Accelerated Water Absorption Test
Water Immersion Test
Ionization
High-Voltage
Partial Discharge Test
Qualification Test Report

SD-08 Manufacturer's Instructions

Provide manufacturer's instructions showing the recommended sequence and method of installation for the following:

Single Conductor 15 kV Shielded Cable
Terminations
Splice Kits (including splice grounding)

1.5 QUALIFICATIONS

Personnel performing Medium Voltage (MV) splicing or terminations shall have 5 years minimum experience in cable splicing and terminations of the type used in this project. In addition, the cable splicer shall submit Splicer/Terminator Certifications issued by the cable splice and termination manufacturer who has examined and tested a test test splice or termination of each type required by this contract for each cable splicer.The certification shall identify which splices and terminations it applies to. If the contractor does not have an individual with the manufacturer's certification as described, each individual with the required 5 years medium voltage splicing and terminating who is to perform cable splicing or terminating shall be required to perform a minimum of one splice or termination of each type in the presence of the manufacturers' representative. Each splice or termination shall be submitted to the manufacturer for testing and subsequent certification. Proof of certification will be verified by the NASA Contracting Officer's Technical Representative prior to installation of any splices or terminations. Certification shall not be required for load break elbows and dead break connectors.

Once a splice or termination has been started by a splicer, the same splicer shall complete that particular splice. Each termination and splice shall be started and completed in one continuous work period.

1.6 CABLE VOLTAGE RATINGS AND USE

Medium-voltage power cables must include single-conductor cables rated as follows, phase-to-phase, for grounded neutral systems:

Cables rated 15,000 volts, grounded neutral,shall be used on 13,800-volt, three-phase, 60-hertz distribution systems.

Install cables in a duct and manhole system which can be subject to continuous immersion in a coastal environment containing brackish water at depths of up to 15 feet.

1.7 FACTORY TESTING

Submit certified evidence that the cable manufacturer has made factory-conducted tests on each shipping length (reel) of cable; submit certified copies of test data in accordance with applicable provisions of the referenced standard. Tests on each length of cable must include

conductor resistance, ionization, high voltage, partial discharge test. Contracting Officer or designee must have the option of witnessing required factory testing at no additional cost. Provide a schedule of manufacturing and testing in advance to permit such witnessing, if desired.

Submit certified Qualification Test Report in accordance with AEIC CS8 made in accordance with the applicable referenced standards. Certified copies of test data must show conformance to the requirements of referenced standards and must be submitted for approval prior to shipment of the cable.

Prior to manufacturing, data regarding degradation of proposed insulating material and cable performance due to water immersion test as specified in this specification must be provided to Contracting Officer or designee. Information must indicate A.C. breakdown stress in kV/mm or V/mil versus immersion time. A complete cable description and condition under which cable was tested must accompany the test information. Also submit Accelerated water absorption test.

1.8 SHIPMENT

The shipment of cable must be made on reels in such a manner that the cable is protected from mechanical injury. Each end of each length of cable must be hermetically sealed using heat-shrinkable molded cable end caps to exclude moisture and securely attached to the reel.

The minimum diameter of the reel drum must be 14 times the overall diameter of the cable. Those reels less than 60 inches in diameter must have arbor holes sized for 2-1/2 inches spindles; those greater than 60 inches in diameter must have arbor holes sized for 3 inch spindles. Reel sizes must accommodate reel lengths specified in purchase order. Each reel must contain only one length of cable cut to order.

Each reel must have an arrow and appropriate wording stenciled in plain view on each side to indicate proper rotation of reels. Each reel must be plainly marked on each side, and on a tag attached to the cable end inside the lagging, with the following information:

a. Purchaser's order number;

b. Complete description of cable including manufacturer, cable size, voltage rating, percent insulation rating, insulating material, conductor size(s), year of manufacture;

c. Actual shipping cable (reel) length;

d. Reel number (e.g. 2 of 10);

e. Gross weight (i.e. with reel) and net weight (i.e. cable only).

Reels must be shipped in a vertical position, sufficiently blocked in the bed of shipping vehicle to preclude movement.

PART 2 PRODUCTS

2.1 CONDUCTORS

2.1.1 Material

Core (phase) conductor material must be annealed copper in accordance with

ASTM B 8.

2.1.2 Stranding

Conductors must be Class B stranded.

2.2 CABLE IDENTIFICATION

Cables must have printing on the outer jacket showing the cable type, name of the manufacturer, the year in which the cable was manufactured, sequential cable reel length markings and a unique number for identification purposes. Information must be closely grouped on the tape at 6 foot maximum intervals to permit complete identification.

2.3 15 KV CABLES

2.3.1 General; 15 kV Cable

Single conductor 15 kV shielded cable assemblies must consist of: Conductor core described above, an extruded semiconducting shield over the conductors, 220 mils of ethylene-propylene-rubber (EPR) insulation, an extruded semiconducting insulation shield, a concentric neutral, and a polyethylene (PE) jacket. The cable must be rated for minimum 90 degrees C continuous conductor temperature and 130 degrees emergency overload.

Single-conductor, ethylene-propylene-insulated, polyethylene-jacketed, shielded cable must conform to ICEA S-94-649 and AEIC CS8.

2.3.2 15 kV Cable Conductor Shielding

Conductors must have a stress control layer consisting of extruded material applied between the conductor and the insulation to form a conductor shield (strand screen). This material must have proven long-term chemical compatibility with both the conductor and overlying insulation materials. This stress control layer must meet the electrical and physical requirements of ICEA S-94-649.

2.3.3 Insulation; 15 kV Cable

Insulation material must be an ozone resistant, extruded thermosetting ethylene-propylene based polymer. Insulation must be capable of withstanding the continuous and emergency overload temperature ratings of the conductor.

2.3.4 Non-metallic Insulation Shield; 15 kV Cable

Extruded insulation shield must be an extruded thermoset material compatible with the insulation and jacket. Insulation shield must be applied directly over and bonded to the insulation, and must comply with AEIC CS8.

2.3.5 Concentric Neutral Shield; 15 kV Cable

Copper wires helically applied over the insulation shield. Minimum total cross sectional area of the shield wires is 1/3 of the core conductor for 350 Kcmil cable, and full core conductor for 4/0 cable, and no less than 20 No. 14 AWG, 13 No. 12 AWG or 9 No. 10 AWG. Minimum size of an individual shield wire is No. 14 AWG.

