suspended immediately and 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. The testing program shall include, but shall not be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, moisture in the asphalt mixture, laboratory air voids, stability, flow, in-place density, grade and smoothness. A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

3.1.3.1 Asphalt Content

A minimum of two tests to determine asphalt content will be performed per lot (a lot is defined in paragraph QUALITY ASSURANCE) by one of the following methods: extraction method in accordance with ASTM D2172/D2172M, Method A or B, the ignition method in accordance with the AASHTO T 308, ASTM D6307, or the nuclear method in accordance with ASTM D4125/D4125M, provided each method is calibrated for the specific mix being used. For the extraction method, the weight of ash, as described in ASTM D2172/D2172M, shall be determined as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction test performed thereafter, for the duration of plant production. The last weight of ash value obtained shall be used in the calculation of the asphalt content for the mixture.

3.1.3.2 Aggregate Properties

Aggregate gradations shall be determined a minimum of twice per lot from mechanical analysis of recovered aggregate in accordance with ASTM D5444 or ASTM D6307. For batch plants, aggregates shall be tested in accordance with ASTM C136 using actual batch weights to determine the combined aggregate gradation of the mixture. The specific gravity of each aggregate size grouping shall be determined for each 20,000 tons in accordance with ASTM C127 or ASTM C128. Fractured faces for gravel sources shall be determined for each 18,000 20,000 tons in accordance with COE CRD-C 171. The uncompacted void content of manufactured sand shall be determined for each 20,000 tons in accordance with ASTM C1252 Method A.

3.1.3.3 Temperatures

Temperatures shall be checked at least four times per lot, at necessary locations, to determine the temperature at the dryer, the asphalt cement in the storage tank, the asphalt mixture at the plant, and the asphalt mixture at the job site.

3.1.3.4 Aggregate Moisture

The moisture content of aggregate used for production shall be determined a minimum of once per lot in accordance with ASTM C566.

3.1.3.5 Moisture Content of Mixture

The moisture content of the mixture shall be determined at least once per lot in accordance with AASHTO T 329.

3.1.3.6 Laboratory Air Voids, VMA

Mixture samples shall be taken at least four times per lot and compacted into specimens, After compaction, the laboratory air voids and VMA of each specimen shall be determined.. The VMA shall be within the limits of Table 8.

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 may be used to monitor pavement density.

3.1.3.8 Grade and Smoothness

Conduct the necessary checks to ensure the grade and smoothness requirements are met in accordance with paragraph QUALITY ASSURANCE.

3.1.3.9 Additional Testing

Any additional testing, which the Contractor deems necessary to control the process, may be performed at the Contractor's option.

3.1.3.10 QC Monitoring

Submit all QC test results to the Contracting Officer on a daily basis as the tests are performed. The Contracting Officer 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 Contracting Officer , sample and test any material which appears inconsistent with similar material being produced, unless such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

3.1.5 Control Charts

For process control, establish and maintain linear control charts on both individual samples and the running average of last four samples for the parameters listed in Table 9, as a minimum. These control charts shall be posted as directed by the Contracting Officer and shall be kept current at all times. The control charts shall identify the project number, the test parameter being plotted, the individual sample numbers, the Action and Suspension Limits listed in Table 9 applicable to the test parameter being plotted, and the Contractor's test results. Target values (JMF) shall also be shown on the control charts as indicators of central tendency for the cumulative percent passing, asphalt content, and laboratory air voids parameters. When the test results exceed either applicable Action Limit, take immediate steps to bring the process back in control. When the test results exceed either applicable Suspension Limit, halt production until the problem is solved. When the Suspension Limit is

exceeded for individual values or running average values, the Contracting Officer has the option to require the Contractor to remove and replace the material represented by the samples or to leave in place and base acceptance on mixture volumetric properties and in place density. Use the control charts as part of the process control system for identifying trends so that potential problems can be corrected before they occur. Decisions concerning mix modifications shall be made based on analysis of the results provided in the control charts. The Quality Control Plan shall indicate the appropriate action which shall be taken to bring the process into control when certain parameters exceed their Action Limits.

Table 9. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts

	Individual Samples		Running Average of Last Four Samples	
Parameter to be Plotted	Action Limit	Suspension Limit	Action Limit	Suspension Limit
No. 4 sieve, Cumulative Percent Passing, deviation from JMF target; plus or minus values	6	8	4	5
No. 30 sieve, Cumulative Percent Passing, deviation from JMF target; plus or minus values	4	6	3	4
No. 200 sieve, Cumulative Percent Passing, deviation from JMF target; plus or minus values	1.4	2.0	1.1	1.5
Asphalt content, percent deviation from JMF target; plus or minus value	0.4	0.5	0.2	0.3
Laboratory Air Voids, percent deviation from JMF target value	No specific action and suspension limits set since this parameter is used to determine percent payment			

Table 9. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts

	Individual Samples		Running Average of Last Four Samples	
Parameter to be Plotted	Action Limit	Suspension Limit	Action Limit	Suspension Limit
In-place Mat Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Joint Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			
VMA				
Gradation 1	13.3	13.0	13.5	13.0
Gradation 2	14.3	14.0	14.5	14.0
Gradation 3	15.3	15.0	15.0	15.0

3.2 PREPARATION OF ASPHALT BINDER MATERIAL

The asphalt cement material shall be heated avoiding local overheating and providing a continuous supply of the asphalt material to the mixer at a uniform temperature. The temperature of unmodified asphalts shall be no more than 325 degrees F when added to the aggregates. Performance Graded (PG) asphalts shall be within the temperature range of 280 to 333 degrees F when added to the aggregates.

3.3 PREPARATION OF MINERAL AGGREGATE

The aggregate for the mixture shall be heated and dried prior to mixing. No damage shall occur to the aggregates due to the maximum temperature and rate of heating used. The temperature of the aggregate and mineral filler shall not exceed 350 degrees F when the asphalt cement is added. The temperature shall not be 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 HOT-MIX ASPHALT MIXTURE

The aggregates and the asphalt cement shall be weighed or metered and introduced into the mixer in the amount specified by the JMF. The combined materials shall be mixed until the aggregate obtains a thorough and uniform coating of asphalt binder (testing in accordance with ASTM D2489/D2489M may be required by the Contracting Officer) and is thoroughly distributed throughout the mixture. The moisture content of all hot-mix asphalt upon discharge from the plant shall not exceed 0.5 percent by total weight of mixture as measured by ASTM D1461.

3.5 PREPARATION OF THE UNDERLYING SURFACE

Immediately before placing the hot mix asphalt, the underlying course shall be cleaned of dust and debris. A prime coat and/or tack coat shall be applied in accordance with the contract specifications.

3.6 TEST SECTION

Prior to full production, place a test section for each JMF used. Construct a test section consisting of a maximum of 250 tons and two paver passes wide placed in two lanes, with a longitudinal cold joint. The test section shall be of the same depth as the course which it represents. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment used in construction of the test section shall be the same equipment to be used on the remainder of the course represented by the test section. The test section shall be placed as part of the project pavement as approved by the Contracting Officer .

3.6.1 Sampling and Testing for Test Section

One random sample shall be taken at the plant, triplicate specimens compacted, and tested for stability, flow, and laboratory air voids. A portion of the same sample shall be tested for theoretical maximum density (TMD), aggregate gradation and asphalt content. An additional portion of the sample shall be tested to determine the Tensile Strength Ratio (TSR). Adjust the compactive effort as required to provide TSR specimens with an air void content of 7 plus/minus 1 percent. Four randomly selected cores shall be taken from the finished pavement mat, and four from the longitudinal joint, and tested for density. Random sampling shall be in accordance with procedures contained in ASTM D3665. The test results shall be within the tolerances or exceed the minimum values shown in Table 10 for work to continue. If all test results meet the specified requirements, the test section shall remain as part of the project pavement. If test results exceed the tolerances shown, the test section shall be removed and replaced at no cost to the Government and another test section shall be constructed.

Table 10. Test Section Requirements for Material and Mixture Properties

Property	Specification Limit
Aggregate Gradation-Percent Passing (Individual Test Result)	
No. 4 and larger	JMF plus or minus 8
No. 8, No. 16, No. 30, and No. 50	JMF plus or minus 6
No. 100 and No. 200	JMF plus or minus 2.0
Asphalt Content, Percent (Individual Test Result)	JMF plus or minus 0.5
Laboratory Air Voids, Percent (Average of 3 specimens)	JMF plus or minus 1.0
VMA, Percent (Average of 3 specimens)	See Table 8
Tensile Strength Ratio (TSR) (At 7 percent plus/minus 1 percent air void content)	75 percent minimum

Table 10. Test Section Requirements for Material and Mixture Properties

Property	Specification Limit
Conditioned Strength	60 psi minimum
Mat Density, Percent of TMD (Average of 4 Random Cores)	92.0 - 96.0
Joint Density, Percent of TMD (Average of 4 Random Cores)	90.5 minimum

3.6.2 Additional Test Sections

If the initial test section should prove to be unacceptable, the necessary adjustments to the JMF, plant operation, placing procedures, and/or rolling procedures shall be made. A second test section shall then be placed. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Full production shall not begin until an acceptable section has been constructed and accepted.

3.7 TESTING LABORATORY

The laboratories used to develop the JMF, perform Contractor Quality Control testing, and for acceptance testing shall meet the requirements of ASTM D3666. All required test methods shall be performed by an accredited laboratory. Submit a certification of compliance signed by the manager of the laboratory stating that it meets these requirements to the Contracting Officer prior to the start of construction. The certification shall contain as a minimum:

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.

d. Evidence of participation in the AASHTO Materials Reference Laboratory (AMRL) program.

3.8 TRANSPORTING AND PLACING

3.8.1 Transporting

The hot-mix asphalt shall be transported from the mixing plant to the site in clean, tight vehicles. Deliveries shall be scheduled so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Adequate artificial lighting shall be provided 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.

3.8.2 Placing

The mix shall be placed in lifts of adequate thickness and compacted at a temperature suitable for obtaining density, surface smoothness, and other specified requirements. Upon arrival, the mixture shall be placed to the full width by an asphalt paver; it shall be struck off in a uniform layer

of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. Waste mixture shall not be broadcast onto the mat or recycled into the paver hopper. Collect waste mixture and dispose off site. The speed of the paver shall be regulated to eliminate pulling and tearing of the asphalt mat. Placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. The mixture shall be placed in consecutive adjacent strips having a minimum width of 10 feet. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 1 foot; however, the joint in the surface course shall be at the centerline of the pavement. Transverse joints in one course shall be offset by at least 10 feet from transverse joints in the previous course. Transverse joints in adjacent lanes shall be offset 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 may be spread and luted by hand tools.

3.9 COMPACTION OF MIXTURE

3.9.1 General

a. After placing, the mixture shall be thoroughly and uniformly compacted by rolling. The surface shall be compacted as soon as possible without causing displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used are at the discretion of the Contractor, with the exception that application of more than three passes with a vibratory roller in the vibrating mode is prohibited. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and 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 will not be permitted. In areas not accessible to the roller, thoroughly compact the mixture with hand tampers. 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 hot mixture and immediately compact to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching will not be allowed.

3.9.2 Segregation

The Contracting Officer can sample and test any material that looks deficient. When the in-place material appears to be segregated, the Contracting Officer has the option to sample the material and have it tested and compared to the aggregate gradation, asphalt content, and in-place density requirements in Table 10. If the material fails to meet these specification requirements, the extent of the segregated material will be removed and replaced 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.

3.10 JOINTS

The formation of joints shall be made ensuring a continuous bond between the courses and to obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

3.10.1 Transverse Joints

The roller shall not pass over the unprotected end of the freshly laid mixture, except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. The cutback material shall be removed from the project. In both methods, all contact surfaces shall be given a light tack coat of asphalt material before placing any fresh mixture against the joint.

3.10.2 Longitudinal Joints

Longitudinal joints which are irregular, damaged, uncompacted, cold (less than 175 degrees F at the time of placing the adjacent lane), or otherwise defective, shall be cut back a maximum of 3 inches from the top edge of the lift with a cutting wheel to expose a clean, sound, near vertical surface for the full depth of the course. All cutback material shall be removed from the project. Cutting equipment that uses water as a cooling or cutting agent shall not be permitted. All contact surfaces shall be given a light tack coat of asphalt material prior to placing any fresh mixture against the joint.

3.10.3 HMA-Portland Cement Concrete Joints

Joints between HMA and PCC will require specific construction procedures for the HMA. The following criteria are applicable to the first 10 feet or paver width of HMA adjacent to the PCC.

a. Pave the HMA side of the joint in a direction parallel to the joint.

b. Place the HMA side sufficiently high so that when fully compacted the HMA will be greater than 1/8 inch but less than 1/4 inch higher than the PCC side of the joint.

c. Compaction shall be provided with steel wheel rollers and at least one rubber tire roller. The rubber tire roller shall be at least 20 tons in weight and have tires that are inflated to at least 90 psi. Avoid spalling the PCC during placement and compaction of the HMA. Steel wheel rollers shall be operated in a way that prevents spalling the PCC. Any damage to PCC edges or joints shall be repaired as directed by the Contracting Officer. If damage to the PCC joint or edge exceeds a total of 3 feet, the PCC panel shall be removed and replaced at no additional expense to the Government.

d. After compaction is finished the HMA shall be leveled by grinding so that the HMA side is less than 1/8 inch higher than the PCC side. The HMA immediately adjacent to the joint shall not be lower than the PCC after the grinding operation. Transition the grinding into the HMA in a way that ensures good smoothness and provides drainage of water. The joint and adjacent materials when completed shall meet all of the

requirements for grade and smoothness. Measure smoothness across the PCC-HMA joint using a 12 feet straightedge. The acceptable tolerance is 1/8 inch.

e. Consider the HMA next to the PCC as a separate lot for evaluation. Lots are based on individual lifts. Do not comingle cores from different lifts for density evaluation purposes. Take four cores for each lot of material placed adjacent to the joint. The size of lot shall be 10 feet wide by the length of the joint being paved. Lots are based on individual lifts and shall not be comingled for density evaluation purposes. Locate the center of each of the four cores 6 inches from the edge of the concrete. Take each core at a random location along the length of the joint. The requirements for density for this lot, adjacent to the joint, are the same as that for the mat specified earlier.

f. All procedures, including repair of damaged PCC, shall be in accordance with the approved Quality Control Plan.

-- End of Section --

SECTION 32 13 11

CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurements

The quantity of concrete to be paid for will be the volume of concrete in cubic yards including thickened edges , where required, placed in the completed and accepted pavement. Concrete will be measured in place in the completed and accepted pavement only within the neat line dimensions shown in the plan and cross section. No deductions will be made for rounded or beveled edges or the space occupied by pavement reinforcement, dowel bars, tie bars, or electrical conduits, nor for any void, or other structure extending into or through the pavement slab, measuring 3 cubic feet or less in volume. No other allowance for concrete will be made unless placed in specified locations in accordance with written instructions previously issued by the Contracting Officer. The quantity of other materials specified herein, and used in the construction of the work covered by this section, will not be measured for payment, but will be considered a subsidiary obligation of the Contractor, covered under the price per cubic yard for concrete. Joint sealing materials are covered in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS .

1.1.2 Payments

1.1.2.1 Unit Price

The quantity of concrete measured as specified above will be paid for at the contract unit price when placed in completed and accepted pavements. Payment will be made at the contract price for cubic yard for the scheduled item, with necessary adjustments as specified below. Payment will constitute full compensation for furnishing all materials, equipment, plant and tools, and for all labor and other incidentals necessary to complete the concrete pavement, except for other items specified herein for separate payment.

1.1.2.2 Lump Sum

The quantity of concrete will be paid for and included in the lump-sum contract price. If less than 100 percent payment is due based on the pay factors stipulated below, a unit price of $125.00 per cubic yard will be used for purposes of calculating the payment reduction.

1.1.3 Payment of Lots

When a lot of material fails to meet the specification requirements, that lot will be accepted at a reduced price or shall be removed and replaced. The lowest computed percent payment determined for any pavement characteristic (i.e., thickness, grade, and surface smoothness) discussed below shall be the actual percent payment for that lot. The actual percent payment will be applied to the unit price and the measured

quantity of concrete in the lot to determine actual payment. Use results of strength tests to control concreting operations. Strength will be evaluated, but will not be considered for payment adjustment. Any pavement not meeting the required 'specified strength' shall be removed and replaced at no additional cost to the Government.

1.1.4 Payment Adjustment for Smoothness

a. Straightedge Testing: Location and deviation from straightedge for all measurements shall be recorded. When more than 5.0 and less than or equal to 10.0 percent of all measurements made within a lot exceed the tolerance specified in paragraph "Surface Smoothness", after any reduction of high spots or removal and replacement, the computed percent payment based on surface smoothness will be 95 percent. When more than 10.0 percent and less than or equal to 15.0 percent of all measurements exceed the tolerance, the computed percent payment will be 90 percent. When more than 15.0 and less than or equal to 20.0 percent of all measurements exceed the tolerance, the computed percent payment will be 75 percent. When more than 20.0 percent of the measurements exceed the tolerance, the lot shall be removed and replaced at no additional cost to the Government.

b. Profilograph Testing: Location and data from all profilograph measurements shall be recorded. When the Profile Index of a 0.1 mile segment of a lot exceeds the tolerance specified in paragraph "Surface Smoothness" by 1.0 inch per mile but less than 2.0 inches per mile, after any reduction of high spots or removal and replacement, the computed percent payment based on surface smoothness will be 95 percent. When the Profile Index exceeds the tolerance by 2.0 inches per mile but less than 3.0 inches per mile, the computed percent payment will be 90 percent. When the Profile Index exceeds the tolerance by 3.0 inches per mile but less than 4.0 inches per mile, the computed percent payment will be 75 percent. When the Profile Index exceeds the tolerance by 4.0 inches per mile or more, the lot shall be removed and replaced at no additional cost to the Government.

c. Aircraft Arresting Systems. The 200 feet of airfield pavement on both the approach and departure sides of the arresting system pendant is a critical area. Consider this area as a separate lot for payment adjustment for smoothness. Protruding objects and undulating surfaces are detrimental to successful tailhook engagements and are not allowable. No exceedance of the tolerances specified in paragraph: "Surface Smoothness" is acceptable. Remove and replace pavements exceeding the tolerances, unless otherwise directed by the Contracting Officer.

1.1.5 Payment Adjustment for Plan Grade

When more than 5.0 and less than or equal to 10.0 percent of all measurements made within a lot are outside the specified tolerance, the computed percent payment for that lot will be 95 percent. When more than 10.0 percent but less than 50 percent are outside the specified tolerances, the computed percent payment for the lot will be 75 percent. In any areas where the deviation from grade exceeds the specified tolerances by 50 percent or more, the deficient area shall be removed and replaced at no additional cost to the Government.

1.1.6 Payment Adjustment for Thickness

Using the Average Thickness of the lot, determine the computed percent payment for thickness by entering the following table:

Computed Percent Payment for Thickness		
	Deficiency in Thickness	
Determined by cores Inches	Pavements Equal To or Over 8 Inches Thick	Pavements Less Than 8 Inches Thick
0.00 to 0.24	100	100
0.25 to 0.49	75	65
0.50 to 0.74	50	0
0.75 or greater	0	0

Where 0 percent payment is indicated, remove the entire lot and replace at no additional cost to the Government. Where either of the two cores from a sublot show a thickness deficiency of 0.75 inch or greater, drill two more cores in the sublot and compute the average thickness of the four cores.

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 182 (2005; R 2009) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 211.1 (1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete

ACI 214R (2011) Evaluation of Strength Test Results of Concrete

ACI 305R (2010) Guide to Hot Weather Concreting

ACI 306R (2010) Guide to Cold Weather Concreting

ASTM INTERNATIONAL (ASTM)

ASTM A1064/A1064M (2013) Standard Specification for

	Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM A184/A184M	(2006; E2011) Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A192/A192M	(2002; R 2012) Standard Specification for Seamless Carbon Steel Boiler Tubes for High-Pressure Service
ASTM A313/A313M	(2013) Standard Specification for Stainless Steel Spring Wire
ASTM A615/A615M	(2013) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A775/A775M	(2007b) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A996/A996M	(2009b) Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM C1017/C1017M	(2007) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1064/C1064M	(2011) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C1077	(2014) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C123/C123M	(2012) Standard Test Method for Lightweight Particles in Aggregate
ASTM C1240	(2012) Standard Specification for Silica Fume Used in Cementitious Mixtures
ASTM C1260	(2007) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve

	Analysis of Fine and Coarse Aggregates
ASTM C138/C138M	(2013a) Standard Test Method for Density ("Unit Weight"), Yield, and Air Content (Gravimetric) of Concrete
ASTM C142/C142M	(2010) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C143/C143M	(2012) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C1567	(2013) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602/C1602M	(2012) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C1646/C1646M	(2008a) Making and Curing Test Specimens for Evaluating Frost Resistance of Coarse Aggregate in Air-Entrained Concrete by Rapid Freezing and Thawing
ASTM C172/C172M	(2010) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C174/C174M	(2013) Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C192/C192M	(2013a) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2010) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C294	(2012) Standard Descriptive Nomenclature for Constituents of Concrete Aggregates
ASTM C295/C295M	(2012) Petrographic Examination of Aggregates for Concrete
ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing

	Concrete
ASTM C31/C31M	(2012) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2014a) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C494/C494M	(2013) Standard Specification for Chemical Admixtures for Concrete
ASTM C595/C595M	(2013) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2012a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C666/C666M	(2003; R 2008) Resistance of Concrete to Rapid Freezing and Thawing
ASTM C78/C78M	(2012; E 2013) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C88	(2013) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C881/C881M	(2013) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C94/C94M	(2014) Standard Specification for Ready-Mixed Concrete
ASTM C989/C989M	(2013) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM D1751	(2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2004a; R 2013) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D2995	(1999; R 2009) Determining Application Rate of Bituminous Distributors
ASTM D3665	(2012) Random Sampling of Construction Materials

ASTM D4791	(2010) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D75/D75M	(2013) Standard Practice for Sampling Aggregates
ASTM E1274	(2003; R 2012) Standard Test Method for Measuring Pavement Roughness Using a Profilograph

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA QC 3	(2011) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities

STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION (CALTRANS)

CTM 526	(2002) Operation of California Profilograph and Evaluation of Profiles

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 130	(2001) Standard Recommended Practice for Estimating Scratch Hardness of Coarse Aggregate Particles
COE CRD-C 143	(1962) Specifications for Meters for Automatic Indication of Moisture in Fine Aggregate
COE CRD-C 300	(1990) Specifications for Membrane-Forming Compounds for Curing Concrete
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete
COE CRD-C 55	(1992) Test Method for Within-Batch Uniformity of Freshly Mixed Concrete
COE CRD-C 662	(2009) Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials, Lithium Nitrate Admixture and Aggregate (Accelerated Mortar-Bar Method)

1.3 SYSTEM DESCRIPTION

This section is intended to stand alone for construction of concrete pavement. However, where the construction covered herein interfaces with other sections, the construction at each interface shall conform to the requirements of both this section and the other section, including tolerances for both.

1.3.1 Surface Smoothness

Use the profilograph method for all longitudinal testing, except for paving lanes less than 200 feet in length. Use the straightedge method for transverse testing, for longitudinal testing where the length of each pavement lane is less than 200 feet, within 200 feet on both the approach and departure sides of an aircraft arresting gear, and at the ends of the paving limits for the project. Where drawings show required deviations from a plane surface (crowns, drainage inlets, etc.) or existing rough or high PI pavement, finish the surface to meet the approval of the Contracting Officer. Detailed notes shall be kept of the results of the testing and a copy furnished to the Government after each day's testing.

a. Straightedge Testing: The finished surfaces of the pavements shall have no abrupt change of 1/4 inch or more, and all pavements shall be within the limits specified when checked with an approved 12 foot straightedge. Runways and taxiways shall have a variation from the specified straight edge not greater than 1/8 inch in the longitudinal direction and not greater than 1/4 inch in the transverse direction. Runway pavement within 200 feet on both the approach and departure sides of an aircraft arresting gear shall have a variation in the longitudinal direction from the specified straightedge not more than plus or minus 1/8 inch. All other airfield areas shall have a variation from a straight edge not greater than 1/4 inch in either the longitudinal or transverse direction.

b. Profilograph Testing: The finished surfaces of the pavements shall have no abrupt change of 1/4 inch or more, and each 0.1 mile segment of each pavement lot shall have a Profile Index not greater than specified when tested with an approved California-type profilograph. Runways and taxiways shall have a Profile index not greater than 7 inches per mile in the longitudinal direction. Runway and taxiway transverse smoothness shall be measured with the straight edge method and the straight edge requirements shall apply. All other airfield areas shall have a Profile Index not greater than 9 inches per mile in the longitudinal direction.

c. Bumps ("Must Grind" Areas): Any bumps ("must grind" areas) shown on the profilograph trace which exceed 0.4 inch in height shall be reduced by diamond grinding in accordance with subparagraph "Diamond Grinding of PCC Surfaces" below until they do not exceed 0.3 inch when retested. Such grinding shall be tapered in all directions to provide smooth transitions to areas not requiring grinding.

d. Testing Method: After the concrete has hardened sufficiently to permit walking thereon, but not later than 48 hours after placement, test the entire surface of the pavement in each lot in such a manner as to reveal all surface irregularities exceeding the tolerances specified above. If any pavement areas are ground, these areas shall be retested immediately after diamond grinding. The entire area of the pavement shall be tested in both a longitudinal and a transverse direction on parallel lines. The transverse lines shall be 15 feet or less apart, as directed. The longitudinal lines shall be at the centerline of each paving lane shown on the drawings, regardless of whether the Contractor is allowed to pave two lanes at a time, and at the 1/8th point in from each side of the lane. Other areas having obvious deviations shall also be tested. Longitudinal testing lines shall be continuous across all joints. Transverse testing lines for pilot lanes shall be carried to construction joint lines and for

fill-in lanes shall be carried 24 inches across construction joints, and the readings in this area applied to the fill-in lane. Straightedge testing of the longitudinal edges of slipformed pilot lanes shall also be performed before paving fill-in lanes as specified below.

(1) Straightedge Testing: The straightedge shall be held in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and measuring the maximum gap between the straightedge and the pavement surface. Measurements shall be determined along the entire length of the straight edge.

(2) Profilograph Testing: Perform profilograph testing using approved California profilograph and procedures described in ASTM E1274. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate "must-grind" bumps and the Profile Index for each 0.1 mile segment of the pavement lot. Grade breaks on aprons shall be accommodated by breaking the profile segment into short sections and repositioning the blanking band on each section. The "blanking band" shall be 0.2 inches wide and the "bump template" shall span 1 inch with an offset of 0.4 inch. The profilograph testing of the last 30 feet of a paving lane in the longitudinal direction from each day's paving operation shall be counted on the following day's continuation lane. The profile index shall be computed for each pass of the profilograph (3 per lane) in each 0.1 mile segment. The profile index for each segment shall be the average of the profile indices for each pass in each segment. Profilographs of unequal lengths shall be scaled and proportioned to an equivalent 0.1 mile as outlined in the CTM 526. A copy of the reduced tapes shall be furnished the Government at the end of each day's testing.

1.3.2 Edge Slump and Joint Face Deformation

a. Edge Slump: When slip-form paving is used, not more than 15.0 percent of the total free edge of each pavement panel shall have an edge slump exceeding 1/4 inch and none of the free edge of the pavement lot shall have an edge slump exceeding 3/8 inch. (A pavement panel is defined as a lane width by the length between two adjacent transverse contraction joints. The total free edge of the pavement will be considered to be the cumulative total linear measurement of pavement panel edge originally constructed as non-adjacent to any existing pavement; i.e., 100 feet of pilot lane originally constructed as a separate lane, will have 200 feet of free edge; 100 feet of fill-in lane will have no free edge, etc.,). The area affected by the downward movement of the concrete along the pavement edge shall not exceed 18 inches back from the edge.

b. Joint Face Deformation: In addition to the edge slump limits specified above, the vertical joint face shall have a surface within the maximum limits shown below:

Offset from Straightedge Applied Longitudinally to Pavement Surface	Offset from Straightedge Applied Longitudinally to Vertical Face	Offset from Straightedge Applied Top to Bottom Against the Joint Face	Abrupt Offset in Any Direction	Offset of Joint Face from True Vertical
Airfield Pavement				
1/8 inch	1/4 inch	3/8 inch	1/8 inch	1 inch/12 inches
All Other Pavement				
1/4 inch	All other items same as airfield pavement			

c. Slump Determination: Immediately after the concrete has hardened sufficiently to permit walking thereon, the pavement surface of each lot shall be tested by the Contractor. Testing shall be performed with a minimum 12 foot straightedge to reveal irregularities exceeding the edge slump tolerance specified above. The vertical edge slump shall be determined at each free edge of each slipformed paving lane constructed. The straightedge shall be placed transverse to the direction of paving and the end of the straightedge located at the edge of the paving lane. Measurements shall be made at 5 to 15 foot spacings, as directed, commencing at the header where paving was started. Initially measurements shall be made at 5 foot intervals in each lane. When no deficiencies are present, the Contracting Officer may approve an increase in the interval. When any deficiencies exist, the interval will be returned to 5 feet. In no case shall the interval exceed 15 feet. In addition to the transverse edge slump determination above, the Contractor, at the same time, shall check the longitudinal surface smoothness of the joint on a continuous line 1 inch back from the joint line using the 12 foot straightedge advanced one-half its length for each reading. Other tests of the exposed joint face shall be made to ensure that a uniform, true vertical joint face is attained. The measurements shall be made by the Contractor, shall be properly referenced in accordance with paving lane identification and stationing, and a report given to the Contracting Officer within 24 hours after measurement is made. The report shall also identify areas requiring replacement.

d. Excessive Edge Slump: When edge slump exceeding the limits specified above is encountered on either side of the paving lane, additional straightedge measurements shall be made, if required, to define the linear limits of the excessive slump. The concrete slabs having excessive edge slump or joint deformation shall be removed and replaced to the next transverse joint in conformance with paragraph: REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS. Use of slip-form paving equipment and procedures that fail to consistently provide edges within the specified tolerances on edge slump and joint face deformation shall be discontinued and the pavements shall be constructed by means of standard paving procedures using fixed forms.

1.3.3 Plan Grade

Within 5 days after paving of each lot, the finished surface of the pavement area shall be tested, by running lines of levels at intervals

corresponding with every longitudinal and transverse joint to determine the elevation at each joint intersection. The results of this survey shall be recorded and a copy given to the Government at the completion of the survey of each lot. The finished surfaces of airfield runway, taxiway, and apron pavements shall vary not more than 1/2 inch above or below the plan grade line or elevation indicated. The surfaces of other pavements shall vary not more than 3/4 inch. The above deviations from the approved grade line and elevation will not be permitted in areas where closer conformance with the planned grade and elevation is required for the proper functioning of appurtenant structures. The finished surfaces of new abutting pavements shall coincide at their juncture.

1.3.4 Flexural Strength

Submit certified copies of laboratory test reports and sources for cement, supplementary cementitious materials (SCM), aggregates, admixtures, curing compound, epoxy, and proprietary patching materials proposed for use on this project. All aggregate tests shall have been performed no earlier than 6 months prior to contract award. Each lot of pavement will be evaluated for acceptance in accordance with the following procedures.

a. Sampling and Testing: For acceptance, one composite sample of concrete from each sublot shall be obtained in accordance with ASTM C172/C172M from one batch or truckload.Test beams 6x6 inches shall be fabricated, and cured in accordance with ASTM C31/C31M and tested in accordance withASTM C138/C138M.

b. Computations: Average the eight 14-day strength tests for the lot. The average strength shall be used in accordance with paragraph "Concrete Strength for Final Acceptance" in PART 2.

1.3.5 Thickness

Each lot of pavement will be evaluated for acceptance and payment adjustment in accordance with the following procedure. Two cores, between 4 and 6 inches in diameter, shall be drilled from the pavement, per sublot (8 per lot). The Contractor is responsible for drilling the cores within 3 days after lot placement, filling the core holes with an approved non-shrink concrete, respraying the cored areas with curing compound, and for measuring the cores. Each core shall be inspected for voids, thickness of paste on the surface, and depth of reinforcement (if required). Provide the results with the thickness measurement data. Eight measurements of thickness shall be made around the circumference of each core and one in the center, in accordance with ASTM C174/C174M, using calibrated calipers for specimens longer than 10 inches. The pavement thickness from the 8 cores for the lot shall be averaged and shall be evaluated as described in paragraph: PAYMENT ADJUSTMENT FOR THICKNESS above.

1.3.6 Diamond Grinding of PCC Surfaces

In areas not meeting the specified limits for surface smoothness and plan grade, high areas shall be reduced to attain the required smoothness and grade, except as depth is limited below. High areas shall be reduced by grinding the hardened concrete with an approved diamond grinding machine after the concrete is 14 days or more old. Grinding shall be accomplished by sawing with an industrial diamond abrasive which is impregnated in the saw blades. The saw blades shall be assembled in a cutting head mounted on a machine designed specifically for diamond grinding that will produce

the required texture and smoothness level without damage to the concrete pavement or joint faces. The saw blades shall be 1/8-inch wide and there shall be a minimum of 55 to 60 blades per 12 inches of cutting head width depending on the hardness of the aggregate. Each machine shall be capable of cutting a path 3 to 4 ft wide. Grinding equipment that causes ravels, aggregate fractures, spalls or disturbance to the joints will not be permitted. The area corrected by grinding the surface of the hardened concrete shall not exceed 10 percent of the total area of any sublot. The depth of diamond grinding shall not exceed 1/4 inch. All pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified above, shall be removed and replaced in conformance with paragraph REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS. In pavement areas given a wire comb or tined texture, areas exceeding 25 square feet that have been corrected by diamond grinding shall be retextured by transverse grooving using an approved grooving machine of standard manufacture. The grooves shall be 1/4 inch deep by 1/4 inch wide on 1-1/2 inch centers and shall be carried into, and tapered to zero depth within the non-corrected surface, or shall match any existing grooves in the adjacent pavement. All areas in which diamond grinding has been performed will be subject to the thickness tolerances specified in paragraph: Thickness, above.

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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment
Proposed Techniques; G
Dowels; G
Dowel Bar Assemblies; G

SD-05 Design Data

Proportioning Studies; G, ED

SD-06 Test Reports

Sampling and Testing; G, ED

SD-07 Certificates

Contractor Quality Control Staff; G, ED
Laboratory Accreditation; G, ED
NRMCA Certificate of Conformance; G, ED

1.5 QUALITY ASSURANCE

1.5.1 Contractor Quality Control Staff

Submit American Concrete Institute certification for Contractor Quality Control staff. Qualifications and resumes for petrographer, surveyor, concrete batch plant operator, and profilograph operator. All Contractor Quality Control personnel assigned to concrete construction shall be

American Concrete Institute (ACI) certified in the following grade (or shall have written evidence acceptable to the Contracting Officer's representative of having completed similar qualification programs):

a. CQC personnel responsible for inspection of concrete paving operations: ACI Concrete Transportation Inspector.

b. Lead Foreman or Journeyman of the Concrete Placing, Finishing, and Curing Crews: ACI Concrete Flatwork Technician/Finisher.

c. Field Testing Technicians: ACI Concrete Field Testing Technician, Grade I.

d. Laboratory Testing Technicians: ACI Concrete Strength Testing Technician and Laboratory Testing Technician, Grade I or II.

1.5.2 Other Staff

Submit for approval, the qualifications and resumes for the following staff:

a. Petrographer: Bachelor of Science degree in geology or petrography, trained in petrographic examination of concrete aggregate according to ASTM C294 and ASTM C295/C295M and trained in identification of the specific deleterious materials and tests identified in this specification. Resume shall detail the education, training and experience related to the project-specific test methods and deleterious materials and shall be submitted at least 20 days before petrographic and deleterious materials examination is to commence.

b. Licensed Surveyor: All survey work shall be performed under the supervision of a Licensed Surveyor.

c. Concrete Batch Plant Operator: National Ready Mix Concrete Association (NRMCA) Plant Manager certification at the Plant Operator level.

d. Profilograph Operator: Certification by equipment manufacturer or a state Department of Transportation.

1.5.3 Laboratory Accreditation

Laboratory and testing facilities shall be provided by and at the expense of the Contractor. Submit accreditation of the commercial laboratory by an independent evaluation authority, indicating conformance to ASTM C1077, including all applicable test procedures. The laboratories performing the tests shall be accredited in accordance with ASTM C1077, including ASTM C78/C78M and ASTM C1260. The accreditation shall be current and shall include the required and optional test methods, as specified throughout this Section. Onsite temperature-controlled concrete curing facilities shall be provided.

a. Aggregate Testing and Mix Proportioning: Aggregate testing and mixture proportioning studies shall be performed by a commercial laboratory.

b. Acceptance Testing: Furnish all materials, labor, and facilities required for molding, curing, testing, and protecting test specimens at the site and in the laboratory. Steel molds shall be used for

molding the beam specimens. Furnish and maintain boxes or other facilities suitable for storing and curing the specimens at the site while in the mold within the temperature range stipulated by ASTM C31/C31M. Flexural loading equipment shall be in accordance with ASTM C78/C78M.

c. Contractor Quality Control: All sampling and testing shall be performed by an approved, onsite, independent, commercial laboratory, or for cementitious materials and admixtures, the manufacturer's laboratory. Submit USACE validation letter for commercial laboratory.

d. Laboratory Inspection: The Government will inspect the laboratory equipment and test procedures prior to the start of concreting operations for conformance to ASTM C1077. The laboratory shall maintain this certification for the duration of the project.

1.5.4 Preconstruction Testing of Materials

All sampling and testing shall be performed by, and at the expense of, the Contractor. Use an approved commercial laboratory or, for cementitious materials and chemical admixtures, a laboratory maintained by the manufacturer of the material. No material shall be used until notice of acceptance has been given. The Contractor will not be entitled to any additional payment or extension of time due to failure of any material to meet project requirements, or for any additional sampling or testing required. Additional tests may be performed by the Government at the discretion of the Contracting Officer; such Government testing will not relieve the Contractor of any testing responsibilities.

1.5.4.1 Aggregates

Aggregates shall be sampled in the presence of a Government Representative. Samples shall be obtained in accordance with ASTM D75/D75M and shall be representative of the materials to be used for the project. Test results shall be submitted 7 days before commencing mixture proportioning studies.

1.5.4.2 Chemical Admixtures, Curing Compounds and Epoxies

At least 30 days before the material is used, submit certified copies of test results for the specific lots or batches to be used on the project. Test results shall be not more than 6 months old prior to use in the work. Chemical admixtures that have been in storage at the project site for longer than 6 months or that have been subjected to freezing will be retested at the expense of the Contractor and will be rejected if test results are not satisfactory.

1.5.4.3 Cementitious Materials

Cement, ground granulated blast furnace (GGBF) slag, and pozzolan will be accepted on the basis of manufacturer's certification of compliance, accompanied by mill test reports showing that the material in each shipment meets the requirements of the specification under which it is furnished. Mill test reports shall be no more than 1 month old, prior to use in the work. No cementitious material shall be used until notice of acceptance has been given by the Contracting Officer. Cementitious material may be subjected to testing by the Government from samples obtained at the mill, at transfer points, or at the project site. If tests prove that a cementitious material that has been delivered is

unsatisfactory, it shall be promptly removed from the site of the work. Cementitious material that has not been used within 6 months after testing shall be retested at the Contractor's expense and shall be rejected if test results are not satisfactory.

1.5.5 Testing During Construction

During construction, the Contractor is responsible for sampling and testing aggregates, cementitious materials, and concrete as specified herein. The Government will sample and test concrete and ingredient materials as considered appropriate. Provide facilities and labor as may be necessary for procurement of representative test samples. Testing by the Government will in no way relieve the Contractor of the specified testing requirements.

1.5.6 Test Section

Up to 10 days, but not more than 60 days, prior to construction of the concrete pavement, construct a test section near the job site, but not as part of the production pavement area. . Use the test section to develop and demonstrate to the satisfaction of the Contracting Officer the proposed techniques of mixing, hauling, placing, consolidating, finishing, curing, initial saw cutting, start-up procedures, testing methods, plant operations, and the preparation of the construction joints. Variations in mixture proportions, other than water, shall be made if directed. Vary the water content, as necessary, to arrive at the appropriate content. The mixing plant shall be operated and calibrated prior to start of placing the test section. Use the same equipment, materials, and construction techniques on the test section as will be used in all subsequent work. Base course preparation, concrete production, placing, consolidating, curing, construction of joints, and all testing shall be in accordance with applicable provisions of this specification. Three days after completion of the test section, provide eight cores at least 6 inch diameter by full depth cut from points selected in the test section by the Government. The cores will be evaluated for homogeneity, consolidation and segregation. Construct the test section meeting all specification requirements and being acceptable to the Contracting Officer in all aspects, including surface texture. Failure to construct an acceptable test section will necessitate construction of additional test sections at no additional cost to the Government. Test sections allowed to be constructed as part of the production paving which do not meet specification requirements shall be removed at the Contractor's expense. If the Contractor proposes to use slipform paving and is unable to construct an acceptable test section, the slipform paving equipment shall be removed from the job and the construction completed using stationary side forms and equipment compatible with them. Production paving shall not commence until the results on aggregates and concrete, including evaluation of the cores, and all pavement measurements for edge slump, joint face deformation, actual plan grade, surface smoothness and thickness have been submitted and approved by the Contracting Officer. Pavement accepted as a production lot will be evaluated and paid in accordance with Paragraph: ACCEPTABILITY OF WORK below.

1.5.6.1 Pilot Lane

The test section shall consist of one paving lane at least 400 feet long and shall be constructed to the same thickness as the thickest portion of pavement shown on the Drawings. The lane width shall be the same as that required for use in the project. The test section shall contain at least

one transverse construction joint. If doweled longitudinal construction joints are required in any of the production pavements, they shall be installed full length along one side of the test strip throughout the test section. Two separate days shall be used for construction of the test section.

1.5.6.2 Fill-In Lane

The first 400 feet of the initial production fill-in lane shall be considered a fill-in lane test section for purposes of testing and evaluation. All requirements for the test section are applicable, as appropriate. Obtain cores from the fill-lane lane side of the longitudinal construction joint with the pilot lane. The cores will be evaluated for homogeneity, consolidation, and segregation.

1.5.7 Acceptability of Work

The materials and the pavement itself will be accepted on the basis of tests made by the Contractor. The Government may make check tests to validate the results of the Contractor's testing. If the results of the Contractor tests vary by less than 2.0 percent of the Government's test results, the results of the Contractor's tests will be used. If the results of the Government and Contractor tests vary by 2.0 percent, but less than 4.0 percent, the average of the two will be considered the value to be used. If these vary by 4.0 percent or more, each sampling and testing procedure shall be carefully evaluated and both the Government and the Contractor shall take another series of tests on duplicate samples of material. If these vary by 4.0 percent or more, the results of the tests made by the Government shall be used and the Government will continue check testing of this item on a continuous basis until the two sets of tests agree within less than 4.0 percent on a regular basis. Testing performed by the Government will in no way at any time relieve the Contractor from the specified testing requirements.

1.5.8 Acceptance Requirements

1.5.8.1 Pavement Lots

A lot will be that quantity of construction that will be evaluated for acceptance with specification requirements. A lot will be equal to one shift of production not to exceed 1000 cubic yards. In order to evaluate thickness, each lot will be divided into four equal sublots. Grade determinations will be made on the lot as a whole. Surface smoothness determinations will be made on every 0.1 mile segment in each lot. Location of all samples shall be selected on a random basis in accordance with ASTM D3665. When operational conditions cause a lot to be terminated before the specified four sublots have been completed, the following procedure shall be used to adjust the lot size and number of tests for the lot. Where three sublots have been completed, they shall constitute a lot. Where one or two sublots have been completed, they shall be incorporated into the next lot (except for the last lot), and the total number of sublots shall be used and acceptance criteria adjusted accordingly.

1.5.8.2 Evaluation

Provide all sampling and testing required for acceptance and payment adjustment at the Contractor's expense. Individuals performing sampling, testing and inspection duties shall meet the required Qualifications. The

Contracting Officer reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. Testing in these areas will be in addition to the sublot or lot testing, and the requirements for these areas will be the same as those for a sublot or lot. Provide facilities for and, where directed, personnel to assist in obtaining samples for any Government testing.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 Bulk Cementitious Materials

Furnish all cementitious material in bulk. The temperature of the cementitious material, as delivered to storage at the site, shall not exceed 150 degrees F. Sufficient cementitious materials shall be in storage to sustain continuous operation of the concrete mixing plant while the pavement is being placed. Provide separate facilities to prevent any intermixing during unloading, transporting, storing, and handling of each type of cementitious material.

1.6.2 Aggregate Materials

Store aggregate at the site of the batching and mixing plant avoiding breakage, segregation, intermixing or contamination by foreign materials. Each size of aggregate from each source shall be stored separately in free-draining stockpiles. Aggregate stored on ground shall have a minimum 24 inch thick sacrificial layer left undisturbed. Fine aggregate and the smallest size coarse aggregate shall remain in free-draining storage for at least 24 hours immediately prior to use. Sufficient aggregate shall be maintained at the site at all times to permit continuous uninterrupted operation of the mixing plant at the time concrete pavement is being placed. Tracked equipment shall not be allowed on coarse aggregate stockpiles.

1.6.3 Other Materials

Store reinforcing bars and accessories above the ground on supports. All materials shall be stored avoiding contamination and deterioration.

PART 2 PRODUCTS

2.1 CEMENTITIOUS MATERIALS

Cementitious materials shall be portland cement, blended cement or only portland cement in combination with supplementary cementitious materials (SCM), and shall conform to appropriate specifications listed below. New submittals are required when the cementitious materials sources or types change.

2.1.1 Portland Cement

Provide portland cement conforming to ASTM C150/C150M, Type II , low alkali .

2.1.2 Blended Cements

Blended cement shall conform to ASTM C595/C595M, Type IP or IS, including the optional requirement for mortar expansion and sulfate soundness. The pozzolan added to the Type IP blend shall be ASTM C618 Class F or Class N and shall be interground with the cement clinker. The manufacturer shall

state in writing that the amount of pozzolan in the finished cement will not vary more than plus or minus 5 mass percent of the finished cement from lot to lot or within a lot. The percentage and type of mineral admixture used in the blend shall not change from that submitted for the aggregate evaluation and mixture proportioning. The requirements of Table 2 in paragraph SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCM) CONTENT do not apply to the SCM content of blended cement.

2.1.3 Pozzolan

2.1.3.1 Fly Ash

Fly ash shall conform to ASTM C618, Class F, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction and shall have a loss on ignition not exceeding 3 percent. Class F fly ash for use in mitigating Alkali-Silica Reactivity shall have a total equivalent alkali content less than 3 percent.2.1.3.2 Raw or Calcined Natural Pozzolan

Natural pozzolan shall be raw or calcined and conform to ASTM C618, Class N, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction and shall have a loss on ignition not exceeding 3 percent. Class N pozzolan for use in mitigating Alkali-Silica Reactivity shall have a total equivalent alkali content less than 3 percent.

2.1.3.3 Ultra Fine Fly Ash and Ultra Fine Pozzolan

Ultra Fine Fly Ash (UFFA) and Ultra Fine Pozzolan (UFP) shall conform to ASTM C618, Class F or N, and the following additional requirements:

a. The strength activity index at 28 days of age shall be at least 95 percent of the control specimens.

b. The average particle size shall not exceed 6 microns.

2.1.4 Ground Granulated Blast-Furnace (GGBF) Slag

Ground Granulated Blast-Furnace Slag shall conform to ASTM C989/C989M, Grade 120.