2.3.6 Jacket; 15 kV Cable

Polyethylene (PE) must be extruded over the concentric neutral to a minimum thickness of 80 mils.

2.4 INSULATED MEDIUM VOLTAGE CONNECTORS

IEEE Std 386. Connector must have a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material Provide connectors as indicated.

a. 200 Ampere loadbreak connector ratings: Voltage: 15kV, 95kV BIL. Short time rating: 10,000 amperes rms, symmetrical for a time duration of 0.17 seconds.

b. 600 Ampere deadbreak connector ratings: Voltage: 15kV, 95kV BIL. Short time rating: 27,000 ampere rms, symmetrical for a time duration of 4.0 seconds.

Connections must be compatible with equipment bushings.

2.5 SPLICES

Splice kits must be the product of a single manufacturer, either heat shrink or cold shrink, meeting the requirements of the paragraph entitled "Splices and Terminations" under Part 3 of this specification.

2.6 TERMINATIONS

Terminations must be Class 1 per IEEE Std 48.

2.7 CABLE SUPPORTS AND FITTINGS

Cable supports, related fittings, and accessories for use in corrosive underground locations, such as manholes, shall be provided with a factory applied coating of polyvinylchloride (PVC) of at least .051 millimeter thick.

PVC coated items shall have a uniform thickness and be free of blisters, breaks, and holidays. PVC compound shall conform to ASTM D 746.

Cable racks, rack arms, cable tray supports, and related fittings shall be UL listed heavy-duty nonmetallic glass-reinforced nylon.

On existing galvanized cable racks, rack hooks shall be heavy duty, hot dipped galvanized, with rounded surfaces and the hook insulators shall be white glazed porcelain.

2.8 CABLE TAGS IN MANHOLES AND AT TERMINATIONS

Provide tags for each cable or wire located in manholes and at each termination. Tag all cables indicated to have tags.

2.8.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 4500 pounds per square inch; and that are 0.035-inch thick, non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 300 degrees F. 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 pound. The cable tags must have block letters, numbers, and symbols 1 inch high on a yellow background. Letters, numbers, and symbols must not fall off or change positions regardless of the cable tags orientation.

2.9 FIREPROOF TAPE

Fireproof tape must be approximately 30 mils thick by 3 inches 3 inches wide. The tape must consist of a flexible, unsupported elastomer that expands in fire to provide a thick char buildup between the flame and the cable. The tape must not give off a smoke when subjected to flames or support combustion. The tape must not deteriorate when subjected to oil, water, gases, salt water, sewage and fungus.

PART 3 EXECUTION

3.1 DEMOLITION OR CABLE CUTTING

Notify the Contracting Officer 14 working days prior to an outage for demolition or cable cutting of medium voltage electrical system.

The Government has established a mandatory inspection point prior to Contractor performing any medium voltage cable cuts or demolition. Notify the Contracting Officer 48 hours in advance of this mandatory inspection point.

As part of the mandatory inspection point, positively identify and label the medium voltage cable to be worked utilizing electronic cable identifier. Ensure the process of identifying and labeling the cable to be worked is witnessed by the Government. Cable cutting and demolition of any medium voltage cable can occur only after approval by the Contracting Officer.

3.2 INSTALLATION

Install medium-voltage cables in accordance with NFPA 70.

The Contractor shall notify the Contracting Officer 14 working days prior to an outage that will require testing for phasing and phase rotation of 15 KV medium voltage electrical systems. The Institutional Services Contractor shall identify and tag the phasing at equipment and shall provide to the Contractor, in writing, the results of phasing and phase rotation tests. The Contractor shall be responsible for maintaining the phasing and phase rotation tests. The Contractor shall be responsible for maintaining the phasing, and shall match the existing phase rotation and phasing when installing conductors in existing electrical systems.

Cable must be installed in underground duct banks; in conduit above and below grade; inside buildings; by open wire method; on insulator hooks; on racks; in wall and ceiling mounted cable trays; in manholes; and by direct burial.

Cable or conductors of a primary distribution system must be rejected when installed openly in cable trays or openly racked along interior walls; in the same raceway or conduit with ac/dc control circuits or ac power circuits operating at less than 600 volts; or in a manner allowing cable to support its own weight.

3.2.1 Protection During Splicing Operations

Blowers must be provided to force fresh air into manholes or confined areas where free movement or circulation of air is obstructed. Waterproof protective coverings must be available on the work site to provide protection against moisture while a splice is being made. Pumps must be used to keep manholes dry during splicing operations. Under no conditions must a splice or termination be made with the interior of a cable exposed to moisture. Moisture-test conductor insulation paper before the splice is made. Use a manhole ring at least 6 inches above ground around the manhole entrance to keep surface water from entering the manhole. Plug unused ducts and stop water seepage through ducts in use before the splice is started.

3.2.2 Duct Cleaning

Thoroughly clean ducts before installation of power cables. A standard flexible mandrel must be pulled through each duct to loosen particles of earth, sand, or foreign material in the line.

3.2.2.1 PVC Duct

Mandrel length must be not less than 12 inches long and must have a diameter 1/2 inch less than the inside diameter of the duct. A brush with stiff bristles must then be pulled through each duct to remove the loosened particles. Brush diameter must be the same or slightly larger than the diameter of the duct.

3.2.2.2 Existing Fiber (Orangeburg) Duct

Push rod through duct using accepted appropriate procedures and eqipment for this type of work and as approved by the Contracting Officer. Pull a series of four-2 inch wire brushes back and forth through the duct. Progressively increase the size of the four wire brushes until four-4 inch wire brushes can be pulled back and forth, and all of the debris has been removed. Next pull a flexible mandrel with two-4 inch heavy duty wire brushes on each side through the duct. The mandrel shall not be less than 12 inches long, and shall have a diameter that is 1/2 inch to 1 inch less than the inside diameter of the duct. Next, pull a 5 foot section of sample cable, equivalent to what is being used. Finally, make the final cable pull on the same day the sample cable was pulled.