2.1.5 Supplementary Cementitious Materials (SCM) Content

TABLE 2
SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT

Supplementary Cementitious Material	Minimum Content (percent)	Maximum Content (percent)
Class N Pozzolan and Class F Fly Ash		
$SiO_2 + Al_2O_3 + Fe_2O_3 > 70$ percent	25	35
$SiO_2 + A1_2O_3 + Fe_2O_3 > 80$ percent	20	35
$SiO_2 + A1_2O_3 + Fe_2O_3 > 90$ percent	15	35

TABLE 2
SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT

Supplementary Cementitious Material	Minimum Content (percent)	Maximum Content (percent)
UFFA and UFP	7	16
GGBF Slag	40	50

2.2 AGGREGATES

2.2.1 Aggregate Sources

2.2.1.1 Durability

Fine and coarse aggregates to be used in all concrete shall be evaluated and tested with ASTM C88.Results shall not show more than 18 percent loss when subjected to 5 cycles using magnesium sulfate. If sodium sulfate is used, results shall not show more than 12 percent loss when subjected to 5 cycles

2.2.1.2 Alkali-Silica Reactivity

Fine and coarse aggregates to be used in all concrete shall be evaluated and tested for alkali-aggregate reactivity. Both coarse aggregate size groups shall be tested.

a. The fine and coarse aggregates shall be evaluated separately, using ASTM C1260. Test results of the individual aggregates shall have a measured expansion equal to or less than 0.08 percent after 28 days of immersion in a 1N NaOH solution. Should the test data indicate an expansion of greater than 0.08 percent, the aggregate(s) shall be rejected or additional testing shall be performed as follows: utilize the Contractor's proposed low alkali portland cement, blended cement, and/or SCM, and/or Lithium Nitrate in combination with each individual aggregate. If only SCMs are being evaluated, the testing shall be in accordance with ASTM C1567. If Lithium Nitrate is being evaluated, with or without SCMs, the testing shall be in accordance with COE CRD-C 662. Determine the quantity that will meet all the requirements of these specifications and that will lower the expansion equal to or less than 0.08 percent after 28 days of immersion in a 1N NaOH solution. Mixture proportioning shall be based on the highest percentage of SCM required to mitigate ASR-reactivity

b. If any of the above options does not lower the expansion to less than 0.08 percent after 28 days of immersion in a 1N NaOH solution, reject the aggregate(s) and submit new aggregate sources for retesting. Submit the results of testing to the Contracting Officer for evaluation and acceptance.

2.2.1.3 Combined Aggregate Gradation

In addition to the grading requirements specified for coarse aggregate and for fine aggregate, the combined aggregate grading shall meet the following requirements:

a. The materials selected and the proportions used shall be such that

when the Coarseness Factor (CF) and the Workability Factor (WF) are plotted on a diagram as described in d. below, the point thus determined shall fall within the parallelogram described therein.

b. The Coarseness Factor (CF) shall be determined from the following equation:

CF = (cumulative percent retained on the 3/8 in. sieve)(100)/(cumulative percent retained on the No. 8 sieve)

c. The Workability Factor WF is defined as the percent passing the No. 8 sieve based on the combined gradation. However, WF shall be adjusted, upwards only, by 2.5 percentage points for each 94 pounds of cementitious material per cubic yard greater than 564 pounds per cubic yard.

d. A diagram shall be plotted using a rectangular scale with WF on the Y-axis with units from 20 (bottom) to 45 (top), and with CF on the X-axis with units from 80 (left side) to 30 (right side). On this diagram a parallelogram shall be plotted with corners at the following coordinates (CF-75, WF-28), (CF-75, WF-40), (CF-45, WF-32.5), and (CF-45, WF-44.5). If the point determined by the intersection of the computed CF and WF does not fall within the above parallelogram, the grading of each size of aggregate used and the proportions selected shall be changed as necessary.)

2.2.2 Coarse Aggregate

2.2.2.1 Material Composition

Coarse aggregate shall consist of crushed or uncrushed gravel, crushed stone, , or a combination thereof. Aggregate used for paving compass calibration hardstands shall be free of materials having undesirable magnetic properties, including magnetite in granite, high-iron minerals in traprock, and pyrite in limestone. Aggregates, as delivered to the mixers, shall consist of clean, hard, uncoated particles meeting the requirements of ASTM C33/C33M except as specified herein. Coarse aggregate shall be washed. Washing shall be sufficient to remove dust and other coatings. . Coarse aggregate shall not show more than 40 percent loss when subjected to the Los Angeles abrasion test in accordance with ASTM C131. The sodium sulfate soundness loss shall not exceed 12 percent, or the magnesium sulfate soundness loss shall not exceed 18 percent after five cycles when tested in accordance with ASTM C88.

2.2.2.2 Particle Shape Characteristics

Particles of the coarse aggregate shall be generally spherical or cubical in shape. The quantity of flat and elongated particles in any size group coarser than the 3/8 inch sieve shall not exceed 20 percent by weight as determined by the Flat Particle Test and the Elongated Particle Test of ASTM D4791. A flat particle is defined as one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3.

2.2.2.3 Size and Grading

The nominal maximum size of the coarse aggregate shall be 1.5 inch. Grade and furnish the individual aggregates in two size groups meeting the individual grading requirements of ASTM C33/C33M, Size No. 4 (1.5 to 0.75

inches) and Size No. 67 (0.75 inches to No. 4) to meet the coarseness and workability factor criteria for the contractor-proposed combined gradation. A third aggregate size group may be required to meet the above mentioned coarseness and workability criteria of paragraph COMBINED AGGREGATE GRADATION.

2.2.2.4 Deleterious Materials - Airfield Pavements

The amount of deleterious material in each size group of coarse aggregate shall not exceed the limits shown in Table 5 below, determined in accordance with the test methods shown.

TABLE 5	
LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR AIRFIELD PAVEMENTS	
Percentage by Mass	
Materials (h)	Severe Weather
Clay lumps and friable particles (ASTM C142/C142M)	0.2
Shale (a) (ASTM C295/C295M)	0.1
Material finer than No. 200 sieve (b) (ASTM C117)	0.5
Lightweight particles (c) (ASTM C123/C123M)	0.2
Clay ironstone (d) (ASTM C295/C295M)	0.1
Chert and cherty stone (less than 2.40 Sp. Gr.) (e) (ASTM C123/C123M and ASTM C295/C295M)	0.1
Claystone, mudstone, and siltstone (f) (ASTM C295/C295M)	0.1
Shaly and argillaceous limestone (g) (ASTM C295/C295M)	0.2
Other soft particles (COE CRD-C 130)	1.0
Total of all deleterious substances exclusive of material finer than No. 200 sieve	1.0
(a) Shale is defined as a fine-grained, thinly laminated or fissile sedimentary rock. It is commonly composed of clay or silt or both. It has been indurated by compaction or by cementation, but not so much as to have become slate.	
(b) Limit for material finer than No. 200 sieve will be increased to 1.5 percent for crushed aggregates if the fine material consists of crusher dust that is essentially free from clay or shale.	

TABLE 5	
LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR AIRFIELD PAVEMENTS	
Percentage by Mass	
Materials (h)	Severe Weather
(c) The separation medium shall have a density of Sp. Gr. of 2.0. This limit does not apply to coarse aggregate manufactured from blast-furnace slag unless contamination is evident.	
(d) Clay ironstone is defined as an impure variety of iron carbonate, iron oxide, hydrous iron oxide, or combinations thereof, commonly mixed with clay, silt, or sand. It commonly occurs as dull, earthy particles, homogeneous concretionary masses, or hard-shell particles with soft interiors. Other names commonly used for clay ironstone are "chocolate bars" and limonite concretions.	
(e) Chert is defined as a rock composed of quartz, chalcedony or opal, or any mixture of these forms of silica. It is variable in color. The texture is so fine that the individual mineral grains are too small to be distinguished by the unaided eye. Its hardness is such that it scratches glass but is not scratched by a knife blade. It may contain impurities such as clay, carbonates, iron oxides, and other minerals. Cherty stone is defined as any type of rock (generally limestone) that contains chert as lenses and nodules, or irregular masses partially or completely replacing the original stone.	
(f) Claystone, mudstone, or siltstone, is defined as a massive fine-grained sedimentary rock that consists predominantly of indurated clay or silt without laminations or fissility. It may be indurated either by compaction or by cementation.	
(g) Shaly limestone is defined as limestone in which shale occurs as one or more thin beds or laminae. These laminae may be regular or very irregular and may be spaced from a few inches down to minute fractions of an inch. Argillaceous limestone is defined as a limestone in which clay minerals occur disseminated in the stone in the amount of 10 to 50 percent by weight of the rock; when these make up from 50 to 90 percent, the rock is known as calcareous (or dolomitic) shale (or claystone, mudstone, or siltstone).	
(h) Perform testing in accordance with the referenced test methods, except that the minimum sample size shall be as specified below.	

2.2.2.5 Testing Sequence/Deleterious Materials in Coarse Aggregate - Airfields Only

The Contractor will not be entitled to any extension of time or additional payment due to any delays caused by the testing, evaluation, or personnel requirements.

2.2.3 Fine Aggregate

2.2.3.1 Composition

Fine aggregate shall consist of natural sand, manufactured sand, or a combination of the two, and shall be composed of clean, hard, durable particles meeting the requirements of ASTM C33/C33M. Aggregate used for paving compass calibration hardstands shall be free of materials having undesirable magnetic properties, including magnetite in granite, high-iron minerals in traprock, and pyrite in limestone. Each type of fine aggregate shall be stockpiled and batched separately. Particles of the fine aggregate shall be generally spherical or cubical in shape.

2.2.3.2 Grading

Grading of the fine aggregate, as delivered to the mixer, shall conform to the requirements of ASTM C33/C33M and shall have a fineness modulus of not less than 2.50 nor more than 3.40.

2.2.3.3 Deleterious Material

Sample size for fine aggregate proposed for use in airfield paving shall be 200 pounds. The amount of deleterious material in the fine aggregate shall not exceed the following limits by mass:

Material	Percentage by Mass
Clay lumps and friable particles ASTM C142/C142M	1.0
Material finer than No. 200 sieve ASTM C117	3.0
Lightweight particles ASTM C123/C123M using a medium with a density of Sp. Gr. of 2.0	0.5
Total of all above	3.0

2.3 CHEMICAL ADMIXTURES

2.3.1 General Requirements

Chemical admixtures may only be used when the specific admixture type and manufacturer is the same material used in the mixture proportioning studies. The air-entraining admixture shall conform to ASTM C260/C260M. An accelerator conforming to ASTM C494/C494M, Type C, may be used only when specified in paragraph: SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES below and shall not be used to reduce the amount of cementitious material used. Calcium chloride and admixtures containing calcium chloride shall not be used. Retarding or water-reducing admixture shall meet the requirements of ASTM C494/C494M, Type A, B, or D, except that the 6-month and 1-year compressive strength tests are waived. ASTM C494/C494M, Type F and G high range water reducing admixtures and ASTM C1017/C1017M flowable admixtures shall not be used.

2.3.2 Lithium Nitrate

The lithium admixture shall be a nominal 30 percent aqueous solution of Lithium Nitrate, with a density of 10 pounds/gallon, and shall have the approximate chemical form as shown below:

Constituent	Limit (Percent by Mass)
$LiNo_3$ (Lithium Nitrate)	30 +/- 0.5
SO_4^{-2} (Sulfate Ion)	0.1 (max)
Cl^- (Chloride Ion)	0.2 (max)
Na^+ (Sodium Ion)	0.1 (max)
K^+ (Potassium Ion)	0.1 (max)

Provide a trained representative to supervise the lithium nitrate admixture dispensing and mixing operations.

2.4 MEMBRANE FORMING CURING COMPOUND

Membrane forming curing compound shall be a white pigmented compound conforming to COE CRD-C 300. .

2.5 WATER

Water for mixing and curing shall be fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that non-potable water, or water from concrete production operations, may be used if it meets the requirements of ASTM C1602/C1602M.

2.6 JOINT MATERIALS

2.6.1 Expansion Joint Material

Expansion joint filler shall be a preformed material conforming to ASTM D1751 Expansion joint filler shall be 3/4 inch thick, unless otherwise indicated, and shall be furnished in a single full depth piece.

2.6.2 Slip Joint Material

Slip joint material shall be 1/4 inch thick expansion joint filler, unless otherwise indicated, conforming to paragraph: Expansion Joint Material.

2.7 REINFORCING

All reinforcement shall be free from loose, flaky rust, loose scale, oil, grease, mud, or other coatings that might reduce the bond with concrete. Removal of thin powdery rust and tight rust is not required. However, reinforcing steel which is rusted to the extent that it does not conform to the required dimensions or mechanical properties shall not be used.

2.7.1 Reinforcing Bars and Bar Mats

Reinforcing bars shall conform to ASTM A615/A615M, billet-steel , Grade 60 . Bar mats shall conform to ASTM A184/A184M. The bar members may be billet rail or axle steel.

2.7.2 Welded Wire Reinforcement

Welded Wire Reinforcement shall be deformed or smooth, conforming to ASTM A1064/A1064M, and shall be furnished in flat sheets.

2.8 DOWELS AND TIE BARS

2.8.1 Dowels

Dowels shall be single piece bars fabricated or cut to length at the shop or mill before delivery to the site. Dowels shall be free of loose, flaky rust and loose scale and shall be clean and straight. Dowels may be sheared to length provided that the deformation from true shape caused by shearing does not exceed 0.04 inch on the diameter of the dowel and does not extend more than 0.04 inch from the end of the dowel. Dowels shall be plain (non-deformed) steel bars conforming to ASTM A615/A615M, Grade 40 or 60; ASTM A996/A996M, Grade 50 or 60. Dowel bars shall be epoxy coated in conformance with ASTM A775/A775M. Grout retention rings shall be fully circular metal or plastic devices capable of supporting the dowel until the epoxy hardens. Dowel sleeves or inserts are not permitted.

2.8.2 Dowel Bar Assemblies

Dowel bar assemblies shall consist of a framework of metal bars or wires arranged to provide rigid support for the dowels throughout the paving operation, with a minimum of four continuous bars or wires extending along the joint line. The dowels shall be welded to the assembly or held firmly by mechanical locking arrangements that will prevent them from rising, sliding out, or becoming distorted during paving operations.

2.8.3 Tie Bars

Tie bars shall be deformed steel bars conforming to ASTM A615/A615M, or ASTM A996/A996M, Grade 60 , and of the sizes and dimensions indicated. Deformed rail steel bars and high-strength billet or axle steel bars, Grade 50 or higher, shall not be used for bars that are bent and straightened during construction.

2.9 EPOXY RESIN

All epoxy-resin materials shall be two-component materials conforming to the requirements of ASTM C881/C881M, Class as appropriate for each application temperature to be encountered, except that in addition, the materials shall meet the following requirements:

a. Material for use for embedding dowels and anchor bolts shall be Type IV, Grade 3.

b. Material for use as patching materials for complete filling of spalls and other voids and for use in preparing epoxy resin mortar shall be Type III, Grade as approved.

c. Material for use for injecting cracks shall be Type IV, Grade 1.

d. Material for bonding freshly mixed portland cement concrete or mortar or freshly mixed epoxy resin concrete or mortar to hardened concrete shall be Type V, Grade as approved.

2.10 EQUIPMENT

All plant, equipment, tools, and machines used in the work shall be maintained in satisfactory working conditions at all times. Submit the following:

a. Details and data on the batching and mixing plant prior to plant assembly including manufacturer's literature showing that the equipment meets all requirements specified herein.

b. Obtain National Ready Mixed Concrete Association (NRMCA) certification of the concrete plant. The concrete plant shall be inspected by an engineer approved by the NRMCA. A list of NRMCA approved engineers is available on the NRMCA website at http://www.nrmca.org. All fees and costs associated with this inspection shall be paid by the Contractor. Submit a copy of the NRMCA QC Manual Section 3 Concrete Plant Certification Checklist, NRMCA Certificate of Conformance, and Calibration documentation on all measuring and weighing devices prior to uniformity testing.

c. A description of the equipment proposed for transporting concrete mixture from the central mixing plant to the paving equipment.

d. A description of the equipment proposed for the machine and hand placing, consolidating and curing of the concrete mixture. Manufacturer's literature on the paver and finisher, together with the manufacturer's written instructions on adjustments and operating procedures necessary to assure a tight, smooth surface on the concrete pavement. The literature shall show that the equipment meets all details of these specifications. Detailed information on automatic laser controlled systems shall be submitted if proposed for use.

2.10.1 Batching and Mixing Plant

a. Location: The batching and mixing plant may be located on project site as indicated on the drawingsoff Government premises no more than 15 minutes haul time from the placing site. Water and electrical power are not available on the project site. There shall be operable telephonic or radio communication between the plant and the placing site at all times concreting is taking place.

b. Type and Capacity: The batching and mixing plant shall be a stationary-type central mix plant, including permanent installations or portable/relocatable plants installed on stable foundations. The plant shall be designed and operated to produce concrete within the specified tolerances, and shall have a capacity of at least 250 cubic yards per hour. The batching and mixing plant shall conform to the requirements of NRMCA QC 3 including provisions addressing:

    1. Material Storage and Handling
    2. Batching Equipment
    3. Central Mixer
    4. Ticketing System
    5. Delivery System

c. Tolerances: The following tolerances shall apply.

Materials	Percentage of Required Mass
Cementitious Materials	plus or minus 1
Aggregate	plus or minus 2
Water	plus or minus 1
Admixture	plus or minus 3

For volumetric batching equipment for water and admixtures, the above numeric tolerances shall apply to the required volume of material being batched. Concentrated admixtures shall be uniformly diluted, if necessary, to provide sufficient volume per batch to ensure that the batchers will consistently operate within the above tolerance.

d. Moisture Control: The plant shall be capable of ready adjustment to compensate for the varying moisture contents of the aggregates and to change the quantities of the materials being batched. An electric moisture meter complying with the provisions of COE CRD-C 143 shall be provided for measuring of moisture in the fine aggregate. The sensing element shall be arranged so that measurement is made near the batcher charging gate of the fine aggregate bin or in the fine aggregate batcher. The Contractor shall submit daily production moisture measurements.

2.10.2 Concrete Mixers

a. General: Mixers shall be stationary or truck mixers. Mixers shall be capable of combining the materials into a uniform mixture and of discharging this mixture without segregation. The mixers shall not be charged in excess of the capacity recommended by the manufacturer. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer. The mixers shall be maintained in satisfactory operating condition, and the mixer drums shall be kept free of hardened concrete. Mixer blades or paddles shall be replaced when worn down more than 10 percent of their depth when compared with the manufacturer's dimension for new blades or paddles.

b. Stationary: Stationary mixers shall be drum or pan mixers. Mixers shall be provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed.

c. Mixing Time and Uniformity for Stationary Mixers: For stationary mixers, before uniformity data are available, the mixing time for each batch after all solid materials are in the mixer, provided that all of the mixing water is introduced before one-fourth of the mixing time has elapsed, shall be 1 minute for mixers having a capacity of 1 cubic yard. For mixers of greater capacity, this minimum time shall be increased 20 seconds for each additional 1.33 cubic yard or fraction thereof. After results of uniformity tests are available, the mixing time may be reduced to the minimum time required to meet uniformity requirements; but if uniformity requirements are not being met, the mixing time shall be increased as directed. The mixing time for full batch production shall be a minimum of 75 seconds. Mixer performance tests at new mixing times shall be performed immediately after any change in mixing time. The Regular Test sequence shall be conducted for initial determination of the mixing time or as directed. When

regular testing is performed, the concrete shall meet the limits of any five of the six uniformity requirements listed in Table 1 below.

d. The Abbreviated Test sequence shall be conducted for production concrete verification at the frequency specified in Table 6. When abbreviated testing is performed, the concrete shall meet only those requirements listed for abbreviated testing. The concrete proportions used for uniformity tests shall be as used on the project. Regular testing shall consist of performing all six tests on three batches of concrete. The range for regular testing shall be the average of the ranges of the three batches. Abbreviated testing shall consist of performing the three required tests on a single batch of concrete. The range for abbreviated testing shall be the range for one batch. If more than one mixer is used and all are identical in terms of make, type, capacity, condition, speed of rotation, etc., the results of tests on one of the mixers shall apply to the others, subject to the approval of the Contracting Officer. All mixer performance (uniformity) testing shall be performed in accordance with COE CRD-C 55 and with paragraph titled TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL in PART 3.

TABLE 1 UNIFORMITY REQUIREMENTS--STATIONARY MIXERS

Parameter	Regular Tests Allowable Maximum Range for Average of 3 Batches	Abbreviated Tests Allowable Maximum Range for 1 Batch
Unit weight of air-free mortar	2.0 lbs/cubic ft	2.0 lbs/cubic ft
Air content	1.0 percent	--
Slump	1.0 inch	1.0 inch
Coarse aggregate	6.0 percent	6.0 percent
Compressive strength at 7 days	10.0 percent	10.0 percent
Water content	1.5 percent	

e. Truck: Truck mixers shall not be used for mixing or transporting slipformed paving concrete. The only truck mixers used for mixing or transporting paving concrete shall be those designed with extra large blading and rear opening specifically for low-slump paving concrete. Truck mixers, the mixing of concrete therein, and concrete uniformity and testing thereof shall conform to the requirements of ASTM C94/C94M. The number of revolutions between 70 to 100 for truck-mixed concrete and the number of revolutions for shrink-mixed concrete shall be determined by uniformity tests as specified in ASTM C94/C94M and in requirements for mixer performance stated in paragraph TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL in PART 3. If requirements for the uniformity of concrete are not met with 100 revolutions of mixing after all ingredients including water are in the truck mixer drum, the mixer shall not be used until the condition is corrected. Water shall not be added after the initial introduction of mixing water except, when on arrival at the job site, the slump is less than specified and the water-cement ratio is less than that given as a

maximum in the approved mixture. Additional water may be added to bring the slump within the specified range provided the approved water-cement ratio is not exceeded. Water shall be injected into the head of the mixer (end opposite the discharge opening) drum under pressure, and the drum or blades shall be turned a minimum of 30 additional revolutions at mixing speed. Water shall not be added to the batch at any later time. Mixer performance (uniformity) tests for truck mixers shall be made in accordance with ASTM C94/C94M.

2.10.3 Transporting Equipment

Slipform concrete shall be transported to the paving site in nonagitating equipment conforming to ASTM C94/C94M or in approved agitators. Fixed form concrete shall be transported in approved truck mixers designed with extra large blading and rear opening specifically for low slump concrete. All transporting equipment shall be designed and operated to deliver and discharge the required concrete mixture completely without segregation.

2.10.4 Paver-Finisher

The following items a through e apply to both fixed-form and slip-form paver-finishers. Item f is applicable to fixed-form paver-finishers and item g is applicable to slip-form paver-finishers.

a. General: The paver-finisher shall be a heavy-duty, self-propelled machine designed specifically for paving and finishing high quality pavement. The paver-finisher shall weigh at least 2200 lb/foot of lane width, and shall be powered by an engine having at least 6.0 horsepower/foot of lane width. The paver-finisher shall spread, consolidate, and shape the plastic concrete to the desired cross section in one pass. The mechanisms for forming the pavement shall be easily adjustable in width and thickness and for required crown. In addition to other spreaders required by paragraph above, the paver-finisher shall be equipped with a full width knock-down auger or paddle mechanism, capable of operating in both directions, which will evenly spread the fresh concrete in front of the screed or extrusion plate.

b. Vibrators: Immersion vibrators shall be gang mounted at the front of the paver on a frame equipped with suitable controls so that all vibrators can be operated at any desired depth within the slab or completely withdrawn from the concrete, as required. The vibrators shall be automatically controlled so that they will be immediately stopped as forward motion of the paver ceases. The paver-finisher shall be equipped with an electronic vibrator monitoring device displaying the operating frequency of each individual internal vibrator. The monitoring device shall have a readout display visible to the paver operator. It shall operate continuously while paving, and shall display all vibrator frequencies with manual or automatic sequencing among all individual vibrators. The spacing of the immersion vibrators across the paving lane shall be as necessary to properly consolidate the concrete, but the clear distance between vibrators shall not exceed 30 inches. The outside vibrators shall not be more than 12 inches from the lane edge. Spud vibrators shall operate at a frequency of not less than 8000 impulses/minute and an amplitude of not less than 0.03 inch, as determined by COE CRD-C 521.

c. Screed or Extrusion Plate: The paver-finisher shall be equipped with a transversely oscillating screed or an extrusion plate to shape,

compact, and smooth the surface and shall so finish the surface that no significant amount of hand finishing, except use of cutting straightedges, is required. The screed or extrusion plate shall be constructed to provide adjustment for crown in the pavement. The entire machine shall provide adjustment for variation in lane width or thickness and to prevent more than 8 inches of the screed or extrusion plate extending over previously placed concrete on either end when paving fill-in lanes. Machines that cause displacement of properly installed forms or cause ruts or indentations in the prepared underlying materials and machines that cause frequent delays due to mechanical failures shall be replaced as directed.

d. Longitudinal Mechanical Float: A longitudinal mechanical float may be used. If used, the float shall be specially designed and manufactured to smooth and finish the pavement surface without working excess paste to the surface. It shall be rigidly attached to the rear of the paver-finisher or to a separate self-propelled frame spanning the paving lane. The float plate shall be at least 5 feet long by 8 inches wide and shall automatically be oscillated in the longitudinal direction while slowly moving from edge to edge of the paving lane, with the float plate in contact with the surface at all times.

e. Other Types of Finishing Equipment: Clary screeds, other rotating tube floats, or bridge deck finishers are not allowed on mainline paving, but may be allowed on irregular or odd-shaped slabs, and near buildings or trench drains, subject to the Contracting Officer's approval. Bridge deck finishers shall have a minimum operating weight of 7500 pounds and shall have a transversely operating carriage containing a knock-down auger and a minimum of two immersion vibrators. Vibrating screeds or pans shall be used only for isolated slabs where hand finishing is permitted as specified, and only where specifically approved.

f. Fixed Forms: The paver-finisher shall be equipped with wheels designed to ride the forms, keep it aligned with the forms, and spread the load so as to prevent deformation of the forms. Paver-finishers traveling on guide rails located outside the paving lane shall be equipped with wheels when traveling on new or existing concrete to remain.

g. Slipform: The slipform paver-finisher shall be automatically controlled and crawler mounted with padded tracks so as to be completely stable under all operating conditions. The paver-finisher shall finish the surface and edges so that no edge slump beyond allowable tolerance occurs. Suitable moving side forms shall be provided that are adjustable and will produce smooth, even edges, perpendicular to the top surface and meeting specification requirements for alignment and freedom from edge slump.

2.10.5 Curing Equipment

Equipment for applying membrane-forming curing compound shall be mounted on a self-propelled frame that spans the paving lane. The reservoir for curing compound shall be constantly mechanically (not air) agitated during operation and shall contain means for completely draining the reservoir. The spraying system shall consist of a mechanically powered pump which will maintain constant pressure during operation, an operable pressure gauge, and either a series of spray nozzles evenly spaced across the lane to give uniformly overlapping coverage or a single spray nozzle which is mounted on a carriage which automatically traverses the lane width at a

speed correlated with the forward movement of the overall frame. All spray nozzles shall be protected with wind screens. Calibrate the spraying system in accordance with ASTM D2995, Method A, for the rate of application required in paragraph: Membrane Curing. Any hand-operated sprayers allowed by that paragraph shall be compressed air supplied by a mechanical air compressor. If the curing equipment fails to apply an even coating of compound at the specified rate, it shall immediately be replaced.

2.10.6 Texturing Equipment

a. General: Texturing equipment shall be as specified below. Before use, the texturing equipment shall be demonstrated on a test section, and the equipment shall be modified as necessary to produce the texture directed.

b. Burlap Drag: A burlap drag shall be securely attached to a separate wheel mounted frame spanning the paving lane or to one of the other similar pieces of equipment. Length of the material shall provide 24 to 36 inches dragging flat on the pavement surface. Width shall be at least equal to the width of the slab. The material shall be clean, reasonably new burlap, completely saturated with water before attachment to the frame, always resaturated before start of use, and kept clean and saturated during use. Burlap shall conform to AASHTO M 182, Class 3 or 4.

2.10.7 Sawing Equipment

Equipment for sawing joints and for other similar sawing of concrete shall be standard diamond-type concrete saws mounted on a wheeled chassis which can be easily guided to follow the required alignment. Blades shall be diamond tipped. If demonstrated to operate properly, abrasive blades may be used. Provide spares as required to maintain the required sawing rate. All saws shall be capable of sawing to the full depth required. Early-entry saws may be used, subject to demonstration and approval of the Contracting Officer. No change to the initial sawcut depth shall be permitted.

2.10.8 Straightedge

Furnish and maintain at the job site, in good condition, one 12 foot straightedge for each paving train for testing the hardened portland cement concrete surfaces. These straightedges shall be constructed of aluminum or magnesium alloy and shall have blades of box or box-girder cross section with flat bottom, adequately reinforced to insure rigidity and accuracy. Straightedges shall have handles for operation on the pavement.

2.11 SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES

2.11.1 Specified Flexural Strength

Specified flexural strength, R, for concrete is 650 psi at 28 days, as determined by tests made in accordance with ASTM C192/C192M, as determined equivalent flexural strength, as specified in paragraph Mixture proportioning for Flexural Stength below. Maximum allowable water-cementitious material ratio is 0.45. The water-cementitious

material ratio will be the equivalent water-cement ratio as determined by conversion from the weight ratio of water to cement plus SCM by the mass equivalency method described in ACI 211.1. The concrete shall be air-entrained with a total air content of 6 plus or minus 1.5 percentage points, at the point of placement. Air content shall be determined in accordance with ASTM C231/C231M. The maximum allowable slump of the concrete at the point of placement shall be 2 inches for pavement constructed with fixed forms. For slipformed pavement, at the start of the project, select a maximum allowable slump which will produce in-place pavement meeting the specified tolerances for control of edge slump. The selected slump shall be applicable to both pilot and fill-in lanes.

2.11.2 Concrete Temperature

The temperature of the concrete as delivered shall conform to the requirements of paragraphs, Paving in Hot Weather and Paving in Cold Weather, in PART 3. Temperature of concrete shall be determined in accordance with ASTM C1064/C1064M.

2.11.3 Concrete Strength for Final Acceptance

The strength of concrete, and no individual set (2 specimens per sublot) in the lot are 25 psi or more below the equivalent 'Specified Flexural Strength'. If any lot or sublot, respectively, fails to meet the above criteria, the lot or sublot shall be removed and replaced at no additional cost to the Government. This is in addition to and does not replace the average strength required for day-to-day CQC operations as specified in paragraph: Average CQC Flexural Strength Required for Mixtures, below.

2.12 MIXTURE PROPORTIONS

2.12.1 Composition

Concrete shall be composed of cementitious material, water, fine and coarse aggregates, and admixtures. Supplementary Cementitious Materials (SCM) choice and usage shall be in accordance with paragraph: Supplementary Cementitious Materials (SCM) Content. The total cementitious material content shall be at least 470 lb./cu. yd. 517 lb./cu. yd.. Admixtures shall consist of air entraining admixture and may also include, as approved, accelerator retarder or water-reducing admixture.

2.12.2 Proportioning Studies

Trial design batches, mixture proportioning studies, and testing requirements are the responsibility of the Contractor. Submit the results of the mixture proportioning studies signed and stamped by the registered professional engineer having technical responsibility for the mix design study, and submitted at least 30 days prior to commencing concrete placing operations. The results shall include a statement giving the maximum nominal coarse aggregate size and the weights and volumes of each ingredient proportioned on a one cubic yard basis. Aggregate quantities shall be based on the mass in a saturated surface dry condition. The recommended mixture proportions shall be accompanied by test results demonstrating that the proportions selected will produce concrete of the qualities indicated. Trial mixtures having proportions, slumps, and air content suitable for the work shall be based on methodology described in ACI 211.1, modified as necessary to accommodate flexural strength. Submit test results including:

a. Coarse and fine aggregate gradations and plots.
b. Combined aggregate gradation and coarseness/workability plots.
c. Coarse aggregate quality test results, include deleterious materials.
d. Fine aggregate quality test results.
e. Mill certificates for cement and supplemental cementitious materials.
f. Certified test results for air entraining, water reducing, retarding, non-chloride accelerating, and Lithium Nitrate admixtures.
g. Specified flexural strength, slump, and air content.
h. Documentation of required average CQC flexural strength, Ra.
i. Recommended proportions/volumes for proposed mixture and each of three trial water-cementitious materials ratios.
j. Individual beam breaks.
k. Flexural strength summaries and plots.
l. Correlation ratios for acceptance testing and CQC testing.
m. Historical record of test results, documenting production standard deviation (if available).

2.12.2.1 Water-Cement Ratio

At least three different water-cement ratios, which will produce a range of strength encompassing that required on the project, shall be used. The maximum allowable water-cement ratio required in paragraph: Specified Flexural Strength, above will be the equivalent water-cement ratio. Laboratory trial mixtures shall be proportioned for maximum permitted slump and air content.

2.12.2.2 Trial Mixture Studies

Separate sets of trial mixture studies shall be made for each combination of cementitious materials and each combination of admixtures proposed for use. No combination of either shall be used until proven by such studies, except that, if approved in writing and otherwise permitted by these specifications, an accelerator or a retarder may be used without separate trial mixture study. Separate trial mixture studies shall also be made for concrete for each placing method (slip form, fixed form, or hand placement) proposed. The temperature of concrete in each trial batch shall be reported. Each mixture shall be designed to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding.

2.12.2.3 Mixture Proportioning for Flexural Strength

The following step by step procedure shall be followed:

a. Fabricate all beams for each mixture from the same batch or blend of batches. Fabricate and cure all beams in accordance with ASTM A192/A192Musing 6x6 inch steel beam forms.

b. Cure test beams from each mixture for 3,7, 14 and 28 day flexural tests; 6 beams to be tested per age.

c. Test beams in accordance with ASTM C78/C78M.

d. Using the average strenght for each w/c at each age, pliot all results from each of the three mixtures on seperate graphs for w/c versus:

3- day flexural strength
7-day flexural strength
14-day flexural strength
28-day flexural strength

e. From these graphs select a w/c that will produce a mixture giving a 28-day flexural strength equal to the required strength determined in accordnace with the next paragraph.

f. Using the abot selected w/c, elect from the graphs the expected 3,7, and 14-day flexural strengths.

g. From the above expected strengths for the slected mixture, determine the ratio of 7-day flexural strength of the slected mixture to the 28-day flexural strength of the mixture (for CQC control).

h. From the above expected strengths for the slected mixture, determine the ratio of 14-day flexural strength of the slected mixture to the 28-day flexural strength of the mixture (for acceptance)

i. If there is a change in materials, additonal mixture design studies shall be made using the new materials and new Correlation Ratios shall be dteremined.

j. No concrete pavement shall be placed until the Contracting Officer has approved the Contractor's mixture proportions. The approved water-cementious materials ratio shall not exceed the maximum value specified in paragraph: Specified Flexural Strength, above and shall not be increased without the Contracting Officer's writted approval.

2.12.3 Average CQC Flexural Strength Required for Mixtures

In order to ensure meeting the strength requirements specified in paragraph: SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES above, during production, the mixture proportions selected during mixture proportioning studies and used during construction shall produce a required average CQC flexural strength exceeding the specified strength, R, by the amount indicated below. This required average CQC flexural strength, Ra, will be used only for CQC operations as specified in paragraph: TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL in PART 3 and as specified in the previous paragraph. During production, the required Ra shall be adjusted , as appropriate and as approved, based on the standard deviation equivalent of 28-day strengths being attained during paving.

a. From Previous Test Records: Where a concrete production facility has previous test records current to within 18 months, a standard deviation shall be established in accordance with the applicable provisions of ACI 214R. Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected, shall represent concrete produced to meet a specified flexural strength or strengths within 150 psi of the 28 -day flexural strength specified for the proposed work, and shall consist of at least 30 consecutive tests. Perform verification testing, as directed by the Contracting Officer, to

document the current strength. A strength test shall be the average of the strengths of two specimens made from the same sample of concrete and tested at 28 days. Required average CQC flexural strength, Ra, used as the basis for selection of concrete proportions shall be the value from the equation that follows, using the standard deviation as determined above:

$$Ra = R + 1.34S$$

Where: S = standard deviation
R = specified flexural strength
Ra = required average flexural strength

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, a standard deviation shall be established as the product of the calculated standard deviation and a modification factor from the following table:

NUMBER OF TESTS	MODIFICATION FACTOR FOR STANDARD DEVIATION
15	1.16
20	1.08
25	1.03
30 or more	1.00

b. Without Previous Test Records: When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, the required average strength, Ra, shall be determined by adding 15 percent to the specified flexural strength, R.

PART 3 EXECUTION

3.1 PREPARATION FOR PAVING

Before commencing paving, perform the following. If used, forms shall be in place, cleaned, coated, and adequately supported. Any reinforcing steel needed shall be at the paving site. All transporting and transfer equipment shall be ready for use, clean, and free of hardened concrete and foreign material. Equipment for spreading, consolidating, screeding, finishing, and texturing concrete shall be at the paving site, clean and in proper working order. All equipment and material for curing and for protecting concrete from weather or mechanical damage shall be at the paving site, in proper working condition, and in sufficient amount for the entire placement.

3.1.1 Weather Precaution

When windy conditions during paving appear probable, equipment and material shall be at the paving site to provide windbreaks, shading, fogging, or other action to prevent plastic shrinkage cracking or other damaging drying of the concrete.

3.1.2 Proposed Techniques

Submit placing and protection methods; paving sequence; jointing pattern; data on curing equipment and profilographs; demolition of existing pavements, as specified; pavement diamond grinding equipment and procedures. Submit for approval the following items:

a. A description of the placing and protection methods proposed when concrete is to be placed in or exposed to hot, cold, or rainy weather conditions.

b. A detailed paving sequence plan and proposed paving pattern showing all planned construction joints; transverse and longitudinal dowel bar spacing; and identifying pilot lanes and hand placement areas. No deviation from the jointing pattern shown on the drawings shall be made without written approval of the Contracting Officer .

c. Plan and equipment proposed to control alignment of sawn joints within the specified tolerances.

d. Data on the curing equipment, media and methods to be used.

e. Data on profilograph and methods to measure pavement smoothness.

f. Pavement demolition work plan, presenting the proposed methods and equipment to remove existing pavement and protect pavement to remain in place.

3.2 CONDITIONING OF UNDERLYING MATERIAL

3.2.1 General Procedures

Underlying material, upon which concrete is to be placed shall be clean, damp, and free from debris, waste concrete or cement, frost, ice, and standing or running water. Prior to setting forms or placement of concrete, the underlying material shall be well drained and shall have been satisfactorily graded by string-line controlled, automated, trimmer/fine grader and uniformly compacted in accordance with the applicable Section of these specifications. The surface of the underlying material shall be tested as to crown, elevation, and density in advance of setting forms or of concrete placement using slip-form techniques. High areas shall be trimmed to proper elevation. Low areas shall be filled and compacted to a condition similar to that of surrounding grade, or filled with concrete monolithically with the pavement. Low areas filled with concrete shall not be cored for thickness to avoid biasing the average thickness used for evaluation and payment adjustment. Any underlying material disturbed by construction operations shall be reworked and recompacted to specified density immediately in front of the paver. If a slipform paver is used, the same underlying material under the paving lane shall be continued beyond the edge of the lane a sufficient distance and shall be thoroughly compacted and true to grade to provide a suitable trackline for the slipform paver and firm support for the edge of the paving lane.

3.2.2 Traffic on Underlying Material

After the underlying material has been prepared for concrete placement, no equipment shall be permitted thereon. Subject to specific approval, crossing of the prepared underlying material at specified intervals for

construction purposes may be permitted, provided rutting or indentations do not occur. The surface shall be reworked and reprepared to the satisfaction of the Contracting Officer before concrete is placed. Equipment shall be allowed to operate on the underlying material only if approved by the Contracting Officer and only if no damage is done to the underlying material and its degree of compaction. Any disturbance to the underlying material that does occur shall be corrected, as approved, before the paver-finisher or the deposited concrete reaches the location of the disturbance and the equipment shall be replaced or procedures changed to prevent any future damage.

3.3 WEATHER LIMITATIONS

3.3.1 Placement and Protection During Inclement Weather

Do not commence placing operations when heavy rain or other damaging weather conditions appear imminent. At all times when placing concrete, maintain on-site sufficient waterproof cover and means to rapidly place it over all unhardened concrete or concrete that might be damaged by rain. Suspend placement of concrete whenever rain, high winds, or other damaging weather commences to damage the surface or texture of the placed unhardened concrete, washes cement out of the concrete, or changes the water content of the surface concrete. All unhardened concrete shall be immediately covered and protected from the rain or other damaging weather. Any slab damaged by rain or other weather shall be completely removed full depth, by full slab width, to the nearest original joint, and replaced at the Contractor's expense as specified in paragraph: REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS below.

3.3.2 Paving in Hot Weather

When the ambient temperature during paving is expected to exceed 90 degrees F, the concrete shall be properly placed and finished in accordance with procedures previously submitted, approved, and as specified herein. The concrete temperature at time of delivery to the forms shall not exceed the temperature shown in the table below when measured in accordance with ASTM C1064/C1064M. Cooling of the mixing water or aggregates or placing in the cooler part of the day may be required to obtain an adequate placing temperature. Steel forms and reinforcing shall be cooled as needed to maintain steel temperatures below 120 degrees F. Transporting and placing equipment shall be cooled or protected if necessary to maintain proper concrete placing temperature. The finished surfaces of the newly laid pavement shall be kept damp by applying a fog spray (mist) with approved spraying equipment until the pavement is covered by the curing medium.

Maximum Allowable Concrete Placing Temperature	
Relative Humidity, Percent, During Time of Concrete Placement	Maximum Allowable Concrete Temperature in Degrees F
Greater than 60	95
40-60	85
Less than 40	80

3.3.3 Prevention of Plastic Shrinkage Cracking

During weather with low humidity, and particularly with high temperature and appreciable wind, develop and institute measures to prevent plastic shrinkage cracks from developing. If plastic shrinkage cracking occurs, halt further placement of concrete until protective measures are in place to prevent further cracking. Periods of high potential for plastic shrinkage cracking can be anticipated by use of Fig. 4.2 of ACI 305R. In addition to the protective measures specified in the previous paragraph, the concrete placement shall be further protected by erecting shades and windbreaks and by applying fog sprays of water, the addition of monomolecular films, or wet covering. Apply monomolecular films after finishing is complete, do not use in the finishing process. When such water treatment is stopped, curing procedures shall be immediately commenced. Plastic shrinkage cracks that occur shall be repaired in accordance with paragraph: REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS. Plastic shrinkage cracks shall never be troweled over or filled with slurry.

3.3.4 Paving in Cold Weather

Cold weather paving shall conform to ACI 306R. Special protection measures, as specified herein, shall be used if freezing temperatures are anticipated before the expiration of the specified curing period. Placement of concrete shall not begin unless the ambient temperature is at least 35 degrees F and rising. Thereafter, placement of concrete shall be halted whenever the ambient temperature drops below 40 degrees F. When the ambient temperature is less than 50 degrees F, the temperature of the concrete when placed shall be not less than 50 degrees F nor more than 75 degrees F. Heating of the mixing water or aggregates will be required to regulate the concrete placing temperature. Materials entering the mixer shall be free from ice, snow, or frozen lumps. Salt, chemicals or other materials shall not be incorporated in the concrete to prevent freezing. If allowed under paragraph: MIXTURE PROPORTIONS in PART 2, an accelerating admixture may be used when the ambient temperature is below 50 degrees F. Covering and other means shall be provided for maintaining the concrete at a temperature of at least 50 degrees F for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period. Remove pavement slabs damaged by freezing or falling below freezing temperature to full depth, by full slab width, to the nearest original joint, and replace at the Contractor's expense as specified in paragraph REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS.

3.4 CONCRETE PRODUCTION

Batching, mixing, and transporting equipment shall have a capacity sufficient to maintain a continuous, uniform forward movement of the paver of not less than 2.5 feet per minute. Concrete transported in non-agitating equipment shall be deposited in front of the paver within 45 minutes from the time cement has been charged into the mixing drum, except that if the ambient temperature is above 90 degrees F, the time shall be reduced to 30 minutes. Concrete transported in truck mixers shall be deposited in front of the paver within 90 minutes from the time cement has been charged into the mixer drum of the plant or truck mixer. If the ambient temperature is above 90 degrees F, the time shall be reduced to 60 minutes. Every load of concrete delivered to the paving site shall be accompanied by a batch ticket from the operator of the batching plant. Tickets shall be on approved forms and shall show at least the mass, or volume, of all ingredients in each batch delivered, the water meter and

revolution meter reading on truck mixers and the time of day. Tickets shall be delivered to the placing foreman who shall keep them on file and deliver them to the Government weekly, or as directed by the Contracting Officer.

3.4.1 Batching and Mixing Concrete

Scale pivots and bearings shall be kept clean and free of rust. Any equipment which fails to perform as specified shall immediately be removed from use until properly repaired and adjusted, or replaced.

3.4.2 Transporting and Transfer - Spreading Operations

Non-agitating equipment shall be used only on smooth roads and for haul time less than 15 minutes. Concrete shall be deposited as close as possible to its final position in the paving lane. All equipment shall be operated to discharge and transfer concrete without segregation. In no case shall dumping of concrete in discrete piles be permitted. No transfer or spreading operation which requires the use of front-end loaders, dozers, or similar equipment to distribute the concrete will be permitted.

3.5 PAVING

3.5.1 General Requirements

Pavement shall be constructed with paving and finishing equipment utilizing rigid fixed forms or by use of slipform paving equipment. Paving and finishing equipment and procedures shall be capable of constructing paving lanes of the required width at a rate of at least 2.5 feet of paving lane per minute on a routine basis. Paving equipment and its operation shall be controlled, and coordinated with all other operations, such that the paver-finisher has a continuous forward movement, at a reasonably uniform speed, from beginning to end of each paving lane, except for inadvertent equipment breakdown. Backing the paver and refinishing a lane is not permitted. Remove and replace concrete refinished in this manner. Failure to achieve a continuous forward motion requires halting operations, regrouping, and modifying operations to achieve this requirement. Workmen with foreign material on their footwear or construction equipment that might deposit foreign material shall not be permitted to walk or operate in the plastic concrete. Where an open-graded granular base is required under the concrete, select paving equipment and procedures which will operate properly on the base course without causing displacement or other damage.

3.5.2 Consolidation

Concrete shall be consolidated with the specified type of lane-spanning, gang-mounted, mechanical, immersion type vibrating equipment mounted in front of the paver, supplemented, in rare instances as specified, by hand-operated vibrators. The vibrators shall be inserted into the concrete to a depth that will provide the best full-depth consolidation but not closer to the underlying material than 2 inches. Excessive vibration shall not be permitted. If the vibrators cause visible tracking in the paving lane, the paving operation shall be stopped and equipment and operations modified to prevent it. Concrete in small, odd-shaped slabs or in isolated locations inaccessible to the gang-mounted vibration equipment shall be vibrated with an approved hand-operated immersion vibrator operated from a bridge spanning the area. Vibrators shall not be

used to transport or spread the concrete. Hand-operated vibrators shall not be operated in the concrete at one location for more than 20 seconds. Insertion locations for hand-operated vibrators shall be between 6 to 15 inches on centers. For each paving train, at least one additional vibrator spud, or sufficient parts for rapid replacement and repair of vibrators shall be maintained at the paving site at all times. Any evidence of inadequate consolidation (honeycomb along the edges, large air pockets, or any other evidence) shall require the immediate stopping of the paving operation and approved adjustment of the equipment or procedures.

3.5.3 Operation

When the paver approaches a header at the end of a paving lane, a sufficient amount of concrete shall be maintained ahead of the paver to provide a roll of concrete which will spill over the header. The amount of extra concrete shall be sufficient to prevent any slurry that is formed and carried along ahead of the paver from being deposited adjacent to the header. The spud vibrators in front of the paver shall be brought as close to the header as possible before they are lifted. Additional consolidation shall be provided adjacent to the headers by hand-manipulated vibrators. When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), provisions shall be made to prevent damage to the previously constructed pavement. Screeds or extrusion plates shall be electronically controlled from the previously placed pavement so as to prevent them from applying pressure to the existing pavement and to prevent abrasion of the pavement surface. The overlapping area of existing pavement surface shall at all times be kept completely free of any loose or bonded foreign material as the paver-finisher operates across it. When the paver travels on existing pavement, approved provisions shall be made to prevent damage to the existing pavement. Pavers using transversely oscillating screeds shall not be used to form fill-in lanes that have widths less than a full width for which the paver was designed or adjusted.

3.5.4 Required Results

The paver-finisher, and its gang-mounted vibrators, together with its operating procedures shall be adjusted and operated and coordinated with the concrete mixture being used to produce a thoroughly consolidated slab throughout, true to line and grade within specified tolerances. The paver-finishing operation shall produce a surface finish free of irregularities, tears, voids of any kind, and any other discontinuities. The paver-finisher shall make only one pass across the pavement; multiple passes will not be permitted. The equipment and its operation shall produce a finished surface requiring no hand finishing other than the use of cutting straightedges, except in very infrequent instances. If any equipment or operation fails to produce the above results, the paving shall be stopped, the equipment shall be replaced or properly adjusted, the operation shall be appropriately modified, or the mixture proportions modified, in order to produce the required results before recommencing paving. No water, other than fog sprays (mist) as specified in paragraph: Prevention of Plastic Shrinkage Cracking above, shall be applied to the concrete or the concrete surface during paving and finishing.

3.5.5 Fixed Form Paving

Paving equipment for fixed-form paving and the operation thereof shall conform to the requirements of paragraph EQUIPMENT, and all requirements

specified herein.

3.5.5.1 Forms for Fixed-Form Paving

a. Straight forms shall be made of steel and shall be furnished in sections not less than 10 feet in length. Flexible or curved forms of proper radius shall be used for curves of 100-foot radius or less. Wood forms for curves and fillets shall be made of well-seasoned, surfaced plank or plywood, straight, and free from warp or bend. Wood forms shall be adequate in strength and rigidly braced. Forms shall have a depth equal to the pavement thickness at the edge. Where the project requires several different slab thicknesses, forms may be built up by bolting or welding a tubular metal section or by bolting wood planks to the bottom of the form to completely cover the underside of the base of the form and provide an increase in depth of not more than 25 percent. The base width of the one-piece or built-up form shall be not less than eight-tenths of the vertical height of the form, except than forms 8 inches or less in vertical height shall have a base width not less than the vertical height of the form. Maximum vertical deviation of top of any side form, including joints, shall not vary from a true plane more than 1/8 inch in 10 feet, and the upstanding leg shall not vary more than 1/4 inch.

b. Form sections shall be tightly locked and shall be free from play or movement in any direction. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment.

c. Set forms for full bearing on foundation for entire length and width and in alignment with edge of finished pavement. Support forms during entire operation of placing, compaction, and finishing so that forms will not deviate vertically more than 0.01 foot from required grade and elevations indicated. Conformity to the alignment and grade elevations shown on the drawings shall be checked and necessary corrections shall be made immediately prior to placing the concrete. The forms shall be cleaned and oiled each time before concrete is placed. No concrete shall be placed until setting of forms has been checked and approved by the CQC team.

d. Do not anchor guide rails for fixed form pavers into new concrete or existing concrete to remain.

e. Forms for overlay pavements and for other locations where forms must be set on existing pavements shall be held securely in place with stakes or by other approved methods. Holes in existing pavements for form stakes shall be carefully drilled by methods which will not crack or spall the existing pavement. After use, the holes shall be filled flush with the surrounding surface using approved material, prior to overlying materials being placed. Any method which does not hold the form securely or which damages the existing pavement shall be immediately discontinued. Prior to setting forms for paving operations, demonstrate the proposed form setting procedures at an approved location without proceeding further until the proposed method is approved by the Contracting Officer.

3.5.5.2 Form Removal

Keep forms in place at least 12 hours after the concrete has been placed.

When conditions are such that the early strength gain of the concrete is delayed, leave the forms in place for a longer time, as directed. Remove forms by procedures that do not injure the concrete. Bars or heavy metal tools shall not be used directly against the concrete in removing the forms. Any concrete found to be defective after form removal shall be repaired promptly, using procedures specified or as directed.

3.5.6 Slipform Paving

3.5.6.1 General

Paving equipment for slipform paving and the operation thereof shall conform to the requirement of paragraph EQUIPMENT, and all requirements specified herein. The slipform paver shall shape the concrete to the specified and indicated cross section, meeting all tolerances, in one pass. The slipform paver shall finish the surface and edges so that only a very minimum isolated amount of hand finishing is required. If the paving operation does not meet the above requirements and the specified tolerances, immediately stop the operation, and regroup and replace or modify any equipment as necessary, modify paving procedures or modify the concrete mix, in order to resolve the problem. The slipform paver shall be automatically electronically controlled from a taut wire guideline for horizontal alignment and on both sides from a taut wire guideline for vertical alignment, except that electronic control from a ski operating on a previously constructed adjoining lane shall be used where applicable for either or both sides. Automatic, electronic controls for vertical alignment shall always be used on both sides of the lane. Control from a slope-adjustment control or control operating from the underlying material shall never be used. Side forms on slipform pavers shall be properly adjusted so that the finished edge of the paving lane meets all specified tolerances. Dowels in longitudinal construction joints shall be installed as specified below. The installation of these dowels by dowel inserters attached to the paver or by any other means of inserting the dowels into the plastic concrete shall not be permitted.

3.5.6.2 Guideline for Slipform Paving

Accurately and securely install guidelines well in advance of concrete placement. Provide supports at necessary intervals to eliminate all sag in the guideline when properly tightened. The guideline shall be high strength wire set with sufficient tension to remove all sag between supports. Supports shall be securely staked to the underlying material or other provisions made to ensure that the supports will not be displaced when the guideline is tightened or when the guideline or supports are accidentally touched by workmen or equipment during construction. The appliances for attaching the guideline to the supports shall be capable of easy adjustment in both the horizontal and vertical directions. When it is necessary to leave gaps in the guideline to permit equipment to use or cross underlying material, provisions shall be made for quickly and accurately replacing the guideline without any delay to the forward progress of the paver. Supports on either side of the gap shall be secured in such a manner as to avoid disturbing the remainder of the guideline when the portion across the gap is positioned and tightened. The guideline across the gap and adjacent to the gap for a distance of 200 feet shall be checked for horizontal and vertical alignment after the guideline across the gap is tightened. Vertical and horizontal positioning of the guideline shall be such that the finished pavement shall conform to the alignment and grade elevations shown on the drawings within the specified tolerances for grade and smoothness. The specified

tolerances are intended to cover only the normal deviations in the finished pavement that may occur under good supervision and do not apply to setting of the guideline. The guideline shall be set true to line and grade.

3.5.6.3 Laser Controls

If the Contractor proposes to use any type of automatic laser controls, submit a detailed description of the system and perform a trial field demonstration in the presence of the Contracting Officer at least one week prior to start of paving. Approval of the control system will be based on the results of the demonstration and on continuing satisfactory operation during paving.

3.5.7 Placing Reinforcing Steel

The type and amount of steel reinforcement shall be as shown on the drawings.

3.5.7.1 Pavement Thickness Greater Than 12 Inches

For pavement thickness of 12 inches or more, the reinforcement steel shall be installed by the strike-off method wherein a layer of concrete is deposited on the underlying material, consolidated, and struck to the indicated elevation of the steel reinforcement. The reinforcement shall be laid upon the prestruck surface, and the remaining concrete shall then be placed and finished in the required manner. When placement of the second lift causes the steel to be displaced horizontally from its original position, provisions shall be made for increasing the thickness of the first lift and depressing the reinforcement into the unhardened concrete to the required elevation. The increase in thickness shall be only as necessary to permit correct horizontal alignment to be maintained. Any portions of the bottom layer of concrete that have been placed more than 30 minutes without being covered with the top layer shall be removed and replaced with newly mixed concrete without additional cost to the Government.

3.5.7.2 Pavement Thickness Less Than 12 Inches

For pavements less than 12 inches thick, the reinforcement shall be positioned on suitable chairs or continuous mesh support devices securely fastened to the subgrade prior to concrete placement. Concrete shall be vibrated after the steel has been placed. Regardless of placement procedure, the reinforcing steel shall be free from coatings which could impair bond between the steel and concrete, and laps in the reinforcement shall be as indicated. Regardless of the equipment or procedures used for installing reinforcement, ensure that the entire depth of concrete is adequately consolidated.

3.5.8 Placing Dowels

The method used in installing and holding dowels in position shall ensure that the error in alignment of any dowel from its required horizontal and vertical alignment after the pavement has been completed will not be greater than 1/8 in. per ft. Except as otherwise specified below, horizontal spacing of dowels shall be within a tolerance of plus or minus 5/8 inch. The vertical location on the face of the slab shall be within a tolerance of plus or minus 1/2 inch). The vertical alignment of the dowels shall be measured parallel to the designated top surface of the pavement,

except for those across the crown or other grade change joints. Dowels across crowns and other joints at grade changes shall be measured to a level surface. Horizontal alignment shall be checked perpendicular to the joint edge. The horizontal alignment shall be checked with a framing square. Dowels shall not be placed closer than 0.6 times the dowel bar length to the planned joint line. If the last regularly spaced longitudinal dowel is closer than that dimension, it shall be moved away from the joint to a location 0.6 times the dowel bar length, but not closer than 6 inches to its nearest neighbor. Dowel (tie bar) interference at a transverse joint-longitudinal joint intersection shall be resolved by deleting the closest transverse dowel (tie bar). Dowels shall be installed as specified in the following subparagraphs.

3.5.8.1 Contraction Joints

Dowels in longitudinal and transverse contraction joints within the paving lane shall be held securely in place, as indicated, by means of rigid metal frames or basket assemblies of an approved type. The basket assemblies shall be held securely in the proper location by means of suitable pins or anchors. Do not cut or crimp the dowel basket tie wires. At the Contractor's option, in lieu of the above, dowels in contraction joints shall be installed near the front of the paver by insertion into the plastic concrete using approved equipment and procedures. Approval will be based on the results of a preconstruction demonstration, showing that the dowels are installed within specified tolerances.

3.5.8.2 Construction Joints-Fixed Form Paving

Install dowels by the bonded-in-place method or the drill-and-dowel method. Installation by removing and replacing in preformed holes will not be permitted. Dowels shall be prepared and placed across joints where indicated, correctly aligned, and securely held in the proper horizontal and vertical position during placing and finishing operations, by means of devices fastened to the forms. The spacing of dowels in construction joints shall be as indicated, except that, where the planned spacing cannot be maintained because of form length or interference with form braces, closer spacing with additional dowels shall be used.

3.5.8.3 Dowels Installed in Hardened Concrete

Install dowels in hardened concrete by bonding the dowels into holes drilled into the hardened concrete. The concrete shall have cured for 7 days or reached a minimum compressive strength of 2500 pi before drilling commences. Holes 1/8 inch greater in diameter than the dowels shall be drilled into the hardened concrete using rotary-core drills. Rotary-percussion drills may be used, provided that excessive spalling does not occur to the concrete joint face. Continuing damage shall require modification of the equipment and operation. Depth of dowel hole shall be within a tolerance of plus/minus 1/2 inch of the dimension shown on the drawings. Upon completion of the drilling operation, the dowel hole shall be blown out with oil-free, compressed air. Dowels shall be bonded in the drilled holes using epoxy resin. Epoxy resin shall be injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel will not be permitted. The dowels shall be held in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic grout retention ring fitted around the dowel. Dowels

required to be installed in any joints between new and existing concrete shall be grouted in holes drilled in the existing concrete, all as specified above.

3.5.8.4 Lubricating Dowel Bars

The portion of each dowel intended to move within the concrete or expansion cap shall be wiped clean and coated with a thin, even film of lubricating oil or light grease before the concrete is placed.

3.6 FINISHING

Finishing operations shall be a continuing part of placing operations starting immediately behind the strike-off of the paver. Initial finishing shall be provided by the transverse screed or extrusion plate. The sequence of operations shall be transverse finishing, longitudinal machine floating if used, straightedge finishing, texturing, and then edging of joints. Finishing shall be by the machine method. The hand method shall be used only on isolated areas of odd slab widths or shapes and in the event of a breakdown of the mechanical finishing equipment. Supplemental hand finishing for machine finished pavement shall be kept to an absolute minimum. Any machine finishing operation which requires appreciable hand finishing, other than a moderate amount of straightedge finishing, shall be immediately stopped and proper adjustments made or the equipment replaced. Any operations which produce more than 1/8 inch of mortar-rich surface (defined as deficient in plus U.S. No. 4 sieve size aggregate) shall be halted immediately and the equipment, mixture, or procedures modified as necessary. Compensation shall be made for surging behind the screeds or extrusion plate and settlement during hardening and care shall be taken to ensure that paving and finishing machines are properly adjusted so that the finished surface of the concrete (not just the cutting edges of the screeds) will be at the required line and grade. Finishing equipment and tools shall be maintained clean and in an approved condition. At no time shall water be added to the surface of the slab with the finishing equipment or tools, or in any other way, except for fog (mist) sprays specified to prevent plastic shrinkage cracking.

3.6.1 Machine Finishing With Fixed Forms

The machine shall be designed to straddle the forms and shall be operated to screed and consolidate the concrete. Machines that cause displacement of the forms shall be replaced. The machine shall make only one pass over each area of pavement. If the equipment and procedures do not produce a surface of uniform texture, true to grade, in one pass, the operation shall be immediately stopped and the equipment, mixture, and procedures adjusted as necessary.

3.6.2 Machine Finishing with Slipform Pavers

The slipform paver shall be operated so that only a very minimum of additional finishing work is required to produce pavement surfaces and edges meeting the specified tolerances. Any equipment or procedure that fails to meet these specified requirements shall immediately be replaced or modified as necessary. A self-propelled nonrotating pipe float may be used while the concrete is still plastic, to remove minor irregularities and score marks. Only one pass of the pipe float shall be allowed. If there is concrete slurry or fluid paste on the surface that runs over the edge of the pavement, the paving operation shall be immediately stopped and the equipment, mixture, or operation modified to prevent formation of

such slurry. Any slurry which does run down the vertical edges shall be immediately removed by hand, using stiff brushes or scrapers. No slurry, concrete or concrete mortar shall be used to build up along the edges of the pavement to compensate for excessive edge slump, either while the concrete is plastic or after it hardens.

3.6.3 Surface Correction and Testing

After all other finishing is completed but while the concrete is still plastic, minor irregularities and score marks in the pavement surface shall be eliminated by means of cutting straightedges. Such straightedges shall be 12 feet in length and shall be operated from the sides of the pavement and from bridges. A straightedge operated from the side of the pavement shall be equipped with a handle 3 feet longer than one-half the width of the pavement. The surface shall then be tested for trueness with a straightedge held in successive positions parallel and at right angles to the center line of the pavement, and the whole area covered as necessary to detect variations. The straightedge shall be advanced along the pavement in successive stages of not more than one-half the length of the straightedge. Depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated with an internal vibrator, and refinished. Projections above the required elevation shall also be struck off and refinished. The straightedge testing and finishing shall continue until the entire surface of the concrete is free from observable departure from the straightedge and conforms to the surface requirements specified in paragraph: ACCEPTABILITY OF WORK in PART 1. This straightedging shall not be used as a replacement for the straightedge testing of paragraph: Surface Smoothness in PART 1. Long-handled, flat bull floats shall be used very sparingly and only as necessary to correct minor, scattered surface defects. If frequent use of bull floats is necessary, the paving operation shall be stopped and the equipment, mixture or procedures adjusted to eliminate the surface defects. Finishing with hand floats and trowels shall be held to the absolute minimum necessary. Extreme care shall be taken to prevent overfinishing joints and edges. The surface finish of the pavement shall be produced essentially by the finishing machine and not by subsequent hand finishing operations. All hand finishing operations shall be subject to approval and shall be modified when directed.

3.6.4 Hand Finishing

Use hand finishing operations only as specified below.

3.6.4.1 Equipment and Template

In addition to approved mechanical internal vibrators for consolidating the concrete, provide a strike-off and tamping template and a longitudinal float for hand finishing. The template shall be at least 1 foot longer than the width of pavement being finished, of an approved design, and sufficiently rigid to retain its shape, and shall be constructed of metal or other suitable material shod with metal. The longitudinal float shall be at least 10 feet long, of approved design, and rigid and substantially braced, and shall maintain a plane surface on the bottom. Grate tampers (jitterbugs) shall not be used.

3.6.4.2 Finishing and Floating

As soon as placed and vibrated, the concrete shall be struck off and screeded to the crown and cross section and to such elevation above grade

that when consolidated and finished, the surface of the pavement will be at the required elevation. In addition to previously specified complete coverage with handheld immersion vibrators, the entire surface shall be tamped with the strike-off and tamping template, and the tamping operation continued until the required compaction and reduction of internal and surface voids are accomplished. Immediately following the final tamping of the surface, the pavement shall be floated longitudinally from bridges resting on the side forms and spanning but not touching the concrete. If necessary, additional concrete shall be placed, consolidated and screeded, and the float operated until a satisfactory surface has been produced. The floating operation shall be advanced not more than half the length of the float and then continued over the new and previously floated surfaces.

3.6.5 Texturing

Before the surface sheen has disappeared and before the concrete hardens or curing compound is applied, the surface of the pavement shall be given a texture as described herein. After curing is complete, all textured surfaces shall be thoroughly power broomed to remove all debris.

3.6.5.1 Burlap Drag Surface

Surface texture shall be applied by dragging the surface of the pavement, in the direction of the concrete placement, with an approved burlap drag. The drag shall be operated with the fabric moist, and the fabric shall be cleaned or changed as required to keep clean. The dragging shall be done so as to produce a uniform finished surface having a fine sandy texture without disfiguring marks.

3.6.5.2 Artificial Turf Drag Surface

Artificial turf texture shall be applied by dragging the surface of the pavement in the direction of concrete placement with an approved full-width drag made with artificial turf.

3.6.5.3 Broom Texturing

Brooming should be completed before the concrete has hardened to the point where the surface will be unduly torn or roughened, but after hardening has progressed enough so that the mortar will not flow and reduce the sharpness of the scores. Successive passes of the broom shall be overlapped the minimum necessary to obtain a uniformly textured surface. Brooms shall be washed thoroughly at frequent intervals during use. Worn or damaged brooms shall be removed from the job site. Hand brooming will be permitted only on isolated odd shaped slabs or slabs where hand finishing is permitted. For hand brooming, the brooms shall have handles longer than half the width of slab to be finished. The hand brooms shall be drawn transversely across the surface from the center line to each edge with slight overlapping strokes.

3.6.5.4 Wire-Comb Texturing

Surface texture shall be applied using an approved mechanical wire comb drag operated to comb the surface transverse to the pavement center line. The comb shall be capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. Successive passes of the comb shall be overlapped the minimum necessary to obtain a continuous and uniformly textured surface. Texturing shall be completed before the concrete has hardened to the point where the surface and edges

will be unduly torn, but after hardening has progressed to the point where the serrations will not close up. The serrations shall be 1/16 to 3/16 inch deep, 1/16 to 1/8 inch wide, and spaced 3/8 inch apart. Transverse texturing shall produce grooves in straight lines across each lane within a tolerance of plus or minus 1/2 inch of a true line.

3.6.5.5 Surface Grooving

The areas indicated on the drawings shall be grooved with a spring tine drag producing individual grooves 1/4 inch deep and 1/4 inch wide at a spacing between groove centerlines of 1-1/2 inches. These grooves shall be cut perpendicular to the centerline. Before grooving begins, the concrete shall be allowed to attain sufficient strength to prevent aggregate spalling. Grooves shall not be cut within 6 inches of a runway centerline, transverse joint, or crack; and they shall not be cut through neoprene compression seals. Transverse texturing shall produce grooves in straight lines across each lane within a tolerance of plus or minus 1/2 inch of a true line.

3.6.6 Edging

After texturing has been completed, the edge of the slabs along the forms, along the edges of slipformed lanes, and at the joints shall be carefully finished with an edging tool to form a smooth rounded surface of 1/8 inch radius. Tool marks shall be eliminated, and the edges shall be smooth and true to line. No water shall be added to the surface during edging. Extreme care shall be taken to prevent overworking the concrete.

3.6.7 Outlets in Pavement

Recesses for the tie-down anchors, lighting fixtures, and other outlets in the pavement shall be constructed to conform to the details and dimensions shown. The concrete in these areas shall be carefully finished to provide a surface of the same texture as the surrounding area that will be within the requirements for plan grade and surface smoothness.

3.7 CURING

3.7.1 Protection of Concrete

Concrete shall be continuously protected against loss of moisture and rapid temperature changes for at least 7 days from the completion of finishing operations. All equipment needed for adequate curing and protection of the concrete shall be on hand and ready for use before actual concrete placement begins. If any selected method of curing does not afford the proper curing and protection against concrete cracking, the damaged pavement shall be removed and replaced, and another method of curing shall be employed as directed. Curing shall be accomplished by one of the following methods .

3.7.2 Membrane Curing

A uniform coating of white-pigmented, membrane-forming, curing compound shall be applied to the entire exposed surface of the concrete as soon as the free water has disappeared from the surface after finishing . Along the formed edge faces, it shall be applied immediately after the forms are removed. Concrete shall not be allowed to dry before the application of the membrane. If any drying has occurred, the surface of the concrete shall be moistened with a fine spray of water, and the curing compound

applied as soon as the free water disappears. The curing compound shall be applied to the finished surfaces by means of an approved automatic spraying machine. The curing compound shall be applied with a single overlapping application that will give a uniform coverage of 150 square feet.

The curing compound shall be applied with a single overlapping application that will give a uniform coverage of 150 square feet per gallon.

The application of curing compound by hand-operated, mechanical powered pressure sprayers will be permitted only on odd widths or shapes of slabs and on concrete surfaces exposed by the removal of forms. When the application is made by hand-operated sprayers, a second coat shall be applied in a direction approximately at right angles to the direction of the first coat. If pinholes, abrasions, or other discontinuities exist, an additional coat shall be applied to the affected areas within 30 minutes. Concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied shall be resprayed by the method and at the coverage specified above. Areas where the curing compound is damaged by subsequent construction operations within the curing period shall be immediately resprayed. Concrete surfaces to which membrane-curing compounds have been applied shall be adequately protected during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane.

3.7.3 Moist Curing

Concrete to be moist-cured shall be maintained continuously wet for the entire curing period, or until curing compound is applied, commencing immediately after finishing. If forms are removed before the end of the curing period, curing shall be carried out as on unformed surfaces, using suitable materials. Surfaces shall be cured by ponding, by continuous sprinkling, by continuously saturated burlap or cotton mats, or by continuously saturated plastic coated burlap. Burlap and mats shall be clean and free from any contamination and shall be completely saturated before being placed on the concrete. Lap sheets to provide full coverage. Provide an approved work system to ensure that moist curing is continuous 24 hours per day and that the entire surface is wet.

3.8 JOINTS

3.8.1 General Requirements for Joints

Joints shall conform to the locations and details indicated and shall be perpendicular to the finished grade of the pavement. All joints shall be straight and continuous from edge to edge or end to end of the pavement with no abrupt offset and no gradual deviation greater than 1/2 inch. Where any joint fails to meet these tolerances, the slabs adjacent to the joint shall be removed and replaced at no additional cost to the Government. No change from the jointing pattern shown on the drawings shall be made without written approval of the Contracting Officer. Joints shall be sealed immediately following curing of the concrete or as soon thereafter as weather conditions permit. Joints shall be sealed as specified in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS .

3.8.2 Longitudinal Construction Joints

Dowels shall be installed in the longitudinal construction joints, or the edges shall be thickened as indicated. Dowels shall be installed as specified above. After the end of the curing period, longitudinal construction joints shall be sawed to provide a groove at the top for sealant conforming to the details and dimensions indicated.

3.8.3 Transverse Construction Joints

Transverse construction joints shall be installed at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for 30 minutes or longer. The transverse construction joint shall be installed at a planned transverse joint. Transverse construction joints shall be constructed by utilizing headers or by paving through the joint, then full-depth sawcutting the excess concrete. Pavement shall be constructed with the paver as close to the header as possible, and the paver shall be run out completely past the header. Transverse construction joints installed at a planned transverse joint shall be constructed as shown or, if not shown otherwise, shall be dowelled in accordance with paragraph: Dowels Installed in Hardened Concrete, or paragraph: Fixed Form Paving above.

3.8.4 Expansion Joints

Expansion joints shall be formed where indicated, and about any structures and features that project through or into the pavement, using joint filler of the type, thickness, and width indicated, and shall be installed to form a complete, uniform separation between the structure and the pavement. The filler shall be attached to the original concrete placement with adhesive or other fasteners and shall extend the full slab depth. After placement and curing of the adjacent slab, sawcut the sealant reservior depth from the filler. Adjacent sections of filler shall be fitted tightly together, and the filler shall extend across the full width of the paving lane or other complete distance in order to prevent entrance of concrete into the expansion space. Edges of the concrete at the joint face shall be finished with an edger with a radius of 1/8 inch.

3.8.5 Slip Joints

Slip joints shall be installed where indicated using the specified materials. Preformed joint filler material shall be attached to the face of the original concrete placement with adhesive or other fasteners. A 3/4 inch deep reservoir for joint sealant shall be constructed at the top of the joint. Edges of the joint face shall be finished with an edger with a radius of 1/8 inch.

3.8.6 Contraction Joints

Construct transverse and longitudinal contraction joints by sawing an initial groove in the concrete with a 1/8 inch blade to the indicated depth. During sawing of joints, and again 24 hours later, the CQC team shall inspect all exposed lane edges for development of cracks below the saw cut, and shall immediately report results to the Contracting Officer. If the Contracting Officer determines that there are more uncracked joints than desired, the Contractor will be directed to saw succeeding joints 25 percent deeper than originally indicated at no additional cost to the Government. The time of initial sawing shall vary depending on existing and anticipated weather conditions and shall be such as to prevent

uncontrolled cracking of the pavement. Sawing of the joints shall commence as soon as the concrete has hardened sufficiently to permit cutting the concrete without chipping, spalling, or tearing. The sawed faces of joints will be inspected for undercutting or washing of the concrete due to the early sawing, and sawing shall be delayed if undercutting is sufficiently deep to cause structural weakness or excessive roughness in the joint. The sawing operation shall be carried on as required during both day and night regardless of weather conditions. The joints shall be sawed at the required spacing consecutively in the sequence of the concrete placement. Adequate lighting shall be provided for night work. Illumination using vehicle headlights will not be permitted. A chalk line or other suitable guide shall be used to mark the alignment of the joint. Before sawing a joint, the concrete shall be examined closely for cracks, and the joint shall not be sawed if a crack has occurred near the planned joint location. Sawing shall be discontinued when a crack develops ahead of the saw cut. Immediately after the joint is sawed, the saw cut and adjacent concrete surface shall be thoroughly flushed with water and vacuumed until all waste from sawing is removed from the joint and adjacent concrete surface. The surface shall be resprayed with curing compound as soon as free water disappears. Necessary precautions shall be taken to insure that the concrete is properly protected from damage and cured at sawed joints. The top of the joint opening and the joint groove at exposed edges shall be tightly sealed with cord backer rod before the concrete in the region of the joint is resprayed with curing compound, and shall be maintained until removed immediately before sawing the joint sealant reservoir. The exposed saw cuts on the faces of pilot lanes shall be sealed with bituminous mastic or masking tape. After expiration of the curing period, the upper portion of the groove shall be widened by sawing with ganged diamond saw blades to the width and depth indicated for the joint sealer. The reservoir shall be centered over the initial sawcut.

3.8.7 Thickened Edge Joints

Construct thickened edge joints as indicated on the drawings. Underlying material in the transition area shall be graded as shown and shall meet the requirements for smoothness and compaction specified for all other areas of the underlying material.

3.9 REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS

3.9.1 General Criteria

New pavement slabs that are broken, have spalled edges, or contain cracks shall be removed and replaced or repaired, as specified at no cost to the Government. Removal of partial slabs is not permitted. Not more than 15.0 percent of each slab's longitudinal joint edge shall be spalled. Prior to fill-in lane placement, pilot lane slabs with spalls exceeding this quantity, regardless of spall size, shall be sawn full depth to remove the spalled face. All other slabs shall be removed, as directed. The Contracting Officer will determine whether cracks extend full depth of the pavement and may require cores to be drilled on the crack to determine depth of cracking. Such cores shall be at least 6 inch diameter, and shall be drilled and backfilled with an approved non-shrink concrete. Perform drilling of cores and refilling holes at no expense to the Government.

3.9.2 Slabs with Cracks

Clean cracks that do not exceed 2 inches in depth; then pressure injected full depth with epoxy resin, Type IV, Grade 1. Remove slabs containing cracks deeper than 2 inches.

3.9.3 Removal and Replacement of Full Slabs

Where it is necessary to remove full slabs, removal shall be in accordance with paragraph: Removal of Existing Pavement Slab below. Removal and replacement shall be full depth, by full width of the slab, and the limit of removal shall be normal to the paving lane and extend to each original joint. Dowels of the size and spacing as specified for other joints in similar pavement shall be installed by epoxy grouting them into holes drilled into the existing concrete using procedures as specified in paragraph PLACING DOWELS, above. Original damaged dowels shall be cut off flush with the joint face. Protruding portions of dowels shall be painted and lightly oiled. All four edges of the new slab shall thus contain dowels. Placement of concrete shall be as specified for original construction. Prior to placement of new concrete, the underlying material shall be recompacted and shaped as specified in the appropriate section of these specifications, and the surfaces of all four joint faces shall be cleaned of all loose material and contaminants and coated with a double application of membrane forming curing compound as bond breaker. Care shall be taken to prevent any curing compound from contacting dowels. The resulting joints around the new slab shall be prepared and sealed as specified for original construction.

3.9.4 Repairing Spalls Along Joints

Where directed, spalls along joints of new slabs, along edges of adjacent existing concrete, and along parallel cracks shall be repaired by first making a vertical saw cut at least 1 inch outside the spalled area and to a depth of at least 2 inches. Saw cuts shall be straight lines forming rectangular areas. The concrete between the saw cut and the joint, or crack, shall be chipped out to remove all unsound concrete and into at least 1/2 inch of visually sound concrete. Spalls along joints to be sealed with compression seals shall be sawn, chipped out, and repaired to a depth to restore the full joint-face support. The cavity thus formed shall be thoroughly cleaned with high pressure water jets supplemented with oil-free compressed air to remove all loose material. Immediately before filling the cavity, a prime coat shall be applied to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. The prime coat shall be applied in a thin coating and scrubbed into the surface with a stiff-bristle brush. Prime coat for portland cement repairs shall be a neat cement grout and for epoxy resin repairs shall be epoxy resin, Type III, Grade 1. The prepared cavity shall be filled with: Portland cement concrete or latex modified mortar for larger cavities, those more than 1/3 cu. ft. in size after removal operations; Portland cement mortar for cavities between 0.03 cu. ft. and 1/3 cu. ft.; and epoxy resin mortar or epoxy resin or latex modified mortar for those cavities less than 0.03 cu. ft. in size. Portland cement concretes and mortars shall be very low slump mixtures, 1/2 inch slump or less, proportioned, mixed, placed, consolidated by tamping, and cured, all as directed. Epoxy resin mortars shall be made with Type III, Grade 1, epoxy resin, using proportions and mixing and placing procedures as recommended by the manufacturer and approved by the Contracting Officer. Proprietary patching materials may be used, subject to approval by the Contracting Officer. The epoxy resin materials shall be placed in the cavity in

layers not over 2 inches thick. The time interval between placement of additional layers shall be such that the temperature of the epoxy resin material does not exceed 140 degrees F at any time during hardening. Mechanical vibrators and hand tampers shall be used to consolidate the concrete or mortar. Any repair material on the surrounding surfaces of the existing concrete shall be removed before it hardens. Where the spalled area abuts a joint, an insert or other bond-breaking medium shall be used to prevent bond at the joint face. A reservoir for the joint sealant shall be sawed to the dimensions required for other joints. The reservoir shall be thoroughly cleaned and then sealed with the sealer specified for the joints.

3.9.5 Repair of Weak Surfaces

Weak surfaces are defined as mortar-rich, rain-damaged, uncured, or containing exposed voids or deleterious materials. Diamond grind slabs containing weak surfaces less than 1/4 inch thick to remove the weak surface. Diamond grinding shall be in accordance with paragraph DIAMOND GRINDING OF PCC SURFACES in PART 1. All ground areas shall meet the thickness, smoothness and grade criteria of paragraph ACCEPTANCE REQUIREMENTS in PART 1. Remove and replace slabs containing weak surfaces greater than 1/4 inch thick.

3.9.6 Repair of Pilot Lane Vertical Faces

Excessive edge slump and joint face deformation shall be repaired in accordance with paragraph EDGE SLUMP AND JOINT FACE DEFORMATION in PART 1. Inadequate consolidation (honeycombing or air voids) shall be repaired by saw cutting the face full depth along the entire lane length with a diamond blade. Obtain cores, as directed, to determine the depth of removal.

3.10 EXISTING CONCRETE PAVEMENT REMOVAL AND REPAIR

Existing concrete pavement shall be removed at locations indicated on the drawings. Prior to commencing pavement removal operations, inventory the pavement distresses (cracks, spalls, and corner breaks) along the pavement edge to remain. After pavement removal, the remaining edge shall again be surveyed to quantify any damage caused by Contractor's removal operations. Perform both surveys in the presence of the Contracting Officer. Repairs shall be made as indicated and as specified herein. All operations shall be carefully controlled to prevent damage to the concrete pavement and to the underlying material to remain in place. All saw cuts shall be made perpendicular to the slab surface, forming rectangular areas.

3.10.1 Removal of Existing Pavement Slab

When existing concrete pavement is to be removed and adjacent concrete is to be left in place, the joint between the removal area and adjoining pavement to stay in place shall first be cut full depth with a standard diamond-type concrete saw. Next, a full depth saw cut shall be made parallel to the joint at least 24 inches from the joint and at least 6 inches from the end of any dowels. This saw cut shall be made with a diamond saw as specified in paragraph: Sawing Equipment. All pavement to be removed beyond this last saw cut shall be removed in accordance with the approved demolition work plan. All pavement between this last saw cut and the joint line shall be removed by carefully pulling pieces and blocks away from the joint face with suitable equipment and then picking them up for removal. In lieu of this method, this strip of concrete may be

carefully broken up and removed using hand-held jackhammers, 30 lb or less, or other approved light-duty equipment which will not cause stress to propagate across the joint saw cut and cause distress in the pavement which is to remain in place. In lieu of the above specified removal method, the slab may be sawcut full depth to divide it into several pieces and each piece lifted out and removed. Suitable equipment shall be used to provide a truly vertical lift, and safe lifting devices used for attachment to the slab.

3.10.2 Edge Repair

The edge of existing concrete pavement against which new pavement abuts shall be protected from damage at all times. Slabs which are damaged during construction shall be removed and replaced as directed by the Contracting Officer at no cost to the Government. Repair of previously existing damage areas will be considered a subsidiary part of concrete pavement construction. All exposed keys and keyways shall be sawn off full depth.

3.10.2.1 Spall Repair

Not more than 15.0 percent of each slab's edge shall be spalled as a result of the Contractor's actions. Unless otherwise directed by the Contracting Officer, damaged slabs with spalls exceeding this quantity, regardless of spall size, shall be sawn full depth on the exposed face to remove the spalled face. Repair materials and procedures shall be as previously specified in paragraph: Repairing Spalls Along Joints.

3.10.2.2 Underbreak and Underlying Material

All underbreak shall be repaired by removal and replacement of the damaged slabs in accordance with paragraph: Removal and Replacement of Full Slabs above. The underlying material adjacent to the edge of and under the existing pavement which is to remain in place shall be protected from damage or disturbance during removal operations and until placement of new concrete, and shall be shaped as shown on the drawings or as directed. Sufficient underlying material shall be kept in place outside the joint line to completely prevent disturbance of material under the pavement which is to remain in place. Any material under the portion of the concrete pavement to remain in place which is disturbed or loses its compaction shall be carefully removed and replaced with concrete.

3.11 PAVEMENT PROTECTION

Protect the pavement against all damage prior to final acceptance of the work by the Government. Aggregates, rubble, or other similar construction materials shall not be placed on airfield pavements. Traffic shall be excluded from the new pavement by erecting and maintaining barricades and signs until the concrete is at least 14 days old, or for a longer period if so directed. As a construction expedient in paving intermediate lanes between newly paved pilot lanes, operation of the hauling and paving equipment will be permitted on the new pavement after the pavement has been cured for 7 days and the joints have been sealed or otherwise protected, the concrete has attained a minimum field cured flexural strength of 550 psi. and approved means are furnished to prevent damage to the slab edge. All new and existing pavement carrying construction traffic or equipment shall be continuously kept completely clean, and spillage of concrete or other materials shall be cleaned up immediately upon occurrence. Special care shall be used where Contractor's traffic

uses or crosses active airfield pavement. Power broom other existing pavements at least daily when traffic operates. For fill-in lanes, equipment shall be used that will not damage or spall the edges or joints of the previously constructed pavement.

3.12 TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL

3.12.1 Testing and Inspection by Contractor

During construction, the Contractor is responsible for sampling and testing aggregates, cementitious materials (cement, GGBF and pozzolan), and concrete to determine compliance with the specifications. Provide facilities and labor as may be necessary for procurement of representative test samples. Furnish sampling platforms and belt templates to obtain representative samples of aggregates from charging belts at the concrete plant. Samples of concrete shall be obtained at the point of delivery to the paver. Testing by the Government will in no way relieve the Contractor of the specified testing requirements. Perform the inspection and tests described below, and based upon the results of these inspections and tests, take the action required and submit reports as required. This testing shall be performed regardless of any other testing performed by the Government, either for pay adjustment purposes or for any other reason.

3.12.2 Testing and Inspection Requirements

Contractor CQC sampling, testing, inspection and reporting shall be in accordance with the following Table.

TABLE 6
CONTRACTOR TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit	Corrective Action
Fine Aggregate Gradation and Fineness Modulus			
2 per lot	ASTM C136 sample at belt	9 of 10 tests vary <0.15 from average	
		Outside limits on any sieve	Retest
		2nd failure	Stop, repair, retest
Coarse Aggregate Gradation			
2 per lot	ASTM C136 sample at belt	Outside limits on any sieve	Retest
		2nd failure	report to COR, correct
		2 consecutive avgs of 5 tests out	report to COR, stop ops, repair, retest
Workability Factor and Coarseness Factor Computation			

TABLE 6
CONTRACTOR TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit	Corrective Action
Same as C.A. and F.A.	see paragraph AGGREGATES	Use individual C.A. and F.A. gradations. Combine using batch ticket percentages. Tolerances: +/- 3 points on WF; +/- 5 points on CF from approved mix design values	Check batching tolerances, recalibrate scales
Aggregate Deleterious, Quality, and ASR Tests			
Every 30 days	see paragraph AGGREGATES		Stop production, retest, replace aggregate. Increase testing interval to 90 days if previous 2 tests pass
Plant - Scales, Weighing Accuracy			
Monthly	NRMCA QC 3		Stop plant ops, repair, recalibrate
Plant - Batching and Recording Accuracy			
Weekly	Record/Report	Record required/recorded/actual batch mass	Stop plant ops, repair, recalibrate
Plant - Batch Plant Control			
Every lot	Record/Report		Record type/amt of each material per lot
Plant - Mixer Uniformity - Stationary Mixers			
Every 4 months during paving	COE CRD-C 55	After initial approval, use abbreviated method	Increase mixing time, change batching sequence, reduce batch size to bring into compliance. Retest
Plant - Mixer Uniformity - Truck Mixers			
Every 4 months during paving	ASTM C94/C94M	Random selection of truck.	Increase mixing time, change batching sequence, reduce batch size to bring into compliance. Retest
Concrete Mixture - Air Content			

TABLE 6
CONTRACTOR TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit	Corrective Action
When test specimens prepared + 2 random	ASTM C231/C231M sample at paving site	Individual test control chart: Warning +/-1.0	Adjust AEA, retest
		Individual test control chart: Action +/-1.5	Halt operations, repair, retest
		Range between 2 consecutive tests: Warning +2.0	Recalibrate AEA dispenser
		Range between 2 consecutive tests: Action +3.0	Halt operations, repair, retest
Concrete Mixture - Unit Weight and Yield			
Same as Air Content	ASTM C138/C138M sample at paving site	Individual test basis: Warning Yield -0/+1 percent	Check batching tolerances
		Individual test basis: Action Yield -0/+5 percent	Halt operations
Concrete Mixture - Slump			
When test specimens prepared + 4 random	ASTM C143/C143M sample at paving site	Individual test control chart: Upper Warning - 1/2 inch below max	Adjust batch masses within max W/C ratio
		Individual test control chart: Upper Action - maximum allowable slump	Stop operations, adjust, retest
		Range between each consecutive test: 1-1/2 inches	Stop operations, repair, retest
Concrete Mixture - Temperature			
When test specimens prepared	ASTM C1064/C1064M sample at paving site	See paragraph WEATHER LIMITATIONS	
Concrete Mixture - Strength			
8 per lot	ASTM C31/C31M sample at paving station	See paragraph CONCRETE STRENGTH TESTING for CQC	
Paving - Inspection Before Paving			

TABLE 6
CONTRACTOR TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit	Corrective Action
Prior to each paving operation	Report	Inspect underlying materials, construction joint faces, forms, reinforcing, dowels, and embedded items	
Paving - Inspection During Paving			
During paving operation		Monitor and control paving operation, including placement, consolidation, finishing, texturing, curing, and joint sawing.	
Paving - Vibrators			
Weekly during paving	COE CRD-C 521	Test frequency (in concrete), and amplitude (in air), measure at tip/head and average.	Repair or replace defective vibrators.
Moist Curing			
2 per lot, min 4 per day	Visual		Repair defects, extend curing by 1 day
Membrane Compound Curing			
Daily	Visual	Calculate coverage based on quantity/area	Respray areas where coverage defective. Recalibrate equipment
Cold Weather Protection			
Once per day	Visual		Repair defects, report conditions to COR

3.12.3 Concrete Strength Testing for Contractor CQC

Contractor Quality Control operations for concrete strength shall consist of the following steps:

a. Take samples for strength test at the paving site. Fabricate and cure test cylinders in accordance with ASTM C31/C31M; test them in accordance withASTM C39/C39M

b.Fabricate and cure 2 test cylinders per sublot from the same batch or truckload and at the same time acceptance cylinders are fabricated and test them for comppressive strength strength at 7-day age.

c.Average all 8 compressive tests per lot. Convert this average 7-day compressive strength per lot to equivalent 28 flexuralstrength using the Correlation Ratio determined during mixture propotioning studies.

d. Compare to the equivalent 28-day flexural strength from the conversion to the Average Flexural Strength requried for Mixtures from paragraph of same title.

e. If the equivalent 28-day strength for the lot is below the Average Flexural Strength requried for Mixtures by 20 psi flexural strength more, at any time, adjust the mixture to increase the strength, as appoved.

f. Fabricate and cure two beams for every 2000 cubic yards of concrete placed. Fabricate and cure in accordance with ASTM C31/C31M; test at 14-days of age in accordance with ASTM C78/C78M. Use the flexural strengh results to verify the cylinder-beam accpetance correlation ratio.

g. The Contractor's CQC testing agency shall maintain up-to-date control charts for strength, showing 7-day CQC compressive strength, the 14-day compressive strength (from accpetance tests) and the 28-day equivalent flexural strength of each of these for each lot.

3.12.4 Reports

All results of tests or inspections conducted shall be reported informally as they are completed and in writing daily. Prepare a weekly report for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold-weather protection, make daily reports of pertinent temperatures. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failures and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer has the right to examine all Contractor quality control records.

-- End of Section --

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SECTION 32 17 23.00 20

PAVEMENT MARKINGS

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.

ASTM INTERNATIONAL (ASTM)

ASTM D2240	(2005; R 2010) Standard Test Method for Rubber Property - Durometer Hardness
ASTM D2621	(1987; R 2011) Infrared Identification of Vehicle Solids from Solvent-Reducible Paints
ASTM D2697	(2003; R 2008) Volume Nonvolatile Matter in Clear or Pigmented Coatings
ASTM D3335	(1985a; R 2009) Low Concentrations of Lead, Cadmium, and Cobalt in Paint by Atomic Absorption Spectroscopy
ASTM D3718	(1985a; R 2010) Low Concentrations of Chromium in Paint by Atomic Absorption Spectroscopy
ASTM D3924	(1980; R 2011) Standard Environment for Conditioning and Testing Paint, Varnish, Lacquer, and Related Materials
ASTM D3960	(2005; R 2013) Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
ASTM D4280	(2012) Extended Life Type, Nonplowable, Raised, Retroreflective Pavement Markers
ASTM D4505	(2012) Preformed Retroflective Pavement Marking Tape for Extended Service Life
ASTM D4541	(2009; E 2010) Pull-Off Strength of Coatings Using Portable Adhesion Testers
ASTM D471	(2012a) Standard Test Method for Rubber Property - Effect of Liquids
ASTM D522/D522M	(2014) Mandrel Bend Test of Attached Organic Coatings
ASTM D711	(2010) No-Pick-Up Time of Traffic Paint

ASTM D792	(2013) Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D823	(1995; E 2012; R 2012) Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels.
ASTM E28	(1999; R 2009) Softening Point of Resins Derived from Naval Stores by Ring and Ball Apparatus
ASTM G154	(2012a) Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials

INTERNATIONAL CONCRETE REPAIR INSTITUTE (ICRI)

ICRI 03732	(1997) Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays

MASTER PAINTERS INSTITUTE (MPI)

MPI 32	(2005) Standard for Alkyd Traffic Marking Paint

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-595	(Rev C; Notice 1) Colors Used in Government Procurement
FS TT-B-1325	(Rev D; Notice 1) Beads (Glass Spheres) Retro-Reflective (Metric)
FS TT-P-1952	(Rev E) Paint, Traffic and Airfield Markings, Waterborne

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Reflective media for airfields

Reflective media for roads and streets

Paints for airfields

Paints for roads and streets

Equipment; G

Lists of proposed equipment, including descriptive data, and notifications of proposed Contractor actions as specified in this section. List of removal equipment shall include descriptive data indicating area of coverage per pass, pressure adjustment range, tank and flow capacities, and safety precautions required for the equipment operation.

Qualifications

Documentation on personnel qualifications, as specified.

SD-06 Test Reports

Reflective media for airfields

Reflective media for roads and streets

Paints for airfields

Paints for roads and streets

Certified reports from sampling and testing made in accordance with paragraph entitled "Sampling and Testing" prior to the use of the materials at the jobsite. Testing shall be performed in an approved independent laboratory.

SD-07 Certificates

Reflective media for airfields

Reflective media for roads and streets

Paints for airfields

Paints for roads and streets

Volatile Organic Compound, (VOC)

Certificate stating that the proposed pavement marking paint meets the VOC regulations of the local Air Pollution Control District having jurisdiction over the geographical area in which the project is located.

Construction equipment list

SD-08 Manufacturer's Instructions

Paints for airfields

Paints for roads and streets

Submit manufacturer's Material Safety Data Sheets.

1.3 DELIVERY AND STORAGE

Deliver paints, paint materials and thermoplastic compound materials in original sealed containers that plainly show the designated name, specification number, batch number, color, date of manufacture, manufacturer's directions, and name of manufacturer. Provide storage facilities at the job site, only in areas approved by the Contracting Officer or authorized representative, for maintaining materials at temperatures recommended by the manufacturer. Make available paint stored at the project site or segregated at the source for sampling not less than 30 days prior to date of required approval for use to allow sufficient time for testing. Notify the Contracting Officer when paint is available for sampling.