3.2.3 Pulling Cables in Ducts and Manholes

The Contractor shall provide and submit a pulling plan including calculations of pulling tension and side wall pressure anticipated, and the maximum allowable pulling tension for each pull. No pull shall be performed until Government review and approval of pulling plan.

Medium-voltage cables shall be pulled into ducts with equipment designed for this purpose, including power-driven winch, jamb skid, cable-feeding flexible tube guide, long radius quadrant block cable pulling sheaves, pulling eyes, and lubricants. A sufficient number of trained personnel and equipment with two-way radio communication capability shall be employed to ensure the careful and proper installation of the cable.

Cable reel shall be set up at the side of the manhole or tunnel hatch opening and above the duct or hatch level, allowing the cable to enter through the opening without reverse bending. Flexible tube guide shall be

installed through the opening in a manner that will prevent the cable from rubbing on the edges of any structural member (manhole frame, chimney, duct, etc.).

Two long-radius (30 inches minimum) quadrant block cable pulling sheaves and necessary jamb skid support shall be used at the pulling end to ensure that sidewall pressures during pulling will not be excessive. A dynamometer shall be used in the pulling line to ensure that the pulling force is not exceeded. The pulling force shall not exceed the smaller of: allowable tension on pulling device, allowable tension on cable, or the tension which produces the allowable sidewall pressure. The allowable tension on the pulling device is 6500 pounds for pulling eyes and 1000 pounds for pulling grip (where allowed). The allowable tension on cable must not exceed the value computed from the following equation:

TM = 0.036 X N X CM

Where: TM = maximum allowable pulling tension in pounds

N = number of conductors in the cable

CM = cross-sectional area of each conductor in circular mils

The allowable sidewall pressure is the smaller of 500 pounds per foot of bend radius or the cable manufacturer's recommended maximum value. The pulling plan submittal shall show the calculations for allowable tension and sidewall pressure as well as the anticipated tension and sidewall pressure for each pull in the project.

Cable shall be unreeled from the top of the reel. Payout shall be carefully controlled. Cable to be pulled shall be attached through a swivel to the main pulling wire by means of a pulling eye installed by the factory or approved cable splicer.

Attach pulling eyes to the cable conductors of the 3-1/C circuit to prevent damage to the cable structure. The entire 3-1/C circuit must be pulled simultaneously.

Minimum bending radius during cable pulling operations must be 30 inches. For permanent cable bending/racking the minimum bending radius must be 12 times cable diameter.
Cables shall be liberally coated with a suitable cable-pulling lubricant as it enters the tube guide or duct. Grease and oil lubricants shall not be used. Nonmetallic sheathed cables shall be covered with wire-pulling compounds,when required, which have no deleterious effects on the cable. Rollers, sheaves or tube guides around which the cable is pulled shall conform to the 30 inches minimum bending radius of the cable during the pulling operations.

Cables shall be pulled into ducts at a speed not to exceed 50 feet per minute and not in excess of maximum permissible pulling tension specified by the cable manufacturer. Cable pulling using a vehicle shall not be permitted. Pulling operations shall be stopped immediately with any indication of binding or obstruction and shall not be resumed until such difficulty is corrected. Sufficient slack shall be provided for free movement of cable due to expansion or contraction.

Cable splices made up in manholes shall be firmly supported on cable racks as indicated. No cable splices shall be pulled in ducts. Cable ends shall

overlap at the ends of a section to provide sufficient undamaged cable for splicing. Cables to be spliced in manholes shall overlap the centerline of the proposed joint by not less than 2 feet

Cables cut in the field must have the cut ends immediately sealed to prevent entrance of moisture with heat-shrinkable molded cable end caps.

3.2.4 Splices and Terminations

Splices shall be made in manholes or direct buried as shown on the drawings. Cable terminations shall be made at equipment specifically indicated. Splicing and terminating of cables shall be expedited to minimize exposure and cable deterioration.

The cable concentric neutral/shield wires shall be connected across one side of the splice by split bundling the splice neutral wiring and connecting each bundle set to a continuous #4 AWG solid bare copper conductor via two compression conductors. The #4 AWG conductor shall be extruded from the cable splice jacket and connected to the manholes grounding system. All connections within the splice shall be made utilizing barrel-type compression connectors and appropriate compression tools with proper size dies to ensure a satisfactory mechanical and electrical joint. Bare connections of concentric neutral/shield wires must be either contained within the splice kit or shall be sealed via an additional outer covering. This outer covering shall consist of a heavy wall, heat-shrinkable tubing containing adhesive material (mastic) that melts as heat is applied and the outer tubing shrinks to form a moisture proof environmental seal. The outer tubing shall conform to ANSI C119.1. The splice shall meet the requirements of IEEE Std 404 for a 15kV rating and must be rated by the manufacturer for use on 15 kV class feeder cable systems. Optionally, the splice may be of a cold shrink design that does not require any additional heat source for installation. The Cold Shrink splice body must be of a molded design made of silicone rubber. The splice jacketing shall be of a cold shrink tubing make of EPDM rubber. Extra precautions shall be taken to seal around the exit area of the bare copper jumpers with an additional mastic per the splice manufacturer's recommendations.

Cables shall be terminated in approved cable terminations, rated Class 1 per IEEE Std 48. Dry terminations with medium voltage pennants, preformed, and hand wrapped stress cones can be used for terminating cables. Terminations must be provided with adequate means for making external connections to the cable conductors of single-conductor cables (phase and concentric neutral); protecting the cable insulation against moisture, oil, or other contaminant; physically protecting and supporting cables, and maintaining the insulation level of the cable.

Terminations shall be field fabricated from termination kits supplied by, and in accordance with, the termination manufacturer's recommendations for the type, size, and electrical characteristics of the cable.

Installation shall include built-up or prefabricated heat or cold shrink stress-relief cones at the terminals of all shielded cables and at the terminals of single-conductor lead-covered cables rated 15 kV and above.

Cable splices shall be field fabricated from pre-molded or heat-shrinkable splicing kits supplied by, and in accordance with, the cable manufacturer's recommendations for the type, size, and electrical characteristics of the cable specified. Cable splices in manholes shall be located midway between cable racks on walls of manholes and supported with cable arms at

approximately the same elevation as the enclosing duct.