1.4 WEATHER LIMITATIONS

Apply paint to clean, dry surfaces, and unless otherwise approved, only when the air and pavement surface temperature is at least 5 degrees above the dew point and the air and pavement temperatures are above 40 degrees F and less than 95 degrees F for oil-based materials; above 50 degrees F and less than 110 degrees F for water-based materials. Maintain paint temperature within these same limits.

1.5 EQUIPMENT

Machines, tools, and equipment used in the performance of the work shall be approved by the Contracting Officer and maintained in satisfactory operating condition. Submit construction equipment list for approval by the Contracting Officer.

1.5.1 Mobile and Maneuverable

Application equipment shall be mobile and maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc.

1.5.2 Paint Application Equipment

1.5.2.1 Hand-Operated, Push-Type Machines

Provide hand-operated push-type applicator machine of a type commonly used for application of paint to pavement surfaces. Applicator machine shall be equipped with the necessary paint tanks and spraying nozzles, and shall be capable of applying paint uniformly at coverage specified. Applicator for water-based markings shall be equipped with non-stick coated hoses; metal parts in contact with the paint material shall be constructed of grade 302, 304, 316, or equal stainless steel.

1.5.2.2 Self-Propelled or Mobile-Drawn Pneumatic Spraying Machines

Provide self-propelled or mobile-drawn pneumatic spraying machine with

suitable arrangements of atomizing nozzles and controls to obtain the specified results. Provide machine having a speed during application capable of applying the stripe widths indicated at the paint coverage rate specified herein and of even uniform thickness with clear-cut edges. The equipment for applying the paint for airfield pavements shall be a self-propelled or mobile-drawn pneumatic spraying machine with an arrangement of atomizing nozzles capable of applying a width of line at any one time in multiples of 6 inches, from 6 to 36 inches . Provide paint applicator with paint reservoirs or tanks of sufficient capacity and suitable gages to apply paint in accordance with requirements specified. Equip tanks with suitable air-driven mechanical agitators. Equip spray mechanism with quick-action valves conveniently located, and include necessary pressure regulators and gages in full view and reach of the operator. Install paint strainers in paint supply lines to ensure freedom from residue and foreign matter that may cause malfunction of the spray guns. The paint applicator shall be readily adaptable for attachment of an air-actuated dispenser for the reflective media approved for use. Provide pneumatic spray guns for hand application of paint in areas where the mobile paint applicator cannot be used. Applicator for water-based markings shall be equipped with non-stick coated hoses; metal parts in contact with the paint material shall be constructed of grade 302, 304, 316, or equal stainless steel.

1.5.3 Reflective Media Dispenser

The dispenser for applying the reflective media shall be attached to the paint dispenser and shall operate automatically and simultaneously with the applicator through the same control mechanism. The dispenser shall be capable of adjustment and designed to provide uniform flow of reflective media over the full length and width of the stripe at the rate of coverage specified in paragraph APPLICATION, at all operating speeds of the applicator to which it is attached.

1.5.4 Surface Preparation Equipment

1.5.4.1 Sandblasting Equipment

Sandblasting equipment shall include an air compressor, hoses, and nozzles of proper size and capacity as required for cleaning surfaces to be painted. The compressor shall be capable of furnishing not less than 150 cfm of air at a pressure of not less than 90 psi at each nozzle used, and shall be equipped with traps that will maintain the compressed air free of oil and water.

1.5.4.2 Waterblast Equipment

The water pressure shall be specified at 2600 psi at 140 degrees F in order to adequately clean the surfaces to be marked.

1.5.5 Marking Removal Equipment

Equipment shall be mounted on rubber tires and shall be capable of removing markings from the pavement without damaging the pavement surface or joint sealant. Waterblasting equipment shall be capable of producing an adjustable, pressurized stream of water. Sandblasting equipment shall include an air compressor, hoses, and nozzles. The compressor shall be equipped with traps to maintain the air free of oil and water.

1.5.5.1 Shotblasting Equipment

Shotblasting equipment shall be capable of producing an adjustable depth of removal of marking and pavement. Each unit shall be self-cleaning and self-contained, shall be able to confine dust and debris from the operation, and shall be capable of recycling the abrasive for reuse.

1.5.5.2 Chemical Equipment

Chemical equipment shall be capable of application and removal of chemicals from the pavement surface, and shall leave only non-toxic biodegradable residue.

1.5.6 Traffic Controls

Suitable warning signs shall be placed near the beginning of the worksite and well ahead of the worksite for alerting approaching traffic from both directions. Small markers shall be placed along newly painted lines or freshly placed raised markers to control traffic and prevent damage to newly painted surfaces or displacement of raised pavement markers. Painting equipment shall be marked with large warning signs indicating slow-moving painting equipment in operation.

1.6 MAINTENANCE OF TRAFFIC

1.6.1 Airfield

The performance of work in the controlled zones of airfields shall be coordinated with the Contracting Officer and with the Flight Operations Officer. Verbal communications shall be maintained with the control tower before and during work in the controlled zones of the airfield. The control tower shall be advised when the work is completed. A radio for this purpose shall be provided by the Contractor and approved by the Contracting Officer.

1.6.2 Lighting

When night operations are necessary, all necessary lighting and equipment shall be provided. Lighting shall be directed or shaded to prevent interference with aircraft, the air traffic control tower, and other base operations. All lighting and related equipment shall be capable of being removed from the runway within 15 minutes of notification of an emergency. Night work must be coordinated with the Airfield Manager and approved in advance by the Contracting Officer or authorized representative. The Government reserves the right to accept or reject night work on the day following night activities by the Contractor.

1.6.3 Roads, Streets, and Parking Areas

When traffic must be rerouted or controlled to accomplish the work, the necessary warning signs, flagpersons, and related equipment for the safe passage of vehicles shall be provided.

1.7 WEATHER LIMITATIONS FOR REMOVAL

Pavement surface shall be free of snow, ice, or slush. Surface temperature shall be at least 40 degrees F and rising at the beginning of operations, except those involving shot or sand blasting. Operation shall cease during thunderstorms. Operation shall cease during rainfall, except

for waterblasting and removal of previously applied chemicals. Waterblasting shall cease where surface water accumulation alters the effectiveness of material removal.

1.8 QUALIFICATIONS

The Contractor shall submit documentation certifying that pertinent personnel are qualified for equipment operation and handling of chemicals.

PART 2 PRODUCTS

2.1 MATERIALS

Provide materials conforming to the requirements specified herein.

2.1.1 Paints for Airfields

FS TT-P-1952, color as indicated .

2.1.2 Paints for Roads and Streets

FS TT-P-1952, color as indicated .

2.1.3 Reflective Media for Airfields

FS TT-B-1325, Type I, Gradation A.

2.1.4 Reflective Media for Roads and Streets

FS TT-B-1325, Type I, Gradation A.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Allow new pavement surfaces to cure for a period of not less than 30 days before application of marking materials. Thoroughly clean surfaces to be marked before application of the paint. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water, or a combination of these methods as required. Remove existing paint markings, residual curing compounds, and other coatings adhering to the pavement by water blasting according to the removal requirements and procedures outlined in Section 32 01 11.51. For Portland Cement Concrete pavement, grinding, light shot blasting, and light scarification, to a resulting profile equal to ICRI 03732 CSP 2, CSP 3, and CSP 4, respectively, can be used in addition to water blasting, to either remove existing coatings or for surface preparation on most pavements: shot blasting shall not be used on airfield pavements due to the potential of Foreign Object Damage (FOD) to aircraft. Scrub affected areas, where oil or grease is present on old pavements to be marked, with several applications of trisodium phosphate solution or other approved detergent or degreaser and rinse thoroughly after each application. After cleaning oil-soaked areas, seal with shellac or primer recommended by the manufacturer to prevent bleeding through the new paint. Do not commence painting in any area until pavement surfaces are dry and clean.

3.1.1 Early Painting of Rigid Pavements

Pretreat rigid pavements that require early painting with an aqueous

solution containing 3 percent phosphoric acid and 2 percent zinc chloride. Apply the solution to the areas to be marked.

3.1.2 Early Painting of Asphalt Pavements

For asphalt pavement systems requiring painting application at less than 30 days, apply the paint and beads at half the normal application rate, followed by a second application at the normal rate after 30 days.

3.2 APPLICATION

3.2.1 Testing for Moisture

Apply pavement markings to dry pavement only. The Contractor shall test the pavement surface for moisture before beginning work after each period of rainfall, fog, high humidity, or cleaning, or when the ambient temperature has fallen below the dew point. Do not commence marking until the pavement is sufficiently dry and the pavement condition has been approved by the CO or authorized representative. Employ the "plastic wrap method" to test the pavement for moisture as follows: Cover the pavement with a 300 mm by 300 mm (12 inch by 12 inch) section of clear plastic wrap and seal the edges with tape. After 15 minutes, examine the plastic wrap for any visible moisture accumulation inside the plastic. Do not begin marking operations until the test can be performed with no visible moisture accumulation inside the plastic wrap.

3.2.2 Rate of Application

3.2.2.1 Reflective Markings

Apply paint evenly to the pavement area to be coated at a rate of 105 plus or minus 5 square feet per gallon. Apply glass spheres uniformly to the wet paint on airfield pavement at a rate of (10) plus or minus (0.5) pounds of glass spheres per gallon. Collect and record readings for white and yellow retroreflective markings at the rate of one reading per 1000 linear feet. The minimum acceptable average for white markings is 200 millicandelas per square meter per lux (mcd/m2/lx) (measured with Mirolux 12 Retroreflectometer or similar instrument as agreed). The minimum acceptable average for yellow markings is 175 millicandelas per square meter per lux (mcd/m2/lx). Readings shall be computed by averaging a minimum of 10 readings taken within the area at random locations. Areas not meeting the retroreflective requirements stated above shall be re-marked.

3.2.2.2 Nonreflective Markings

Apply paint evenly to the pavement surface to be coated at a rate of 105 plus or minus 5 square feet per gallon.

3.2.3 Painting

Apply paint pneumatically with approved equipment at rate of coverage specified herein. Provide guidelines and templates as necessary to control paint application. Take special precautions in marking numbers, letters, and symbols. Manually paint numbers, letters, and symbols. Sharply outline all edges of markings. The maximum drying time requirements of the paint specifications will be strictly enforced, to prevent undue softening of bitumen, and pickup, displacement, or discoloration by tires of traffic. Discontinue painting operations if

there is a deficiency in drying of the markings until cause of the slow drying is determined and corrected.

3.2.4 Reflective Media

Application of reflective media shall immediately follow the application of paint. Accomplish drop-on application of the glass spheres to ensure even distribution at the specified rate of coverage. Should there be malfunction of either paint applicator or reflective media dispenser, discontinue operations until deficiency is corrected.

3.3 FIELD TESTING, INSPECTION, AND DEMONSTRATIONS

3.3.1 Sampling and Testing

As soon as the paint and reflective materials are available for sampling, obtain by random selection from the sealed containers, two quart samples of each batch in the presence of the Contracting Officer. Accomplish adequate mixing prior to sampling to ensure a uniform, representative sample. A batch is defined as that quantity of material processed by the manufacturer at one time and identified by number on the label. Clearly identify samples by designated name, specification number, batch number, project contract number, intended use, and quantity involved. Test samples by an approved laboratory. If a sample fails to meet specification, replace the material in the area represented by the samples and retest the replacement material as specified above. Submit copy of the test results to the Contracting Officer. Include in the report of test results a listing of any specification requirements not verified by the test laboratory.

3.3.2 Inspection

Examine material at the job site to determine that it is the material referenced in the report of test results or certificate of compliance. A certificate of compliance shall be accompanied by test results substantiating conformance to the specified requirements.

3.3.3 Surface Preparations and Application Procedures

Surface preparations and application procedures will be examined by the Contracting Officer to determine conformance with the requirements specified. Approve each separate operation prior to initiation of subsequent operations.

3.3.3.1 Surface Preparation Demonstration

Prior to surface preparation, demonstrate surface preparation using the proposed methods and equipment according to the procedures outlined in Section 32 01 11.51. Prepare areas large enough to determine cleanliness, adhesion of remaining coating and rate of cleaning.

3.3.3.2 Test Stripe Demonstration

Prior to paint application, demonstrate test stripe application within the work area using the proposed materials and equipment. Apply separate test stripes in each of the line widths and configurations required herein using the proposed equipment. The test stripes shall be long enough to determine the proper speed and operating pressures for the vehicle(s) and machinery, but not less than 50 feet long.

3.3.3.3 Application Rate Demonstration

During the Test Stripe Demonstration, demonstrate compliance with the application rates specified herein. Document the equipment speed and operating pressures required to meet the specified rates in each configuration of the equipment and provide a copy of the documentation to the Contracting Officer or authorized representative 7 days prior to proceeding with the work.

3.3.3.4 Retroreflective Value Demonstration

After the test stripes have cured to a "no-track" condition, demonstrate compliance with the average retroreflective values specified herein. Take a minimum of ten readings on each test stripe with a Mirolux 12 Retroreflectometer, or similar instrument with the same measuring geometry and direct readout in millicandelas per square meter per lux (mcd/m2/lx).

3.3.3.5 Level of Performance Demonstration

The Contracting Officer or authorized representative will be present at the application demonstrations to observe the results obtained and to validate the operating parameters of the vehicle(s) and equipment. If accepted by the Contracting Officer or authorized representative, the test stripe shall be the measure of performance required for this project. Work shall not proceed until the demonstration results are satisfactory to the Contracting Officer or authorized representative.

3.4 TRAFFIC CONTROL AND PROTECTION

Place warning signs near the beginning of the work site and well ahead of the work site for alerting approaching traffic from both directions. Place small markers along newly painted lines to control traffic and prevent damage to newly painted surfaces. Mark painting equipment with large warning signs indicating slow-moving painting equipment in operation. Do not use foil-backed material for temporary pavement marking because of its potential to conduct electricity during accidents involving downed power lines.

3.5 QUALITY ASSURANCE

Demonstrate success of bond of reflective media, new paint marking and the pavement surface, vacuum cured surface of new marking after a seven (7) day dry time. Inspect newly applied markings for signs of bond failure based on visual inspection and comparison to results from Test Stripe Demonstration paragraph.

3.5.1 Reflective Media and Coating Bond Verification

Within seven (7) days after pavement marking application, use industrial vacuum to sweep new markings. Visually inspect the pavement markings and the material captured by the vacuum. Verify that no significant loss of reflective media has occurred to the pavement marking due to the vacuum cleaning.

3.5.2 Reflective Media and Coating Application Verification

Use a wet film thickness gauge to measure the application of wet paint.

Use a microscope or magnifying glass to evaluate the embedment of glass beads in the paint. Verify the glass bead embedment with approximately 50 percent of the beads embedded and 50 percent of the beads exposed.

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SECTION 33 05 24

UTILITY HORIZONTAL DIRECTIONAL DRILLING

PART 1 GENERAL

1.1 SUMMARY

This Section specifies the installation of casing pipe for electric conduits crossing under runways at Naval Air station Oceana (NASO) using high density polyethylene (HDPE) pipe by horizontal directional drilling (HDD).

Scope of Work. Provide all plant, materials, equipment and incidentals necessary for the construction of new casing pipe by horizontal directional drilling as shown on the Drawings and as specified herein. Horizontal Directional Drilling (HDD) is meant as a method of trenchless pipe installation using a steerable drilling operation which directly installs a pipe along a specified alignment.

Furnish all survey including layout, inspection and record-keeping incidental to the drilling and pipe installation.

1.2 CONTRACTOR DESIGN REQUIREMENTS

a. Contractor shall review and modify proposed drill locations shown as needed to not impact existing utilities and to optimize the installation. Contractor shall determine actual lengths of pipe needed for installation including an appropriate allowance of pipe required for the pipe to recover and relax from installation loads and other conditions.

b. Contractor shall be fully responsible for field confirmation of the exact location of all existing utilities which could be impacted by the installations. Contractor shall verify locations of all existing utilities prior to construction.

c. Contractor shall determine the handling and installation loads for all phases of the work. Contractor shall include forces resulting from frictional resistance between the pipe and the borehole, frictional resistance from the pipe and the ground, forces from bends, hydrokinetic drag, resistance due to pipe stiffness, as well as other installation and handling loads as applicable. Contractor shall determine allowable loads for the proposed pipe including the appropriate factor of safety for successful installation, however, the factor of safety shall not be less than 1.5 for the yield stress of the pipe material nor shall it exceed the recommended limits identified by the pipe manufacturer, whichever is more stringent.

d. Determine appropriate size of reamed borehole and appropriated reaming tool(s) proposed for installation.

e. Determine optimal drilling fluid design required for installation.

f. Contractor shall confirm minimum radii to be used based on his proposed equipment, drilling fluid design, borehole dimensions and selected exit and entry angles.

g. Provide minimum cover to prevent pavement movement. Minimum cover shall not be less than 6 feet except at entry and exit points.

h. The entry and exit angles shall be determined by Contractor.

i. Contractor shall propose procedures for assembly of pipe including pipe layby areas and fusing schedule. Where Contractor proposes to fuse the pipe in two separate strings, pausing in mid-pull back to fuse the two strings, the procedures for preventive sieze-up of the pipe segment already pulled in during the fusing operation shall be identified.

j. The proposed drill rig site (bore hole entry and pipe pull back exit site) shall be chosen to least impact airfield operations.

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.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180	(2009) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop

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

29 CFR 1926.652	Safety and Health Regulations for Construction; Subpart P, Excavations; Requirements for Protective Systems

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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Submit Statement of Qualifications and Records or previous similar jobs.

Submit Soil Test Data prior to commencement of drilling/excavation work.

Submit Design Package prior to commencement of work.

SD-02 Shop Drawings

Record Drawings

SD-03 Product Data

Submit Manufacturer's Catalog Data for the polyethylene pipe.

SD-07 Certificates

Drill Rod

SD-08 Manufacturer's Instructions

Material Safety Data Sheets for bentonite and additives

SD-11 Closeout Submittals

Work Complete Logs of Guided Directional Drill Operations to be submitted during or a maximum of 10 days after completion of HDD installation to include the following:

1. Raw pilot hole data including all magnetic steering tool and surface monitoring system readings.

2. A tabulation of coordinates, referenced to the drilled entry point, which accurately describes the location of the pilot hole a maximum of every 25 feet of pipe length.

3. A log of all readings recorded during the course of HDD operations, including thrust, torque, pull back load or push back load, and slurry flow rate recorded every 20 feet of pipe length pulled or pushed.

1.5 COMMENCEMENT, DELIVERY, STORAGE, AND HANDLING OF MATERIALS

Prior to commencement of the work, submit the following to the Engineer of Record for review and approval:

Manufacturer's Catalog Data

Material Safety Data Sheets

Statement of Qualifications and Records

Soil Test Data

Design Package

Design Package to include the following:

1. Proposed alignment and profile taking into account verified locations of utilities. Include modifications as needed to optimize the installation.

2. Anticipated loads for pipe installation and related calculations for all phases of the work. Submit maximum allowable load for the pipe. Include manufacturer's written recommendations.

3. Advance rate and work activity durations for drilling, reaming, and pipe installation activities.

4. Diagram showing pipe spacing and arrangement for the installation configuration selected.

5. Joining methods and equipment for pipe and fitting materials selected.

6. Equipment data for drilling, reaming, pulling, pushing and locating equipment.

7. Drilling fluid handling equipment.

8. Detailed site layout plan showing locations of all items of equipment, piping, Contractor's access limits, pipe assembly and layout area, materials storage, and other considerations affecting public use of lands near the work.

9. Identify disposal sites for drilling fluid and cuttings disposal and provide procedures for handling and disposal of cuttings and drilling fluid.

10. Copies of all required permits that are not provided by Owner.

11. Work plan for minimizing release of drilling fluid to infield areas and storm drainage inlets.

12. A contingency plan for inadvertent loss of drilling fluid and related containment plan for land based loss.

13. Project schedule to include all major tasks including the following:

a. high density polyethylene pipe fittings delivery

b. Mobilization and setup

c. high density polyethylene pipe assembly

d. Pilot hole drilling

e. Reaming

f. Pipe pushing/pulling

g. Demobilization

h. Restoration of disturbed areas

14. A work plan shall be submitted with the following information:

a. The pipe configuration to be installed.

b. The size and thickness of pipe to be installed.

c. Method of monitoring location of directional drill and method of adjusting heading of drill path.

15. Proposed airfield pavement movement monitor locations, equipment, and survey results.

16. Complete as-built of installed pipeline.

Provide written documentation of conformance with AASHTO T 180. Submit a complete list of all drilling fluids, additives, and mixtures to be used along with Material Safety Data Sheets.

Inspect materials delivered to the site for damage. All materials found during inspection or during the progress of work to have cracks, flaws, surface abrasions, or other defects will be rejected. Remove defective materials from the job site.

Disposal of fluids is the responsibility of the Contractor. Dispose of fluids in a manner that is in compliance with all permits and applicable federal, state, and local regulations.

1.6 QUALIFICATIONS

Ensure that Contractor and his field supervisor assigned to this project are experienced in work of this nature and have successfully completed similar projects of similar length, pipe type, pipe size, and soil type using directional drilling as stipulated below. As part of the bid submission, submit a description of such project(s) which include, at a minimum, a listing of the location(s), date of project(s), owner, pipe type, size installed, length of installation, type, and manufacturer of equipment used, and other information relevant to the successful completion of the project.

a. Contractor shall have a minimum of eight (8) years of documented experience in HDD and shall have completed at least five (5) projects each in the last five (5) years in which pipe of silimar diameter and with similar lengths as required in this contract were successfully installed.

b. The HDD superintendent shall have at least eight (8) years of trenchless pipe installation experience and shall have worked on at least two (2) HDD projects in the last three (3) years using the same equipment required for this project. The machine operators shall have at least five (5) years of trenchless pipe installation experience and shall have worked on at least two (2) HDD projects using the same equipment required for this project.

Qualifications shall be submitted with the bid for all HDD Contractors. The submitted qualifications shall clearly show that the proposed HDD Contractor has the experience and qualifications listed above.

Survey work shall be conducted by a surveyor licensed in the State of virginia.

1.7 PROJECT CONDITIONS

Contractor shall positively locate all utilities within 15 feet of proposed bore path prior to setup of equipment and selection of final alignment and profile for the drilling operation.

Maintain access to taxiways, aprons and runways at all times.

Adhere to all DEQ permit requirements. Contractor shall be responsible for fines associated with not following permit requirements.

Contractor shall use approved non-potable water for use in mixing with drilling fluid. If Contractor connects to Owner's water system a

suitable backflow prevention device shall be used and charged rates apply.

Contractor shall minimize noise related to their work to the extent practicable, particularly after 11 pm and before 7 am.

Pipe installation shall be coordinated with the Airfield Manager through the contracting Officer. To the extent practicable, work requiring 24-hour per day effort shall begin on a Friday.

Contractor shall control its methods to minimize ground movement. See requirements later in this section.

1.8 SAFETY

Include in directional drilling equipment machine safety requirements a common grounding system to prevent electrical shock in the event of underground electrical cable strike. Ensure the grounding system connects all pieces of interconnecting machinery; the drill, mud mixing system, drill power unit, drill rod trailer, operators booth, worker grounding mats, and any other interconnected equipment to a common ground. Equip the drill with an "electrical strike" audible and visual warning system that notifies the system operators of an electrical strike.

PART 2 PRODUCTS

2.1 DRILL ROD

Select the appropriate drill rod to be used. Submit certified statement that the drill rod has been inspected and is in satisfactory condition for its intended use.

2.2 PIPE

Install high density polyethylene (HDPE) conforming to AWWA C906 IPS DR 9.

2.3 DRILLING FLUIDS

Use a high quality bentonite drilling fluid to ensure hole stability, cuttings transport, bit and electronics cooling, and hole lubrication to reduce drag on the drill pipe and the product pipe. Contractor may provide admixtures to improve the physical qualities of the mixture subject to approval by the Contracting Officer. The drilling fluid including admixtures shall be inert and non-toxic. Use only fluid with a composition which complies with all federal, state, and local environmental regulations.

Mix the bentonite drilling fluid with potable water (of proper pH) to ensure no contamination is introduced into the soil during the drilling, reaming, or pipe installation process. The Contractor is responsible for any required pH adjustments.

Disposal of the drilling fluids is the responsibility of the Contractor. Conduct disposal in compliance with all relative environmental regulations, right-of-way and work space agreements, and permit requirements.

Collect drilling fluid returns in the entrance pit, exit pit, or spoils

recovery pit. Immediately clean up any drilling fluid spills or overflows from these pits.

PART 3 EXECUTION

3.1 GENERAL

Install the casing pipe by pulling the pipe into a continuous hole created by the steerable pilot borehead and enlarged with reamers to the required diameter. No intermediate excavations shall be permitted.

Conduct all operations such that trucks and other vehicles do not create a dust nuisance to the adjacent areas. Each day clean up, remove and dispose of any spilled drilling fluid or other waste.

All work within the work limits shall be done in accordance with the terms and conditions of DEQ permit. Contractor shall be responsible for obtaining rights to use any additional area necessary. Contain all drilling fluids within tanks on the site for haul off and disposal.

Work outside the areas approved or as shown on the Contractor's approved work plans is not allowed unless with written permission from the Contracting Officer.

3.2 DRILL SET-UP AREA

The Contractor is responsible for design and construction of the drill entrance and exit pits.

3.3 DRILL ENTRANCE AND EXIT PITS

Drill entrance and exit pits are required. Maintain at minimum size to allow only the minimum amount of drilling fluid storage prior to transfer to mud recycling or processing system or removal from the site.

Do not allow drilling mud to flow freely on the site or around the entrance or exit pits. Remove spilled mud and restore ground to original condition. Provide shore pits in compliance with OSHA Standards, 29 CFR 1926.652.

When drilling near wetlands or water courses, provide secondary containment to prevent drilling fluids from entering the wetlands, and secure written approval of secondary containment plan from the Contracting Officer .

3.4 DRILL ENTRANCE AND EXIT ANGLE

Ensure entrance and exit angles and elevation profile maintains adequate cover to reduce risk of drilling fluid breakouts and ground exit occurs as specified herein. Ensure that entrance and exit angles ensure pullback forces do not exceed that recommended by the manufacturer or specified herein.

3.5 PIPE ASSEMBLY, HANDLING AND INSTALLATION

Assemble HDPE water main in accordance with the manufacturer's recommendations.

If required to to relieve strain, pull the casing pipe into the drilled hole guided over a system of roller supports. Provide elevated rollers where necessary.

3.6 PILOT HOLE

The type and size of the pilot string cutting head and the diameter of the drill pipe is at the Contractor's discretion.

Directional Tolerance: Drill the pilot hole along the minimum radius as described in this section and to the tolerances listed in this section. Additionally, concern for adjacent utilities and/or structures shall take precedence over the listed tolerances. Listing of tolerances does not relieve Contractor from responsibility for safe operations or damage to adjacent utilities and structures.

Curve Radius: Drill all horizontal and vertical curves at a radius equal to or greater than that required by the pipe manufacturer.

3.7 HANDLING OF DRILLING FLUID AND CUTTINGS

Provide adequate measures for handling and disposal of drilling fluid and cuttings. Provide watertight piping, pumps, storage containers and other measures to guard against leakage. Drilling fluid and cuttings shall not be discharged into any waterway, storm drain, sanitary sewer or other such conveyance, nor shall it be disposed of at the work site.

a. When Contractor's provisions for storage of the fluids or cuttings on site are exceeded, these materials shall be hauled away to a suitable legal disposal site. Contractor shall conduct his directional drilling operation in such a manner that drilling fluids are not allowed into storm drains, sanitary sewers or other such conveyances. After completion of the directional drilling work, the entry and exit pit locations shall be restored to original conditions. Contractor shall comply with all permit provisions.

b. Pits constructed at the entry or exit point area shall be so constructed to completely contain the drill fluid and prevent its escape.

c. Contractor shall utilize drilling tools and procedures which will minimize the unintentional discharge of any drill fluids. Contractor shall comply with all mitigation measures listed in the required permits and elsewhere in these Specifications.

d. To the extent practical, Contractor shall maintain a closed loop drilling fluid system.

e. Contractor shall minimize drilling fluid disposal quantities by utilizing a drilling fluid cleaning system which allows the returned fluids to be reused.

f. As part of the installation plan specified herein before, Contractor shall submit a drilling fluid plan which details types of drilling fluids, drilling fluid admixtures, cleaning and recycling equipment, estimated flow rates, methods for containing drilling fluid escape, and procedures for minimizing drilling fluid escape.

Regulate the pressure of drilling fluid and conduct drilling operations in such a manner that minimizes potential for drilling fluid to migrate to the surface.

Dispose of all drilling fluid and excavated materials properly away from the construction site in accordance with applicable State and Federal regulations for disposal of these materials. Use the disposal sites identified in Contractor's accepted submittal for cuttings and drilling fluid disposal.

3.8 RECIRCULATION

Optimize recirculation of drilling fluid surface returns. Provide solids control and fluid cleaning equipment of a configuration and capacity that can process surface returns and produce drilling fluid suitable for reuse.

3.9 INADVERTENT DRILLING FLUID RETURNS

Contractor shall be responsible for, control and handle all inadvertent drilling fluid returns and their mitigation.

3.10 REAMING

Conduct prereaming operations to insure that a hole sufficient to accommodate the product pipe pull has been produced. The hole shall be prereamed to the minimum of 150 percent of the effective outside diameter of the pipe. Any damage to the pipe resulting from inadequate prereaming shall be the responsibility of Contractor.

3.11 PULL BACK

Fully assemble the entire pipeline to be installed via direction drill prior to commencement of pull back operations.

Support the pipeline during pullback operations and as it moves along the ground in a manner to enable it to move freely and prevent damage. Install the pipeline in one continuous pull.

Minimize torsion stress by using a swivel to connect the pull section to the reaming assembly.

Maximum allowable tensile force imposed on the pull section is not to exceed the pipe manufacturer's maximum allowable tensile load with a safety factor of 1.5.

Minimize external pressure during installation of the pullback section in the reamed hole and maintain an appropriate counter balancing internal pressure as required. Replace damaged pipe resulting from external pressure at no cost to the Government.

3.12 INSTRUMENTATION

At all times provide and maintain instrumentation which shall accurately locate the pilot hole, measure drill string axial and torsional loads, and measure drilling fluid discharge rate and pressure.

Provide Contracting Officer with access to these instruments and their readings at all times.

Maintain a log of all recorded readings.

3.13 GUIDANCE SYSTEMS/CONTROL OF LINE AND GRADE

Record and plot the actual horizontal and vertical alignment of the pilot borehead at intervals not to exceed 10 feet. Update these records continuously as the pilot bore is advanced. Submit the complete records to Contracting Officer immediately after completion of the pilot boring. During installation, grant Contracting Officer unrestricted access to these records, as well as the readouts showing the position and inclination of the borehead. Interpret such readouts for the Contracting Officer when requested.

Utilize a surface monitoring system to accurately determine the location of the steering tool during pilot hole drilling and to correct the alignment.

3.14 GROUND MOVEMENT MONITORING AND MITIGATION

Contractor shall control its methods to minimize ground movement.

Monitor ground movement of taxiways, aprons and runways within 20 feet of the proposed alignment. Measure at locations such that separation between monitoring points does not exceed 25 feet.

Monitor prior to construction to establish baseline elevations. Monitor on an as needed basis during reaming and pipe or casing installation.

Submit survey monitor information within 24 hours of taking readings. Text

3.15 DOCUMENTATION

Maintain drilling logs that accurately provide drill bit location (both horizontally and vertically) at least every 2 inches along the drill path. In addition, keep logs that record, as a minimum the following, every 15 minutes throughout each drill pass, back ream pass, or pipe installation pass:

a. Drilling Fluid Pressure

b. Drilling Fluid Flow Rate

c. Drill Thrust Pressure

d. Drill Pullback Pressure

e. Drill Head Torque

Make all instrumentation, readings, and logs available to the Contracting Officer at all times during operation.

3.16 UTILITY LOCATING AND MARKING

Locate and clearly mark all utilities prior to start of excavation or drilling. The Contractor is responsible for damage to utilities, and

repairs for such damages, at no cost to the Government.

Undertake the following steps prior to commencing drilling operations in a location that might contain underground facilities:

a. Contact the utility owners for utilities along project alignment. Make contact a minimum of four (2) weeks before drilling.

b. Positively locate and stake all existing lines, cables, or other underground facilities including exposing any facilities that are located within 20 feet of the proposed bore path.

c. Modify drilling practices and downhole assemblies to prevent damage to existing facilities.

d. Locate any and all underground facilities regardless of previous efforts in this regard.

1. Locate utilities and adjust arrangement of equipment if needed to avoid existing utilities.

2. Prior to drilling, hold a site meeting with the Contracting Officer in the vicinity of the work present. Discuss proposed work activities, safety procedures as they relate to the specific utilities, and emergency procedures and contact information. Meeting shall occur after utilities have been positively located and a minimum of seven (7) days prior to anticipated start of drilling.

3.17 CLEANUP AND FINAL CLOSEOUT

Upon completion of surveying and successful testing of the pull section, terminate and cap both ends of the casing pipe until final insertion of ductwork and grouting of annular space is complete. Sufficiently cap all pipes to prevent water, soil, and all other foreign material from entering pipes until annular space is grouted.

Immediately upon completion of work of this section, remove all rubbish and debris from the job site. Remove all construction equipment and implements of service leaving the entire area involved in a neat condition acceptable of the Contracting Officer .

Immediately clean "blow holes" or "breakouts" of drilling fluid to the surface and return the surface area to its original condition. Dispose of all drilling fluids, soils, and separated materials in compliance with federal, state, and local environmental regulations.

Submit an electronic copy and three hard copies of the record drawings to the Contracting Officer within five days after completing the pull back. Include in the record drawings a plan, profile, and all information recorded during the progress of the work. Clearly tie the record drawings to the project's survey control. Maintain and submit upon completion signed final work complete logs of guided directional drill operations.

-- End of Section --

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SECTION 33 40 00

STORM DRAINAGE UTILITIES

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 HB-17	(2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges
AASHTO M 167M/M 167	(2014) Standard Specification for Corrugated Steel Structural Plate, Zinc-Coated, for Field-Bolted Pipe, Pipe-Arches, and Arches
AASHTO M 190	(2004; R 2012) Standard Specification for Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches
AASHTO M 20	(2013; R 2014) Standard Specification for Steel-Reinforced Polyethylene (PE) Pipe
AASHTO M 219	(1992; R 2012) Standard Specification for Corrugated Aluminum Alloy Structural Plate for Field-Bolted Pipe, Pipe-Arches, and Arches
AASHTO M 243	(1996; R 2012) Standard Specification for Field-Applied Coating of Corrugated Metal Structural Plate for Pipe, Pipe-Arches, and Arches
AASHTO M 294	(2013) Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm Diameter

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 346	(2009) Specification for Cast-in-Place Concrete Pipe

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA)

AREMA Eng Man	(2012) Manual for Railway Engineering

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM A536	(1984; R 2009) Standard Specification for Ductile Iron Castings
ASTM A716	(2008) Standard Specification for Ductile Iron Culvert Pipe
ASTM A74	(2013a) Standard Specification for Cast Iron Soil Pipe and Fittings
ASTM A742/A742M	(2013) Standard Specification for Steel Sheet, Metallic Coated and Polymer Precoated for Corrugated Steel Pipe
ASTM A760/A760M	(2013) Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains
ASTM A762/A762M	(2008) Standard Specification for Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains
ASTM A798/A798M	(2013) Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications
ASTM A807/A807M	(2013) Standard Practice for Installing Corrugated Steel Structural Plate Pipe for Sewers and Other Applications
ASTM A849	(2010) Standard Specification for Post-Applied Coatings, Pavings, and Linings for Corrugated Steel Sewer and Drainage Pipe
ASTM A929/A929M	(2001; R 2013) Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe
ASTM B26/B26M	(2012) Standard Specification for Aluminum-Alloy Sand Castings
ASTM B745/B745M	(2012) Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains
ASTM C1103	(2003; R 2009) Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
ASTM C1103M	(2003; R 2009) Standard Practice for Joint

	Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines (Metric)
ASTM C12	(2013a) Standard Practice for Installing Vitrified Clay Pipe Lines
ASTM C139	(2011) Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C14	(2014) Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C1433	(2014) Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers
ASTM C1433M	(2014) Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers (Metric)
ASTM C14M	(2014) Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe (Metric)
ASTM C231/C231M	(2014) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C270	(2014) Standard Specification for Mortar for Unit Masonry
ASTM C32	(2013) Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C425	(2004; R 2013) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C443	(2011) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C443M	(2012) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric)
ASTM C444	(2003; R 2009) Perforated Concrete Pipe
ASTM C444M	(2003; R 2009) Perforated Concrete Pipe (Metric)
ASTM C478	(2013) Standard Specification for Precast Reinforced Concrete Manhole Sections
ASTM C478M	(2013) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)

ASTM C506	(2014) Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe
ASTM C506M	(2014) Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C507	(2014) Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe
ASTM C507M	(2014) Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C55	(2014) Concrete Brick
ASTM C564	(2014) Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C62	(2013a) Building Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C655	(2014) Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
ASTM C700	(2013) Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
ASTM C76	(2014) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C76M	(2014) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C828	(2011) Low-Pressure Air Test of Vitrified Clay Pipe Lines
ASTM C877	(2008) External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections
ASTM C877M	(2002; R 2009) External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections (Metric)
ASTM C923	(2008; R 2013) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
ASTM C923M	(2008b; R 2013) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals (Metric)

ASTM C969	(2002; R 2009) Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
ASTM C969M	(2002; R 2009) Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines (Metric)
ASTM C990	(2009; R 2014) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM D1056	(2014) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D1171	(1999; R 2007) Rubber Deterioration - Surface Ozone Cracking Outdoors or Chamber (Triangular Specimens)
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1751	(2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2004a; R 2013) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2167	(2008) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2321	(2011) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2729	(2011) Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3034	(2014) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	(2007; R 2013) Standard Specification for

	Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3350	(2012) Polyethylene Plastics Pipe and Fittings Materials
ASTM D6938	(2010) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM F1417	(2011a) Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low Pressure Air
ASTM F2562	(2008) Specification for Steel Reinforced Thermoplastic Ribbed Pipe and Fittings for Non-Pressure Drainage and Sewerage 8-120" (200-3000mm)
ASTM F2736	(2013) Standard Specification for 6 to 30 in. (152 To 762 mm) Polypropylene (PP) Corrugated Single Wall Pipe And Double Wall Pipe
ASTM F2764/F2764M	(2011a; E 2013; E 2013) Standard Specification for 30 to 60 in. [750 to 1500 mm] Polypropylene (PP) Triple Wall Pipe and Fittings for Non-Pressure Sanitary Sewer Applications
ASTM F2881	(2011) Standard Specification for 12 to 60 in. (300 to 1500 mm) Polypropylene (PP) Dual Wall Pipe and Fittings for Non-Pressure Storm Sewer Applications
ASTM F477	(2010) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F679	(2013a) Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
ASTM F714	(2013) Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM F794	(2003; R 2009) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F894	(2013) Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
ASTM F949	(2010) Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Placing Pipe

Submit printed copies of the manufacturer's recommendations for installation procedures of the material being placed, prior to installation.

SD-07 Certificates

Resin Certification
Pipeline Testing
Hydrostatic Test on Watertight Joints
Determination of Density
Frame and Cover for Gratings

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery and Storage

Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Before, during, and after installation, plastic pipe and fittings shall be protected from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe shall be stored in accordance with the manufacturer's recommendations and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.

1.3.2 Handling

Materials shall be handled in a manner that ensures delivery to the trench in sound, undamaged condition. Pipe shall be carried to the trench, not dragged.

PART 2 PRODUCTS

2.1 PIPE FOR CULVERTS AND STORM DRAINS

Pipe for culverts and storm drains shall be of the sizes indicated and shall conform to the requirements specified.

2.1.1 Concrete Pipe

Manufactured in accordance with and conforming to ASTM C76, Class V, or ASTM C655, .

2.2 DRAINAGE STRUCTURES

2.2.1 Precast Reinforced Concrete Box

Manufactured in accordance with and conforming to ASTM C1433.

2.3 MISCELLANEOUS MATERIALS

2.3.1 Concrete

Unless otherwise specified, concrete and reinforced concrete shall conform to the requirements for 3000 psi concrete under Section 03 30 00 CAST-IN-PLACE CONCRETE. The concrete mixture shall have air content by volume of concrete, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 1-1/2 inches. Air content shall be determined in accordance with ASTM C231/C231M. The concrete covering over steel reinforcing shall not be less than 1 inch thick for covers and not less than 1-1/2 inches thick for walls and flooring. Concrete covering deposited directly against the ground shall have a thickness of at least 3 inches between steel and ground. Expansion-joint filler material shall conform to ASTM D1751, or ASTM D1752, or shall be resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752.

2.3.2 Mortar

Mortar for pipe joints, connections to other drainage structures, and brick or block construction shall conform to ASTM C270, Type M, except that the maximum placement time shall be 1 hour. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar but in no case shall exceed manufacturer recommendations . Water shall be clean and free of harmful acids, alkalis, and organic impurities. The mortar shall be used within 30 minutes after the ingredients are mixed with water. The inside of the joint shall be wiped clean and finished smooth. The mortar head on the outside shall be protected from air and sun with a proper covering until satisfactorily cured.

2.3.3 Brick

Brick shall conform to ASTM C62, Grade SW; ASTM C55, Grade S-I or S-II; or ASTM C32, Grade MS. Mortar for jointing and plastering shall consist of one part portland cement and two parts fine sand. Lime may be added to the mortar in a quantity not more than 25 percent of the volume of cement. The joints shall be filled completely and shall be smooth and free from surplus mortar on the inside of the structure. Brick structures shall be plastered with 1/2 inch of mortar over the entire outside surface of the walls. For square or rectangular structures, brick shall be laid in stretcher courses with a header course every sixth course. For round structures, brick shall be laid radially with every sixth course a stretcher course.

2.3.4 Precast Reinforced Concrete Manholes

Conform to ASTM C478. Joints between precast concrete risers and tops shall be made with flexible watertight, rubber-type gaskets meeting the requirements of paragraph JOINTS.

2.3.5 Frame and Cover for Gratings

Submit certification on the ability of frame and cover or gratings to carry the imposed live load. Frame and cover for gratings shall be cast gray iron, ASTM A48/A48M, Class 35B; cast ductile iron, ASTM A536, Grade 65-45-12; or cast aluminum, ASTM B26/B26M, Alloy 356.OT6. Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the plans. The word "Storm Sewer" shall be stamped or cast into covers so that it is plainly visible.

2.3.6 Joints

2.3.6.1 Flexible Watertight Joints

a. Materials: Flexible watertight joints shall be made with plastic or rubber-type gaskets for concrete pipe and with factory-fabricated resilient materials for clay pipe. The design of joints and the physical requirements for preformed flexible joint sealants shall conform to ASTM C990, and rubber-type gaskets shall conform to ASTM C443. Factory-fabricated resilient joint materials shall conform to ASTM C425. Gaskets shall have not more than one factory-fabricated splice, except that two factory-fabricated splices of the rubber-type gasket are permitted if the nominal diameter of the pipe being gasketed exceeds 54 inches.

b. Test Requirements: Watertight joints shall be tested and shall meet test requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS. Rubber gaskets shall comply with the oil resistant gasket requirements of ASTM C443. Certified copies of test results shall be delivered to the Contracting Officer before gaskets or jointing materials are installed. Alternate types of watertight joint may be furnished, if specifically approved.

2.3.6.2 External Sealing Bands

Requirements for external sealing bands shall conform to ASTM C877.

2.4 STEEL LADDER

Steel ladder shall be provided where the depth of the storm drainage structure exceeds 12 feet. These ladders shall be not less than 16 inches in width, with 3/4 inch diameter rungs spaced 12 inches apart. The two stringers shall be a minimum 3/8 inch thick and 2-1/2 inches wide. Ladders and inserts shall be galvanized after fabrication in conformance with ASTM A123/A123M.

2.5 RESILIENT CONNECTORS

Flexible, watertight connectors used for connecting pipe to manholes and inlets shall conform to ASTM C923.

PART 3 EXECUTION

3.1 EXCAVATION FOR PIPE CULVERTS, STORM DRAINS, AND DRAINAGE STRUCTURES

Excavation of trenches, and for appurtenances and backfilling for culverts and storm drains, shall be in accordance with the applicable portions of Section 31 23 00.00 20 EXCAVATION AND FILL and the requirements specified below.

3.1.1 Trenching

The width of trenches at any point below the top of the pipe shall be not greater than the outside diameter of the pipe plus 12 inches to permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Sheeting and bracing, where required, shall be placed within the trench width as specified, without any overexcavation. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures will be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Government.

3.1.2 Removal of Unstable Material

Where wet or otherwise unstable soil incapable of properly supporting the pipe, as determined by the Contracting Officer, is unexpectedly encountered in the bottom of a trench, such material shall be removed to the depth required and replaced to the proper grade with select granular material, compacted as provided in paragraph BACKFILLING. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, such removal and replacement shall be performed at no additional cost to the Government.

3.2 BEDDING

The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe.

3.2.1 Concrete Pipe Requirements

When no bedding class is specified or detailed on the drawings, concrete pipe shall be bedded in granular material minimum 4 inch in depth in trenches with soil foundation. Depth of granular bedding in trenches with rock foundation shall be 1/2 inch in depth per foot of depth of fill, minimum depth of bedding shall be 8 inch up to maximum depth of 24 inches. The middle third of the granular bedding shall be loosely placed. Bell holes and depressions for joints shall be removed and formed so entire barrel of pipe is uniformly supported. The bell hole and depressions for the joints shall be not more than the length, depth, and width required for properly making the particular type of joint.

3.3 PLACING PIPE

Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated metal pipe shall be placed in the same vertical plane as the major axis of the pipe. Pipe shall not be laid in water, and pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary.
Note post installation requirements of paragraph DEFLECTION TESTING in PART 3 of this specification for all pipe products including deflection testing requirements for flexible pipe.

3.3.1 Concrete, Pipe

Laying shall proceed upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.3.2 Multiple Culverts

Where multiple lines of pipe are installed, adjacent sides of pipe shall be at least half the nominal pipe diameter or 3 feet apart, whichever is less.

3.4 JOINTING

3.4.1 Concrete

3.4.1.1 Cement-Mortar Bell-and-Spigot Joint

The first pipe shall be bedded to the established grade line, with the bell end placed upstream. The interior surface of the bell shall be thoroughly cleaned with a wet brush and the lower portion of the bell filled with mortar as required to bring inner surfaces of abutting pipes flush and even. The spigot end of each subsequent pipe shall be cleaned with a wet brush and uniformly matched into a bell so that sections are closely fitted. After each section is laid, the remainder of the joint shall be filled with mortar, and a bead shall be formed around the outside of the joint with sufficient additional mortar. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint shall be wrapped or bandaged with cheesecloth to hold mortar in place.

3.4.1.2 Flexible Watertight Joints

Gaskets and jointing materials shall be as recommended by the particular manufacturer in regard to use of lubricants, cements, adhesives, and other special installation requirements. Surfaces to receive lubricants, cements, or adhesives shall be clean and dry. Gaskets and jointing materials shall be affixed to the pipe not more than 24 hours prior to the installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Gaskets and jointing materials shall be inspected before installing the pipe; any loose or improperly affixed gaskets and jointing materials shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pushed home. If, while the joint is being made the gasket becomes visibly dislocated the pipe shall be removed and the joint remade.

3.4.1.3 External Sealing Band Joint for Noncircular Pipe

Surfaces to receive sealing bands shall be dry and clean. Bands shall be installed in accordance with manufacturer's recommendations.

3.5 DRAINAGE STRUCTURES

3.5.1 Manholes and Inlets

Construction shall be of reinforced concrete, plain concrete, brick, precast reinforced concrete, precast concrete segmental blocks, prefabricated corrugated metal, or bituminous coated corrugated metal; complete with frames and covers or gratings; and with fixed galvanized

steel ladders where indicated. Pipe studs and junction chambers of prefabricated corrugated metal manholes shall be fully bituminous-coated and paved when the connecting branch lines are so treated. Pipe connections to concrete manholes and inlets shall be made with flexible, watertight connectors.

3.6 STEEL LADDER INSTALLATION

Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 6 feet vertically, and shall be installed to provide at least 6 inches of space between the wall and the rungs. The wall along the line of the ladder shall be vertical for its entire length.

3.7 BACKFILLING

3.7.1 Backfilling Pipe in Trenches

After the pipe has been properly bedded, selected material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of pipe in layers not exceeding 6 inches in compacted depth. The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. The fill shall be thoroughly compacted under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached an elevation equal to the midpoint (spring line) of RCP or has reached an elevation of at least 12 inches above the top of the pipe for flexible pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical rammers or tampers in layers not exceeding 12 inches. Tests for density shall be made as necessary to ensure conformance to the compaction requirements specified below. Where it is necessary, in the opinion of the Contracting Officer, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly. Untreated sheeting shall not be left in place beneath structures or pavements.

3.7.2 Backfilling Pipe in Fill Sections

For pipe placed in fill sections, backfill material and the placement and compaction procedures shall be as specified below. The fill material shall be uniformly spread in layers longitudinally on both sides of the pipe, not exceeding 6 inches in compacted depth, and shall be compacted by rolling parallel with pipe or by mechanical tamping or ramming. Prior to commencing normal filling operations, the crown width of the fill at a height of 12 inches above the top of the pipe shall extend a distance of not less than twice the outside pipe diameter on each side of the pipe or 12 feet, whichever is less. After the backfill has reached at least 12 inches above the top of the pipe, the remainder of the fill shall be placed and thoroughly compacted in layers not exceeding 12 inches. Use select granular material for this entire region of backfill for flexible pipe installations.

3.7.3 Movement of Construction Machinery

When compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a culvert or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be repaired or replaced.

3.7.4 Compaction

3.7.4.1 General Requirements

Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel-silt mixtures, clayey and silty sands, sand-clay mixtures, clays, silts, and very fine sands. When results of compaction tests for moisture-density relations are recorded on graphs, cohesionless soils will show straight lines or reverse-shaped moisture-density curves, and cohesive soils will show normal moisture-density curves.

3.7.4.2 Minimum Density

Backfill over and around the pipe and backfill around and adjacent to drainage structures shall be compacted at the approved moisture content to the following applicable minimum density, which will be determined as specified below.

a. Under airfield and heliport pavements, paved roads, streets, parking areas, and similar-use pavements including adjacent shoulder areas, the density shall be not less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material, up to the elevation where requirements for pavement subgrade materials and compaction shall control.

b. Under unpaved or turfed traffic areas, density shall not be less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material.

c. Under nontraffic areas, density shall be not less than that of the surrounding material.

3.7.5 Determination of Density

Testing is the responsibility of the Contractor and performed at no additional cost to the Government. Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. Tests shall be performed in sufficient number to ensure that specified density is being obtained. Laboratory tests for moisture-density relations shall be made in accordance with ASTM D1557 except that mechanical tampers may be used provided the results are correlated with those obtained with the specified hand tamper. Field density tests shall be determined in accordance with ASTM D2167 or ASTM D6938. When ASTM D6938 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in paragraph Calibration of the referenced publications. ASTM D6938 results in a wet unit weight of soil and ASTM D6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D6938. Test results shall be furnished the Contracting Officer. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.

3.8 PIPELINE TESTING

3.8.1 Leakage Tests

Lines shall be tested for leakage by low pressure air or water testing or exfiltration tests, as appropriate. Low pressure air testing for concrete pipes shall conform to ASTM C969. Testing of individual joints for leakage by low pressure air or water shall conform to ASTM C1103. Prior to exfiltration tests, the trench shall be backfilled up to at least the lower half of the pipe. If required, sufficient additional backfill shall be placed to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. Visible leaks encountered shall be corrected regardless of leakage test results. When the water table is 2 feet or more above the top of the pipe at the upper end of the pipeline section to be tested, infiltration shall be measured using a suitable weir or other device acceptable to the Contracting Officer. An exfiltration test shall be made by filling the line to be tested with water so that a head of at least 2 feet is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. The filled line shall be allowed to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, the head shall be reestablished. The amount of water required to maintain this water level during a 2-hour test period shall be measured. Leakage as measured by the exfiltration test shall not exceed 0.2 gallons per inch in diameter per 100 feet of pipeline per hour. When leakage exceeds the maximum amount specified, satisfactory correction shall be made and retesting accomplished.

3.8.2 Post-Installation Inspection

Check each reinforced concrete pipe installation for joint separations, soil migration through the joint, cracks greater than 0.01 inches, settlement and alignment. Check each flexible pipe (HDPE, PVC, CMP, PP) for rips, tears, joint separations, soil migration through the joint, cracks, localized bucking, bulges, settlement and alignment.

a. Replace pipes having cracks greater than 0.1 inches in width or deflection greater than 5 percent deflection. An engineer shall evaluate all pipes with cracks greater than 0.01 inches but less than 0.10 inches to determine if any remediation or repair is required. RCP with crack width less than 0.10 inches and located in a non-corrosive environment (pH 5.5) are generally acceptable. Repair or replace any pipe with crack exhibiting displacement across the crack, exhibiting bulges, creases, tears, spalls, or delamination.

b. Reports: The deflection results and final post installation inspection report shall include: a copy of all video taken, pipe location identification, equipment used for inspection, inspector name, deviation from design, grade, deviation from line, deflection and deformation of flexible pipe systems, inspector notes, condition of joints, condition of pipe wall (e.g. distress, cracking, wall damage dents, bulges, creases, tears, holes, etc.).

3.9 FIELD PAINTING

After installation, clean cast-iron frames, covers, gratings, and steps not buried in masonry or concrete to bare metal of mortar, rust, grease, dirt, and other deleterious materials and apply a coat of bituminous paint.

Do not paint surfaces subject to abrasion.

-- End of Section --

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SECTION 33 71 01

OVERHEAD TRANSMISSION AND DISTRIBUTION

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.

ALLIANCE FOR TELECOMMUNICATIONS INDUSTRY SOLUTIONS (ATIS)

ATIS ANSI O5.1	(2008) Wood Poles -- Specifications & Dimensions

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C135.14	(1979) Staples with Rolled or Slash Points for Overhead Line Construction

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA C1	(2003) All Timber Products - Preservative Treatment by Pressure Processes
AWPA C25	(2003) Sawn Crossarms - Preservative Treatment by Pressure Processes
AWPA C4	(2003) Poles - Preservative Treatment by Pressure Processes

ASME INTERNATIONAL (ASME)

ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A167	(1999; R 2009) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A475	(2003a; E 2009; R 2009) Standard

	Specification for Zinc-Coated Steel Wire Strand
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A575	(1996; E 2013; R 2013) Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
ASTM A576	(1990b; R 2012) Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B2	(2013) Standard Specification for Medium-Hard-Drawn Copper Wire
ASTM B230/B230M	(2007; R 2012) Standard Specification for Aluminum 1350-H19 Wire for Electrical Purposes
ASTM B231/B231M	(2012) Standard Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors
ASTM B232/B232M	(2011) Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Coated-Steel Reinforced (ACSR)
ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B398/B398M	(2014) Standard Specification for Aluminum-Alloy 6201-T81 Wire for Electrical Purposes
ASTM B399/B399M	(2004; R 2010) Standard Specification for Concentric-Lay-Stranded Aluminum-Alloy 6201-T81 Conductors
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D117	(2010) Standard Guide for Sampling, Test Methods, Specifications and Guide for Electrical Insulating Oils of Petroleum Origin
ASTM D1654	(2008) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

ASTM D3487	(2009) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
ASTM D709	(2013) Laminated Thermosetting Materials
ASTM D877/D877M	(2013) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D92	(2012b) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2012) Pour Point of Petroleum Products

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 18	(2012) Standard for Shunt Power Capacitors
IEEE 404	(2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V
IEEE C135.1	(1999) Standard for Zinc-Coated Steel Bolts and Nuts for Overhead Line Construction
IEEE C135.2	(1999) Threaded Zinc-Coated Ferrous Strand-Eye Anchor Rods and Nuts for Overhead Line Construction
IEEE C135.22	(1988) Standard for Zinc-Coated Ferrous Pole-Top Insulator Pins with Lead Threads for Overhead Line Construction
IEEE C135.30	(1988) Standard for Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013) National Electrical Safety Code
IEEE C37.32	(2002) Standard for High-Voltage Switches, Bus Supports, and Accessories - Schedules of Preferred Ratings, Construction Guidelines and Specifications
IEEE C37.41	(2008; Errata 2009) Standard Design Tests for High-Voltage (>1000 V) Fuses, Fuse and Disconnecting Cutouts, Distribution Enclosed Single-Pole Air Switches, Fuse

	Disconnecting Switches, and Accessories Used with These Devices
IEEE C37.42	(2009) Standard Specifications for High-Voltage (> 1000 V) Expulsion-Type Distribution-Class Fuses, Fuse and Disconnecting Cutouts, Fuse Disconnecting Switches, and Fuse Links, and Accessories Used with These Devices
IEEE C37.63	(2013) Standard Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Line Sectionalizers for AC Systems
IEEE C57.12.00	(2010) Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.20	(2011) Standard for Overhead Type Distribution Transformers, 500 KVA and Smaller: High Voltage 34 500 Volts and Below: Low Voltage, 7970/13,800 Y Volts and Below
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.90	(2010) Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(2008; INT 2009) Standard Requirements for Instrument Transformers
IEEE C57.15	(2009) Standard Requirements, Terminology, and Test Code for Step-Voltage Regulators
IEEE C62.11	(2012) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 62271-111	(2012; ED 2.0) High Voltage Switchgear And Controlgear - Part 111: Automatic Circuit Reclosers and Fault Interrupters for Alternating Current Systems up to 38 kV

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering

ANSI C12.7	(2005) Requirements for Watthour Meter Sockets
ANSI C29.2	(2012) American National Standard for Insulators - Wet-Process Porcelain and Toughened Glass - Suspension Type
ANSI C29.3	(1986; R 2012) American National Standard for Wet Process Porcelain Insulators - Spool Type
ANSI C29.4	(1989; R 2012) Standard for Wet-Process Porcelain Insulators - Strain Type
ANSI C29.5	(1984; R 2002) Wet-Process Porcelain Insulators (Low and Medium Voltage Pin Type)
ANSI/NEMA WC 71/ICEA S-96-659	(1999) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA C135.4	(1987) Zinc-Coated Ferrous Eyebolts and Nuts for Overhead Line Construction
NEMA ICS 6	(1993; R 2011) Enclosures
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
NEMA/ANSI C12.10	(2011) Physical Aspects of Watthour Meters - Safety Standards
NEMA/ANSI C29.7	(1996; 2002) American National Standard for Wet Process Porcelain Insulators - High-Voltage Line Post Type

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS 202-1	(2004) List of Materials Acceptable for Use on Systems of RUS Electrification Borrowers

RUS Bull 1728H-701	(1993) Wood Crossarms (Solid and Laminated), Transmission Timbers and Pole Keys
RUS Bull 345-67	(1998) REA Specification for Filled Telephone Cables, PE-39

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

UNDERWRITERS LABORATORIES (UL)

UL 467	(2007) Grounding and Bonding Equipment
UL 486A-486B	(2013; Reprint Feb 2014) Wire Connectors
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 6	(2007; reprint Nov 2010) Electrical Rigid Metal Conduit-Steel

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section with 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, shall be 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 Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

a. A certification, from the manufacturer, that the technical requirements of this specification shall be met.

b. Routine and other tests (paragraph entitled "Routine and Other Tests, shall be conducted by the manufacturer and may be witnessed by the Government (paragraph entitled "Source Quality Control"). Provide certified copies of the tests.

c. Provide field test reports (paragraph entitled "Field Quality Control").

SD-03 Product Data

Conductors; G

Insulators; G

Pole top switch; G

Recloser; G

Sectionalizer; G

Cutouts; G

Surge arresters; G

SD-06 Test Reports

Wood Crossarm Inspection Report

Field Test Plan; G

Field Quality Control; G

Ground resistance test reports; G

Submit report of the acceptance test results as specified by paragraph entitled "Field Quality Control"

SD-07 Certificates

Wood crossarms; G

Submit certification from the manufacturer indicating conformance with the paragraph entitled "Specified Transformer Losses."

SD-09 Manufacturer's Field Reports

Overhead-type distribution transformer routine and other tests; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals, Data Package 5; G

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein.

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, "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 and IEEE C2 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 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.

1.5.2.1 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.

1.5.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.5.3 Ground Resistance Test Reports

Submit the measured ground resistance of grounding system. When testing grounding electrodes and grounding systems, identify each grounding electrode and each grounding system for testing. 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.

1.5.4 Wood Crossarm Inspection Report

Furnish an inspection report from an independent inspection agency, approved by the Contracting Officer, stating that offered products comply with applicable AWPA and RUS standards. The RUS approved Quality Mark "WQC" on each crossarm will be accepted, in lieu of inspection reports, as evidence of compliance with applicable AWPA treatment standards.

1.5.4.1 Field Test Plan

Provide a proposed field test plan 30 days prior to testing the installed system. No field test shall be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

1.6 MAINTENANCE

1.6.1 Additions to Operations and Maintenance Data

In addition to requirements of Data Package 5, include the following in the operation and maintenance manuals provided:

a. Assembly and installation drawings

b. Prices for spare parts and supply list

c. Date of purchase

1.7 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected by the Contractor when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced.

1.8 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.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Consider materials specified herein or shown on contract drawings which are identical to materials listed in RUS 202-1 as conforming to requirements. Equipment and component items, not hot-dip galvanized or porcelain enamel finished, shall be provided with corrosion-resistant

finishes which shall withstand 480 hours of exposure to the salt spray test specified in ASTM B117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1/16 inch from the test mark. The described test mark and test evaluation shall be in accordance with ASTM D1654 with a rating of not less than 7 in accordance with TABLE 1, (procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with a zinc rich paint conforming to the manufacturer's standard.

2.2 CROSSARMS AND BRACKETS

2.2.1 Wood Crossarms

Conform to RUS Bull 1728H-701. Pressure treat crossarms with pentachlorophenol, chromated copper arsenate (CCA), or ammoniacal copper arsenate (ACA). Treatment shall conform to AWPA C25. Crossarms shall be solid wood, distribution type, and a 1/4 inch 45 degree chamfer on all top edges. Cross-sectional area minimum dimensions shall be 4-1/4 inches in height by 3-1/4 inches in depth in accordance with IEEE C2 for Grade B construction. Crossarms shall be 8 feet in length, except that 10 foot crossarms shall be used for crossarm-mounted banked single-phase transformers or elsewhere as indicated. Crossarms shall be machined, chamfered, trimmed, and bored for stud and bolt holes before pressure treatment. Factory drilling shall be provided for pole and brace mounting, for four pin or four vertical line-post insulators, and for four suspension insulators, except where otherwise indicated or required. Drilling shall provide required climbing space and wire clearances. Crossarms shall be straight and free of twists to within 1/10 inch per foot of length. Bend or twist shall be in one direction only.

2.2.2 Crossarm Braces

Provide flat steel or steel angle as indicated. Provide braces with 38 inch span for 8 foot crossarms and 60 inch span for 10 foot crossarms.

2.2.3 Armless Construction

Pole mounting brackets for line-post or pin insulators and eye bolts for suspension insulators shall be as shown. Brackets shall be attached to poles with a minimum of two bolts. Brackets may be either provided integrally as part of an insulator or attached to an insulator with a suitable stud. Bracket mounting surface shall be suitable for the shape of the pole. Brackets for wood poles shall have wood gripping members. Horizontal offset brackets shall have a 5-degree uplift angle. Pole top brackets shall conform to IEEE C135.22, except for modifications necessary to provide support for a line-post insulator. Brackets shall provide a strength exceeding that of the required insulator strength, but in no case less than a 2800 pound cantilever strength.

2.3 HARDWARE

Hardware shall be hot-dip galvanized in accordance with ASTM A153/A153M and ASTM A123/A123M.

2.4 NEUTRAL-SUPPORTED SECONDARY AND SERVICE DROP CABLES

Service cables shall be copper, triplex with cross-linked polyethylene insulation on the phase conductors. Neutral shall be bare hard drawn copper and shall be the same size as the phase conductors unless otherwise

indicated. Cables shall conform to NEMA WC 70 and ANSI/NEMA WC 71/ICEA S-96-659 for cross-linked polyethylene insulation.

2.5 GROUNDING AND BONDING

2.5.1 Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467 not less than 3/4 inch in diameter by 10 feet in length. Sectional type rods may be used for rods 20 feet or longer.

2.5.2 Grounding Conductors

ASTM B3. Provide soft drawn copper wire ground conductors a minimum No. 4 AWG. Ground wire protectors shall be PVC.

2.5.3 Grounding Connections

UL 467. Exothermic weld or compression connector.

2.6 SURGE ARRESTERS

IEEE C62.11, metal oxide, polymeric-housed, surge arresters arranged for crossarm mounting. RMS voltage rating shall be 6 kV. Arresters shall be Distribution class.

2.7 FUSED CUTOUTS

Open type fused cutouts rated 100 amperes and 20 KAIC amperes symmetrical interrupting current at 7.8 kV ungrounded , conforming to IEEE C37.42. Type K fuses conforming to IEEE C37.42 with ampere ratings equal to 150 percent of the transformer full load rating. Open link type fuse cutouts are not acceptable.

2.8 CONDUIT RISERS AND CONDUCTORS

The riser shield shall be PVC containing a PVC back plate and PVC extension shield or a rigid galvanized steel conduit, as indicated, and conforming to UL 6. Provide conductors and terminations as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.9 GROUP-OPERATED LOAD INTERRUPTER SWITCHES

2.9.1 Manually Operated Type (Switch Handle Operated)

Manually operated (switch handle operated) load interrupter switches shall comply with IEEE C37.32 and shall be of the outdoor, manually-operated, three-pole, single-throw type with either tilting or rotating insulators. Switches shall be equipped with interrupters capable of interrupting currents equal to the switch's continuous current rating. Each switch shall be preassembled for the indicated configuration and mounting. Moving contacts shall be of the high-pressure, limited-area type, designed to ensure continuous surface contact. Switches shall be fused or non-fused as indicated. Switches shall be complete with necessary operating mechanisms, handles, and other items required for manual operation from the ground. Switch operating handles shall be located approximately 3 feet 6 inches above final grade. Insulation of switch operating mechanisms shall include both insulated interphase rod sections and insulated vertical shafts. Each handle shall be provided with a

padlock arranged to lock the switch in both the open and the closed position.

2.10 RECLOSER

IEC 62271-111. Recloser controller shall be hydraulically operated and utilize oil operating medium.

2.11 SECTIONALIZER

IEEE C37.63.

2.12 ELECTRICAL TAPES

Tapes shall be UL listed for electrical insulation and other purposes in wire and cable splices. Terminations, repairs and miscellaneous purposes, electrical tapes shall comply with UL 510.

2.13 CAULKING COMPOUND

Compound for sealing of conduit risers shall be of a puttylike consistency workable with hands at temperatures as low as 35 degrees F, shall not slump at a temperature of 300 degrees F, and shall not harden materially when exposed to air. Compound shall readily caulking or adhere to clean surfaces of the materials with which it is designed to be used. Compound shall have no injurious effects upon the workmen or upon the materials.

2.14 NAMEPLATES

2.14.1 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. Equipment containing liquid-dielectrics shall have the type of dielectric on the nameplate.

2.14.2 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 inch 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 inch high normal block style.

PART 3 EXECUTION

3.1 INSTALLATION

Provide overhead pole line installation conforming to requirements of IEEE C2 for Grade B construction of overhead lines in heavy loading districts and NFPA 70 for overhead services. Provide material required to make connections into existing system and perform excavating, backfilling, and other incidental labor. Consider street, alleys, roads and drives "public." Pole configuration shall be as indicated.

3.1.1 Hardware

Provide hardware with washer against wood and with nuts and lock nuts applied wrench tight. Provide locknuts on threaded hardware connections. Locknuts shall be M-F style and not palnut style.

3.1.2 Grounding

Unless otherwise indicated, grounding shall conform to IEEE C2 and NFPA 70. Pole grounding electrodes shall have a resistance to ground not exceeding 25 ohms. When work in addition to that indicated or specified is directed in order to obtain specified ground resistance, provisions of the contract covering changes shall apply.

3.1.2.1 Grounding Electrode Installation

Grounding electrodes shall be installed as follows:

a. Driven rod electrodes - Unless otherwise indicated, ground rods shall be located approximately 3 feetout from base of the pole and shall be driven into the earth until the tops of the rods are approximately 1 foot below finished grade. Multiple rods shall be evenly spaced at least 10 feet apart and connected together 2 feet below grade with a minimum No. 6 bare copper conductor.

3.1.2.2 Grounding Electrode Conductors

Grounding electrode conductors shall be sized as indicated. Secondary system neutral conductors shall be connected directly to the transformer neutral bushings, then connected with a neutral bonding jumper between the transformer neutral bushing and the vertical grounding electrode conductor as indicated. Bends greater than 45 degrees in grounding electrode conductor are not permitted.

3.1.2.3 Grounding Electrode Connections

Make above grade grounding connections on pole lines by exothermic weld or by using a compression connector. Make below grade grounding connections by exothermic weld. Make exothermic welds strictly in accordance with manufacturer's written recommendations. Welds which have puffed up or which show convex surfaces indicating improper cleaning, are not acceptable. No mechanical connectors are required at exothermic weldments. Compression connectors shall be type that uses a hydraulic compression tool to provide correct pressure. Provide tools and dies recommended by compression connector manufacturer. An embossing die code or similar method shall provide visible indication that a connector has been fully compressed on ground wire.

3.1.2.4 Grounding and Grounded Connections

a. Where no primary or common neutral exists, surge arresters and frames of equipment operating at over 750 volts shall be bonded together and connected to a dedicated primary grounding electrode.

b. Where no primary or common neutral exists, transformer secondary neutral bushing, secondary neutral conductor, and frames of equipment operating at under 750 volts shall be bonded together and connected to

a dedicated secondary grounding electrode.

c. When a primary or common neutral exists, connect all grounding and grounded conductors to a common grounding electrode.

3.1.2.5 Protective Molding

Protect grounding conductors which are run on surface of wood poles by PVC molding extending from ground line throughout communication and transformer spaces.

3.1.3 CONDUCTOR INSTALLATION

3.1.3.1 Line Conductors

Conductors shall be handled with care necessary to prevent nicking, kinking, gouging, abrasions, sharp bends, cuts, flattening, or otherwise deforming or weakening conductor or any damage to insulation or impairing its conductivity. Remove damaged sections of conductor and splice conductor. Conductors shall be paid out with the free end of conductors fixed and cable reels portable, except where terrain or obstructions make this method unfeasible. Bend radius for any insulated conductor shall not be less than the applicable NEMA specification recommendation. Conductors shall not be drawn over rough or rocky ground, nor around sharp bends. When installed by machine power, conductors shall be drawn from a mounted reel through stringing sheaves in straight lines clear of obstructions. Initial sag and tension shall be checked by the Contractor, in accordance with the manufacturer's approved sag and tension charts, within an elapsed time after installation as recommended by the manufacturer.

3.1.3.2 Connectors and Splices

Conductor splices, as installed, shall exceed ultimate rated strength of conductor and shall be of type recommended by conductor manufacturer. No splice shall be permitted within 10 feet of a support. Connectors and splices shall be mechanically and electrically secure under tension and shall be of the nonbolted compression type. The tensile strength of any splice shall be not less than the rated breaking strength of the conductor. Splice materials, sleeves, fittings, and connectors shall be noncorrosive and shall not adversely affect conductors. Aluminum-composition conductors shall be wire brushed and an oxide inhibitor applied before making a compression connection. Connectors which are factory-filled with an inhibitor are acceptable. Inhibitors and compression tools shall be of types recommended by the connector manufacturer. Primary line apparatus taps shall be by means of hot line clamps attached to compression type bail clamps (stirrups). Low-voltage connectors for copper conductors shall be of the solderless pressure type. Noninsulated connectors shall be smoothly taped to provide a waterproof insulation equivalent to the original insulation, when installed on insulated conductors. On overhead connections of aluminum and copper, the aluminum shall be installed above the copper.

3.1.3.3 Conductor-To-Insulator Attachments

Conductors shall be attached to insulators by means of clamps, shoes or tie wires, in accordance with the type of insulator. For insulators requiring conductor tie-wire attachments, tie-wire sizes shall be as specified in TABLE I.

TABLE I - TIE-WIRE REQUIREMENTS	
CONDUCTOR Copper (AWG)	TIE WIRE Soft-Drawn Copper (AWG)
6	8
4 and 2	6
1 through 3/0	4
4/0 and larger	2
AAC, AAAC, or ACSR (AWG	AAAC OR AAC (AWG)
Any size	6 or 4

3.1.3.4 Armor Rods

Armor rods shall be provided for AAC, AAAC, and ACSR conductors. Armor rods shall be installed at supports, except armor rods will not be required at primary dead-end assemblies if aluminum or aluminum-lined zinc-coated steel clamps are used. Lengths and methods of fastening armor rods shall be in accordance with the manufacturer's recommendations. For span lengths of less than 200 feet, flat aluminum armor rods may be used. Flat armor rods, not less than 0.03 by 0.25 inch shall be used on No. 1 AWG AAC and AAAC and smaller conductors and on No. 5 AWG ACSR and smaller conductors. On larger sizes, flat armor rods shall be not less than 0.05 by 0.30 inches. For span lengths of 200 feet or more, preformed round armor rods shall be used.

3.1.3.5 Ties

Provide ties on pin insulators tight against conductor and insulator and ends turned down flat against conductor so that no wire ends project.

3.1.3.6 Low-Voltage Insulated Cables

Low-voltage cables shall be supported on clevis fittings using spool insulators. Dead-end clevis fittings and suspensions insulators shall be provided where required for adequate strength. Dead-end construction shall provide a strength exceeding the rated breaking strength of the neutral messenger. Clevis attachments shall be provided with not less than 5/8 inch through-bolts. Secondary racks may be used when installed on wood poles and where the span length does not exceed 200 feet. Secondary racks shall be two-, three-, or four-wire, complete with spool insulators. Racks shall meet strength and deflection requirements for heavy-duty steel racks, and shall be rounded and smooth to avoid damage to conductor insulation. Each insulator shall be held in place with a 5/8 inch button-head bolt equipped with a nonferrous cotter pin, or equivalent, at the bottom. Racks for dead-ending four No. 4/0 AWG or four larger conductors shall be attached to poles with three 5/8 inch through-bolts. Other secondary racks shall be attached to poles with at least two 5/8 inch through-bolts. Minimum vertical spacing between conductors shall not be less than 8 inches.

3.1.3.7 Reinstalling Conductors

Existing conductors to be reinstalled or resagged shall be strung to "final" sag table values indicated for the particular conductor type and size involved.

3.1.3.8 New Conductor Installation

String new conductors to "initial" sag table values recommended by the manufacturer for conductor type and size of conductor and ruling span indicated.

3.1.3.9 Fittings

Dead end fittings, clamp or compression type, shall conform to written recommendations of conductor manufacturer and shall develop full ultimate strength of conductor.

3.1.3.10 Aluminum Connections

Make aluminum connections to copper or other material using only splices, connectors, lugs, or fittings designed for that specific purpose. Keep a copy of manufacturer's instructions for applying these fittings at job site for use of the inspector.

3.1.4 Pole Top Switch Installation

Install pole top switch strictly according to manufacturer's installation drawings and information.

3.1.4.1 Operating Handle

Locate approximately 5 feet above ground on field side of pole.

3.1.5 Recloser

Install recloser(s) strictly in accordance with manufacturer's instructions.

3.1.6 Sectionalizer

Install sectionalizer(s) strictly in accordance with manufacturer's instructions.

3.1.7 Risers

Secure galvanized steel conduits on poles by two hole galvanized steel pipe straps spaced as indicated and within 3 feet of any outlet or termination. Ground metallic conduits.

3.2 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.

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 FIELD QUALITY CONTROL

3.4.1 General

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 10 days prior to conducting tests. The Contractor shall furnish materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Field reports will be signed and dated by the Contractor.

3.4.2 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.4.3 Medium-Voltage Preassembled Cable Test

After installation, prior to connection to an existing system, and before the operating test, the medium-voltage preassembled cable system shall be given a high potential test. Direct-current voltage shall be applied on each phase conductor of the system by connecting conductors at one terminal and connecting grounds or metallic shieldings or sheaths of the cable at the other terminal for each test. Prior to the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The method, voltage, length of time, and other characteristics of the test for initial installation shall be in accordance with NEMA WC 74/ICEA S-93-639 for the particular type of cable installed, and shall not exceed the recommendations of IEEE 404 for cable joints unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, the Contractor shall make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

3.4.4 Sag and Tension Test

The Contracting Officer shall be given prior notice of the time schedule for stringing conductors or cables serving overhead medium-voltage circuits and reserves the right to witness the procedures used for ascertaining that initial stringing sags and tensions are in compliance with requirements for the applicable loading district and cable weight.

3.4.5 Low-Voltage Cable Test

For underground secondary or service laterals from overhead lines, the low-voltage cable, complete with splices, shall be tested for insulation

resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. The test voltage shall be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations of conductors in the same trench, duct, or cable, with other conductors in the same trench, duct, or conduit. The minimum value of insulation shall be:

R in megohms = (rated voltage in kV + 1) x 1000/(length of cable in feet)

Each cable failing this test shall be repaired or replaced. The repaired cable shall then be retested until failures have been eliminated.

3.4.6 Pre-Energization Services

The following services shall be performed on the equipment listed below. These services shall be performed subsequent to testing but prior to the initial energization. The equipment shall be inspected to insure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall be inspected for damage caused during installation or shipment and to ensure that packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer. Items for which such services shall be provided, but are not limited to, are the following:

Capacitors.

Switches.

3.4.7 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.

3.4.7.1 Overhead-Type Distribution Transformers

a. Visual and mechanical inspection

(1) Compare equipment nameplate information 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. Thermographic survey is not required.

(4) Perform specific inspections and mechanical tests as recommended by manufacturer.

(5) Verify correct equipment grounding.

b. Electrical tests

(1) Perform insulation-resistance tests.

(2) Perform continuity test.

3.4.7.2 Pole Top Interrupter Switch

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate information with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify appropriate equipment grounding.

(4) Perform mechanical operator tests in accordance with manufacturer's instructions.

(5) Verify correct blade alignment, blade penetration, travel stops, arc interrupter operation, and mechanical operation.

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform dc over-potential tests.

(3) Perform contact-resistance tests across each switch blade.

3.4.7.3 Reclosers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect alignment and grounding.

(4) Perform mechanical operation and contact alignment tests on both the recloser and its operating mechanism in accordance with manufacturer's instructions.

(5) Verify tightness of accessible bolted electrical connections.

(6) Inspect for correct insulating liquid level.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

(2) Perform a contact resistance test

(3) Sample insulating liquid. Sample shall be tested for:

(a) Dielectric breakdown voltage

(b) Color

(c) Visual condition

(4) Test protective functions.

(5) Perform overpotential tests.

(6) Determine time delay for each programmed reclosing interval.

(7) Verify lockout for unsuccessful reclosing.

(8) Determine reset time.

(9) Verify instantaneous overcurrent lockout.

3.4.7.4 Sectionalizers

a. Visual and Mechanical inspection

(1) Compare equipment nameplate data with approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect alignment and grounding.

(4) Perform mechanical operation and contact alignment tests on both the sectionalizer and its operating mechanism in accordance with manufacturer's instructions.

(5) Verify tightness of accessible bolted electrical connections.

(6) Inspect for correct insulating liquid level.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

(2) Perform a contact resistance test.

(3) Sample insulating liquid. Sample shall be tested for:

(a) Dielectric breakdown voltage

(b) Color

(c) Visual condition

(4) Perform overpotential tests.

(5) Test sectionalizer counting function.

(6) Test sectionalizer lockout function.

(7) Test for reset timing on trip actuator.

3.4.7.5 Grounding System

a. Visual and mechanical inspection

Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

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 testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be 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.

3.4.8 Devices Subject to Manual Operation

Each device subject to manual operation shall be operated at least three times, demonstrating satisfactory operation each time.

3.4.9 Follow-Up Verification

Upon completion of acceptance checks and tests, the Contractor shall 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, the Contracting Officer shall be given 5 working days advance notice of the dates and times of checking and testing.

-- End of Section --

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SECTION 33 71 02

UNDERGROUND ELECTRICAL DISTRIBUTION

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 HB-17	(2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 318M	(2011; Errata 2013) Building Code Requirements for Structural Concrete & Commentary
ACI SP-66	(2004) ACI Detailing Manual

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2013) specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B231/B231M	(2012) Standard Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors
ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B400/B400M	(2008; E 2013) Standard Specification for Compact Round Concentric-Lay-Stranded Aluminum 1350 Conductor

ASTM B496	(2014) Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors
ASTM B609/B609M	(2012) Standard Specification for Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical purposes
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B800	(2005; R 2011) Standard Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes-Annealed and Intermediate Tempers
ASTM B801	(2007; R 2012) Standard Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation
ASTM C139	(2011) Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C32	(2013) Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C478	(2013) Standard Specification for Precast Reinforced Concrete Manhole Sections
ASTM C478M	(2013) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C857	(2014) Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
ASTM C990	(2009; R 2014) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C990M	(2009; R 2014) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants (Metric)
ASTM F2160	(2010) Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)

ASTM F512	(2012) Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2006; INT 1 2011) Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V
IEEE 400.2	(2013) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)
IEEE 404	(2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V
IEEE 48	(2009) Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C135.30	(1988) Standard for Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013) National Electrical Safety Code
IEEE C37.20.3	(2013) Standard for Metal-Enclosed Interrupter Switchgear
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-94-649	(2013) Standard for Concentric Neutral Cables Rated 5 Through 46 KV

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2011) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts

ANSI/NEMA WC 71/ICEA S-96-659	(1999) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA C119.4	(2011) Electric Connectors - Connectors for Use Between Aluminum-to-Aluminum or Aluminum-to-Copper Conductors Designed for Normal Operation at or Below 93 Degrees C and Copper-to-Copper Conductors Designed for Normal Operation at or Below 100 Degrees C
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2013) Standard for Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 6 & 8	(2013) Standard for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations
NEMA TC 7	(2013) Standard for Smooth-Wall Coilable Electrical Polyethylene Conduit
NEMA TC 9	(2004) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation
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	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard

THE SOCIETY OF CABLE TELECOMMUNICATIONS ENGINEERS (SCTE)

ANSI/SCTE 77	(2013) Specification for Underground Enclosure Integrity

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1751F-644	(2002) Underground Plant Construction

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-60005	(Basic; Notice 2) Frames, Covers, Gratings, Steps, Sump And Catch Basin, Manhole

UNDERWRITERS LABORATORIES (UL)

UL 1072	(2006; Reprint Jun 2013) Medium-Voltage Power Cables
UL 1242	(2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 44	(2014) Thermoset-Insulated Wires and Cables
UL 467	(2007) Grounding and Bonding Equipment
UL 486A-486B	(2013; Reprint Feb 2014) Wire Connectors
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013) Metallic Outlet Boxes
UL 514B	(2012) Conduit, Tubing and Cable Fittings
UL 6	(2007; reprint Nov 2010) Electrical Rigid Metal Conduit-Steel
UL 651	(2011; Reprint May 2014) Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
UL 83	(2014) Thermoplastic-Insulated Wires and Cables
UL 854	(2004; Reprint Sep 2011) Standard for Service-Entrance Cables

1.2 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.

c. In the text of this section, "medium voltage cable splices," and "medium voltage cable joints" are used interchangeably and have the same meaning.

d. Underground structures subject to aircraft loading are indicated on the drawings.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Precast underground structures; G

SD-03 Product Data

Medium voltage cable; G

Medium voltage cable joints; G

Medium voltage cable terminations; G

Live end caps; G

Precast concrete structures; G

Sealing Material

Pulling-In Irons

Manhole frames and covers; G

Handhole frames and covers; G

Frames and Covers for Airfield Facilities; GDuctile Iron Frames and Covers for Airfield Facilities; GCable supports (racks, arms and insulators); G

SD-06 Test Reports

Medium voltage cable qualification and production tests; G

Field Acceptance Checks and Tests; G

Arc-proofing test for cable fireproofing tape; G

Cable Installation Plan and Procedure; G

Six copies of the information described below in 8-1/2 by 11 inch binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each cable pull. Separate sections by heavy plastic dividers with tabs, with all data sheets signed and dated by the person supervising the pull.

a. Site layout drawing with cable pulls numerically identified.

b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.

c. The cable manufacturer and type of cable.

d. The dates of cable pulls, time of day, and ambient temperature.

e. The length of cable pull and calculated cable pulling tensions.

f. The actual cable pulling tensions encountered during pull.

SD-07 Certificates

Cable splicer/terminator; G

Cable Installer Qualifications; G

Directional Boring Certificate of Conformance; G

1.4 QUALITY ASSURANCE

1.4.1 Precast Underground Structures

Submittal required for each type used. Provide calculations and drawings for precast manholes and handholes bearing the seal of a registered professional engineer including:

a. Material description (i.e., f'c and Fy)

b. Manufacturer's printed assembly and installation instructions

c. Design calculations

d. Reinforcing shop drawings in accordance with ACI SP-66

e. Plans and elevations showing opening and pulling-in iron locations and details

1.4.2 Certificate of Competency for Cable Splicer/Terminator

The cable splicer/terminator must have a certification from the National Cable Splicing Certification Board (NCSCB) in the field of splicing and terminating shielded medium voltage (5 kV to 35 kV) power cable using pre-manufactured kits (pre-molded, heat-shrink, cold shrink). Submit "Proof of Certification" for approval, for the individuals that will be performing cable splicer and termination work, 30 days before splices or terminations are to be made.

1.4.3 Cable Installer Qualifications

Provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. Provide a resume showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers. Cable installer must demonstrate experience with a minimum of three medium voltage cable installations. The Contracting Officer reserves the right to require additional proof of competency or to reject the individual and call for an alternate qualified cable installer.

1.4.4 Directional Boring Certificate of Conformance

Provide certification of compliance with the registered Professional Engineer's design requirements for each directional bore, including: HDPE conduit size and type, bend radius, elevation changes, vertical and horizontal path deviations, conductor size and type and any conductor derating due to depth of conduit. Record location and depth of all directional-bore installed HDPE conduits using Global Positioning System (GPS) recording means with "resource grade" accuracy.

1.4.5 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 IEEE C2 and NFPA 70 unless more stringent requirements are specified or indicated.

1.4.6 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. Products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for 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 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.

1.4.6.1 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.

1.4.6.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable, unless specified otherwise.

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Rigid Metal Conduit

UL 6.

2.1.2 Intermediate Metal Conduit

UL 1242.

2.1.3 Plastic Conduit for Direct Burial

UL 651, Schedule 40 as indicated.

2.1.4 Plastic Duct for Concrete Encasement

UL 651 and ASTM F512, NEMA TC 6 & 8, Type EB-20-PVCNEMA TC 2, Type EPC-40-PVC or as indicated.

2.1.5 High Density Polyethylene (HDPE) Electrical Conduit for Directional Boring

Smoothwall, approved/listed for directional boring, minimum Schedule 80, ASTM F2160, NEMA TC 7.

2.1.6 Innerduct

Provide corrugated or solid wall polyethylene (PE) or PVC innerducts, or fabric-mesh innerducts, with pullwire. Size as indicated.

2.1.7 Conduit Sealing Compound

Compounds for sealing ducts and conduit must have a putty-like consistency workable with the hands at temperatures as low as 35 degrees F, must neither slump at a temperature of 300 degrees F, nor harden materially when exposed to the air. Compounds must adhere to clean surfaces of fiber or plastic ducts; metallic conduits or conduit coatings; concrete, masonry, or lead; any cable sheaths, jackets, covers, or insulation materials; and the common metals. Compounds must form a seal without dissolving, noticeably changing characteristics, or removing any of the ingredients. Compounds must have no injurious effect upon the hands of workmen or upon materials. Inflatable bladders may be used as an option.

2.1.8 Fittings

2.1.8.1 Metal Fittings

UL 514B.

2.1.8.2 PVC Conduit Fittings

UL 514B, UL 651.

2.1.8.3 PVC Duct Fittings

NEMA TC 9.

2.1.8.4 Outlet Boxes for Steel Conduit

Outlet boxes for use with rigid or flexible steel conduit must be cast-metal cadmium or zinc-coated if of ferrous metal with gasketed closures and must conform to UL 514A.

2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

Insulated conductors must be rated 600 volts and conform to the requirements of NFPA 70, including listing requirements. Wires and cables manufactured more than 12 months prior to date of delivery to the site are not acceptable. Service entrance conductors must conform to UL 854, type

USE.

2.2.1 Conductor Types

Cable and duct sizes indicated are for copper conductors and THHN/THWN unless otherwise noted. Conductors No. 10 AWG and smaller must be solid. Conductors No. 8 AWG and larger must be stranded. All conductors must be copper.

2.2.2 Conductor Material

Unless specified or indicated otherwise or required by NFPA 70, wires in conduit, other than service entrance, must be 600-volt, Type THWN/THHN conforming to UL 83. Copper conductors must be annealed copper complying with ASTM B3 and ASTM B8.

2.2.3 In Duct

2.2.4 Cable Marking

Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout the cable length.

Identify each cable by means of a fiber, laminated plastic, or non-ferrous metal tags, or approved equal, in each manhole, handhole, junction box, and each terminal. Each tag must contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification.

Conductors must be color coded. Provide conductor identification within each enclosure where a tap, splice, or termination is made. Conductor identification must be by color-coded insulated conductors, plastic-coated self-sticking printed markers, colored nylon cable ties and plates, heat shrink type sleeves,or colored electrical tape. Control circuit terminations must be properly identified. Color must be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutrals must be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems must be 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

2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

Must provide a uniform compression over the entire conductor contact surface. Use solderless terminal lugs on stranded conductors.

a. For use with copper conductors: UL 486A-486B.

2.4 LOW VOLTAGE SPLICES

Provide splices in conductors with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with ANSI C119.1.

2.4.1 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material applied in accordance with the manufacturer's written instructions.

2.4.2 Cold Shrink Rubber Splice

Provide a cold-shrink rubber splice which consists of EPDM rubber tube which has been factory stretched onto a spiraled core which is removed during splice installation. The installation must not require heat or flame, or any additional materials such as covering or adhesive. It must be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

2.5 MEDIUM VOLTAGE CABLE

Cable (conductor) sizes are designated by American Wire Gauge (AWG) and Thousand Circular Mils (Kcmil). Conductor and conduit sizes indicated are for copper conductors unless otherwise noted. Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout cable length. Wires and cables manufactured more than 12 months prior to date of delivery to the site are not acceptable. Provide single conductor type cables unless otherwise indicated.

2.5.1 Cable Configuration

Provide Type MV cable, conforming to NEMA WC 74/ICEA S-93-639 and UL 1072 . Provide cables manufactured for use in duct applications. Cable must be rated 5 kV with 133 percent insulation level.

2.5.2 Conductor Material

Provide concentric-lay-stranded, Class B conductors. Provide soft drawn copper cables complying with ASTM B3 and ASTM B8 for regular concentric and compressed stranding or ASTM B496 for compact stranding.

2.5.3 Insulation

Provide ethylene-propylene-rubber (EPR) insulation conforming to the requirements of ANSI/NEMA WC 71/ICEA S-96-659 and AEIC CS8.

2.5.4 Shielding

Cables rated for 2 kV and above must have a semiconducting conductor shield, a semiconducting insulation shield, and an overall copper tape shield for each phase.

2.5.5 Neutrals

Neutral conductors must be copper, employing the same insulation and jacket materials as phase conductors, except that a 600-volt insulation rating is acceptable.

2.5.6 Jackets

Provide cables with a PVC jacket. Provide PVC jackets with a separator that prevents contact with underlying semiconducting insulating shield. Provide jackets with different colors as indicated on the drawings.

2.6 MEDIUM VOLTAGE CABLE TERMINATIONS

IEEE 48 Class 1; of the molded elastomer, prestretched elastomer, or heat-shrinkable elastomer. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations, where required, must be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, or armor. Terminations must be provided in a kit, including: skirts, stress control terminator, ground clamp, connectors, lugs, and complete instructions for assembly and installation. Terminations must be the product of one manufacturer, suitable for the type, diameter, insulation class and level, and materials of the cable terminated. Do not use separate parts of copper or copper alloy in contact with aluminum alloy parts in the construction or installation of the terminator.

2.6.1 Cold-Shrink Type

Terminator must be a one-piece design, utilizing the manufacturer's latest technology, where high-dielectric constant (capacitive) stress control is integrated within a skirted insulator made of silicone rubber. Termination must not require heat or flame for installation. Termination kit must contain all necessary materials (except for the lugs). Termination must be designed for installation in low or highly contaminated indoor and outdoor locations and must resist ultraviolet rays and oxidative decomposition.

2.6.2 Heat Shrinkable Type

Terminator must consist of a uniform cross section heat shrinkable polymeric construction stress relief tubing and environmentally sealed outer covering that is nontracking, resists heavy atmospheric contaminants, ultra violet rays and oxidative decomposition. Provide heat shrinkable sheds or skirts of the same material. Termination must be designed for installation in low or highly contaminated indoor or outdoor locations.

2.6.3 Separable Insulated Connector Type

IEEE 386. Provide connector with steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material. Provide connectors of the loadbreak or deadbreak type as indicated, of suitable construction for the application and the type of cable connected, and that include cable shield adaptors. Provide external clamping points and test points.

a. 200 Ampere loadbreak connector ratings: Voltage: 5 kV, 60 kV BIL. Short time rating: 10,000 rms symmetrical amperes.
b. 600 Ampere deadbreak connector ratings: Voltage: 5 kV, 60 kV BIL. Short time rating: 25,000 rms symmetrical amperes. Connectors must have 200 ampere bushing interface for surge arresters.

2.7 MEDIUM VOLTAGE CABLE JOINTS

Provide joints (splices) in accordance with IEEE 404 suitable for the rated voltage, insulation level, insulation type, and construction of the cable. Joints must be certified by the manufacturer for waterproof, submersible applications. Upon request, supply manufacturer's design qualification test report in accordance with IEEE 404. Connectors for joint must be tin-plated electrolytic copper, having ends tapered and having center stops to equalize cable insertion.

2.7.1 Heat-Shrinkable Joint

Consists of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system, a high dielectric strength insulating material, and an integrally bonded outer conductor layer for shielding. Replace original cable jacket with a heavy-wall heat-shrinkable sleeve with hot-melt adhesive coating.

2.7.2 Cold-Shrink Rubber-Type Joint

Joint must be of a cold shrink design that does not require any heat source for its installation. Splice insulation and jacket must be of a one-piece factory formed cold shrink sleeve made of black EPDM rubber. Splice must be packaged three splices per kit, including complete installation instructions.

2.8 TELECOMMUNICATIONS CABLING

Provide telecommunications cabling in accordance with Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

2.9 LIVE END CAPS

Provide live end caps using a "kit" including a heat-shrinkable tube and a high dielectric strength, polymeric plug overlapping the conductor. End cap must conform to applicable portions of IEEE 48.

2.10 TAPE

2.10.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.10.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section 31 23 00.00 20 EXCAVATION AND FILL.

2.10.3 Fireproofing Tape

Provide tape composed of a flexible conformable unsupported intumescent elastomer. Tape must be not less than .030 inch thick, noncorrosive to cable sheath, self-extinguishing, noncombustible, and must not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

2.11 PULL ROPE

Plastic or flat pull line (bull line) having a minimum tensile strength of 200 pounds.