Cable splices shall be installed on cable racks or by other approved methods which will minimize physical stress on the splice connections. Splices shall be supported at approximately the same elevation as the installed cable, except where space limitations or existing cable length limitations make this method impractical or impossible.

All universal demountable splices shall be supported in such manner so as to minimize physical stress on the splice connections. Each cable end termination shall be supported using a pair of saddle type supports under the cable end termination and/or cable with a minimum 12 inches and a maximum 30 inches separation between the supports. Cable end termination and cable shall be secured to the supports in such a manner as to prevent movement of termination or cable at the support. Saddle type supports shall be installed on galvanized steel framing channel anchored to the wall or securely fastened to the cable tray or installed by other approved methods.

3.2.5 Splice and Termination Certification

The Contractor shall secure the services of the manufacturer of the splice/termination kits being used during the installation of this project to witness,test, and examine test splices, and to certify the competence of the technicians performing splices and terminations. The splice/termination certification shall confirm in writing that the splicer has constructed the splices/terminations in accordance with the manufacturer's approved training and/or installation instructions. Certification shall not be required for loadbreak elbow and deadbreak connectors. Certification for various types of splices and terminations that may be used on the project shall include, but not be limited to, the following:

Single conductor 15 kV EPR with concentric neutral to single conductor 15 kV EPR with concentric neutral-straight splice.

Single conductor 15 kV EPR with concentric neutral terminations.

The certification shall be for a specific time period determined by the manufacturer.

3.2.6 Fireproofing

Provide fireproofing (Arc Proofing) for individual cable conductor in manholes, handholes and vaults which carry current at 2200 volts or more.

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Extend the tape 1 inch into the ducts. To prevent unraveling, random wrap the fireproofing tape the entire length of the fireproofing with pressure-sensitive glass cloth tape.

3.2.7 Cable Tag Installation

Install cable tags in each manhole and at each termination as specified. Install cable tags over the fireproofing and position the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes and equipment.

3.3 FIELD TESTING

After the installation of power cables has been completed, including splices, joints, and terminations, and before the cable is energized, each medium voltage cable shall be subjected to field testing in accordance with the following requirements.

The Contractor shall provide test equipment, labor, and trained technical personnel as necessary to perform the electrical acceptance tests.

The Contractor shall obtain KSC Medium Voltage Cable Test Form from the Contracting Officer prior to commencing Field Testing. All tests shall be recorded on forms provided.

Arrangements shall be made to have tests witnessed and approved by the Contracting Officer.

Each power-cable installation shall be completely isolated from extraneous electrical connections at cable terminations and joints. Safety precautions shall be observed.

Each power cable shall first be given an insulation resistance test using a megohmmeter with a voltage output of at least 2,500-volts. Test shall be applied for a long enough time to fully charge the cable (no less than one minute). Readings shall be recorded as indicated on forms provided. Minimum reading shall be 5000 megohms at an ambient temperature of 68 degrees F. Readings taken at other than 68 degrees F ambient temperatures shall be corrected accordingly.

Upon successful completion of the insulation resistance test, the cable shall be subjected to a Very Low Frequency (VLF) AC Megger test. General VLF testing measures, parameters, considerations, and results shall adhere to the following:

1) Test voltage duration shall be continuous duty for 30 minutes (non-interrupted)

2) The Contractor shall provide the test equipment to test the cable capacity in microfarads and record on the KSC Medium Voltage AC Hi-pot test form (VLF).

3) The Contractor shall provide the test equipment to generate the test voltages required for the 30 minute test duration and adhere to the following table:

VLF Test Voltage for sinusoidal waveform

Cable Rating phase to phase	Acceptance (phase to ground test values)	Acceptance (phase to ground test values)
	(New cable)	(Existing cable spliced to new cable)
(rms voltage, KV)	(peak voltage, KV)	(peak voltage, KV)

15 28 22; (EPR TO NON-EPR)

4) The sinusoidal test frequency shall be 0.1 Hertz.

5) The test shall not be performed on cable attached to equipment.

NOTE: Acceptance test values to include, but not limited to, peak voltage, frequency, and duration, with respect to the cable rating, shall be identified on the test submittal, with pass/fail results identified per cable installation. Reference IEEE Std 400.2. Notify Contracting Officer or Contracting Officer's Technical Representative 48 hours prior to test start. All testing will be witnessed by the Government.

Terminations shall be clean and dry and shall be tested per IEEE Std 48. Radiographic tests on all terminations at the discretion of the Contracting Officer to determine if voids exist in the termination. Unacceptable cable, splices or terminations shall be reworked at no additional expense to the Government.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 05 71.00 40

LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES

PART 1 GENERAL

1.1 REFERENCES
1.2 SUBMITTALS
1.3 GENERAL REQUIREMENTS

PART 2 PRODUCTS

2.1 MOTOR CONTROL
2.1.1 Magnetic Motor Controllers
2.1.1.1 Full-Voltage Controllers
2.1.2 Combination Motor Controllers
2.1.2.1 Nonreversing Combination Motor Controllers
2.2 ENCLOSURES
2.2.1 Equipment Enclosures
2.3 CIRCUIT BREAKERS
2.3.1 Molded-Case Circuit Breakers
2.3.2 Enclosed Molded-Case Circuit Breakers
2.4 FUSES
2.5 CONTROL DEVICES
2.5.1 Magnetic Contactors
2.5.2 Control-Circuit Transformers
2.5.3 Magnetic Control Relays
2.5.4 Pushbuttons and Switches
2.5.4.1 Pushbuttons
2.5.4.2 Selector Switches
2.6 FACTORY TESTING
2.7 FINISH

PART 3 EXECUTION

3.1 INSTALLATION
3.2 FIELD TESTING

-- End of Section Table of Contents --

SECTION 26 05 71.00 40

LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES

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 D 877	(2002; R 2007) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C57.13	(2008) Standard Requirements for Instrument Transformers

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering
NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 1	(2002) Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures
NEMA AB 3	(2006) Molded Case Circuit Breakers and Their Application
NEMA FU 1	(2002; R 2007) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2005; R 2008) 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 2006) Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; TIA 11-1; Errata 2011) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 489	(2009) Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508	(1999; Reprint Apr 2010) Industrial Control Equipment

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-02 Shop Drawings

Submit Connection Diagrams and Fabrication Drawings for the following items in accordance with paragraph entitled, "General Requirements," of this section.