2.12 GROUNDING AND BONDING

2.12.1 Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467 not less than 3/4 inch in diameter by 10 feet in length. Sectional type rods may be used for rods 20 feet or longer.

2.12.2 Grounding Conductors

Stranded-bare copper conductors must conform to ASTM B8, Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors must conform to ASTM B1 for sizes No. 8 and smaller. Insulated conductors must be of the same material as phase conductors and green color-coded, except that conductors must be rated no more than 600 volts. Aluminum is not acceptable.

2.13 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. In addition, provide concrete for encasement of underground ducts with 3000 psi minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts must be 4000 psi minimum 28-day compressive strength unless specified otherwise.

2.14 UNDERGROUND STRUCTURES

Provide precast concrete underground structures or standard type cast-in-place manhole types as indicated, conforming to ASTM C857 and ASTM C478. Top, walls, and bottom must consist of reinforced concrete. Walls and bottom must be of monolithic concrete construction. Locate duct entrances and windows near the corners of structures to facilitate cable racking. Covers must fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Install a pulling-in iron in the wall opposite each duct line entrance. Cable racks, including rack arms and insulators, must be adequate to accommodate the cable.

2.14.1 Cast-In-Place Concrete Structures

Concrete must conform to Section 03 30 00 CAST-IN-PLACE CONCRETE. Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers. Concrete block is not allowed in areas subject to aircraft loading.

2.14.2 Precast Concrete Structures, Risers and Tops

Precast concrete underground structures may be provided in lieu of cast-in-place subject to the requirements specified below. Precast units must be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes.

2.14.2.1 General

Precast concrete structures must have the same accessories and facilities as required for cast-in-place structures. Likewise, precast structures must have plan area and clear heights not less than those of cast-in-place structures. Concrete materials and methods of construction must be the same as for cast-in-place concrete construction, as modified herein. Slope in floor may be omitted provided precast sections are poured in reinforced steel forms. Concrete for precast work must have a 28-day compressive strength of not less than 4000 psi. Structures may be precast to the design and details indicated for cast-in-place construction, precast monolithically and placed as a unit, or structures may be assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. Structures must be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face.

2.14.2.2 Design for Precast Structures

ACI 318M. In the absence of detailed on-site soil information, design for the following soil parameters/site conditions:

a. Angle of Internal Friction (phi) = 30 degrees

b. Unit Weight of Soil (Dry) = 110 pcf, (Saturated) = 130 pcf

c. Coefficient of Lateral Earth Pressure (Ka) = 0.33

d. Ground Water Level = 3 feet below ground elevation

e. Vertical design loads must include full dead, superimposed dead, and live loads including a 30 percent magnification factor for impact. Live loads must consider all types and magnitudes of vehicular (automotive, industrial, or aircraft) traffic to be encountered. The minimum design vertical load must be for H20 highway loading per AASHTO HB-17.

f. Horizontal design loads must include full geostatic and hydrostatic pressures for the soil parameters, water table, and depth of installation to be encountered. Also, horizontal loads imposed by adjacent structure foundations, and horizontal load components of vertical design loads, including impact, must be considered, along with a pulling-in iron design load of 6000 pounds.

g. Each structural component must be designed for the load combination and positioning resulting in the maximum shear and moment for thatparticular component.

h. Design must also consider the live loads induced in the handling, installation, and backfilling of the manholes. Provide lifting devices to ensure structural integrity during handling and installation.

2.14.2.3 Construction

Structure top, bottom, and wall must be of a uniform thickness of not less than 6 inches. Thin-walled knock-out panels for designed or future duct bank entrances are not permitted. Provide quantity, size, and location of duct bank entrance windows as directed, and cast completely open by the precaster. Size of windows must exceed the nominal duct bank envelope dimensions by at least 12 inches vertically and horizontally to preclude in-field window modifications made necessary by duct bank misalignment. However, the sides of precast windows must be a minimum of 6 inches from the inside surface of adjacent walls, floors, or ceilings. Form the perimeter of precast window openings to have a keyed or inward flared surface to provide a positive interlock with the mating duct bank envelope. Provide welded wire fabric reinforcing through window openings for in-field cutting and flaring into duct bank envelopes. Provide additional reinforcing steel comprised of at least two No. 4 bars around window openings. Provide drain sumps a minimum of 12 inches in diameter and 4 inches deep for precast structures.

2.14.2.4 Joints

Provide tongue-and-groove joints on mating edges of precast components. Shiplap joints are not allowed. Design joints to firmly interlock adjoining components and to provide waterproof junctions and adequate shear transfer. Seal joints watertight using preformed plastic strip conforming to ASTM C990. Install sealing material in strict accordance with the sealant manufacturer's printed instructions. Provide waterproofing at conduit/duct entrances into structures, and where access frame meets the top slab, provide continuous grout seal.

2.14.3 Manhole Frames and Covers

Provide cast iron frames and covers for manholes conforming to CID A-A-60005. Cast the words "ELECTRIC" or "TELECOMMUNICATIONS" in the top face of power and telecommunications manhole covers, respectively.

2.14.4 Handhole Frames and Covers

Frames and covers of steel must be welded by qualified welders in accordance with standard commercial practice. Steel covers must be rolled-steel floor plate having an approved antislip surface. Hinges must be of stainless steel with bronze hinge pin , 5 by 5 inches by approximately 3/16 inch thick, without screw holes, and must be for full surface application by fillet welding. Hinges must have nonremovable pins and five knuckles. The surfaces of plates under hinges must be true after the removal of raised antislip surface, by grinding or other approved method. Provide heavy duty spring access hatch.

2.14.5 Frames and Covers for Airfield Facilities

Fabricate frames and covers for airfield use of standard commercial grade steel welded by qualified welders in accordance with AWS D1.1/D1.1M. Covers must be of rolled steel floor plate having an approved anti-slip surface. Steel frames and covers must be hot dipped galvanized after fabrication. Provide heavy duty spring access hatch.

2.14.6 Ductile Iron Frames and Covers for Airfield Facilities

At the contractor's option, ductile iron covers and frames designed for a minimum proof load of 100,000 pounds may be provided in lieu of the steel frames and covers indicated. Covers must be of the same material as the frames (i.e. ductile iron frame with ductile iron cover, galvanized steel frame with galvanized steel cover). Perform proof loading in accordance with CID A-A-60005 and ASTM A48/A48M. Proof loads must be physically stamped into the cover. Provide the Contracting Officer copies of previous proof load test results performed on the same frames and covers as proposed for this contract. Modify the top of the structure to accept the ductile iron structure in lieu of the steel structure indicated. The finished structure must be level and non-rocking, with the top flush with the surrounding pavement. Provide heavy duty spring access hatch.

2.15 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)

The metal portion of racks and arms must be zinc-coated after fabrication.

2.15.1 Cable Rack Stanchions

The wall bracket or stanchion must be 4 inches by approximately 1-1/2 inch by 3/16 inch channel steel, or 4 inches by approximately 1 inch glass-reinforced nylon with recessed bolt mounting holes, 48 inches long (minimum) in manholes. Slots for mounting cable rack arms must be spaced at 8 inch intervals.

2.15.2 Rack Arms

Cable rack arms must be steel or malleable iron or glass reinforced nylon and must be of the removable type. Rack arm length must be a minimum of 8 inches and a maximum of 12 inches.

2.16 CABLE TAGS IN MANHOLES

Provide tags for each power cable located in manholes. The tags must be polyethylene. Do not provide handwritten letters. The first position on the power cable tag must denote the voltage. The second through sixth positions on the tag must identify the circuit. The next to last position must denote the phase of the circuit and include the Greek "phi" symbol. The last position must denote the cable size. As an example, a tag could have the following designation: "11.5 NAS 1-8(Phase A)500," denoting that the tagged cable is on the 11.5kV system circuit number NAS 1-8, underground, Phase A, sized at 500 kcmil.

2.16.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F.

Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties must have a minimum loop tensile strength of 175 pounds. The cable tags must have black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols must not fall off or change positions regardless of the cable tags' orientation.

2.17 SOURCE QUALITY CONTROL

2.17.1 Arc-Proofing Test for Cable Fireproofing Tape

Manufacturer must test one sample assembly consisting of a straight lead tube 12 inches long with a 2 1/2 inch outside diameter, and a 1/8 inch thick wall, and covered with one-half lap layer of arc and fireproofing tape per manufacturer's instructions. The arc and fireproofing tape must withstand extreme temperature of a high-current fault arc 13,000 degrees K for 70 cycles as determined by using an argon directed plasma jet capable of constantly producing and maintaining an arc temperature of 13,000 degrees K. Temperature (13,000 degrees K) of the ignited arc between the cathode and anode must be obtained from a dc power source of 305 (plus or minus 5) amperes and 20 (plus or minus 1) volts. The arc must be directed toward the sample assembly accurately positioned 5 (plus or minus 1) millimeters downstream in the plasma from the anode orifice by fixed flow rate of argon gas (0.18 g per second). Each sample assembly must be tested at three unrelated points. Start time for tests must be taken from recorded peak current when the specimen is exposed to the full test temperature. Surface heat on the specimen prior to that time must be minimal. The end point is established when the plasma or conductive arc penetrates the protective tape and strikes the lead tube. Submittals for arc-proofing tape must indicate that the test has been performed and passed by the manufacturer.

2.17.2 Medium Voltage Cable Qualification and Production Tests

Results of AEIC CS8 qualification and production tests as applicable for each type of medium voltage cable.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of NFPA 70 and IEEE C2 as applicable. In addition to these requirements, install telecommunications in accordance with TIA-758 and RUS Bull 1751F-644.

3.2 CABLE INSPECTION

Inspect each cable reel for correct storage positions, signs of physical damage, and broken end seals prior to installation. If end seal is broken, remove moisture from cable prior to installation in accordance with the cable manufacturer's recommendations.

3.3 CABLE INSTALLATION PLAN AND PROCEDURE

Obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature limits for installation,

lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, maximum allowable pulling tension, and maximum allowable sidewall bearing pressure. Prepare a checklist of significant requirements.Perform pulling calculations and prepare a pulling plan and submit along with the manufacturer's instructions in accordance with SUBMITTALS. Install cable strictly in accordance with the cable manufacturer's recommendations and the approved installation plan.

Calculations and pulling plan must include:

a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.

b. List of cable installation equipment.

c. Lubricant manufacturer's application instructions.

d. Procedure for resealing cable ends to prevent moisture from entering cable.

e. Cable pulling tension calculations of all cable pulls.

f. Cable percentage conduit fill.

g. Cable sidewall bearing pressure.

h. Cable minimum bend radius and minimum diameter of pulling wheels used.

i. Cable jam ratio.

j. Maximum allowable pulling tension on each different type and size of conductor.

k. Maximum allowable pulling tension on pulling device.

3.4 UNDERGROUND FEEDERS SUPPLYING BUILDINGS

Terminate underground feeders supplying building at a point 5 feet outside the building and projections thereof, except that conductors must be continuous to the terminating point indicated. Coordinate connections of the feeders to the service entrance equipment with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide PVC, Type EPC-40 conduit from the supply equipment to a point 5 feet outside the building and projections thereof. Protect ends of underground conduit with plastic plugs until connections are made.

Encase the underground portion of the conduit in a concrete envelope and bury as specified for underground duct with concrete encasement.

3.5 UNDERGROUND STRUCTURE CONSTRUCTION

Provide standard type cast-in-place construction as specified herein and as indicated, or precast construction as specified herein. Horizontal concrete surfaces of floors must have a smooth trowel finish. Cure concrete by applying two coats of white pigmented membrane forming-curing compound in strict accordance with the manufacturer's printed instructions, except that precast concrete may be steam cured. Curing compound must conform to ASTM C309. Locate duct entrances and windows in

the center of end walls (shorter) and near the corners of sidewalls (longer) to facilitate cable racking and splicing. Covers for underground structures must fit the frames without undue play. Steel and iron must be formed to shape and size with sharp lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Manhole locations, as indicated, are approximate. Coordinate exact manhole locations with other utilities and finished grading and paving.

3.5.1 Cast-In-Place Concrete Structures

Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers. Concrete block is not allowed in areas subject to aircraft loading.

3.5.2 Precast Concrete Construction

Set commercial precast structures on 6 inches of level, 90 percent compacted granular fill, 3/4 inch to 1 inch size, extending 12 inches beyond the structure on each side. Compact granular fill by a minimum of four passes with a plate type vibrator. Installation must additionally conform to the manufacturer's instructions.

3.5.3 Pulling-In Irons

Provide steel bars bent as indicated, and cast in the walls and floors. Alternatively, pipe sleeves may be precast into the walls and floors where required to accept U-bolts or other types of pulling-in devices possessing the strengths and clearances stated herein. The final installation of pulling-in devices must be made permanent. Cover and seal exterior projections of thru-wall type pulling-in devices with an appropriate protective coating. In the floor the irons must be a minimum of 6 inches from the edge of the sump, and in the walls the irons must be located within 6 inches of the projected center of the duct bank pattern or precast window in the opposite wall. However, the pulling-in iron must not be located within 6 inches of an adjacent interior surface, or duct or precast window located within the same wall as the iron. If a pulling-in iron cannot be located directly opposite the corresponding duct bank or precast window due to this clearance limitation, locate the iron directly above or below the projected center of the duct bank pattern or precast window the minimum distance required to preserve the 6 inch clearance previously stated. In the case of directly opposing precast windows, pulling-in irons consisting of a 3 foot length of No. 5 reinforcing bar, formed into a hairpin, may be cast-in-place within the precast windows simultaneously with the end of the corresponding duct bank envelope. Irons installed in this manner must be positioned directly in line with, or when not possible, directly above or below the projected center of the duct bank pattern entering the opposite wall, while maintaining a minimum clear distance of 3 inches from any edge of the cast-in-place duct bank envelope or any individual duct. Pulling-in irons must have a clear projection into the structure of approximately 4 inches and must be designed to withstand a minimum pulling-in load of 6000 pounds. Irons must be hot-dipped galvanized after fabrication.

3.5.4 Cable Racks, Arms and Insulators

Cable racks, arms and insulators must be sufficient to accommodate the

cables. Space racks in power manholes not more than 3 feet apart, and provide each manhole wall with a minimum of two racks. Space racks in signal manholes not more than 16 1/2 inches apart with the end rack being no further than 12 inches from the adjacent wall. Methods of anchoring cable racks must be as follows:

a. Provide a 5/8 inch diameter by 5 inch long anchor bolt with 3 inch foot cast in structure wall with 2 inch protrusion of threaded portion of bolt into structure. Provide 5/8 inch steel square head nut on each anchor bolt. Coat threads of anchor bolts with suitable coating immediately prior to installing nuts.

b. Provide concrete channel insert with a minimum load rating of 800 pounds per foot. Insert channel must be steel of the same length as "vertical rack channel;" channel insert must be cast flush in structure wall. Provide 5/8 inch steel nuts in channel insert to receive 5/8 inch diameter by 3 inch long steel, square head anchor bolts.

c. Provide concrete "spot insert" at each anchor bolt location, cast flush in structure wall. Each insert must have minimum 800 pound load rating. Provide 5/8 inch diameter by 3 inch long steel, square head anchor bolt at each anchor point. Coat threads of anchor bolts with suitable coating immediately prior to installing bolts.

3.5.5 Field Painting

Cast-iron frames and covers not buried in concrete or masonry must be cleaned of mortar, rust, grease, dirt and other deleterious materials, and given a coat of bituminous paint.

3.6 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.6.1 Requirements

Run conduit in straight lines except where a change of direction is necessary. Provide numbers and sizes of ducts as indicated. Ducts must have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of 3 inches per 100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius must be 18 inches for ducts of less than 3 inch diameter, and 36 inches for ducts 3 inches or greater in diameter. Otherwise, long sweep bends having a minimum radius of 25 feet must be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends, but the maximum curve used must be 30 degrees and manufactured bends must be used. Provide ducts with end bells whenever duct lines terminate in structures.

3.6.2 Treatment

Ducts must be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers must be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer must be used whenever an existing duct is connected to a duct of different material or shape. Ducts must be stored to avoid warping and

deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts must be thoroughly cleaned before being laid. Plastic ducts must be stored on a flat surface and protected from the direct rays of the sun.

3.6.3 Conduit Cleaning

As each conduit run is completed, for conduit sizes 3 inches and larger, draw a flexible testing mandrel approximately 12 inches long with a diameter less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. For conduit sizes less than 3 inches, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs.

3.6.4 Jacking and Drilling Under Roads and Structures

Conduits to be installed under existing paved areas which are not to be disturbed, and under roads and railroad tracks, must be zinc-coated, rigid steel, jacked into place. Where ducts are jacked under existing pavement, rigid steel conduit must be installed because of its strength. To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 50 feet in length, the predrilling method or the jack-and-sleeve method will be used. Separators or spacing blocks must be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 4 feet on centers.

3.6.5 Galvanized Conduit Concrete Penetrations

Galvanized conduits which penetrate concrete (slabs, pavement, and walls) in wet locations must be PVC coated and must extend from at least 2 inches within the concrete to the first coupling or fitting outside the concrete (minimum of 6 inches from penetration).

3.6.6 Multiple Conduits

Separate multiple conduits by a minimum distance of 3 inches, except that light and power conduits must be separated from control, signal, and telephone conduits by a minimum distance of 12 inches. Stagger the joints of the conduits by rows (horizontally) and layers (vertically) to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly must consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 10 feet of conduit assembly.

3.6.7 Conduit Plugs and Pull Rope

New conduit indicated as being unused or empty must be provided with plugs on each end. Plugs must contain a weephole or screen to allow water drainage. Provide a plastic pull rope having 3 feet of slack at each end of unused or empty conduits.

3.6.8 Conduit and Duct Without Concrete Encasement

Depths to top of the conduit must be not less than 24 inches below finished grade. Provide not less than 3 inches clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 3 inches, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 1/4 inch sieve. The first 6 inch layer of backfill cover must be sand compacted as previously specified. The rest of the excavation must be backfilled and compacted in 3 to 6 inch layers. Provide color, type and depth of warning tape as specified in Section 31 23 00.00 20 EXCAVATION AND FILL.

3.6.8.1 Encasement Under Roads and Structures

Under roads, paved areas, and railroad tracks, install conduits in concrete encasement of rectangular cross-section providing a minimum of 3 inch concrete cover around ducts. Concrete encasement must extend at least 5 feet beyond the edges of paved areas and roads, and 12 feet beyond the rails on each side of railroad tracks. Depths to top of the concrete envelope must be not less than 24 inches below finished grade.

3.6.8.2 Directional Boring

HDPE conduits must be installed below the frostline and as specified herein.

For distribution voltages greater than 1000 volts and less than 34,500 volts, depths to the top of the conduit must not be less than 48 inches in pavement-covered areas and not less than 120 inches in non-pavement-covered areas. For distribution voltages less than 1000 volts, depths to the top of the conduit must not be less than 48 inches in pavement- or non-pavement-covered areas. For branch circuit wiring less than 600 volts, depths to the top of the conduit must not be less than 24 inches in pavement- or non-pavement-covered areas.

3.6.9 Duct Encased in Concrete

Construct underground duct lines of individual conduits encased in concrete. Do not mix different kinds of conduit in any one duct bank. Concrete encasement surrounding the bank must be rectangular in cross-section and must provide at least 3 inches of concrete cover for ducts. Separate conduits by a minimum concrete thickness of 3 inches. Before pouring concrete, anchor duct bank assemblies to prevent the assemblies from floating during concrete pouring. Anchoring must be done by driving reinforcing rods adjacent to duct spacer assemblies and attaching the rods to the spacer assembly. Provide color, type and depth of warning tape as specified in Section 31 23 00.00 20 EXCAVATION AND FILL.

3.6.9.1 Connections to Manholes

Duct bank envelopes connecting to underground structures must be flared to have enlarged cross-section at the manhole entrance to provide additional shear strength. Dimensions of the flared cross-section must be larger than the corresponding manhole opening dimensions by no less than 12 inches in each direction. Perimeter of the duct bank opening in the underground structure must be flared toward the inside or keyed to provide a positive interlock between the duct bank and the wall of the structure. Use vibrators when this portion of the encasement is poured to assure a seal

between the envelope and the wall of the structure.

3.6.9.2 Connections to Existing Underground Structures

For duct bank connections to existing structures, break the structure wall out to the dimensions required and preserve steel in the structure wall. Cut steel and extend into the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.

3.6.9.3 Connections to Existing Concrete Pads

For duct bank connections to concrete pads, break an opening in the pad out to the dimensions required and preserve steel in pad. Cut the steel and extend into the duct bank envelope. Chip out the opening in the pad to form a key for the duct bank envelope.

3.6.9.4 Connections to Existing Ducts

Where connections to existing duct banks are indicated, excavate the banks to the maximum depth necessary. Cut off the banks and remove loose concrete from the conduits before new concrete-encased ducts are installed. Provide a reinforced concrete collar, poured monolithically with the new duct bank, to take the shear at the joint of the duct banks. Remove existing cables which constitute interference with the work.

3.6.9.5 Partially Completed Duct Banks

During construction wherever a construction joint is necessary in a duct bank, prevent debris such as mud, and, and dirt from entering ducts by providing suitable conduit plugs. Fit concrete envelope of a partially completed duct bank with reinforcing steel extending a minimum of 2 feet back into the envelope and a minimum of 2 feet beyond the end of the envelope. Provide one No. 4 bar in each corner, 3 inches from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately one footapart. Restrain reinforcing assembly from moving during concrete pouring.

3.6.9.6 Removal of Ducts

Where duct lines are removed from existing underground structures, close the openings to waterproof the structure. Chip out the wall opening to provide a key for the new section of wall.

3.7 CABLE PULLING

Test existing duct lines with a mandrel and thoroughly swab out to remove foreign material before pulling cables. Pull cables down grade with the feed-in point at the manhole or buildings of the highest elevation. Use flexible cable feeds to convey cables through manhole opening and into duct runs. Do not exceed the specified cable bending radii when installing cable under any conditions, including turnups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with tape shield must have a bending radius not less than 12 times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.7.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.8 CABLES IN UNDERGROUND STRUCTURES

Do not install cables utilizing the shortest path between penetrations, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space open for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each underground structure.

3.8.1 Cable Tag Installation

Install cable tags in each manhole as specified, including each splice. Tag wire and cable provided by this contract. 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.

3.9 CONDUCTORS INSTALLED IN PARALLEL

Conductors must be grouped such that each conduit of a parallel run contains 1 Phase A conductor, 1 Phase B conductor, 1 Phase C conductor, and 1 neutral conductor.

3.10 LOW VOLTAGE CABLE SPLICING AND TERMINATING

Make terminations and splices with materials and methods as indicated or specified herein and as designated by the written instructions of the manufacturer. Do not allow the cables to be moved until after the splicing material has completely set. Make splices in underground distribution systems only in accessible locations such as manholes, handholes, or aboveground termination pedestals.

3.11 MEDIUM VOLTAGE CABLE TERMINATIONS

Make terminations in accordance with the written instruction of the termination kit manufacturer.

3.12 MEDIUM VOLTAGE CABLE JOINTS

Provide power cable joints (splices) suitable for continuous immersion in water. Make joints only in accessible locations in manholes or handholes by using materials and methods in accordance with the written instructions of the joint kit manufacturer.

3.12.1 Joints in Shielded Cables

Cover the joined area with metallic tape, or material like the original cable shield and connect it to the cable shield on each side of the splice. Provide a bare copper ground connection brought out in a watertight manner and grounded to the manhole grounding loop as part of the splice installation. Ground conductors, connections, and rods must be

as specified elsewhere in this section. Wire must be trained to the sides of the enclosure to prevent interference with the working area.

3.13 CABLE END CAPS

Cable ends must be sealed at all times with coated heat shrinkable end caps. Cables ends must be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps must remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.14 LIVE END CAPS

Provide live end caps for single conductor medium voltage cables where indicated.

3.15 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES

Fireproof (arc proof) wire and cables which will carry current at 2200 volts or more in underground structures.

3.15.1 Fireproofing Tape

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Install tape in accordance with manufacturer's instructions.

3.16 GROUNDING SYSTEMS

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 5 ohms.

3.16.1 Grounding Electrodes

Provide cone pointed driven ground rods driven full depth plus 6 inches, installed to provide an earth ground of the appropriate value for the particular equipment being grounded.
If the specified ground resistance is not met, an additional ground rod must be provided in accordance with the requirements of NFPA 70 (placed not less than 6 feet from the first rod). Should the resultant (combined) resistance exceed the specified resistance, measured not less than 48 hours after rainfall, notify the Contracting Officer immediately.

3.16.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, by exothermic weld or 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 compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies must be as recommended by the manufacturer. An embossing die code or other

standard method must provide visible indication that a connector has been adequately compressed on the ground wire.

3.16.3 Grounding Conductors

Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with No. 6 AWG. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of handholes and pull boxes with a braided, copper ground strap with equivalent ampacity of No. 6 AWG.

3.16.4 Ground Cable Crossing Expansion Joints

Protect ground cables crossing expansion joints or similar separations in structures and pavements by use of approved devices or methods of installation which provide the necessary slack in the cable across the joint to permit movement. Use stranded or other approved flexible copper cable across such separations.

3.16.5 Manhole Grounding

Loop a 4/0 AWG grounding conductor around the interior perimeter, approximately 12 inches above finished floor. Secure the conductor to the manhole walls at intervals not exceeding 36 inches. Connect the conductor to the manhole grounding electrode with 4/0 AWG conductor. Connect all incoming 4/0 grounding conductors to the ground loop adjacent to the point of entry into the manhole. Bond the ground loop to all cable shields, metal cable racks, and other metal equipment with a minimum 6 AWG conductor.

3.17 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section 31 23 00.00 20 EXCAVATION AND FILL.

3.17.1 Reconditioning of Surfaces

3.17.1.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct . Preserve sod and topsoil removed during excavation and reinstall after backfilling is completed. Replace sod that is damaged by sod of quality equal to that removed. When the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding, and provide topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.

3.17.1.2 Paving Repairs

Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists , restore such surface treatment or pavement the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces.

3.18 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.18.1 Concrete Slabs for Equipment

Unless otherwise indicated, the slab must be at least 8 inches thick, reinforced with a 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 4 inches from the top of the slab. Slab must be placed on a 6 inch thick, well-compacted gravel base. Top of concrete slab must be approximately 4 inches above finished grade with gradual slope for drainage. Edges above grade must have 1/2 inch chamfer. Slab must be 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.

3.18.2 Sealing

When the installation is complete, seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals must be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.19 FIELD QUALITY CONTROL

3.19.1 Performance of Field 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.

3.19.1.1 Medium Voltage Cables

Perform tests after installation of cable, splices, and terminators and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Inspect for proper shield grounding, cable support, and cable termination.

(4) Verify that cable bends are not less than ICEA or manufacturer's minimum allowable bending radius.

(5) Inspect for proper fireproofing.

(6) Visually inspect jacket and insulation condition.

(7) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform a shield continuity test on each power cable by ohmmeter method. Record ohmic value, resistance values in excess of 10 ohms per 1000 feet of cable must be investigated and justified.

(2) Perform acceptance test on new cables before the new cables are connected to existing cables and placed into service, including terminations and joints. Perform maintenance test on complete cable system after the new cables are connected to existing cables and placed into service, including existing cable, terminations, and joints. Tests must be very low frequency (VLF) alternating voltage withstand tests in accordance with IEEE 400.2. VLF test frequency must be 0.05 Hz minimum for a duration of 60 minutes using a sinusoidal waveform. Test voltages must be as follows:

CABLE RATING AC TEST VOLTAGE for ACCEPTANCE TESTING	
5 kV	10kV rms(peak)

CABLE RATING AC TEST VOLTAGE for MAINTENANCE TESTING	
5 kV	7kV rms(peak)

3.19.1.2 Low Voltage Cables, 600-Volt

Perform tests after installation of cable, splices and terminations and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Verify tightness of accessible bolted electrical connections.

(4) Inspect compression-applied connectors for correct cable match and

indentation.

(5) Visually inspect jacket and insulation condition.

(6) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 1000 volts dc for one minute.

(2) Perform continuity tests to insure correct cable connection.

3.19.1.3 Grounding System

a. Visual and mechanical inspection

Inspect ground system for compliance with contract plans and specifications

b. Electrical tests

Perform ground-impedance measurements utilizing the fall-of-potential method in accordance with IEEE 81. 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 megohmmeter tester in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument must be 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.

3.19.2 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, the Contracting Officer must be given 5 working days advance notice of the dates and times of checking and testing.

-- End of Section --

SECTION 33 82 00

TELECOMMUNICATIONS OUTSIDE PLANT (OSP)

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.

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D709	(2013) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013) National Electrical Safety Code

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-87-640	(2011) Optical Fiber Outside Plant Communications Cable; 4th Edition
ICEA S-98-688	(2012) Broadband Twisted Pair Telecommunication Cable, Aircore, Polyolefin Insulated, Copper Conductors Technical Requirements
ICEA S-99-689	(2012) Broadband Twisted Pair Telecommunication Cable Filled, Polyolefin Insulated, Copper Conductors Technical Requirements

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C62.61	(1993) American National Standard for Gas Tube Surge Arresters on Wire Line Telephone Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-455-107	(1999a) FOTP-107 Determination of Component Reflectance or Link/System Return Loss using a Loss Test Set
TIA-455-46A	(1990) FOTP-46 Spectral Attenuation Measurement for Long-Length, Graded-Index Optical Fibers
TIA-455-78-B	(2002) FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures - Attenuation
TIA-472D000	(2007b) Fiber Optic Communications Cable for Outside Plant Use
TIA-492AAAA	(2009b) 62.5-um Core Diameter/125-um Cladding Diameter Class 1a Graded-Index Multimode Optical Fibers
TIA-492AAAB	(2009a) 50-Um Core Diameter/125-Um Cladding Diameter Class IA Graded-Index Multimode Optical Fibers
TIA-492CAAA	(1998; R 2002) Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers
TIA-492E000	(1996; R 2002) Sectional Specification for Class IVd Nonzero-Dispersion Single-Mode Optical Fibers for the 1550 nm Window
TIA-526-14	(2010b) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
TIA-526-7	(2002; R 2008) OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
TIA-568-C.1	(2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard
TIA-568-C.2	(2009; Errata 2010) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568-C.3	(2008; Add 1 2011) Optical Fiber Cabling Components Standard
TIA-569	(2012c; Addendum 1 2013; Errata 2013)

	Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-590	(1997a) Standard for Physical Location and Protection of Below Ground Fiber Optic Cable Plant
TIA-606	(2012b) Administration Standard for the Telecommunications Infrastructure
TIA-607	(2011b) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard
TIA/EIA-455	(1998b) Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
TIA/EIA-455-204	(2000) Standard for Measurement of Bandwidth on Multimode Fiber
TIA/EIA-598	(2005c) Optical Fiber Cable Color Coding

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS 1755	Telecommunications Standards and Specifications for Materials, Equipment and Construction
RUS Bull 1751F-630	(1996) Design of Aerial Plant
RUS Bull 1751F-640	(1995) Design of Buried Plant, Physical Considerations
RUS Bull 1751F-643	(2002) Underground Plant Design
RUS Bull 1751F-815	(1979) Electrical Protection of Outside Plant
RUS Bull 1753F-201	(1997) Acceptance Tests of Telecommunications Plant (PC-4)
RUS Bull 1753F-401	(1995) Splicing Copper and Fiber Optic Cables (PC-2)
RUS Bull 345-50	(1979) Trunk Carrier Systems (PE-60)
RUS Bull 345-65	(1985) Shield Bonding Connectors (PE-65)
RUS Bull 345-72	(1985) Filled Splice Closures (PE-74)

RUS Bull 345-83	(1979; Rev Oct 1982) Gas Tube Surge Arrestors (PE-80)

UNDERWRITERS LABORATORIES (UL)

UL 497	(2001; Reprint Jul 2013) Protectors for Paired Conductor Communication Circuits
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 83	(2008) Thermoplastic-Insulated Wires and Cables

1.2 RELATED REQUIREMENTS

N, andSection 33 71 02, UNDERGROUND ELECTRICAL DISTRIBUTION 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 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including antennae) including the entrance point at the building wall and continuing to the entrance room or space.

1.3.3 Entrance Room (ER) (Telecommunications)

A 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.

1.3.4 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).)

1.3.5 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The telecommunications outside plant consists of cable, conduit, manholes, poles, etc. required to provide signal paths from the closest point of presence to the new facility, including free standing frames or

backboards, interconnecting hardware, terminating cables, lightning and surge protection modules at the entrance facility. The work consists of providing, testing and making operational cabling, interconnecting hardware and lightning and surge protection necessary to form a complete outside plant telecommunications system for continuous use.

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. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications Outside Plant; G

Telecommunications Entrance Facility Drawings; G

In addition to Section 01 33 00 SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

SD-03 Product Data

Wire and cable; G

Cable splices, and connectors; G

Closures; G

Building protector assemblies; G

Protector modules; G

Cross-connect terminal cabinets; G

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. 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 for certificates in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Pre-installation tests; G

Acceptance tests; G

Outside Plant Test Plan; G

SD-07 Certificates

Telecommunications Contractor Qualifications; G

Key Personnel Qualifications; G

Minimum Manufacturer's Qualifications; G

SD-08 Manufacturer's Instructions

Building protector assembly installation; G

Cable tensions; G

Fiber Optic Splices; G

Submit instructions prior to installation.

SD-09 Manufacturer's Field Reports

Factory Reel Test Data; G

SD-10 Operation and Maintenance Data

Telecommunications outside plant (OSP), Data Package 5; G

Commercial off-the-shelf manuals shall be provided for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications outside plant (OSP). 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 OUTSIDE PLANT SHOP DRAWINGS and TELECOMMUNICATIONS ENTRANCE FACILITY DRAWINGS.

SD-11 Closeout Submittals

Record Documentation; G

In addition to other requirements, provide in accordance with paragraph RECORD DOCUMENTATION.

1.6 QUALITY ASSURANCE

1.6.1 Shop 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. 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 Outside Plant Shop Drawings

Provide Outside Plant Design in accordance with TIA-758, RUS Bull 1751F-630 for aerial system design, and RUS Bull 1751F-643 for underground system

design. Provide T0 shop drawings that show the physical and logical connections from the perspective of an entire campus, such as actual building locations, exterior pathways and campus backbone cabling on plan view drawings, major system nodes, and related connections on the logical system drawings in accordance with TIA-606. Drawings shall include wiring and schematic diagrams for fiber optic and copper cabling and splices, copper conductor gauge and pair count, fiber pair count and type, pathway duct and innerduct arrangement, associated construction materials, and any details required to demonstrate that cable system has been coordinated and will properly support the switching and transmission system identified in specification and drawings. The telecommunications outside plant (OSP) shop drawings shall be included in the operation and maintenance manuals.

1.6.1.2 Telecommunications Entrance Facility Drawings

Provide T3 drawings for EF Telecommunications in accordance with TIA-606 that include telecommunications entrance facility 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.

1.6.2 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, the supervisor (if different from the installer), and the cable splicing and terminating personnel. 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 Qualifications

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 that include outside plant and broadband cabling within the past 3 years. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems in accordance with TIA-758 within the past 3 years.

1.6.2.2 Key Personnel Qualifications

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.

Cable splicing and terminating personnel assigned to the installation of this system or any of its components shall have training in the proper techniques and have a minimum of 3 years experience in splicing and terminating the specified cables. Modular splices shall be performed by factory certified personnel or under direct supervision of factory trained personnel for products used.

Supervisors and installers assigned to the installation of this system or any of its components 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 outside plant systems, including broadband cabling, 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's 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. In addition, cabling manufacturers shall have a minimum of 3 years experience in the manufacturing and factory testing of cabling which comply with ICEA S-87-640, ICEA S-98-688, and ICEA S-99-689.

1.6.3 Outside Plant Test Plan

Prepare and provide a complete and detailed test plan for field tests of the outside plant including a complete list of test equipment for the copper conductor and optical fiber cables, components, and accessories for approval by the Contracting Officer. Include a cut-over plan with procedures and schedules for relocation of facility station numbers without interrupting service to any active location. Submit the plan at least 30 days prior to tests for Contracting Officer approval. Provide outside plant testing and performance measurement criteria in accordance with TIA-568-C.1 and RUS Bull 1753F-201. Include procedures for certification, validation, and testing that includes fiber optic link performance criteria.

1.6.4 Standard Products

Provide materials and equipment that are standard products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and shall be the manufacturer's latest standard design that has been in satisfactory commercial or industrial use for at least 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. Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems. 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.

1.6.4.1 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 provided.

1.6.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6.5 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.

1.6.5.1 Independent Testing Organization Certificate

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.

1.7 DELIVERY, STORAGE, AND HANDLING

Ship cable on reels in 1000 feet length with a minimum overage of 10 percent. Radius of the reel drum shall not be smaller than the minimum bend radius of the cable. Wind cable on the reel so that unwinding can be done without kinking the cable. Two meters of cable at both ends of the cable shall be accessible for testing. Attach permanent label on each reel showing length, cable identification number, cable size, cable type, and date of manufacture. Provide water resistant label and the indelible writing on the labels. Apply end seals to each end of the cables to prevent moisture from entering the cable. Reels with cable shall be suitable for outside storage conditions when temperature ranges from minus 40 degrees C to plus 65 degrees C, with relative humidity from 0 to 100 percent. Equipment, other than cable, delivered and placed in storage shall be stored with protection from weather, humidity and temperature variation, dirt and dust, or other contaminants in accordance with manufacturer's requirements.

1.8 MAINTENANCE

1.8.1 Record Documentation

Provide the activity responsible for telecommunications system maintenance and administration a single complete and accurate set of record documentation for the entire telecommunications system with respect to this project.

Provide record documentation as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

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.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems.

2.2 TELECOMMUNICATIONS ENTRANCE FACILITY

2.2.1 Building Protector Assemblies

Provide self-contained 5 pin unit supplied with a field cable stub factory connected to protector socket blocks to terminate and accept protector modules for 25 pairs of outside cable. Building protector assembly shall have interconnecting hardware for connection to interior cabling at full capacity. Provide manufacturers instructions for building protector assembly installation. Provide copper cable interconnecting hardware as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.2.2 Protector Modules

Provide in accordance with UL 497 three-electrode gas tube or solid state type 5 pin rated for the application. Provide gas tube protection modules in accordance with RUS Bull 345-83 and shall be heavy duty, A>10kA, B>400, C>65A where A is the maximum single impulse discharge current, B is the impulse life and C is the AC discharge current in accordance with ANSI C62.61. The gas modules shall shunt high voltage to ground, fail short, and be equipped with an external spark gap and heat coils in accordance with UL 497. Provide the number of surge protection modules equal to the number of pairs of exterior cable of the building protector assembly.

2.2.3 Fiber Optic Terminations

Provide fiber optic cable terminations as specified in 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.3 CLOSURES

2.3.1 Copper Conductor Closures

2.3.1.1 Underground Cable Closures

a. Aboveground: Provide aboveground closures constructed of not less than 14 gauge steel and acceptable for stake mounting in accordance with RUS 1755.910. Closures shall be sized and contain a marker as indicated. Covers shall be secured to prevent unauthorized entry.

c. In vault or manhole: Provide underground closure suitable to house a straight, butt, and branch splice in a protective housing into which can be poured an encapsulating compound. Closure shall be of suitable thermoplastic, thermoset, or stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Encapsulating compound shall be reenterable and shall not alter the chemical stability of the closure. Provide filled splice cases in accordance with RUS Bull 345-72.

2.3.2 Fiber Optic Closures

2.3.2.1 In Vault or Manhole

Provide underground closure suitable to house splice organizer in a protective housing into which can be poured an encapsulating compound. Closure shall be of thermoplastic, thermoset, or stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Encapsulating compound shall be reenterable and shall not alter the chemical stability of the closure.

2.4 CABLE SPLICES, AND CONNECTORS

2.4.1 Copper Cable Splices

Provide multipair, foldback or in-line splices of a moisture resistant, two

-wire connector held rigidly in place to assure maximum continuity in accordance with RUS Bull 1753F-401. Cables greater than 25 pairs shall be spliced using multipair splicing connectors, which accommodate 25 pairs of conductors at a time. Provide correct connector size to accommodate the cable gauge of the supplied cable.

2.4.2 Copper Cable Splice Connector

Provide splice connectors with a polycarbonate body and cap and a tin-plated brass contact element. Connector shall accommodate 22 to 26 AWG solid wire with a maximum insulation diameter of 0.065 inch. Fill connector with sealant grease to make a moisture resistant connection, in accordance with RUS Bull 1753F-401.

2.4.3 Fiber Optic Cable Splices

Provide fiber optic cable splices and splicing materials for fusion methods at locations shown on the construction drawings. The splice insertion loss shall be 0.3 dB maximum when measured in accordance with TIA-455-78-B using an Optical Time Domain Reflectometer (OTDR). Splices shall be designed for a return loss of 40.0 db max for single mode fiber when tested in accordance with TIA-455-107. Physically protect each fiber optic splice by a splice kit specially designed for the splice.

2.4.4 Shield Connectors

Provide connectors with a stable, low-impedance electrical connection between the cable shield and the bonding conductor in accordance with RUS Bull 345-65.

2.5 CONDUIT

Provide conduit as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.6 PLASTIC INSULATING TAPE

UL 510.

2.7 WIRE AND CABLE

2.7.1 Copper Conductor Cable

Solid copper conductors, covered with an extruded solid insulating compound. Insulated conductors shall be twisted into pairs which are then stranded or oscillated to form a cylindrical core. For special high frequency applications, the cable core shall be separated into compartments. Cable shall be completed by the application of a suitable core wrapping material, a corrugated copper or plastic coated aluminum shield, and an overall extruded jacket. Telecommunications contractor shall verify distances between splice points prior to ordering cable in specific cut lengths. Gauge of conductor shall determine the range of numbers of pairs specified; 19 gauge (6 to 400 pairs), 22 gauge (6 to 1200 pairs), 24 gauge (6 to 2100 pairs), and 26 gauge (6 to 3000 pairs). Copper conductor shall conform to the following:

2.7.1.1 Underground

Provide filled cable meeting the requirements of ICEA S-99-689 and

RUS 1755.390 RUS 1755.890.

2.7.1.2 Screen

Provide screen-compartmental core cable filled cable meeting the requirements of ICEA S-99-689 and RUS 1755.390.

2.7.2 Fiber Optic Cable

Provide single-mode, 8/125-um, 0.10 aperture 1550 nm fiber optic cable in accordance with TIA-492E000, TIA-472D000, and ICEA S-87-640 including any special requirements made necessary by a specialized design. Provide optical fibers as indicated. Fiber optic cable shall be specifically designed for outside use with loose buffer construction. Provide fiber optic color code in accordance with TIA/EIA-598

2.7.2.1 Strength Members

Provide central, strength members with sufficient tensile strength for installation and residual rated loads to meet the applicable performance requirements in accordance with ICEA S-87-640. The strength member is included to serve as a cable core foundation to reduce strain on the fibers, and shall not serve as a pulling strength member.

2.7.2.2 Performance Requirements

Provide fiber optic cable with optical and mechanical performance requirements in accordance with ICEA S-87-640.

2.7.3 Grounding and Bonding Conductors

Provide grounding and bonding conductors in accordance with RUS 1755.200, TIA-607, IEEE C2, and NFPA 70. Solid bare copper wire meeting the requirements of ASTM B1 for sizes No. 8 AWG and smaller and stranded bare copper wire meeting the requirements of ASTM B8, for sizes No. 6 AWG and larger. Insulated conductors shall have 600-volt, Type TW insulation meeting the requirements of UL 83.

2.8 POLES AND HARDWARE

Provide poles and hardware as specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.2.9 CABLE TAGS IN MANHOLES, HANDHOLES, AND VAULTS

Provide tags for each telecommunications cable or wire located in manholes, handholes, and vaults. Cable tags shall be polyethylene and labeled in accordance with TIA-606. Handwritten labeling is unacceptable.

2.9.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties shall have a minimum loop tensile strength of 175 pounds. The cable tags shall have black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols shall not fall off or

change positions regardless of the cable tags' orientation.

2.10 BURIED WARNING AND IDENTIFICATION TAPE

Provide fiber optic media marking and protection in accordance with TIA-590. Provide color, type and depth of tape as specified in paragraph BURIED WARNING AND IDENTIFICATION TAPE in Section EXCAVATION AND FILL, 31 23 00.00 20.

2.11 GROUNDING BRAID

Provide grounding braid that provides low electrical impedance connections for dependable shield bonding in accordance with RUS 1755.200. Braid shall be made from flat tin-plated copper.

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

Provide laminated plastic nameplates in accordance with ASTM D709 for each patch panel, protector assembly, rack, cabinet and other equipment 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 inch 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 inch high normal block style.

2.14 TESTS, INSPECTIONS, AND VERIFICATIONS

2.14.1 Factory Reel Test Data

Test 100 percent OTDR test of FO media at the factory in accordance with TIA-568-C.1 and TIA-568-C.3. Use TIA-526-7 for single mode fiber and TIA-526-14 Method B for multi mode fiber measurements. Calibrate OTDR to show anomalies of 0.2 dB minimum. Enhanced performance filled OSP copper cables, referred to as Broadband Outside Plant (BBOSP), shall meet the requirements of ICEA S-99-689. Enhanced performance air core OSP copper cables shall meet the requirements of ICEA S-98-688. Submit test reports, including manufacture date for each cable reel and receive approval before delivery of cable to the project site.

PART 3 EXECUTION

3.1 INSTALLATION

Install all system components and appurtenances in accordance with manufacturer's instructions IEEE C2, NFPA 70, and as indicated. Provide all necessary interconnections, services, and adjustments required for a complete and operable telecommunications system.

3.1.1 Contractor Damage

Promptly repair indicated utility lines or systems damaged during site

preparation and construction. Damages to lines or systems not indicated, which are caused by Contractor operations, shall be treated as "Changes" under the terms of the Contract Clauses. When Contractor is advised in writing of the location of a nonindicated line or system, such notice shall provide that portion of the line or system with "indicated" status in determining liability for damages. In every event, immediately notify the Contracting Officer of damage.

3.1.2 Cable Inspection and Repair

Handle cable and wire provided in the construction of this project with care. Inspect cable reels for cuts, nicks or other damage. Damaged cable shall be replaced or repaired to the satisfaction of the Contracting Officer. Reel wraps shall remain intact on the reel until the cable is ready for placement.

3.1.3 Underground Duct

Provide underground duct and connections to existing manholes, handholes, concrete pads, and existing ducts as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION with any additional requirements as specified herein.

3.1.4 Reconditioning of Surfaces

Provide reconditioning of surfaces as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.1.5 Penetrations

Caulk and seal cable access penetrations in walls, ceilings and other parts of the building. Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.1.6 Cable Pulling

Test duct lines with a mandrel and swab out to remove foreign material before the pulling of cables. Avoid damage to cables in setting up pulling apparatus or in placing tools or hardware. Do not step on cables when entering or leaving the manhole. Do not place cables in ducts other than those shown without prior written approval of the Contracting Officer. Roll cable reels in the direction indicated by the arrows painted on the reel flanges. Set up cable reels on the same side of the manhole as the conduit section in which the cable is to be placed. Level the reel and bring into proper alignment with the conduit section so that the cable pays off from the top of the reel in a long smooth bend into the duct without twisting. Under no circumstances shall the cable be paid off from the bottom of a reel. Check the equipment set up prior to beginning the cable pulling to avoid an interruption once pulling has started. Use a cable feeder guide of suitable dimensions between cable reel and face of duct to protect cable and guide cable into the duct as it is paid off the reel. As cable is paid off the reel, lubricate and inspect cable for sheath defects. When defects are noticed, stop pulling operations and notify the Contracting Officer to determine required corrective action. Cable pulling shall also be stopped when reel binds or does not pay off freely. Rectify cause of binding before resuming pulling operations. Provide cable lubricants recommended by the cable manufacturer. Avoid bends in cables of small radii and twists that might cause damage. Do not

bend cable and wire in a radius less than 10 times the outside diameter of the cable or wire.