Submit Installation drawings for the following items in accordance with the paragraph entitled, "Installation," of this section.

Control Devices
Protective Devices

SD-03 Product Data

Submit manufacturer's equipment and performance data for the following items including use life, system functional flows, safety features, and mechanical automated details.

Motor Control
Enclosures
Circuit Breakers
Control Devices

SD-08 Manufacturer's Instructions

Submit manufacturer's instructions for the following items, including special provisions required to install equipment components and system packages. Provide detail on resistance impedances, hazards and safety precautions within the special notices.

Control Devices
Protective Devices

SD-10 Operation and Maintenance Data

Submit Operation and Maintenance Manuals for the following equipment:

Magnetic Motor Controllers
Combination Motor Controllers
Circuit Breakers

1.3 GENERAL REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to work specified in this section.

Submit Connection Diagrams showing the relations and connections of control devices and protective devices by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

Submit Fabrication Drawings for control devices and protective devices consisting of fabrication and assembly details to be performed in the factory.

PART 2 PRODUCTS

2.1 MOTOR CONTROL

Conform to NEMA ICS 1, NEMA ICS 2, and UL 508 for motor controllers. Provide controllers that have thermal overload protection in each phase.

2.1.1 Magnetic Motor Controllers

2.1.1.1 Full-Voltage Controllers

Provide full-voltage, full magnetic devices in accordance with NEMA ICS 1, NEMA ICS 2, and UL 508for magnetic motor controllers for the control and protection of single- and three-phase, 60-hertz, squirrel-cage induction motors.

Provide operating coil assembly that operates satisfactorily between 85 and 110 percent of rated coil voltage. Provide 120 volts, 60 hertz motor control circuits.

Provide controller with two normally open and two normally closed auxiliary contacts rated per NEMA ICS 1 and NEMA ICS 2 in addition to the sealing-in contact for control circuits.

Provide solderless pressure wire terminal connectors for line-and load-connections to controllers.

Provide solid state overload (SSOL) relays with the following features:

a. Phase loss protection; trips within 3 seconds.

b. Phase unbalance protection.

c. Ground fault trip when selected.

d. Selectable trip class 5, 10, 20, or 30.

e. Reset trip with selected Auto/Manual.

f. Dip switch selectable with the following features:
   i. Set Phase Unbalanced ON or OFF
   ii. Set Phase Loss ON or OFF
   iii. Set Reset to Manual or Automatic
   iv. Set Ground Fault ON or OFF.

g. Overload shall be self-powered with no need for external power

source.

Provide an externally operable manual-reset button to re-establish control power to the holding coil of the electromagnet. After the controller has tripped from overload, ensure that resetting the motor-overload device does not restart the motor.

2.1.2 Combination Motor Controllers

Following requirements are in addition to the requirements specified for magnetic motor controller:

Provide combination motor controllers for the control and protection of single-and three-phase 60-hertz alternating-current squirrel-cage induction motors with branch-circuit disconnecting and protective devices in accordance with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6.

For combination motor controllers include magnetic motor controllers and molded-case circuit breakers or MCP in metal enclosures in accordance with NEMA 250 or motor-control center draw-out assemblies with control-power transformers, selector switches, pushbuttons, and indicating lights as follows:

Provide full-voltage, full-magnetic devices as specified in this section under paragraph entitled, "Remote-Control Station Enclosures." for magnetic motor controllers and enclosures.

Provide thermal-magnetic breakers as specified in paragraph entitled, "Manual Motor Controllers."for molded-case circuit breakers. Manufacturer's standard MCP may be used in lieu of molded-case circuit breakers.

Provide control-power transformers 120-volt ac maximum, selector switches, pushbuttons, and pilot lights as required.

Identify combination motor controllers with identification plates affixed to front cover of the controller.

2.1.2.1 Nonreversing Combination Motor Controllers

Following requirements are in addition to the requirements for magnetic motor controllers:

For nonreversing combination motor controllers for the control and protection of single-speed squirrel-cage induction motors, include a magnetic controller with molded-case circuit breaker or MCP with selector switch or start/stop pushbutton and indicating light in the cover of the enclosure.

Provide rating of three-phase single-speed full-voltage magnetic controllers for nonplugging and nonjogging duty in accordance with NEMA ICS 1 and NEMA ICS 2.

Provide wiring and connections for full-voltage single-speed magnetic controllers in accordance with NEMA ICS 1 and NEMA ICS 2.

2.2 ENCLOSURES

2.2.1 Equipment Enclosures

Provide enclosures for equipment in accordance with NEMA 250.

Contain equipment installed in wet locations in a NEMA Type 4 watertight, corrosion-resistant sheet-steel enclosure, constructed to prevent entrance of water when tested in accordance with NEMA ICS 6 for Type 4 enclosures.

2.3 CIRCUIT BREAKERS

Provide circuit breakers that conform to UL 489, NEMA AB 1, and NEMA AB 3.

2.3.1 Molded-Case Circuit Breakers

Provide molded case, manually operated, trip-free, circuit breakers, with inverse-time thermal-overload protection and instantaneous magnetic short-circuit protection as required. Completely enclose circuit breakers in a molded case, with the calibrated sensing element factory-sealed to prevent tampering.

Locate thermal-magnetic tripping elements in each pole of the circuit breaker, and provide inverse-time-delay thermal overload protection and instantaneous magnetic short-circuit protection. Provide instantaneous magnetic tripping element, that is adjustable and accessible from the front of the breaker on frame sizes larger than 100 amperes.

Size breaker as required for the continuous current rating of the circuit. Provide breaker class as required.

Provide sufficient interrupting capacity of the panel and lighting branch circuit breakers, to successfully interrupt the maximum short-circuit current imposed on the circuit at the breaker terminals. Provide circuit breaker interrupting capacities with a minimum of 10,000 amperes and that conform to NEMA AB 3.

Provide the common-trip type multipole circuit breakers having a single operating handle and a two-position on/off indication. Provide circuit breakers with temperature compensation for operation in an ambient temperature of 104 degrees F. Provide circuit breakers that have root mean square (rms) symmetrical interrupting ratings sufficient to protect the circuit being supplied. Interrupting ratings may have selective type tripping (time delay, magnetic, thermal, or ground fault).