3.1.6.1 Cable Tensions

Obtain from the cable manufacturer and provide to the Contracting Officer, the maximum allowable pulling tension. This tension shall not be exceeded.

3.1.6.2 Pulling Eyes

Equip cables 1.25 inches in diameter and larger with cable manufacturer's factory installed pulling-in eyes. Provide cables with diameter smaller than 1.25 inches with heat shrinkable type end caps or seals on cable ends when using cable pulling grips. Rings to prevent grip from slipping shall not be beaten into the cable sheath. Use a swivel of 3/4 inch links between pulling-in eyes or grips and pulling strand.

3.1.6.3 Installation of Cables in Manholes, Handholes, and Vaults

Do not install cables utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support cables on brackets and cable insulators at a maximum of 4 feet. In existing manholes, handholes, and vaults where new ducts are to be terminated, or where new cables are to be installed, modify the existing installation of cables, cable supports, and grounding as required with cables arranged and supported as specified for new cables. Identify each cable with corrosion-resistant embossed metal tags.

3.1.7 Cable Splicing

3.1.7.1 Copper Conductor Splices

Perform splicing in accordance with requirements of RUS Bull 1753F-401 except that direct buried splices and twisted and soldered splices are not allowed. Exception does not apply for pairs assigned for carrier application.

3.1.7.2 Fiber Optic Splices

Fiber optic splicing shall be in accordance with manufacturer's recommendation and shall exhibit an insertion loss not greater than 0.2 dB for fusion splices.

3.1.8 Surge Protection

All cables and conductors, except fiber optic cable, which serve as communication lines through off-premise lines, shall have surge protection installed at each end which meet the requirements of RUS Bull 1751F-815.

3.1.9 Grounding

Provide grounding and bonding in accordance with RUS 1755.200, TIA-607, IEEE C2, and NFPA 70. Ground exposed noncurrent carrying metallic parts of telephone equipment, cable sheaths, cable splices, and terminals.

3.1.9.1 Telecommunications Master Ground Bar (TMGB)

The TMGB is the hub of the basic telecommunications grounding system

providing a common point of connection for ground from outside cable, CD, and equipment. Establish a TMGB for connection point for cable stub shields to connector blocks and CD protector assemblies as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.9.2 Incoming Cable Shields

Shields shall not be bonded across the splice to the cable stubs. Ground shields of incoming cables in the EF Telecommunications to the TMGB.

3.1.10 Cut-Over

All necessary transfers and cut-overs, shall be accomplished by the telecommunications contractor.

3.2 LABELING

3.2.1 Labels

Provide labeling for new cabling and termination hardware located within the facility in accordance with TIA-606. Handwritten labeling is unacceptable. Stenciled lettering for cable and termination hardware shall be provided using thermal ink transfer process.

3.2.2 Cable Tag Installation

Install cable tags for each telecommunications cable or wire located in manholes, handholes, and vaults including each splice. Tag new wire and cable provided under this contract and existing wire and cable which are indicated to have splices and terminations provided by this contract. The labeling of telecommunications cable tag identifiers shall be in accordance with TIA-606. Do not provide handwritten letters. Install cable tags so that they are clearly visible without disturbing any cabling or wiring in the manholes, handholes, and vaults.

3.2.3 Termination Hardware

Label patch panels, distribution panels, connector blocks and protection modules using color coded labels with identifiers in accordance with TIA-606.

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 FIELD QUALITY CONTROL

Provide the Contracting Officer 10 working days notice prior to each test. Provide labor, equipment, and incidentals required for testing. Correct defective material and workmanship disclosed as the results of the tests. Furnish a signed copy of the test results to the Contracting Officer within 3 working days after the tests for each segment of construction are completed. Perform testing as construction progresses and do not wait until all construction is complete before starting field tests.

3.4.1 Pre-Installation Tests

Perform the following tests on cable at the job site before it is removed from the cable reel. For cables with factory installed pulling eyes, these tests shall be performed at the factory and certified test results shall accompany the cable.

3.4.1.1 Cable Capacitance

Perform capacitance tests on at least 10 percent of the pairs within a cable to determine if cable capacitance is within the limits specified.

3.4.1.2 Loop Resistance

Perform DC-loop resistance on at least 10 percent of the pairs within a cable to determine if DC-loop resistance is within the manufacturer's calculated resistance.

3.4.1.3 Pre-Installation Test Results

Provide results of pre-installation tests to the Contracting Officer at least 5 working days before installation is to start. Results shall indicate reel number of the cable, manufacturer, size of cable, pairs tested, and recorded readings. When pre-installation tests indicate that cable does not meet specifications, remove cable from the job site.

3.4.2 Acceptance Tests

Perform acceptance testing in accordance with RUS Bull 1753F-201 and as further specified in this section. Provide personnel, equipment, instrumentation, and supplies necessary to perform required testing. Notification of any planned testing shall be given to the Contracting Officer at least 14 days prior to any test unless specified otherwise. Testing shall not proceed until after the Contractor has received written Contracting Officer's approval of the test plans as specified. Test plans shall define the tests required to ensure that the system meets technical, operational, and performance specifications. The test plans shall define milestones for the tests, equipment, personnel, facilities, and supplies required. The test plans shall identify the capabilities and functions to be tested. Provide test reports in booklet form showing all field tests performed, upon completion and testing of the installed system. Measurements shall be tabulated on a pair by pair or strand by strand basis.

3.4.2.1 Copper Conductor Cable

Perform the following acceptance tests in accordance with TIA-758:

a. Wire map (pin to pin continuity)

b. Continuity to remote end

c. Crossed pairs

d. Reversed pairs

e. Split pairs

f. Shorts between two or more conductors

3.4.2.2 Fiber Optic Cable

Test fiber optic cable in accordance with TIA/EIA-455 and as further specified in this section. Two optical tests shall be performed on all optical fibers: Optical Time Domain Reflectometry (OTDR) Test, and Attenuation Test. In addition, a Bandwidth Test shall be performed on all multimode optical fibers. These tests shall be performed on the completed end-to-end spans which include the near-end pre-connectorized single fiber cable assembly, outside plant as specified, and the far-end pre-connectorized single fiber cable assembly.

a. OTDR Test: The OTDR test shall be used to determine the adequacy of the cable installations by showing any irregularities, such as discontinuities, micro-bendings or improper splices for the cable span under test. Hard copy fiber signature records shall be obtained from the OTDR for each fiber in each span and shall be included in the test results. The OTDR test shall be measured in both directions. A reference length of fiber, 66 feet minimum, used as the delay line shall be placed before the new end connector and after the far end patch panel connectors for inspection of connector signature. Conduct OTDR test and provide calculation or interpretation of results in accordance with TIA-526-7 for single-mode fiber and TIA-526-14 for multimode fiber. Splice losses shall not exceed 0.3 db.

b. Attenuation Test: End-to-end attenuation measurements shall be made on all fibers, in both directions, using a 1550 nanometer light source at one end and the optical power meter on the other end to verify that the cable system attenuation requirements are met in accordance with TIA-526-7 for single-mode fiber optic cables. The measurement method shall be in accordance with TIA-455-78-B. Attenuation losses shall not exceed 0.5 db/km at 1310 nm and 1550 nm for single-mode fiber. Attenuation losses shall not exceed 5.0 db/km at 850 nm and 1.5 db/km at 1300 nm for multimode fiber.

c. Bandwidth Test: The end-to-end bandwidth of all multimode fiber span links shall be measured by the frequency domain method. The bandwidth shall be measured in both directions on all fibers. The bandwidth measurements shall be in accordance with TIA/EIA-455-204.

3.4.3 Soil Density Tests

b. Determine soil-density relationships as specified for soil tests in Section EXCAVATION AND FILL 31 23 00.00 20.

-- End of Section --

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SECTION 34 43 00.00 20

AIRFIELD LIGHTING

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 B209	(2010) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2010) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM C603	(2014) Extrusion Rate and Application Life of Elastomeric Sealants
ASTM C639	(2001; R 2011) Rheological (Flow) Properties of Elastomeric Sealants
ASTM C661	(2006; R 2011) Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer
ASTM C679	(2003; E 2009; R 2009) Tack-Free Time of Elastomeric Sealants
ASTM C719	(2014) Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)
ASTM C792	(2004; R 2008) Effects of Heat Aging on Weight Loss, Cracking, and Chalking of Elastomeric Sealants
ASTM C793	(2005; R 2010) Effects of Accelerated Weathering on Elastomeric Joint Sealants
ASTM D1248	(2012) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D1535	(2014) Specifying Color by the Munsell System

ASTM D412	(2006a; R 2013) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D709	(2013) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013) National Electrical Safety Code
IEEE C62.11	(2012) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
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)

ANSI C37.44	(1981; R 1992) Special for Distribution Oil Cutouts and Fuze Links
NEMA ICS 4	(2010) Terminal Blocks
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2013) Standard for Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 7	(2013) Standard for Smooth-Wall Coilable Electrical Polyethylene Conduit
NEMA TC 6 & 8	(2013) Standard for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations
NEMA WC 3	(1992; Rev 1 1994) Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
NEMA WC 8	(1988; Rev 3 1996)

	Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
NEMA WC 70	(2009) Power Cable Rated 2000 V or Less for the Distribution of Electrical Energy--S95-658
NEMA 71	(1999;1998) Standard for Nonshielded Cables Rated 2001-5000 Volts for the use in the Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013) National Electrical Code
NFPA 70B	(2013) Recommended Practice for Electrical Equipment Maintenance
NFPA 780	(2014) Standard for the Installation of Lightning Protection Systems

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS5351	(1987; Rev F; R 2006) Steel Castings, Sand, Corrosion and Moderate Heat Resistant, 13Cr, Normalized and Tempered

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 1	(1982; E 2004) Solvent Cleaning

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1751F-205	(1987) Filled Telephone Cables (PE-39)

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-L-29575	(1989) Light, Wave-Off, Flashing, Capacitance-Discharge
MIL-STD-108	(1966; Rev E; Am 1 1985; Notice 2 1990)

	Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment
MIL-STD-461	(2007; Rev F) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

U.S. FEDERAL AVIATION ADMINISTRATION (FAA)

FAA AC 150/5220-23	(2009) Frangible Connections
FAA AC 150/5340-30	(2010; Rev E) Design and Installation Details for Airport Visual Aids
FAA AC 150/5345-10	(2014; Rev H) Specification for Constant Current Regulators Regulator Monitors
FAA AC 150/5345-12	(2005; Rev E) Specification for Airport and Heliport Beacon
FAA AC 150/5345-13	(2007; Rev B) Specification for L-841 Auxiliary Relay Cabinet Assembly for Pilot Control of Airport Lighting Circuits
FAA AC 150/5345-26	(2008; Rev D) FAA Specification for L-823 Plug and Receptacle, Cable Connectors
FAA AC 150/5345-27	(2013; Rev E) Specification for Wind Cone Assemblies
FAA AC 150/5345-28	(2005; Rev F) Precision Approach Path Indicator (PAPI) Systems
FAA AC 150/5345-3	(2007; Rev F) Specification for L-821 Panels for Control to Airport Lighting
FAA AC 150/5345-42	(2013; Rev G) Specification for Airport Light Bases, Transformer Housings, Junction Boxes and Accessories
FAA AC 150/5345-43	(2012; Rev G) Specification for Obstruction Lighting Equipment
FAA AC 150/5345-44	(2010; Rev J) Specification for Runway and Taxiway Signs
FAA AC 150/5345-46	(2009; Rev D) Specification for Runway and Taxiway Light Fixtures
FAA AC 150/5345-47	(2011; Rev C) Specification for Series to Series Isolation Transformers for Airport Lighting Systems
FAA AC 150/5345-5	(2006; Rev B) Specification for Airport

	Lighting Circuit Selector Switch
FAA AC 150/5345-51	(2010; Rev B) Specification for Discharge-Type Flashing Light Equipment
FAA AC 150/5345-7	(2013; Rev F) Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits
FAA AC 150/5345-53	(2012; Rev D) Airport Lighting Equipment Program
FAA AC 150/5345-56	(2011; Rev B) Specification for L-890 Airport Lighting Control and Monitoring System (ALCMS)
FAA AC 150/5370-10	(2014; Rev G) Standards for Specifying Construction of Airports
FAA AC 70/7460-1	(2007; Rev K) Obstruction Marking and Lighting
FAA E-1315	(1967; Rev A; Am 1971) Light Base and Transformer Housing
FAA E-2628	(1979; Rev B) Sequenced Flashing Lighting System, Elevated and Semiflush with Dimming and Monitoring
FAA E-2690	(2000; Rev A) Isolation Transformer (1500 watt) for High Intensity Approach Lighting Systems
FAA E-2702	(2007; Rev A)Low Impact Resistant (LIR) Structures
FAA E-2756	(2004; Rev B) Four Box Precision Approach Path Indicator (PAPI) without Remote Monitoring Subsystem (RMS)
FAA E-2980	(2005) Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR)

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS SS-S-200	(Rev E; Am 1; Notice 1) Sealant, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied, for Portland Cement Concrete Pavement

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jul 2012) Standard for Flexible Metal Conduit
UL 1242	(2006; Reprint Jul 2012) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 360	(2013; Reprint May 2013) Liquid-Tight Flexible Steel Conduit
UL 44	(2010) Thermoset-Insulated Wires and Cables
UL 467	(2013) Grounding and Bonding Equipment
UL 50	(2010; Reprint Apr 2012) Enclosures for Electrical Equipment, Non-environmental Considerations
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013) Metallic Outlet Boxes
UL 6	(2007; reprint Nov 2010) Electrical Rigid Metal Conduit-Steel
UL 6A	(2008; Reprint May 2013) Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel
UL 773	(1995; Reprint Mar 2002) Standard for Plug-In, Locking Type Photocontrols for Use with Area Lighting
UL 773A	(2006; Reprint Nov 2013) Standard for Nonindustrial Photoelectric Switches for Lighting Control
UL 797	(2007; Reprint Dec 2012) Electrical Metallic Tubing -- Steel
UL 83	(2014) Thermoplastic-Insulated Wires and Cables
UL 854	(2004; Reprint Sep 2011) Standard for Service-Entrance Cables

1.2 RELATED REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS, 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. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Airport Lighting Control and Monitoring System (ALCMS); G

Each type of airfield lighting fixture installation; G

Externally lighted Wind cone indicator assembly connection; G

Wave-Off system; G

SD-03 Product Data

Flood lighting; G

Control cable; G

Series airfield lighting cable; G

Obstruction marker lights; G

High/Medium intensity obstruction lights; G

Externally lighted wind cone; G

Isolating transformers; G

Constant current regulators; G

Frangible couplings; G

Obstruction marker lights; G

Isolating transformers; G

Light bases; G

Each type of runway and taxiway lighting fixture; G

Each type of light bases; G

Frangible couplings; G

FAA Type P-606 sealant; G

FAA Type L-823 connectors; G

ALCMS equipment including components, devices, control panels, enclosures, cabinets and software; G

ALCMS computers; G

ALCMS Wireless Communication Equipment; G

Wave-Off system components complete; G

SD-06 Test Reports

Counterpoise system test

SD-07 Certificates

Installer Qualifications; G

Construction Outage Plan; G

SD-08 Manufacturer's Instructions

Jig for semiflush fixture base installation; G

SD-10 Operation and Maintenance Data

ALCMS data package 5; G

Constant current regulators data package 5; G

Wave-Off system data package 5; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

Do not install materials which are not approved as "Approved Airport Equipment" by FAA unless specifically approved by the electrical design engineer. Inspect wire and cable for date of manufacture. Do not use wire and cable manufactured more than one year before delivery to job site.

1.4.2 Regulatory Requirements

Provide materials and equipment listed by FAA, UL, ETL or approved by Factory Mutual Engineering and Research (FM), when such equipment is listed or approved. Do not use askarel, tetrachlorethylene and insulating liquids containing polychlorinated biphenyls (PCBs) in equipment. Provide submersible type equipment installed below grade in vaults, manholes, and handholes. Materials must be certified and listed as "Approved Airport Lighting Equipment" per the lastest addendum to FAA AC 150/5345-53, Airport Lighting Equipment Certification Program

1.4.3 Installer Qualifications

The aviation lighting equipment contractor and installation electricians must be experienced in installing, testing and maintaining aviation lighting systems of a similar complexity. The contractor must provide a list of government projects and 3 years of experience in constructing similar projects. Include written certification that systems have performed satisfactorily for not less than 18 months.

The ALCMS manufacturer shall have ISO 9001 certification and shall provide a copy of the ISO certification during the submittal process.

The ALCMS manufacturer shall be listed in the FAA Approved Equipment List, FAA AC 150/5345-53 as a FAA approved supplier of L-980 Airfield Lighting Computer and Monitoring Systems in accordance with AC 150/5345/56 (current edition), and be a FAA approved supplier of L-827/L-829 Constant Current Regulator Monitors in accordance with AC 150/5345-10

The ALCMS manufacturer shall have a minimum of five (5) years of experience in computerized airfield lighting control and monitoring systems and shall have installed at least five (5) advanced control and monitoring systems of similar size and complexity to the one specified herein.

1.4.4 Construction Outage Plan

The contractor must provide a construction outage plan and schedule for installing new and retrofitting the existing lighting system to ensure that aviation lighting circuits are fully operational between dusk and dawn during each day of the construction contract. The plan must be submitted to and approved by the Contracting Officer and the Airfield Manager prior to starting construction.

1.5 EQUIPMENT

1.5.1 Equipment for Silicone Sealant

Equipment for silicone sealant shall be air-powered pump, components, and hoses as recommended by the sealant manufacturer. Hoses and seals shall be lined to prevent moisture penetration and withstand pumping pressures. Equipment shall be free of contamination from previously used other type sealant.

1.5.2 Jig for Semiflush Fixture Base Installation

Provide information for jig semiflush light fixture installation in compliance with light base manufacturer, FAA, and NAVAIR installation requirements.

1.6 EXISTING AIRFIELD LIGHTING SYSTEMS

Existing airfield lighting systems shall remain in operating conditions and interruptions shall be held to a minimum. Where interruptions are necessary, they shall be scheduled as approved in writing by the Contracting Officer. Prior to the scheduled time for each interruption, all necessary materials and a sufficient labor force shall be assembled to permit completing the work within the scheduled time interval. Under no circumstances shall any of the existing airfield lighting circuits be left inoperative without making provisions for suitable temporary connections in the affected area or areas. All airfield lighting circuits covered under this contract shall be replaced in such a manner that they will be operational at dusk each day. The Contractor shall submit to the Contracting Officer a plan for outages and maintaining lighting and lighting control for each Construction Sequence.

PART 2 PRODUCTS

2.1 ELECTRICAL TAPE

UL 510, plastic insulating tape.

2.2 NAMEPLATES

Provide laminated plastic nameplates for equipment, controls, and devices to identify function, and where applicable, position. Provide 1/8 inch thick laminated Melamine plastic conforming to ASTM D709, Grade ES-2, white with black center core. Surface shall be a matte finish with square corners. Align and engrave lettering accurately into the black core. Size of nameplates shall be one by 2 1/2 inches minimum with minimum 1/4 inch high normal block lettering. 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.

2.3 CONDUIT, CONDUIT FITTINGS, AND BOXES

2.3.1 Rigid Steel or Intermediate Metal Conduit (IMC) and Fittings

UL 6, UL 6A and UL 1242, respectively.

2.3.2 Flexible Metal Conduit

UL 1, zinc-coated steel. Use UL 360 liquid-tight flexible metal conduit in wet locations.

2.3.3 Outlet Boxes for Use with Steel Conduit, Rigid or Flexible

UL 514A, cast metal with gasketed closures.

2.3.4 Plastic Duct for Concrete Encased Burial

Provide as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.3.5 Plastic Conduit for Direct Burial

Provide as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.3.6 Frangible Couplings and Adapters

FAA AC 150/5220-23. Provide upper section of frangible coupling with one of the following:

a. Unthreaded for slip-fitter connections.

b. 2 13/32 inch: 16N-1A modified thread for nut and compression ring to secure 2 inch EMT.

c. 2 inch: 11 1/2-N.P.T. (tapered) with 7/32-inch nominal wall thickness to accept rigid conduit coupling.

2.3.6.1 Frangible Couplings for Specialized Applications

Acceptable as approved.

2.3.6.2 Electrical Metallic Tubing

UL 797. Provide where indicated for use with frangible couplings and adapters.

2.4 WIRE AND CABLE

Do not provide or install wire and cable manufactured more than one year before delivery to the job site. Conductors shall be copper.

2.4.1 Conductor Sizes

Conform to American Wire Gage (AWG).

2.4.2 Power Cables for Use in Airfield Lighting

Rated 5 kV, 133 percent insulation level, with shield and jacket conforming to NEMA WC 7 for crosslinked polyethylene insulated cables.

2.4.3 Wire and Cable for Airfield Lighting Systems

2.4.3.1 Airfield Lighting Cable

FAA AC 150/5345-7, Type L-824, for ethylene propylene Type B 5000-volt cable. Series airfield lighting cable shall be unshielded. Cable shall be color coded as shown on design drawings.

2.4.3.2 Counterpoise Wire

ASTM B3, ASTM B8. No. 4 AWG bare stranded copper, annealed or soft drawn.

2.4.3.3 Control Cable

Multiconductor type for 120 V ac control, rated 600 volts, No. 12 AWG, and conforming to the following unless indicated or specified otherwise. Insulate each conductor with a thickness of not less than 30 mils and rate for continuous operation at 90 degrees C. Conductors shall be color coded. Cable shall conform to NEMA WC 3 for rubber insulation, NEMA WC 7 for cross-linked polyethylene insulation, or NEMA WC 8 for ethylene-propylene rubber insulation.

2.4.3.4 Fused Cable Connectors

Provide connector consisting of a line side receptacle and a load side plug, each in a molded rubber form and including crimp-on fittings for the cable ends to accommodate a 250-volt cartridge-type fuse. Provide fuse with rating indicated. Provide connectors in kit form properly sized for the specific cable diameter involved. Completed connection shall be watertight.

2.4.4 Cable Tags

Provide cable tags for each cable or wire at duct entrances entering or leaving of manholes, handholes, and at each terminal within the lighting vault. Provide stainless steel, bronze, lead strap, or copper strip tags approximately 1/16 inch thick or hard plastic 1/8 inch thick suitable for immersion in salt water and impervious to petroleum products. Provide sufficient length for imprinting the legend on one line using raised letters not less than 1/4 inch in size. Permanently mark or stamp with the identification as directed on the drawings. Two-color laminated plastic is acceptable. Provide dark colored plastic tags with markings of light color to provide contrast so that identification can be easily read. Provide fastening material of a type that will not deteriorate when exposed to water with a high saline content and petroleum products.

2.4.5 Concrete Markers for Underground Cable Systems

Provide as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.5 GROUND RODS

UL 467. Copper-clad steel with diameter adequate to permit driving to full length of the rod, but not less than 3/4 inch in diameter and 10 feet long, unless indicated otherwise.

2.6 ROTATING LIGHT BEACON

2.6.1 Power and Controls

PThe rotating light beacon is existing and shall remain powered as currently configured. The wireless control wiring for the rotating beacon shall interface to the air traffic control tower ALCMS equipment.

2.7 OBSTRUCTION MARKER LIGHTS

FAA AC 150/5345-43, or Type L-810, . Obstruction marker lights shall emit a steady burning aviation red light. Provide light assembly supplied by 120-volt multiple circuit. Provide single- or double- unit type obstruction marker lights . Provide control for obstruction marker lights as indicated. Lights shall have light emitting diode (LED) light source.

2.8 EXTERNALLY LIGHTED WIND CONE

FAA AC 150/5345-27, Type L-807, with a frangible support assembly, lighted with four lamps, and an orange 12 foot fabric cone. Provide wiring and controls. Lights shall have light emitting diode (LED) light source.

2.9 RUNWAY DISTANCE AND ARRESTING GEAR MARKERS

Runway distance markers shall conform to FAA AC 150/5345-44, Type L-858B, Size 4, Style 3 with white or yellow numerals on a black background. Provide markers to withstand a static wind load of 0.28 pound per square inch, and suitable for connection to the secondary of the isolation transformers specified. Provide internally illuminated markers with illumination of the face not significantly decreasing when the series lighting circuit is operated at the lowest brightness step. Construct marker housing of fiber reinforced epoxy, with information face of high-impact acrylic or ultraviolet stabilized polycarbonate.Markers shall have light emitting diode (LED) light source.

2.9.1 Power Supply and Lamps

Style 3, Class 1 as recommended by the sign manufacturer.

2.9.2 Arresting Gear Markers

Markers shall have a 3.25 foot translucent yellow circle in place of numerals as specified above.

2.10 TRANSFORMERS

2.10.1 Encapsulated Isolating Transformers

FAA AC 150/5345-47, Type (G) L-830 . Provide each transformer with rating as indicated. Insulation Level Primary voltage rating 5000 volts RMS, Secondary 600 V RMS. Operating Temperature range minus 55 degrees Celsius to plus 65 degrees Celsius. Resistant to UV exposure and ozone. Suitable for areas contaminated with oils, aircraft fuels, soil acids, alkalis, and deicing fluids. Compatible with FAA Style 2 and Style 9 connectors.

2.10.2 Power Transformers

As specified in Section 26 12 19.10 THREE-PHASE PAD-MOUNTED TRANSFORMERS .

2.11 LIGHT BASES

FAA AC 150/5345-42 Type L-867 orL-868. Provide steel bases, Class 1, Size as indicated or as required to accommodate the fixture or device installed thereon if diameter is not shown.

2.11.1 Accessories

Provide base plates, cover plates, and adapter plates to accommodate various sizes of fixtures. Bolts shall be stainless steel.

2.12 SEALING FIXTURES AND WIRES IN DRILLED HOLES OR SAW KERFS

FAA AC 150/5370-10, Type P-606.

2.12.1 Sealant Type

FAA Type P-606 sealant for use in asphaltic concrete (AC) or Portland cement concrete (PCC) pavement compatible with AC pavement and having a minimum elongation of 50 percent. Formulations of Type P-606 which are compatible with PCC pavement only are prohibited.

2.12.2 Single Component Cold-Applied Silicone

Silicone sealant shall be self-leveling, non-acid curing, and meet the following requirements.

TEST	TEST METHOD	REQUIREMENTS
Weight Loss	ASTM C792 Modified (See Note 1)	10 percent max.
Flow	ASTM C639 (Type I)	Smooth and level
Extrusion Rate	ASTM C603	30 sec. max.
Tack Free Time	ASTM C679	5 hours max.
Hardness (Shore 00) (See Note 2)	ASTM C661	30 - 80

TEST	TEST METHOD	REQUIREMENTS
Tensile Stress at 150 Percent Elongation (See Note 2)	ASTM D412 (Die C)	30 psi max.
Percent Elongation (See Note 2)	ASTM D412 (Die C)	700 min.
Accelerated Weathering	ASTM C793	Pass 5000 hours
Bond and Movement Capability	ASTM C719	Pass 10 cycles at plus 50 percent movement (no adhesion or cohesion failure)
Flame Resistant	FS SS-S-200	Pass
NOTES: 1. Percent weight loss of wet (uncured) sample after placing in forced-draft oven maintained at 158 degrees F plus 1 degree F for two hours.		
2. Specimen cured 21 days at 73 degrees F plus 1 degree F and 50 percent.		
ACCELERATED WEATHERING FACTORY TEST REPORT. For Accelerated Weathering test, in lieu of testing of actual joint sealant to be used on the project, a report of a factory test, performed within two years of contract award, may be submitted.		

2.13 CONSTANT CURRENT REGULATORS

FAA AC 150/5345-10, Type L-829, with monitor system and with ratings as indicated.

2.13.1 Regulator

Provide a complete and functional CCR switchgear system. The system shall include bus bar, regulators, enclosures, manuals, on-site commissioning, on-site testing, on-site training and any other materials, tools and equipment to provide a fully functional system to the satisfaction of the owner. Regulators shall operate on 60 Hz, have internal primary switch included, have input voltage of 480 and be controlled by 120-volt external control voltage. Provide five brightness steps. Provide monitors as indicated.

2.13.2 Basic Impulse Level (BIL)

Provide 60-kV series circuit BIL except that 2.5-kW, 4-kW, 7.5-kW and 10-kW regulator series circuits may have a BIL of 25 kV.

2.13.3 Manufacturer Qualifications

The manufacturer shall be ISO 9001 certified and provide a copy of certification during the bidding process.

The manufacturer shall be listed in the FAA Approved Equipment List, AC 150/5345-53 (current edition)and a FAA approved supplier of Monitors and Regulators (in accordance with AC 150/5345-10).

The SGRS manufacturer shall have demonstrated a minimum of five (5) years of experience in switchgear regulator systems of similar sizes and complexity.

2.13.4 Project Coordination

The manufacturer shall provide an experienced and qualified Engineering, Sales, and Service staff to support contractor and airport throughout the installation and warranty of the system

The project shall follow this basic cycle of events:

Submittal: The manufacturer shall submit specifications to the contractor.

Submittal Review and Approval: The submittal shall be reviewed by the Government.

Production Release: The manufacturer shall release approved system to manufacturing.

Production: System is manufactured.

Production Testing: System is tested by the manufacturer prior to shipment. Production test reports shall be available upon request.

Shipment of System: CCR switchgear system is shipped to job site for installation by Contractor.

Installation: With the Manufacturer's support, the Contractor installs equipment and completes external wiring.

Power-up: With the manufacturer's support, the Contractor completes CCR switchgear system power-up and initial control testing to verify installation, communication and wiring.

Commissioning: The manufacturer shall complete commissioning of system and verify operation.

System Cut-over: The manufacturer and Contractor shall cut over the new system and bring in on-line and operational.

System Acceptance Testing: System is available for System Acceptance Testing (SAT) which shall be witnessed by the Government.

Manuals/ As-Built drawings: The manufacturer shall issue operator manuals, maintenance manuals and final as-built drawings.

On-Site Training: The manufacturer shall complete on site-training of maintenance and operations personnel.

Final Owner Acceptance: Upon completion of all contractual requirements, system is required, system is accepted in writing by the Government.

Warranty and Support: The SGRS manufacturer shall provide warranty and support per the contractual requirements.

Before shipment, the CCR switchgear system shall be assembled as an operating system at the SGRS Manufacturer's test facilities. The manufacturer shall make the production testing available for representative(s) of the Government to witness the testing of the system if requested. The manufacturer shall complete production and operational testing prior to shipment of equipment to the project site. Production testing reports shall be made available upon request.

The installing contractor shall be responsible for the physical installation of all associated SGRS components. At a minimum, this includes the Constant Current Regulators (CCRs), CCR switchgear system cabinets, CCR insertion into cabinet system and any other control equipment. The Contractor shall provide, relocate, connect and test all equipment, equipment accessories, conduit cables, wires, buses, grounds and support necessary to insure a complete and operable electrical distribution facilities for the airport lighting system as specified herein the submittal package. The equipment installation and mounting shall comply with the requirements of the National Electrical Code and local code agency having jurisdiction.

The Contractor shall make all necessary electrical connections at each location in accordance with the manufacturer's wiring diagrams. All wires called out in the drawings associated with equipment that is to be controlled or monitored should be pulled, terminated and dressed at the appropriate terminal blocks and at the associated equipment. In wiring to the terminal blocks, the Contractor shall leave sufficient extra length on each control lead to make future changes in connections at the terminal block.

All equipment, control wires, terminal blocks, etc., shall be tagged, marked or labeled as specified below:
Wire Identification: The Contractor shall furnish and install self-sticking wire labels or identifying tags on all control wires at the point where they connect to the control equipment or to the terminal blocks.
Wire labels, if used, shall be of the self-sticking, pre-printed type and of the manufacturer's recommended size for the wire involved.

The Regulators shall be L-829 air-cooled Constant Current Regulators and shall meet all requirements of FAA AC 150/5345-10 (latest revision). The Regulator shall provide full FAA L-827 monitoring per FAA AC 150/5345-10 (current edition) including the following:

Loss of input power to the CCR.
CCR shutdown by open-circuit / over-current protective devices.
Drop of more than 10% in the CCR VA load.
Failure of the CCR to deliver the selected output current.
The number of burnt-out lamps in each series circuit.
Remote / Local status of the CCR.
Actual CCR output current
Actual CCR output voltage
Actual CCR output load (wattage)

Each Regulator shall have a digital output meter that displays current,

voltage, wattage and VA. Regulator efficiency and power factor shall be in accordance with FAA AC 150/5345-10 (latest revision).

SGRS Distributed Regulator Control

The CCR switchgear system shall be integrated with distributed control and monitoring equipment (DCME). One (1) DCME shall be associated with each regulator bay including all spare regulators. The DCME equipment shall be capable of interface to ALCMS manufacturers control and monitoring system. The DCME equipment shall communicate via a redundant, 2 pair, communication cable. The redundant communication wiring to the DCME equipment shall be wired to a terminal strip in the base of the CCR switchgear system enclosure. The Contractor shall provide additional communication wiring as recommended by the ALCMS manufacturer to interconnect the communication wiring between each CCR switchgear system bay at the terminal strip.

2.14 LAMPS AND FILTERS

Provide lamps of size and type indicated, or required by fixture manufacturer for each lighting fixture required under this contract. Provide filters as indicated and conforming to the specification for the light concerned or to the standard referenced. Lighting fixtures shall be LED type.

2.15 TRANSFORMERS, SUBSTATIONS AND SWITCHGEAR

Provide as specified in Section 26 12 19.10 THREE-PHASE PAD-MOUNTED TRANSFORMERS and 26 12 21 Single-Phase Pad Mounted Transformers.

2.16 EMERGENCY GENERATOR AND AUTOMATIC TRANSFER SWITCH SYSTEM

Provide as specified in .26 32 13.00 20 SINGLE OPERATION GENERATOR SETS

2.17 AIRPORT LIGHTING CONTROL AND MONITORING SYSTEM (ALCMS)

The ALCMS shall be in accordance with FAA AC 150/5345-56A, Type L-890, a PC-based control and monitoring system

The system shall monitor the operation of the various lighting systems per AC 150/5345-10 (current edition) requirements.

The DCME unit shall provide full FAA L-827/ 9 monitoring per FAA AC 150/5345-10 (current edition).

The Airfield Lighting Computer System (ALCMS) shall combine state-of-the-art programming intelligence with high quality industrial strength components.

The system shall represent the leading edge in aviation lighting technology with innovative PC control stations; distributed control and monitoring; and powerful database storage and retrieval systems.

2.17.1 Project Scope:

The ALCMS Manufacturer shall furnish and commission a complete and functional computerized distributed control and monitoring airfield lighting system based on an industry standard Ethernet network. The ALCMS

shall be in accordance with FAA AC 150/5345-56A. The manufacturer shall provide complete design drawings showing wiring from the ALCMS cabinets and/or rack mounted equipment to the CCR's, antenna, to other vaults, and the air traffic control tower ALCMS equipment with detailed terminations to the equipment. The manufacturer shall provide detailed design drawings for all auxiliary systems, including the wave off lights controls, the rotating beacon controls and the monitoring of the emergency generating system for the generator, the automatic transfer switch and the fuel tank.

This project shall include software, programming, computers, manuals, on-site commissioning, on-site testing, on-site training and any other materials, tools and equipment to provide a fully functional system to the satisfaction of the owner.

The existing SPAWAR lighting control system will be sequentially phased out of service, and its associated equipment and wiring shall be removed and replaced with a completely new Airport Lighting Control and Monitoring System (ALCMS) while under construction there will be two active ALCMS's and the Contractor shall provide clear direction to the contracting officer and air traffic control tower as to what each ALCMS controls as the construction proceeds. The system shall be computer controlled with a touchscreen mouse and keyboard. A fiber optic transmission system shall be provided for the redundant ALCMS communications network, where fiber optic is the primary system and radio is the back-up. The system shall control all airfield taxiway and runway lighting, lighted airfield signs as well as various other airfield lighting aids such as the airport beacon.

The system shall also monitor the stand-by generator and Automatic Transfer Switch and the generator fuel tank leak detection.

The system must be able to control all functions of the airfield lighting systems including on/off functions, multiple light intensities of each airfield lighting and shall include all taxiway and runway lights and airfield signs. Taxiway shall have five intensity levels buttons and runway circuits shall have five. All regulators shall be monitored and have indicators, at a minimum, for on/off, current levels, voltage levels, loss of power of input to the regulator and local or remote setting by the ALCMS. The ALCMS shall also be capable of monitoring the cable insulation resistance measurements. The system shall also be capable of receiving wave off light system inputs and transmit control to the wave off lights. Tower operator stations shall be installed similar to existing with inboard/outboard push buttons and runway selector switch but shall communicate with the system in the field via fiber optic network.

In the event of a system failure, the ALCMS must be capable of maintaining last state - latching to the airfield lights, FAA L-890 specification type "B" failsafe. These preset conditions are as follows. All runways lights must maintain last state. All taxiway lights must maintain last state.

The system shall be capable of controlling the beacon via radio control, the wave off light system and of monitoring the backup generator and ATS (Automatic Transfer Switch) for the airfield lighting vault. The monitoring points are as follow:

CONTROL/MONITORING	SIGNAL DESCRIPTION
Generator running	Feedback Signal
General Generator	Alarm Feedback Signal

ATS Generator	Feedback signal
ATS Utility	Feedback signal
Beacon	On/Off signal
Generator fuel tank leak detection	
Wave off light	Runway Selector Signal
Wave off light	On signal for Inboard and Outboard runways

The ALCMS shall have three (3) Human Machine Interface (HMI) computers. One located in vault E-145, one in electrical vault E-3015 and one in the air traffic control tower for the RM10-9004 project and (3) Human Machine Interface (HMI) computers for Electrical vault E-101, E-3036, and E-1120 for the RM12-0469 project.

Designation of a single Human Machine Interface (HMI) computer with Master control capability. This includes the ability to relinquish, transfer, and regain control of Human Machine Interface (HMI) computer control from the designated master to another Human Machine Interface (HMI) computer. Allowing any HMI computer the ability to relinquish control to another HMI computer but not regain control from a given Human Machine Interface (HMI) computer.

The system Human Machine Interface (HMI) computers shall be capable of but not limited to providing the following visual and audio queues:

Provide a visual queue that a designated HMI computer with Master control capabilities does or does not have control.

Provide visual queues indicating which HMI computer has control.

The Contractor shall coordinate final HMI computer control configuration with the Government. The ALCMS shall have the capability to incorporate system users with password protected accounts having various levels of control and monitoring access to prevent unauthorized system access and control.

2.17.2 Project Coordination

The ALCMS Manufacturer shall provide an experienced and qualified Engineering, Sales and Service staff to support the contractor and airport throughout the installation and life of the system.

The project shall follow this basic cycle of events:

Submittal
The ALCMS Manufacturer shall submit ALCMS specifications to the contractor.

Submittal Review and Approval
Submittal shall be reviewed by the Government.

Production Release
The ALCMS Manufacturer shall release approved system to manufacturing.

Demo CD 35% Software Completion
The ALCMS Manufacturer shall send to the Government a Demo CD of the planned layout of the HMI screens that will be used for the control of the ALCMS system. Type of HMI screens shall include as a minimum operational, maintenance, active alarms, historical alarms, and system administrative screens.

Production: System is manufactured.

Production Testing: System is tested by the ALCMS Manufacturer.

Factory Acceptance Testing: System is available for Factory Acceptance Testing (FAT) witnessed by Government.

Shipment of system: Approved system is shipped to installation site.

Installation: Contractor installs equipment and completes external wiring.

Commissioning: The ALCMS Manufacturer shall complete commissioning of system and verify contractor installation and wiring.

System Readiness Check: The ALCMS Manufacturer shall perform a system readiness check to verify
proper operation of all equipment prior to cut over.

System Cut-over: The ALCMS Manufacturer and Contractor shall cut over the new system and bring it on-line and operational, in a sequential manner that follows the construction phases.

System Acceptance Testing: System is available for System Acceptance Testing (SAT) which shall be witnessed the by Government.

Manuals / As-Built drawings: The ALCMS Manufacturer shall issue operator manuals, maintenance manuals and ATC manuals and final as-built drawings.

On-Site Training: The ALCMS Manufacturer shall complete on-site training of government personnel. The ALCMS manufacturer shall video record the traning and provide four (4) copies of the training video.

Final Owner Acceptance: Upon completion of all contractual requirements, system is accepted by
the government.

Warranty and Support: The ALCMS Manufacturer shall provide warranty and support per the contractual requirements.

2.17.3 Contractor Installation Requirements

The installing contractor shall be responsible for the physical installation of all associated ALCMS components. At a minimum, this includes the Constant Current Regulators (CCRs), computer cabinets, enclosures, PC control stations and Distributed Control and Monitoring Equipment (DCME).

The Contractor shall furnish, install, relocate, connect and test all equipment, equipment accessories, conduit cables, wires, buses, grounds and support necessary to ensure a complete and operable electrical distribution facility for the airport lighting system.

Wire and Connections: The Contractor shall make all necessary electrical connections at each
location in accordance with the ALCMS manufacturer's wiring diagrams.

All wires called out in the drawings associated with equipment that is to

be controlled or monitored should be pulled, terminated and dressed at the appropriate terminal blocks and at the associated equipment.

The Contractor shall leave sufficient extra wire length on each control/monitoring lead to make future changes in connections at the terminal block.

Installation of Data Cables: The Contractor shall furnish, install, terminate and test all telecommunications/data cables required for the project. This includes all of the following components: Data cables (fiber/copper), terminal cabinets, cable extenders, and patch cables.

All associated data cables shall be tested upon completion of the cable installation and termination of connectors.
Tests shall include verification of point-point continuity of each wire/fiber.

All test data shall be recorded and included in a test report that shall be submitted to the government for approval.

Commissioning of the system shall not begin until all test reports are submitted and approved and a copy provided to ALCMS Manufacturer. Commissioning will be performed in multiple stages to follow the construction phases.

Contractor Fiber Optic Communication Equipment Installation:

The Contractor shall install, terminate and test all fiber optic communications required for the project. This includes all of the following components:

Fiber optic cable
Fiber optic patch panels
Fiber optic patch/jumper cables
Fiber connectors / couplings
Fiber junction boxes

Installation of the fiber optic communication equipment shall be done by a trained and qualified fiber optic specialist.

The qualifications of the company and specialist that installs the fiber optic equipment shall be submitted to the Government for approval.

All associated fiber optic equipment including fiber cables, splices and patch/jumper cables shall be tested upon completion of the fiber cable installation and termination of connectors.

Tests shall include verification that the dB loss is within acceptable limits versus the distance of the fiber pull.

All test data shall be recorded and included in a test report that shall be submitted to the Government for approval.

Commissioning of the system shall not begin until all test reports have been submitted and approved. Commissioning will be performed in multiple stages to follow the construction phases.

2.17.4 Contractor ALCMS Wireless Communication Equipment Installation

The antenna and lightning protection shall be provided by the ALCMS manufacturer.

The antenna mast shall be provided and installed by the contractor.

The supply, installation and termination of the interconnecting cable (between the antenna and wireless communication equipment) and associated equipment including connectors and couplings shall be the responsibility of the contractor.

The Contractor shall install and terminate all wireless communication equipment required for the project. This includes all of the following components:

Antenna(s)
Antenna mast(s)
RF cables
Antenna Lightning arrestors
Wireless Communication Modules
CAT 6 Ethernet cables (between wireless communication module and computer)

Wireless communications shall be provided at electrical vaults and at the air traffic control tower and shall include wireless communication for the airport rotating beacon.

Installation of the wireless communication equipment shall be done by a trained and qualified RF specialist with a minimum 5 years of experience.

2.17.5 ALCMS Manufacturer Commissioning

The ALCMS Manufacturer shall perform the following installation and commissioning tasks:

Verify Contractor connections including power, control and monitoring.
Verify proper labeling of equipment.
Verify communication connections.
Perform system testing including control, monitoring and diagnostics this includes network redundancy for all networks, and switching over to vault backup computer.
Training on ALCMS related equipment.
Perform System Acceptance Testing (SAT).

2.17.6 Manuals/Drawings

Maintenance Manuals

The ALCMS Manufacturer shall provide six (6) hard copies of the operation and maintenance manuals that are hard-covered and suitable for daily operation and maintenance of the system. The manuals shall include the following information:

Operational overview and system description
Human Machine Interface (HMI) Screen operation
HMI screens
System Block Diagram
Detailed external wiring diagrams (Electrical Contractor wiring)

Detailed input/output terminal diagrams
Detailed assembly drawings and wiring diagrams
Original Equipment Manufacturer (OEM) Manuals

The manuals shall be spiral bound or supplied in 3-ring binders. The cover of each binder shall be labeled with all project-related information. Provide digital PDF file of the manual on CD.
Government Air Traffic Control Manuals

The ALCMS Manufacturer shall provide six (6) hard copies of the operation manuals for Government use. The manuals shall be hard-covered and suitable for daily operation of the system. At a minimum, the manuals shall include the following information:

PC operation (human machine interface)
PC maintenance (i.e. calibration, backup, loss of computer network, computer)

The manuals shall be spiral bound or supplied in 3-ring binders. The cover of each binder shall be labeled with all project-related information. Provide digital PDF file of the manual on CD.

As-Installed Drawings:

The ALCMS Manufacturer shall provide six (6) hard copies of As-Installed drawings after system acceptance. The As-Installed drawings shall include the following information:

System Block Diagram (One-line drawings)
System External Wiring Diagrams
Assembly Drawings
Assembly Wiring Diagrams

The As-Installed drawings shall be 11" X 17" in size and shall be spiral bound or supplied in 3-ring binders. The cover of each binder shall be labeled with all project-related information

2.17.7 Training

On-site Training:

The ALCMS Manufacturer shall provide to the Government a final training course syllabus and training schedule thirty (30) days before on-site training.

All training sessions shall be held in a facility provided by the Government. This facility should have tables, chairs, projection screen and sufficient space to lay out manuals and drawings. The ALCMS Manufacturer shall provide all required visual aids and projectors.

Government Training:
The ALCMS Manufacturer shall provide two (2), 4 hour User Training Class for personnel.

This training shall include discussion and review of the following:

ALCMS General System Overview
PC Operations
Using the Control System (HMI)

Command and Control Sequences
Alarm and Warning Messages
Failsafe Conditions
Granting Local Control to the Vaults

Training classes for personnel should be limited to a maximum of 4-15 people
per class.

Maintenance Training

The ALCMS Manufacturer shall provide one (1), 8 hour (one day) training class for maintenance personnel. This training shall include discussion and review of the following:

System Block Diagram
System Assemblies and Wiring Diagrams
PC Operation
Graphical User Interface (HMI) Screens
Maintenance and Troubleshooting
Granting Local Control to the Vaults
Power Up and Power Down Sequences
Failsafe Operations
Backup Computer setup for recovery
Implementing Airfield Lighting Changes
Maintenance Report Generation
Training classes for maintenance and operations personnel should be limited to a maximum of 4-15 people per class.

All training shall be video recorded and four (4) copies of the training videos shall be provided.

2.17.8 System Warranty

All equipment shall be warranted against defects in workmanship, hardware and software for a period of one (1) year from initial operation of the system but not more than twenty-four (24) months from the manufacturer's shipment of the system.

During this time period the ALCMS manufacturer shall provide all parts, labor and technical support with the following conditions:

The manufacturer shall correct by replacement equipment or parts which fail because of mechanical, electrical or physical defects, provided that the goods have been properly handled and stored prior to installation, properly installed and properly operated after installation.

2.17.9 System Service and Support

The ALCMS Manufacturer shall provide technical assistance and support during the warranty period.

The ALCMS Manufacturer shall provide a 7 day a week / 24 hours a day support phone line.