Provide phenolic composition breaker body capable of having such accessories as handle-extension, handle-locking, and padlocking devices attached where required.

Provide circuit breakers used for meter circuit disconnects that meet the applicable requirements of NFPA 70 and that are of the motor-circuit protector type.

For circuit breakers used for service disconnection, provide an enclosed circuit-breaker type with external handle for manual operation. Provide sheet metal enclosures with a hinged cover suitable for surface mounting.

2.3.2 Enclosed Molded-Case Circuit Breakers

For enclosed circuit breakers, provide thermal-magnetic molded-case circuit breakers in surface-mounted, nonventilated enclosures conforming to the appropriate articles of NEMA 250 and NEMA AB 1.

Provide enclosed circuit breakers in nonhazardous locations as follows:

Contain circuit breakers installed in wet locations, in NEMA Type 4, watertight corrosion-resistant sheet steel enclosures constructed to prevent entrance of water.

2.4 FUSES

Provide a complete set of fuses for all switches and switchgear. Rate fuses that have a voltage rating of not less than the circuit voltage.

Make no change in continuous-current rating, interrupting rating, and clearing or melting time of fuses unless written permission has first been secured.

Provide nonrenewable cartridge type fuses for ratings 30 amperes, 125 volts or less. Provide renewable cartridge type fuses for ratings above 30 amperes 600 volts or less with time-delay dual elements, except where otherwise indicated. Conform to NEMA FU 1 for fuses.

Install special fuses such as extra-high interrupting-capacity fuses, fuses for welding machines, and capacitor fuses where required. Plug fuses are not permitted.

Label fuses showing UL class, interrupting rating, and time-delay characteristics, when applicable. Additionally, clearly list fuse information on equipment drawings.

Provide porcelain fuse holders when field-mounted in a cabinet or box. Do not use fuse holders made of such materials as ebony asbestos, Bakelite, or pressed fiber for field installation.

2.5 CONTROL DEVICES

2.5.1 Magnetic Contactors

Provide magnetic contactors in accordance with NEMA ICS 1 and NEMA ICS 2 as required for the control of low-voltage, 60-hertz, tungsten-lamp loads, fluorescent-lamp loads, resistance-heating loads, and the primary windings of low-voltage transformers.

Provide core-and-coil assembly that operates satisfactorily with coil voltage between 85 and 110 percent of its voltage rating.

Provide contactor that is designed with a normally open holding circuit auxiliary contact for control circuits, with a rating in accordance with NEMA ICS 1 and NEMA ICS 2.

Furnish solderless pressure wire terminal connectors, or make available for line-and-load connections to contactors in accordance with NEMA ICS 1 and NEMA ICS 2.

Provide magnetic contactors with a rating in accordance with NEMA ICS 1and NEMA ICS 2.

2.5.2 Control-Circuit Transformers

Provide control-circuit transformers within the enclosure of magnetic

contactors and motor controllers when the line voltage is in excess of 120 volts. Provide encapsulated dry type, single-phase, 60-hertz transformer, with a 120-volt (or 24-volt) isolated secondary winding.

Do not provide a transformer with a rated primary voltage less than the rated voltage of the controller, or a rated secondary current less than the continuous-duty current of the control circuit.

Provide voltage regulation of the transformer such that, with rated primary voltage and frequency, the secondary voltage is not less than 95 percent nor more than 105 percent of rated secondary voltage.

Provide source of supply for control-circuit transformers at the load side of the main disconnecting device. Protect secondary winding of the transformer and control-circuit wiring against overloads and short circuits, with fuses selected in accordance with NEMA ICS 6. Ground secondary winding of the control-circuit transformer in accordance with NEMA ICS 6.

2.5.3 Magnetic Control Relays

Provide magnetic control relays for energizing and de-energizing the coils of magnetic contactors or other magnetically operated devices, in response to variations in the conditions of electric control devices in accordance with NEMA ICS 1, and NEMA ICS 2.

Provide core-and-coil assembly that operates satisfactorily with coil voltages between 85 and 110 percent of their voltage rating.

Provide relays that are designed to accommodate normally open and normally closed contacts.

Provide 120-volt, 60-hertz, Class AIB magnetic control relays with a continuous contact rating of 10 amperes, and with current-making and -breaking ability in accordance with NEMA ICS 1 and NEMA ICS 2, two normally open and two normally closed.

2.5.4 Pushbuttons and Switches

2.5.4.1 Pushbuttons

For pushbuttons for low-voltage ac full-voltage magnetic controllers, provide heavy-duty oiltight NEMA 250, Type 4X, momentary-contact devices rated 600 volts, with pilot light, and with the number of buttons and the marking of identification plates as shown. Furnish pushbutton color code in accordance with NEMA ICS 6.

Provide pushbuttons that are designed with normally open, circuit-closing contacts; normally closed circuit-opening contacts; and two-circuit normally open and normally closed circuit-closing and -opening contacts. Provide pushbutton-contact ratings in accordance with NEMA ICS 1 and NEMA ICS 2 with contact designation A600.

Identify pushbuttons in remote control stations with identification plates affixed to front cover in a prominent location. Carry the identification of the system being controlled on the identification plate.

2.5.4.2 Selector Switches

Provide heavy-duty oiltight maintained-contact selector switches for low-voltage control circuits, with the number of positions and the marking of identification plates in accordance with NEMA ICS 1 and NEMA ICS 2.

Identify selector switches in remote control stations with engraved identification plates affixed to front cover in a prominent location. Carry the identification of the system being controlled on the identification plate.

2.6 FACTORY TESTING

Perform factory tests on control and low voltage protective devices in accordance with the manufacturer's recommendations.

Conduct short-circuit tests in accordance with Section 2 of NEMA ICS 1.

2.7 FINISH

Protect metallic materials against corrosion. Provide equipment with the standard finish by the manufacturer when used for most indoor installations.

PART 3 EXECUTION

3.1 INSTALLATION

Install Control devices and protective devices that are not factory installed in equipment, in accordance with the manufacturer's recommendations and field adjusted and operation tested. Conform to NFPA 70, NEMA ICS 1 and NEMA ICS 2 requirements for installation of control and protective devices.

3.2 FIELD TESTING

Demonstrate to operate as indicated control and protective devices not factory installed in equipment.

Ratio and verify tap settings of instrumentation, potential, and current transformers.

Perform dielectric tests on insulating oil in oil circuit breakers before the breakers are energized. Test oil in accordance with ASTM D 877, and provide breakdown voltage that is not less than 25,000 volts. Provide manufacturer certification that the oil contains no PCB's, and affix a label to that effect on each breaker tank and on each oil drum containing the insulating oil.

Field adjust reduced-voltage starting devices to obtain optimum operating conditions. Provide test meters and instrument transformers that conform to ANSI C12.1 and IEEE C57.13.

Do not energize control and protective devices until recorded test data has been approved. Provide final test reports with a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 12 19.00 40

PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.1 REFERENCES
1.2 RELATED REQUIREMENTS
1.3 DEFINITIONS
1.4 SUBMITTALS
1.5 QUALITY ASSURANCE
1.5.1 Pad-Mounted Transformer Drawings
1.5.2 Regulatory Requirements
1.5.3 Standard Products
1.5.3.1 Alternative Qualifications
1.5.3.2 Material and Equipment Manufacturing Date
1.5.4 PREDICTIVE TESTING AND INSPECTION TECHNOLOGY REQUIREMENTS
1.6 MAINTENANCE
1.6.1 Additions to Operation and Maintenance Data
1.7 WARRANTY

PART 2 PRODUCTS

2.1 THREE-PHASE PAD-MOUNTED TRANSFORMERS
2.1.1 Compartments
2.1.1.1 High Voltage, Dead-Front
2.1.1.2 Low Voltage
2.1.2 Multi-Function Circuit Monitor
2.1.2.1 Monitoring Functions
2.1.2.2 Protective Functions
2.1.2.3 Inputs
2.1.2.4 Outputs
2.1.2.5 Test Blocks
2.1.3 Transformer
2.1.3.1 Specified Transformer Losses
2.1.4 Insulating Liquid
2.1.4.1 Liquid-Filled Transformer Nameplates
2.1.5 Corrosion Protection
2.2 WARNING SIGNS
2.3 GROUNDING AND BONDING
2.4 CAST-IN-PLACE CONCRETE
2.5 SOURCE QUALITY CONTROL
2.5.1 Transformer Test Schedule
2.5.2 Design Tests
2.5.3 Routine and Other Tests

PART 3 EXECUTION

3.1 INSTALLATION
3.2 GROUNDING

3.2.1 Grounding Electrodes
3.2.2 Pad-Mounted Transformer Grounding
3.2.3 Connections
3.2.4 Grounding and Bonding Equipment
3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES
3.3.1 Meters and Current Transformers
3.4 FIELD APPLIED PAINTING
3.5 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES
3.6 FIELD QUALITY CONTROL
3.6.1 Performance of Acceptance Checks and Tests
3.6.1.1 Pad-Mounted Transformers
3.6.1.2 Current Transformers
3.6.1.3 Multi-Function circuit monitor
3.6.1.4 Grounding System
3.6.2 Follow-Up Verification

-- End of Section Table of Contents --

SECTION 26 12 19.00 40

PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE 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.

ASTM INTERNATIONAL (ASTM)

ASTM A167	(1999; R 2009) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM D 1535	(2008e1) Specifying Color by the Munsell System
ASTM D 877	(2002; R 2007) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D 92	(2005a; R 2010) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D 924	(2008) Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids
ASTM D 97	(2009) 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) Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V
IEEE C2	(2007; Errata 06-1; TIA 07-1; TIA 07-2; TIA 07-3; Errata 07-2; TIA 08-4; TIA 08-5; TIA 08-6; TIA 08-7; TIA 08-8; TIA 08-9; TIA 08-10; TIA 08-11; TIA 09-12; TIA 09-13; TIA 09-14; Errata 09-3; TIA 09-15; TIA 09-16; TIA 10-17) National Electrical Safety Code

IEEE C37.90	(2005) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C57.12.00	(2010) Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.28	(2005) Standard for Pad-Mounted Equipment - Enclosure Integrity
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 C57.12.80	(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) Standard Requirements for Instrument Transformers
IEEE C57.98	(1993; Errata 1998; R 1999) Guide for Transformer Impulse Tests
IEEE C62.11	(2005; Amd 1 2008) 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	(2009) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; TIA 11-1; Errata 2011) 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 600/4-90/027F	(1993) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms
EPA 712-C-98-075	(1996) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"

UNDERWRITERS LABORATORIES (UL)

UL 467	(2007) Grounding and Bonding Equipment

1.2 RELATED REQUIREMENTS

Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL 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 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 the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Pad-Mounted Transformer Drawings; G

SD-03 Product Data

Pad-Mounted Transformers; G

Submittal shall include manufacturer's information for each component, device, and accessory provided with the transformer.

SD-06 Test Reports

Acceptance Checks And Tests; G

SD-07 Certificates

Transformer Losses; G

Submit certification from the manufacturer indicating conformance with the paragraph entitled "Specified Transformer Losses."

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); 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."

1.5 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

Do not use products manufactured more than 3 years prior to date of delivery to site, unless specified otherwise.

1.5.4 PREDICTIVE TESTING AND INSPECTION TECHNOLOGY REQUIREMENTS

This section contains systems and/or equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure building equipment and systems installed by the Contractor have been installed properly and contain no identifiable defects that shorten the design life of a system and/or its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the Contractor's work.

1.6 MAINTENANCE

1.6.1 Additions to Operation and Maintenance Data

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 THREE-PHASE PAD-MOUNTED TRANSFORMERS

IEEE C57.12.34, IEEE C57.12.28 and as specified herein.

2.1.1 Compartments

Separate the high- and low-voltage compartments with 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.