The ALCMS Manufacturer shall provide technical phone support within four (4) hours of the initial call.

The ALCMS Manufacturer shall provide free phone consultation and technical

support as required during the warranty period and if necessary shall be on-site within 24 hours.

At the request of the Government, the ALCMS Manufacturer shall provide information about preventative maintenance programs and extended warranty packages.

2.17.10 Spare Parts

A recommended spare parts list shall be included with the Submittal including part numbers and pricing. These prices shall be valid for (12) months from date of system acceptance.

A spare parts package shall be included as part of the bid to the contractor.

At a minimum, the spare parts package shall include the following components:

One(1) Computer, Industrial, to match rack mounted industrial hardware supplied

One(1) Ethernet Fiber Optic Transceiver

One(1) Ethernet Switch

2.17.11 ALCMS Equipment and Materials

The ALCMS system shall be based on a network ready system that operates within a Windows operating environment (current version).

The ALCMS shall be a PC-based system and shall not use any Programmable Logic Controller (PLC) components for control or monitoring.

An Ethernet communication network shall be used for data transfer between electrical vaults and the air traffic control tower and any other designated work station location.

The computerized airfield lighting control and monitoring system shall consist of the following major hardware components:

PC control station(s) located in electrical vaults and the air traffic control tower.

Electrical vaults and air traffic control center consisting of an industrial enclosure, industrial grade rack mounted computer, communications equipment, and a redundant vault control / monitoring network including software.

Within the airfield lighting vault shall be a distributed control and monitoring system which operates on a redundant communication network.

The Distributed Control and Monitoring Equipment (DCME) shall be of a distributed nature that shall be installed locally at each controlled element within the vault. The vault industrial grade computer communicates to each DCME via two (2) shielded cables each consisting of two (2) twisted pairs.

Wave off system components shall consist of two operator stations in the

Air Traffic Control Tower, both to include an inboard momentary pushbutton on an outboard momentary pushbutton. One station shall also have a rotary runway selector switch. An I/O rack shall be provided and installed to accommodate input control from the wave off control stations. Coordinate final locations with the government.

Wave off system shall communicate via fiber optic network and shall include a fiber to I/O converter and I/O rack at the wave off system site for wave off light control.

2.17.12 Communication Network

The air traffic control tower, airfield lighting vaults and air traffic control tower computers shall communicate with each other via two or more of the following communication networks:

Fiber Optic Ethernet, 1550nm, single mode

Supply, installation, termination and testing of the fiber optic cable and associated equipment including fiber cable, fiber patch cables, SC connectors and couplings shall be the responsibly of the contractor.

The fiber optic cables shall be single mode, 1550nm wavelength, 8/125 micron fiber cable. Each fiber communication link requires 2 fibers.

All fiber optic cable shall be terminated at a fiber optic patch panel within each subsystem before being terminated at the communication equipment.

Fiber optic patch cables shall be provided from the fiber patch panel to the computer equipment cabinets/enclosures.

Fiber optic cable shall be terminated with SC style connectors at the fiber optic transceivers located within the computer cabinets/enclosures.

Fiber optic runs shall not exceed 5km (16000 feet) when using single mode fiber optic cable.

Fiber optic runs shall be direct point to point runs with no splices when possible.

Fiber cables shall be pulled and terminated within the fiber optic patch panel for future expansion.

Upon completion of fiber optic installation, the contractor shall provide Government with a test report which shall include dB loss test results.

2.17.13 Wireless Ethernet

The antenna shall be provided by the ALCMS manufacturer.

The antenna mast shall be provided and installed by the contractor.

The supply, installation and termination of the interconnecting cable (between the antenna and wireless communication equipment) and associated equipment including connectors and couplings shall be the responsibility of the contractor. Provide equipment, devices, cabling, connectors and conduit for a complete and operable system.

The wireless network shall use direct sequencing, spread spectrum radios.

The wireless Ethernet network shall use the 2.4 GHz ISM band and allow license-free operation.

Contractor shall a hire a specialist to perform radio site survey and select wireless frequency. Wireless equipment shall provide selectable frequency sub-channels that the Contractor must verify that these frequencies are not used at the airport or by local business, police stations, fire departments and government offices. An example of the frequency sub-channels are as follows:

Channel 1: 2.412 GHz
Channel 2: 2.422 GHz
Channel 3: 2.432 GHz
Channel 4: 2.442 GHz
Channel 5: 2.452 GHz
Channel 6: 2.462 GHz

The ALCMS manufacturer's wireless communication system shall be based on line-of-site communication between all subsystems.

No repeaters shall be necessary.

The wireless system shall combine antenna diversity and digital signal processing to assure secure, reliable communications.

Network switches, media converters, and fiber transceivers shall be compatible with copper and fiber connectors and cabling connected to them for a complete and operating network system.

2.17.14 Computers

Industrial grade Rack Mounted Computer:

All the industrial grade rack mounted computers in the ALCMS system shall be identical and have at a minimum, the following technical specifications:

Options	Description
Type	Industrial grade computer
Processor	Type Intel Pentium® 4 or better
Processor	Clock Rate 2.5 GHz or better
Memory	Capacity 2GigaBytes RAM
Hard Disk	4GByte Solid State Flash Drive
Hard Drive Bay	Flash Drive removable, front accessible drive
Compact Flash Card	2GByte Compact Flash Card
2 X USB Ports	2 Front accessible USB Ports
Cache Memory	L2 512KB
CD-ROM	52X
Video (Integrated)	SVGA, 8MB VRAM, minimum support 1280 x 1024
Operating System	Window XP™ Pro or better
Lockable Drive Bay	Front accessible and lockable drive
Redundant Hot Swappable Fans	Front accessible, hot swappable CPU fans
Redundant Power Supplies	Rear accessible and hot swappable CPU
Front LED diagnostics	Front viewable LED diagnostic LEDS
Ethernet	Two RJ-45 ports, 10/100/1000Base-T

All the industrial grade rack mounted computers in the ALCMS system shall

be designed using a slot board computer.

The computer back plane shall be passive, meaning a motherboard and daughter-board design is not acceptable.

The central processing unit (CPU) shall be on a slot board type card that is installed on the back plane of the computer chassis.

CPU upgrades shall be as simple as replacing the CPU of the slot board or removing the slot board card and plugging in a new one.

To ensure stability, the slot board computers shall have undergone a -20 to 80 degrees Celsius dynamic temperature burn-in test.

The slot board computer shall be designed to withstand harsh environmental conditions like shock, vibration, power surges and fluctuations, heavy dust, and extreme temperatures.

Flash Drive:

The computer shall use a internal solid state Flash Drive with no moving parts.

The Flash Drive shall be a minimum of 4G Bytes

The Flash Drive shall operate at temperatures from -40 degrees C to +85 degrees Celsius.

The Flash Drive shall have 1000G operating shock and 15G operating vibration rating.

The drive shall have a 10 year rated data integrity specification.
The Flash Drive shall use Active Remap versus Wear Leveling to assure extended drive life.

The Flash Drive shall store the operating system and any programs that require erase/read/write cycles.

Flash Drive specification sheets shall be provided with Submittal showing proposed flash drive meets specification requirements.

Compact Flash Card:

The computer shall use an external Compact Flash (CF) Card which shall be installed using either a PCMCIA Compact Flash Card Reader or an external 5 ¼" bay with a compact flash card reader.

The CF Card shall be a minimum of 2 GBytes

No erase and/or write cycles shall occur to the Compact Flash Card.

The CF Card shall store programs and configuration files that are only read during power-up. These files should be the airport specific programs and configurations.

The CF Card shall contain "Ghost" image (Exact image of the original drive) of the Flash Drive which allows for easy Flash Drive replacement and repair.

Flash Drive Service / Repair:

The PC computer shall be able to be rebuilt using a new blank Flash Drive or blank standard Hard Drive.

The computer shall be able to boot from the CF Card and execute a "Ghost" image rebuild program.

The rebuild program shall extract and copy the "Ghost" image, all configurations and airport specific programs from the CF Card to the new blank Flash Drive.

Upon completion of the rebuild program, the computer shall be able to be rebooted and be completely operational.

Airfield Lighting Vault Computer:

The vault computer shall be capable of independently carrying out the following functions:

Decode all commands received and transfer them to the corresponding

Distributed Control and Monitoring Equipment (DCME) unit for execution.

Interrogate all the DCME units to determine the status of the Constant Current Regulators (CCRs) and other controllable items.

Transfer the status of the CCRs and other controllable items to the control tower computer and maintenance center computer.

Continuously check for proper operation of all the communication links connected to the computer.

Continuously check for proper operation of the vault distributed control and monitoring network.

Duplicate electrical vaults and the air traffic control tower controls and graphical displays for allowing authorized control from the Airfield Lighting vault computer.

The airfield lighting vault computer shall also duplicate the maintenance center status information.

Provide hard copies of real-time and historical information on the status of the airfield lighting systems and other controlled and monitored items.

The airfield lighting vault computer application shall not be able to initiate lighting commands unless the airfield traffic control tower authorizes control to the airfield light vault computers.

Air traffic control tower and electrical vaults airfield lighting computer (s):

The computer(s) shall be capable of independently carrying out the following functions:

Receive commands from the control station(s) and transfer lighting control commands to the vault(s) for execution.

Receive the airfield lighting status information from the vault(s) and transfer the status to the display.

Maintenance Laptop Computer

The maintenance laptop computer shall be capable of independently carrying out the following functions:

Provide real-time and historical information on the status of the airfield lighting systems and other controlled and monitored items.

Provide information as to the time, type, location and nature of system problems, alarms or warnings.

Provide real-time and historical information on the status of the airfield lighting systems and other controlled and monitored items.

The Maintenance center computer application shall not be able to initiate lighting commands unless air traffic control tower authorizes control to the maintenance center.

Provide remote dial-in and diagnostics for the ALCMS Manufacturer technical service personnel.

Two wireless maintenance computers shall be provided to allow for remote connection to the ALCMS system from a maintenance vehicle or other remote location.

The maintenance computer shall be a laptop computer with docking station to allow the unit to be docked and re-charged.
The computer shall provide real-time and monitoring of the the airfield lighting system when in range of the wireless coverage.

The wireless computer shall use wireless Ethernet to provide wireless roaming access to the ALCMS.

The ALCMS manufacturer shall provide all peripherals, software, computer cards, and wireless equipment required to configure the computer to work with the Ethernet network.

Roaming Maintenance Laptop Computer Technical Specifications:

All roaming maintenance industrial grade laptop computers in the ALCMS system shall have at a minimum, the following technical specifications:

Options	Description
Type Laptop	Industrial grade
Processor Type	Intel Pentium® 4 or better
Processor Clock Rate	2.5 GHz or better
Memory Capacity	1GigaByte RAM
Hard Disk Drive	200Mbytes or larger
Floppy Diskette Drive	1.44 MB, 3.5"
2 X USB Ports	2 USB Ports
Cache Memory L2	512KB or larger
CD-ROM	52X
Video (Integrated)	SVGA, 8MB VRAM, minimum support 1280 x 1024
LCD Screen	12" diagonal viewing area or greater
Operating System	Window XP™ Pro or better

2.17.15 Subsystem Equipment

Electrical vaults equipment

Computers:

The computers shall meet previously specified technical requirements.

120 VAC, uninterruptible power shall be supplied to the computer, switches, and the Monitors.

Monitors

120 VAC, uninterruptible power shall be supplied to the monitors.
Video / Serial Communication Extension Equipment:

If required, Video / Serial Communication extension Receiver box shall be installed in conjunction with each display in the computer enclosure.

If required, Video / Serial Communication extension Transmitter box shall be installed in conjunction with the air traffic control computer located in the tower sub-junction.

If required, the video extension transmitter shall allow for simultaneous connection of the local service monitor and the remote monitor.

A category 6 communications cable shall be installed between the Receiver and Transmitter. A spare CAT 6 cable shall also be installed, for use as a future troubleshooting aid.

Service Monitor (LCD): The service display shall use a 17" LCD monitor. For the electrical vault, the monitor shall be located on a shelf within the equipment enclosure. 120 VAC, uninterruptible power shall be supplied to each monitor.

Audible Alarm assembly: An audible speaker shall be installed in conjunction with each HMI screen display. An audio and volume control cable shall be installed between the audible speaker and the air traffic control located in the tower sub-junction.

Uninterruptible Power System: An uninterruptible power system (UPS) shall be provided for supporting power to electrical vaults and the air traffic control tower building. The UPS shall be capable of supplying full load power for 10 minutes after loss of main input power.

Industrial Enclosures: A NEMA 12 industrial enclosure shall be provided for housing associated computer equipment. Enclosures with rack mounted computers shall provided with cooling fans and filters. Enclosures shall be provided with solid metal doors. Enclosures shall be complete and assembled with hardware, shelves, front and back solid doors, side panels. Frames shall be single-roll-formed, robotically welded design made of 12 gauge steel with solid steel fully welded corners. External sides and doors shall be 16 or 14 gauge steel. Doors shall be provided with locks. Solid doors shall include standard door bars for additional mounting space and rigidity. The computer enclosures shall be an industry standard 19" rack-mount type enclosure. Coordinate with government for exact location of computers, and associated equipment.

Vault Equipment:

Computer:

The vault computer shall be a 19" industrial rack-mount type.
The computers shall meet previously specified technical requirements.
120 VAC, uninterruptible power shall be supplied to the computer.

Monitor (LCD):

The service display shall use a 17" LCD monitor.

The monitor shall be located on a shelf within the vault equipment enclosure(s).

120 VAC, uninterruptible power shall be supplied to the monitor.

Uninterruptible Power System:

An uninterruptible power system (UPS) shall be provided for supporting power to the vault equipment.

The UPS shall be capable of supplying full load power for 10 minutes after loss of main input power.
The UPS shall be a 19" rack-mount unit installed in the vault computer equipment enclosure.

Uninterruptible Power System: DCME Control and Monitoring Equipment:

An uninterruptible power system (UPS) shall be provided for supporting power to the DCME equipment.

The UPS shall be capable of supplying full load power for 10 minutes after loss of main input power.

The UPS shall be a 19" rack-mount unit installed in the vault computer equipment enclosure.

Industrial Enclosures:

A NEMA 12 industrial enclosure shall be provided for housing associated vault computer equipment.

The enclosure is designed for indoor use to provide protection against dust, dirt, dripping water, and external condensation of non-corrosive liquids.

The enclosure shall be an industry standard 19" rack-mount type enclosure.

The industrial enclosure shall include a pagoda top with exhaust fan and ventilation kit for proper convection cooling.

The environmental conditions within the area of the enclosure installation shall not exceed 110F or fall below 60F.

2.17.16 Distributed Control Equipment

The control and monitoring equipment shall be of a distributed nature and shall not be PLC based.

The DCME units shall be installed locally at each device (i.e. CCR) which requires control and/or monitoring within the airfield lighting electrical vault(s).

General:

Each CCR and each controllable item shall be connected to a DCME.

The DCME shall be a microprocessor-based module that includes all of the communication, control commands, input/output connections and failsafe functionality.

The DCME shall communicate via a redundant (2 independent communication links) communications network with wireless backup.

Connections to the communication network shall be via quick disconnect terminal connectors that can easily be plugged and unplugged from the communication equipment.

The DCME shall communicate back to the Vault computer via either of the networks.

Removal of any DCME units from the vault network shall not affect the operation of the ALCMS system.

The DCME shall be a universal device that can be used on any type of CCR and/or controlled element from any manufacturer.

To minimize spare parts needs, each DCME shall be identical and have interchangeable components.

The DCME unit shall provide optical isolation from all high voltage equipment including the CCR output current, CCR output voltage and CCR input voltage.

All high voltage interfaces to the DCME unit shall be via fiber optic cable.

Redundant Vault Control Network:

The DCME redundant communication network shall use two (2) independent communication network cables installed in the electrical vault.

The vault network shall use two (2) cables each consisting of two (2), 24AWG, shielded twisted pairs with a common (drain wire) meeting EIA RS-485 applications (Belden™ no. 9842) or an ALCMS manufacturer approved equivalent.

The network shall be used to control and monitor all the various controllable elements located within the vault(s) such as CCRs and Generator(s).

Any malfunction in one network shall not affect the operation of the other communications network.

Any malfunction in one of the DCME communication ports shall transfer communication to the remaining port without affecting system functions.

Overview of Operation:

Each DCME unit shall have a unique factory set address and a field programmable communication address.

The DCME receives commands via the vault network, executes those commands, and transfers back the status of the element to the vault computer.

The DCME shall perform the following functions:

Brightness setting control of the CCRs or ON/OFF control as required by the controlled element (i.e. generator may only require ON/OFF control).

Perform all failsafe functions.

Communication via both networks to the vault computer.

Self-diagnostic function to monitor for proper operation.

Locally store all data and parameters specific to the controlled element.

For maintenance purposes, the DCME shall have an internal ON/OFF switch and shall have a front hinged access door.

Basic DCME components

The DCME shall consist of the following basic components and functions:

Input / Output Board:

Shall provide eight (8) mechanical latching output points. These control points shall also be self-monitored and provide back-indication to the

Vault computer verifying proper execution of the control command.

Shall provide eight (8) optical-isolated input points.

Shall provide quick-disconnect terminal blocks that can be easily plugged and unplugged from the I/O board.

Monitor Board:

Shall provide redundant communication network circuitry.

Shall provide quick-disconnect terminal blocks for redundant communication network connections.

Receives and transmits data to the vault computer.

Digital Display:

Shall provide visual display of DCME status (Power, communications and monitoring).

Brightness Step: display indicating the commanded step of the CCR.

Channel A: display indicating the status of channel A of the redundant communication network.

Channel B: display indicating the status of channel B of the redundant communication network.

Ability to put the DCME into a "cycle mode" which alternately displays all monitored parameters.

Distributed Monitoring Equipment
The DCME shall provide the following minimum monitoring:

L-827/9 Monitoring:

The DCME shall include the monitoring board and provide the following information for each CCR:

Loss of input power to the CCR.
CCR shutdown by open-circuit / over-current protective devices.
Drop of more than 10% in the CCR VA load.
Failure of the CCR to deliver the selected output current.
Remote / Local status of the CCR.
Actual CCR output current
Actual CCR output voltage
Actual CCR output load wattage (W)
Actual CCR output load Volts-Amps (VA)

The DCME digital display shall provide local indication of the CCR status including:

Remote/Local: display indicating the status of the remote / local switch of the CCR.

Primary Power: display indicating the status of the input power to the CCR.

Over current: display indicating over current, protective shutdown.

Open circuit: display indicating open circuit status.

The DCME shall interface to an external current and voltage module (CVM) used to collect current and voltage information. The CVM shall meet the following minimum requirements.

Collects analog current and voltage samples at a high sample rate of 50,000 samples/second.

Transmits current and voltage samples to the DCME.

Provide digital fiber optical isolation between the DCME and the output of the CCR.

Quick disconnect fiber optic connections for interfacing to the DCME.

The ALCMS manufacturer shall provide the fiber optic cable between the CVM and the DCME.
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Insulation Resistance Monitoring:

The IRMS is capable of automatically or manually monitoring and reporting the insulation resistance value of the series circuit cabling (one IRMS per circuit).

The measured resistance shall be displayed locally at the DCME digital display.

The DCME unit shall be capable of reading and recording resistance values from less than 20k Ohms to circuit cabling (one IRMS per circuit).

The DCME shall interface to an external insulation resistance module (IRM).

The IRM shall meet the following minimum requirements.

Collects insulation resistance samples.

Transmits insulation resistance samples to the DCME.

Provide digital fiber optical isolation between the DCME and the output of the CCR.

The IRMS system shall be capable of taking resistance readings on circuits that are energized or de-energized.

Quick disconnect fiber optic connections for interfacing to the DCME.

Fiber optic communication shall be used between the IRM board and the DCME.

The ALCMS manufacturer shall provide the fiber optic cables between the IRM board and the DCME.

The IRMS system shall provide database record keeping that allows for graphical trend analysis of the insulation resistance readings.

The IRMS shall provide configurable insulation resistance warning and alarm limit notification to the system.

The IRMS shall be able to be configured for a minimum of two (2) reading times per day.

The IRMS shall be able to be configured for a minimum of two (2) reading times per day.

The IRMS shall be able to be configured to take readings hourly, daily, weekly or monthly.

All user programmable variables shall be able to be changed at any specified computer within the ALCMS system.

All the IRMS data shall be viewable either as real-time or as historical data at any specified computer location. The IRMS information shall be available at all times and shall not require any special transfer of data between the IRMS system and the control system (since the IRMS is an integral component of the ALCMS.

Latching Failsafe

Each DCME unit shall provide a self-contained latching failsafe feature that shall perform the following functions:

Insure default operation of the airport lighting, even if the entire airport lighting control system is not functioning.

Display the commands sent by the computer to the CCRs and/or to the other controllable items.

Adaptable to each CCR regardless of internal or external control voltage.

Permits maintenance of portions of the control system, without changing the operational status of the lighting system.

The failsafe mode of each DCME unit shall be "Passive Failsafe" (Latching) mode.

If the CCR was switched ON before the failure, it shall remain ON at the same brightness level.

If the CCR was switched OFF before the failure, it shall remain OFF.

Failsafe shall be able to be bypassed by selecting the CCR locally to any desired brightness level.

Failsafe Technical Specifications:

The failsafe system shall operate independently of the computer, providing failsafe interfacing to the CCR and/or other controllable elements.

The failsafe system shall be based on electromechanical latching relays with the following characteristics:

	Rating
Maximum switching voltage	240VAC, 125VDC
Nominal switching capacity	8A / 250VAC 5A / 30VDC
Rated current (resistive)	1A
Operational Life Mechanical	5X107 Electrical 105
Protection	IP67 (protection against ingress of dust and water in harmful quantities)

Mode of Operation:

The commands executed by the DCME to switch the CCR and/or controllable element shall be momentary commands.

The control commands shall be mechanically latched upon execution.

Failure of the DCME and/or loss of communication to the network shall not change the status of the airport lighting.

DCME Mounting

The DCME equipment shall be mounted integral to each CCR enclosure.
Graphical User Interface Operation:

General:

The electrical vaults and the air traffic control tower display shall control and monitor the airfield lighting system. The display shall show real-time information on the operational status of the airfield lighting systems.

The control stations shall consist of multiple display 'pages' each with a specific function. These display 'pages' are defined as follows:

Preset: Consists of pre-defined preset buttons used to simplify airfield lighting control commands.

Runway Lights: Consists of runway control buttons used to individually control runway circuits. Multiple runway pages may be necessary for airports with several runways.

Taxiway Lights: Consists of taxiway control buttons used to individually control taxiway circuits if required.

Utilities: Consists of miscellaneous functions for granting lighting control to other locations, setting the date and time, etc.

The ALCMS manufacturer shall provide preset tables to be used by the airport/owner to define the configuration settings.

Wave Off Lights: Consist of Pre-defined preset buttons used as backup control for the wave off light system to include inboard and outboard on selectors and runway selectors.

2.17.17 Overview of Operation:

Airfield lighting control commands are entered into the system by touching the corresponding button on the HMI screen video display. When a command is entered, the HMI screen shall respond by graphically displaying the button as being depressed and change the button color.

The associated circuit graphics shall alternately flash indicating the airfield lighting section that shall be affected when this command is "confirmed".

Once confirmed, the air traffic control tower shall register the command, generate a data instruction and transmit the command to the vault computer(s) for implementation. The command is also simultaneously transmitted to the
maintenance computer and all other computers connected to the network.

The air traffic control tower shall receive confirmation from the vault(s) that the corresponding equipment has responded to the control command and displays the current system status on the HMI screen display.

In the event that communications is lost between the air traffic control tower and the vault(s),an alarm is indicated at each computer location.

In the event of a predefined alarm condition, the effected airfield lighting circuit graphic shall flash red and an audible alarm tone shall alert operators to the alarm condition.

ALCMS Alarm Functions

Computer Audible Alarm

The audible alarm shall sound at each computer display when an alarm condition occurs. In addition, the 'ALARM ACK' button shall flash and the associated airfield circuit graphics shall change to red.

Alarm Display Button is a button used to view the current alarms in the computer system. When pressed, this button will open the current alarms

window which provides a text listing of all currently active alarms in the ALCMS.

It is useful for informing maintenance personnel of the exact alarm in the system.

The audible alarm shall stop automatically after three (3) seconds unless the 'ALARM ACK' button is pressed.

If the alarm is not acknowledged, the audible shall cease for sixty (60) seconds while the 'ALARM ACK' continues to flash. If the 'ALARM ACK' is still not pressed after the sixty (60) seconds, the audible shall sound again for three (3) seconds.

This sequence shall repeat indefinitely until the alarm is acknowledged.
Circuit Alarms

The ALCMS shall continuously monitor the status of all of the circuits per the monitoring requirements as specified previously.

If there are any monitoring discrepancies (i.e. incorrect CCR output current, loss of primary power) an alarm shall be generated at the

Touchscreen display for the associated circuit.

Computer Command Sequences

The control station shall allow the airfield lighting circuits to be controlled individually (i.e. RWY Edge) or as a group based on preset tables (See following section).

Each control command shall require two distinct operator actions in order for the command to initiate any state changes in the airfield lighting.

The command sequence shall be as follows:

Select circuit: Operator selects the desired circuit to be changed.

Select intensity: Operator selects the desired brightness step that the circuit is to be changed to.

Graphics flash: The graphics associated with the selected circuit shall begin to flash visually indicating to the operator the airfield lighting section that is going to be affected by the command.

Confirm/Reject: Operator selects the 'CONFIRM' button to accept the selection and initiate the lighting change. Operator selects the 'REJECT' button to cancel the selections and make another selection.

Computer Preset Sequences

The Computer control station shall allow simultaneous airfield lighting circuit changes to be in accordance with NAVAIR 51-50AAA-2 (current revision)to be accomplished using preset lighting sequences.

The preset lighting sequences shall be defined by the airport in airfield lighting preset tables.

Each preset lighting change shall be based on the following operator inputs:

Active Runway Selection: Operator selects the runway(s) that shall be active. This is based on runway direction (i.e. "RWY 05")

Day/Night Setting: Operator selects the day/night setting. The day/night setting shall control the intensity of the circuits.

Visibility: Operator selects a single visibility setting that is based upon the current airport visibility.

Confirm/Reject: Operator selects the 'CONFIRM' button to accept the preset selections and initiate the lighting change. Operator selects the 'REJECT' button to cancel the selections and make another preset selection.

Upon confirmation of the preset selections, the intensity of all the circuits associated with the preset condition shall automatically change to match the visibility requirement.

The preset visibility setting of the CCRs is based on FAA document 7110.65J. Presets shall also be coordinated with the airport to properly define airfield lighting operational usage.

The visibility settings shall include Intensity and Preset Invalid monitoring. This indicates when a preset or intensity setting on the airfield is different than the selected preset intensity.

According to FAA document 7110.65J, the visibility settings for the 5-step CCRs shall be based on the following table:

	Day (Brightness step)	Night(Brightness step
Less than 1 mile	5	4
1 to but not including 2 miles	4	3
2 to but not including 3 miles	3	3
3 to 5 miles inclusive	0	2
More than 5 miles	0	1

According to FAA document 7110.65J, the visibility settings for the Rotating Beacon shall be based on the following table:

	Day (Brightness step)	Night(Brightness step
Less than 1 mile	ON	ON
1 to but not including 2 miles	ON	ON
2 to but not including 3 miles	ON	ON
3 to 5 miles inclusive	OFF	ON
More than 5 miles	OFF	ON

Graphical Airport Pictorial

The ALCMS display screens shall display a graphical pictorial representation of the airport runways, taxiways and other requested airport features.

When there is a change in lighting system status, the appropriate graphical detail shall indicate the status by changing color.

The circuit intensity display colors shall be represented as seen in the

legend as follows.

COLOR LEGEND

STEP 5 CYAN STEP 4 LIGHT GRN STEP 3 MAGENTA STEP 2 DARK GREEN
STEP 1 BLUE STEP 0 DARK GRAY

The circuit selection buttons shall be provided for the desired lighting circuit to be controlled.

The status monitoring display colors shall be represented as seen in the legend as follows. This includes ATS monitoring, generator monitoring and communications monitoring:

COLOR LEGEND

NORMAL ON OR NORMAL STATUS	GREEN
ALARM ON	RED
NORMAL OFF	DARK GRAY

Vault Automatic Transfer Switch (ATS) and Generator Monitoring

The ALCMS system shall provide the optically isolated digital inputs to monitor the following feedback points:

Utility OnAvailable
Generator Available
Generator On-line
Generator Alarm
Generator fuel tank leak detection

Locating and wiring of the monitoring points within the ATS and generator equipment shall be completed by the contractor in coordination with the equipment manufacturer.

2.17.18 Beacon Control

The ALCMS shall provide wireless control of the rotating beacon from the ALCMS node.

The ALCMS shall provide one (1) optically isolated, dry-contact output point. The contact shall be rated 1A at 120Vac.

The ALCMS shall close the output to command the beacon ON and open the output to turn the beacon OFF. The contractor shall provide an interface relay/contactor to connect power to the beacon.

Locating and wiring of the output points within the Beacon equipment shall be completed by the Contractor in coordination with the airport/engineer and equipment manufacturer.

2.17.19 Wave-Off Light Control

The ALCMS shall provide control of the wave off light system from all of the control stations and the two hardwired control stations in the tower cab.

The ALCMS shall provide a minimum of six (6), dry-contact input point(s) in the tower cab for the associated wave off system control stations.

The ALCMS shall monitor the inputs to command the wave off lights ON and

monitor the runway selector.

The ALCMS shall provide one (1), dry-contact output point(s) at each vault for the associated wave off system. The output shall then be transmitted via fiber optic network to the wave off light site and converted to a hard I/O signal for wave off light control.

The ALCMS shall close the output to command the device ON and open the output to turn the device OFF.

Locating and wiring of the output points within the device shall be completed by the Contractor in coordination with the airport/engineer and equipment manufacturer.

2.18 WAVE-OFF SYSTEM

Include wave-off strobe lights (flashhead), equipment pad, control panel, transformers, safety switches, panelboard and the associated equipment and interconnecting wiring to provide a complete system as indicated and as specified herein.

2.18.1 Wave-off Strobe Lights

Provide capacitance-discharge, flashing lights (strobe) for wave-off lighting system. Each light includes a flash head (FH) optical assembly unit, a power converter unit (PCU), and the interconnecting cable.

a. MIL-L-29575

b. Acceptable Source:

(1) Flash Technology of America, 55-T Lake Street, Nashua, N.H., 03060, phone 603/883-6500

Flash Technology Beacon (FTB) 622

(2) Another Wave-Off Strobe Light System by another reputable manufacturer will be acceptable, subject to approval by the Contracting Officer.

2.18.2 Wave-Off Control Cabinet

Provide cabinet with components necessary for complete operation of the lighting system as indicated.

a. Enclosure

(1) UL 50

(2) 14 gage, sheet steel, NEMA 4X stainless steel, enclosure per NEMA ICS 6, with hinged cover

b. Nameplates

Provide nameplates for controls as specified in Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS .

c. Terminal Board

NEMA ICS 4

d. Relays

(1) Provide as indicated.

(2) Coil: 120 Volt, 60 Hz.

(3) Contacts: 10 Amperes

e. Receptacle

(1) UL listed for use in wet locations

(2) Weatherproof on cabinet with threaded cap and chain as indicated.

2.18.3 Pad-mounted Transformer, 25kVA, 1-Phase, Low Profile

As specified in Section 26 12 21 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS.

2.18.4 Safety Switches, Panelboard, and Transformer

a. Provide as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

b. Provide enclosure as specified for Wave-Off Control Panel.

2.18.5 Photo-Electric Switch

a. UL 773 or UL 773A

b. Hermetically sealed cadmium-sulfide cell

c. Single-throw contacts

d. On below 3 footcandles, off 3 - 10 footcandles

e. Time delay to prevent switching from transient light sources

f. Directional lens to prevent turnoff condition from fixed lights.

2.18.6 Equipment Pad

Provide as shown on construction drawings.

2.19 RUNWAY AND TAXIWAY LIGHTING SYSTEMS

Include runway edge lights, runway threshold lights, runway centerline lights, taxiway guidance signs at intersecting taxiway, intersecting runways and adjacent to arresting gears, runway distance and arresting gear markers, taxiway edge lights, lights, taxiway guidance signs, mounting structures, controls, and the associated equipment and interconnecting wiring to provide complete systems as indicated and

specified herein. Provide inpavement light fixtures able to withstand a minimum static single wheel load of 50,000 pounds.

2.19.1 Runway Edge Lights

FAA AC 150/5345-46, Type L-862(L), for elevated mounting; and FAA AC 150/5345-46, Type L-850L Class C, for semiflush mounting at intersecting taxiways, at intersecting runways and adjacent to arresting gear. Provide filters as indicated conforming to requirements of fixture specifications.

2.19.2 Runway Threshold Lights

Elevated L-862E(L) for mounting outboard of edge lights; and L-862E(L)or L-8500(L) as indicated, for mounting inboard of edge lights.

2.19.3 Runway Centerline Lights

Runway centerline lights on the cross runway shall be salvaged and stored for re-installation.

2.19.4 Taxiway Edge Lights

FAA AC 150/5345-46, Type L-861T(L) for elevated taxiway edge lights with 45-watt, 6.6A lamp and blue lens or yellow lens as indicated and FAA AC 150/5345-46, Type L-852E(L), Class 1 for semiflush taxiway edge lights with an LED, 6.6A lamp and blue filter. Taxiway lights shall be salvaged and stored for reinstallation or turned over to airfield operations where indicated.

2.19.5 Inpavement Guard Lights

FAA AC 150/5345-46 Type L-804(L)unidirectional with flashing yellow filter towards the taxiway.

2.19.6 Runway Guard Lights

FAA AC 150/5345-46, Type L-852G(L) unidirectional with yellow filter toward the taxiway.

2.19.7 Taxiway Guidance Signs

FAA AC 150/5345-44. Informational signs Type L-858Y(L) and mandatory signs Type L-858R(L). Provide size as indicated. Provide series circuit power supply adapters approved by the sign manufacturer.

2.20 CONNECTORS

FAA AC 150/5345-26, FAA Type L-823 connectors for use with FAA Type L-824 airfield lighting cable.

2.21 PAINTING

As specified in Section 09 90 00 PAINTS AND COATINGS.

2.22 Flood Lighting

LED flood light rated for Class 1, Div 2 locations as indicated on RM12-0469 Drawings EA509.

PART 3 EXECUTION

3.1 ELECTRICAL REQUIREMENTS

Electrical installation shall conform to IEEE C2, NFPA 70, NFPA 70B and requirements specified herein. Underground electrical work shall be as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.1.1 Electrical Metallic Tubing

Do not install underground or encase in concrete.

3.2 CONCRETE

Unless otherwise specified, provide 3000 psi concrete for below grade and 4000 psi concrete for above grade use with one inch maximum aggregate conforming to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.3 AIRFIELD MANHOLES AND HANDHOLES

Provide as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.4 EARTHWORK

Provide excavation, backfilling, and reconditioning of surfaces as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.5 GROUNDING

Ground non-current carrying metallic parts associated with electrical equipment as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.6 CABLE MARKERS

Provide cable markers or tags for each cable at duct entrances entering or leaving manholes or handholes and at each termination within the lighting vault. Tag cables in each manhole or handhole with not less than two tags per cable, one near each duct entrance hole. Immediately after cable installation, permanently attach tags to cables and wires so that they cannot be accidentally detached.

3.7 FRANGIBLE REQUIREMENTS

Install frangible supports, couplings, and adapters as indicated and specified. Install with the type conduit indicated.

3.8 ELEVATED AIRFIELD LIGHTS

Frangibly mount normally not exceeding 14 inches in height unless higher mounting is permitted in snow accumulation areas. Frangibly mount equipment exceeding 14 inches in height as indicated.

3.9 SEMIFLUSH AIRFIELD LIGHTS

Remove water, debris, and other foreign substances prior to installing semiflush light base and light.

3.10 WIRES, FIXTURES, AND ENCLOSURES IN DRILLED HOLES

Sealant is specified in paragraph entitled "Sealing Fixtures in Drilled Holes ."

3.10.1 Holes for Light Fixtures

Bore holes in pavement to dimensions indicated. Use a diamond-edged bit to provide a smooth, straight cut. Bottom of hole shall be flat or slightly concave, except that an area at least one inch wide around the perimeter shall be flat. Fill surfaces deeper than the prescribed depth with sealant to the level of the flat area and allow to cure before further placement.

3.10.2 Holes for Transformer Enclosures

Drill holes through concrete pavement and remove loose material. Fill hole with concrete to depth indicated. Provide a minimum of 3 inches of concrete at bottom of hole.

3.10.3 Sandblasting

Sandblast holes to remove foreign or loose material. Accomplish sandblasting by using approved equipment maintained in good working order at all times. Provide sand used for blasting of the proper size and quality as necessary to perform the work. Provide nozzles used for sandblasting of the proper size in relation to the holes to be cleaned. Replace nozzles enlarged by wear as necessary. Sandblast at an air pressure of not less than 90 psi.

3.10.4 Cleaning

Immediately prior to installation of wire or light fixtures, flush holes with a high velocity water jet or steam, and clean and dry with a high velocity air jet to remove dirt and foreign material.

3.10.5 Lighting Fixture Installation

Sandblast sides and bottom of each light fixture immediately prior to installation. Cover inside faces of bored hole and bottom and sides of light fixture with a coating of sealant that will completely fill the void between concrete and fixture. Use a jig or holding device for installing each light fixture to ensure positioning to the proper elevation, alignment, level control, and azimuth control. Orient light fixture with light beam parallel to flight deck centerline or runway centerline and facing in the particular direction required. Level outermost edge of fixture with the surrounding pavement. Remove surplus sealant or flexible embedding material. Leave the holding device in place until sealant has reached its initial set. Properly arrange fixture lead wires with respect to their connecting position. Block the wire way entrance into the light recess to retain the sealant material during curing.

3.11 SPLICES FOR AIRFIELD LIGHTING CABLE

3.11.1 Connectors

Use kit type connectors to splice 5 kV single-conductor series lighting cables. During installation and prior to covering with earth, keep mating

surfaces of connectors covered until connected and clean when plugged together. At joint where connectors come together, install heat shrinkable tubing with waterproof sealant. Joint shall prevent entrapment of air which might subsequently loosen the joint.

3.12 GROUNDING SYSTEMS

3.12.1 Counterpoise Installation

Lay counterpoise wire for entire length of circuits supplying airfield lighting. Provide wire in one piece, except where distance exceeds the length usually supplied, and install on top of the envelope of concrete-encased duct and approximately 6 inches above direct burial cables and duct lines. Where trenches or duct lines intersect, electrically interconnect counterpoise wires by exothermic welding. Connect counterpoise wires together and to existing counterpoise wires. Connect counterpoise to earth ground at every 500 feet of cable run, at lighting vault, and at feeder connection to light circuit by means of ground rods as specified.

3.12.2 Fixture Grounding

Ground each fixture or group of adjacent fixtures to the counterpoise system. Connect fixtures, steel light bases or grounding bushings on steel conduits to the counterpoise system by a No. 4 AWG bare-stranded copper wire. Connect copper wire to the counterpoise by exothermic weld.

3.13 MARKING AND LIGHTING OF AIRWAY OBSTRUCTIONS

Mark and light towers, poles, smokestacks, buildings of certain shapes and sizes, and other obstructions in accordance with FAA AC 70/7460-1 and as indicated.

3.13.1 Painting of Airway Obstructions

Patterns and colors to mark obstructions shall conform to FAA AC 70/7460-1 and be as indicated.

3.13.2 Obstruction Marker Lights

Install obstruction marker lights on radio towers, elevated water tanks, smokestacks, buildings, and similar structures with one inchzinc-coated rigid steel conduit stems using standard tees and elbows, except that where lowering devices are required, install in accordance with equipment manufacturer's recommendations.

3.14 WIND DIRECTION INDICATORS

Installation shall include a 25 foot black circle constructed on the ground with center at center of the base. Construct circle of an emulsified asphalt-sand mixture or of a cut-back asphalt sand mixture and not less than 5 inches in thickness. Asphalt sand mixture shall contain not less than 6 percent bitumen. Provide well graded sand with not more than 10 percent material which will pass through a No. 200 mesh sieve. Compact asphalt-sand mixture thoroughly and slope for drainage from center to outer rim from one side to the other.

3.15 ISOLATION TRANSFORMERS

Make connections of transformer primary leads to primary cables with connectors conforming to FAA AC 150/5345-26. Make connection to transformer secondary with connectors conforming to FAA AC 150/5345-26 and plug directly into a mating connector on the transformer secondary leads. During installation, keep mating surfaces of connectors covered until connected and clean when plugged together. At joint where connectors come together, install heat shrinkable tubing with waterproof sealant. Joint shall prevent entrapment of air which might subsequently loosen the joint.

3.16 RUNWAY AND TAXIWAY LIGHTING SYSTEMS

3.16.1 Runway Centerline Lights

Salvage and store for re-installation a transformer for each light fixture and install in light can.

3.17 FIELD QUALITY CONTROL

Give the Contracting Officer 5 working days notice prior to each tests. Correct deficiencies found and repeat tests.

ALCMS Factory Acceptance Test (FAT):

Before shipment, the ALCMS system shall be assembled as an operating system at the ALCMS Manufacturer's test facilities.

The ALCMS Manufacturer shall make the FAT available for representative(s) of the Government to witness the testing of the system.

At a minimum, the FAT shall allow for one (1) day of testing and review, but may require additional time depending on the results of the testing.

The ALCMS Manufacturer shall incur the costs of setting up and performing the test excluding Government related travel and accommodations.

During the FAT, minor software comments shall be finalized and incorporated into the final system.

For ALCMS, all associated RF equipment, including antennas and RF cables, shall be tested upon completion of cable installation and termination of connectors.

The tests shall include an impedance check of the RF cable and VSWR (Voltage Standing Wave Ratio) test.

All test data shall be recorded and included in a test report that shall be submitted to the Government for approval.

Commissioning of the system shall not begin until all test reports have been submitted and approved by the ALCMS manufacturer.

ALCMS System Acceptance Test (SAT):

Following the final installation and commissioning of the ALCMS system, the ALCMS Manufacturer shall perform a demonstration of the system performance.

This demonstration shall include the following:

Lighting control functions
Monitoring functions
Alarm functions
Print and Display functions

The ALCMS Manufacturer shall develop a SAT test plan in accordance with the specifications and issue this to the contractor for approval from the airport engineer.

The SAT shall be witnessed by Government.

3.17.1 Operating Test

After installation has been completed, conduct an operating test. Demonstrate equipment to operate in accordance with the requirements of this section. Conduct tests one day and one night for the Contracting Officer.

3.17.2 Distribution Conductors, 600-Volt Class

Test to verify that no short circuits or accidental grounds exist. Make tests using an instrument which applies a voltage of approximately 500 volts providing a direct reading in resistance.

3.17.3 Counterpoise System Test and Inspection

Make a visual inspection of continuity of counterpoise system at accessible locations. Test continuity of counterpoise system to the vault grounding system in manhole closest to the vault.

3.17.4 Progress Testing for Series Airfield Lighting Circuits

Conduct a megger test on each section of circuit or progressive combinations of sections as they are installed. Check each section or progressive combination of sections with a megohmmeter providing a voltage of approximately 1000 volts to provide a direct reading in resistance, and document results. Locate any faults indicated by these tests and eliminate before proceeding with the circuit installation.

3.17.5 Electrical Acceptance Tests

Perform acceptance tests for series and multiple airfield lighting circuits only on complete lighting circuits. Subject each series and multiple lighting circuit to a high voltage insulation resistance test.

3.17.5.1 Low Voltage Continuity Tests

Test each series circuit for electrical continuity. Locate faults indicated by this test and eliminate before proceeding with the high voltage insulation resistance test.

3.17.5.2 High Voltage Insulation Resistance Test

Subject each series lighting circuit to a high voltage insulation resistance test by measurement of the insulation leakage current. Provide a suitable high voltage test instrument which has a steady, filtered direct current output voltage and limited current. High voltage tester shall include an accurate voltmeter and microammeter for reading voltage applied to the circuit and resultant insulation leakage current. Do not

apply voltages in excess of test values specified below.

a. Test Procedure: Disconnect both leads from regulator output terminals and support so that air gaps of several inches exist between bare conductors and ground. Clean and dry cable sheaths, for a distance of one foot from ends of cables and exposed insulation at ends of cables. Connect ends of both conductors of the circuit together and to high-voltage terminals of test equipment, and apply test voltage specified in the following tabulation between conductors and ground for a period of 5 minutes.

	Test Voltage, dc	
Series Lighting Circuits	First Test on New Circuits	Test on Existing Circuits
High intensity series lighting circuits (5000-volt leads, 500- and 200-watt transformers)	9000	5000
Medium intensity series lighting circuits (5000-volt leads, 30/45-watt transformers)	6000	3000
600-volt circuits	1800	600

When additions are made to existing circuits, test only new sections in accordance with "First Test on New Circuits" in table above. To ensure reliable operation, test complete circuit at reduced voltages indicated above.

b. Leakage Current: Measure and record insulation leakage current in microamperes for each circuit for each minute application of test voltage. Do not exceed the value of the insulation leakage current calculated on the basis of the following leakage current allowances for cable and connected equipment for each circuit:

(1) 3 microamperes for each 1000 feet of cable.

(2) 2 microamperes for each 200-watt and each 500-watt 5000-volt series transformer.

(3) 2 microamperes for each 30/45-watt 5000-volt series transformer.

Note: The above values include allowances for the normal number of connectors and splices.

If measured value of insulation leakage current exceeds calculated value, sectionalize the circuit and repeat specified test for each section. Locate defective components and repair or replace until repeated tests indicate an acceptable value of leakage current for the entire circuit.

3.17.5.3 Operating Test

Upon completion of tests, show by demonstration in service that circuits, control equipment, and lights covered by the contract are in good operating condition. Operate each switch in the control tower lighting panels so that each switch position is engaged at least twice. During this process, observe lights and associated equipment to determine that each switch controls properly corresponding circuit. Provide telephone or radio communication between the operator and the observers. Repeat tests from the alternate control station, from the remote control points, and again from the local control switches on the regulators. Test each lighting circuit by operating the lamps at maximum brightness for not less than 30 minutes. Visually examine at the beginning and at the end of this test to ensure that the correct number of lights are burning at full brightness. Conduct one day and one night operating test for the Contracting Officer.

3.17.6 Constant Current Regulators

3.17.6.1 Visual Examination

Examine each constant current regulator to ensure that porcelain bushings are not cracked, no shipping damage has occurred, internal and external connections are correct, switches and relays operate freely and are not tied or blocked, fuses, if required, are correct, and oil level of oil-filled regulators is correct. Remove relay panel covers only for this examination; it is not necessary to open the main tank of oil-filled regulators. Accomplish the instructions on the plates attached to the regulators. Replace covers tightly after completing examinations and tests.

3.17.6.2 Electric Tests

Ensure that supply voltage and input tap correspond. With load disconnected, energize regulator and observe the open circuit protector to ensure that it de-energizes the regulator within 3 seconds. After testing circuits for open connections and grounds and after determining that lamps are good and in place, apply circuit load to the regulator and measure the voltage and current simultaneously on brightness taps. Voltmeter and ammeter shall have an accuracy of plus or minus one percent. Record readings and make readings during the day and night in order to obtain the average supply voltage. Output current on each brightness tap shall be within plus or minus 2 percent of the nameplate values after making necessary correction in the supply voltage. Late model regulators have automatic supply voltage correction in lieu of input taps, and output current does not change as supply voltage varies. When output current on tap 5 deviates from nameplate value by more than 2 percent, and regulator is not overloaded, check internal adjustment as described on regulator instruction plate. Since adjustment may be rather delicate, allow a deviation of up to plus or minus 5 percent on taps 1 through 4 before attempting to readjust the regulator.

-- End of Section --

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