2.1.1.1 High Voltage, Dead-Front

High-voltage compartment shall contain the incoming line, insulated high-voltage load-break connectors, bushing well inserts, six high-voltage bushing wells configured for loop feed application, load-break switch handle(s), access to oil-immersed 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 15 kV, 95 kV BIL. Current rating: 200 amperes rms continuous. Short time rating: 10,000 amperes rms symmetrical for a time duration of 0.17 seconds. Connector shall have a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material. Provide a "hot line voltage indicator" on each 200 ampere terminator test point.

b. Bushing well inserts: IEEE 386, 200 amperes, 15 kV Class. Provide a bushing well insert for each bushing well unless indicated otherwise.

c. Load-break switch

Loop feed sectionalizer switches: Provide three, two-position, oil-immersed type switches to permit closed transition loop feed and sectionalizing. Each switch shall be rated at 15 kV, 95 kV BIL, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 10,000 rms amperes symmetrical. Locate the switch handles in the high-voltage compartment. Operation of switches shall be as follows:

ARRANGEMENT NO.	DESCRIPTION OF SWITCH ARRANGEMENT	SWITCH POSITION LINE A SW. OPEN	LINE A SW. CLOSE	LINE B SW OPEN	LINE B SW CLOSE	XFMR. SW OPEN	XFMR. SW CLOSE
1	Line A connected to Line B and both lines connected to transformer		X		X		X
2	Transformer connected to Line A only		X	X			X
3	Transformer connected to	X			X		X

ARRANGEMENT NO.	DESCRIPTION OF SWITCH ARRANGEMENT	SWITCH POSITION LINE A SW. OPEN	LINE A SW. CLOSE	LINE B SW OPEN	LINE B SW CLOSE	XFMR. SW OPEN	XFMR. SW CLOSE
	Line B only						
4	Transformer open and loop closed		X		X	X	
5	Transformer open and loop open	X		X		X	

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. Conspicuously display warning 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.

e. Surge arresters: IEEE C62.11, rated 10 kV, fully shielded, dead-front, metal-oxide-varistor, elbow type with resistance-graded gap, suitable for plugging into inserts. Provide three arresters for loop feed circuits.

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

g. Protective caps: IEEE 386, 200 amperes, 15 kV Class. Provide insulated protective caps (not shipping caps) for insulating and sealing out moisture from unused bushing well inserts and insulated standoff bushings.

2.1.1.2 Low Voltage

Low-voltage compartment shall contain low-voltage bushings with NEMA spade terminals, accessories, current transformers (CTs) for metering, stainless steel or laser-etched anodized aluminum diagrammatic transformer nameplate, and ground pad.

a. The low voltage bushings shall be equipped with removable 600 volt insulating covers molded from one piece EPDM rubber.

b. 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.

c. Current transformers: IEEE C57.13. Provide butyl-molded window type multi-ratio CTs with 1.2 kV insulation, 30 kV BIL. Refer to Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES. Provide the appropriate CT as indicated on the drawings.

2.1.2 Multi-Function Circuit Monitor

Multi-function circuit monitor shall be Square-D CM-3250 with display, having the features and functions specified below. Each meter shall be provided with an Ethernet Communication Card (ECC) for communications as shown on the drawings. The device shall be UL recognized, CSA certified and also meet IEEE C37.90. Provide a NEMA 4X type 316 stainless steel enclosure for installing the circuit monitor in accordance with Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL.

2.1.2.1 Monitoring Functions

The device shall provide direct reading metered or calculated values of the items listed below and shall auto range between units, kilo-units, and mega-units for all metered values. Unit shall meet or exceed accuracy listed below. Accuracy indicated below to be of read or calculated values.

AC Amperes in each phase,0.2 percent accuracy.
AC Voltage, phase-to-phase, phase-to-neutral, 0.2 percent accuracy.
Watts, 0.2 percent accuracy.
Vars, 0.2 percent accuracy.
Power Factor, 0.2 percent accuracy.
Frequency, 0.2 percent accuracy.
Watt Demand (5, 10, 15, 30 minutes interval programmable or from utility synchronizing pulse), 0.2 percent accuracy.
Watt Hours, 0.2 percent accuracy.
THD
Waveform Capture

2.1.2.2 Protective Functions

Protective Functions: Voltage phase loss, if any phase RMS is less than 50 percent of the nominal line voltage.

Current phase loss, if the smallest phase value is less than 1/16 of the largest phase value.

Line voltage phase unbalance, selectable from 5 to 40 percent of nominal in 5 percent increments.

Voltage phase reversal.

Overvoltage, selectable from 105 to 140 percent in 5 percent increments.

Undervoltage, selectable from 95 to 60 percent in 5 percent increments.

Time delay (adjustable from 0 to 8 seconds in 1 second intervals) for overvoltage, undervoltage, and phase unbalance trip and alarm settings.

2.1.2.3 Inputs

Input ranges of the device shall accommodate external current transformers with ranges from 100/5 through 5000/5 amperes. Potential input transformer

ratios shall be field settable. Synchronous pulse input shall be provided and when activated shall override the preset watt demand interval and let the utility control the demand window.

2.1.2.4 Outputs

Outputs shall have separate trip and alarm contacts with ratings of 10 amperes at 115/240 volts AC or 30 volt DC resistive. The contacts shall be Form C (NO/NC). In addition, provide a separate Form C (NO/NC) contact to provide a kilowatthour pulse output. KWH/pulse shall be field programmable. Provide communication output compatible with Square D "Powerlogic" communication system.

2.1.2.5 Test Blocks

Provide 10 pole current and potential test block, General Electric Type PK or Westinghouse Type FT in line after the circuit monitor for additional metering or testing.

2.1.3 Transformer

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

b. Transformer shall be rated per transformer schedule as indicated on drawings, 95 kV BIL.

c. Transformer voltage ratings: Per transformer schedule as indicated on drawings.

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 impedance shall not be less than 5.5 percent or more than 6.0 percent at 85 degrees C on Three-Phase transformers.

f. Audible sound levels shall comply with the following:

kVA	DECIBELS (MAX)
75	51
112.5	55
150	55
225	55
300	55
500	56
750	57
1000	58
1500	60

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 on its enclosure. The transformer shall have an insulated low-voltage neutral bushing with NEMA spade terminal, and with

removable ground strap.

2.1.3.1 Specified Transformer Losses

No-load losses (NLL) 300 kVA and 500 kVA units shall be 1363 watts at 20 degrees C and load losses (LL) shall be 8539 watts at 85 degrees C. Use the values for the specified losses for comparison with the losses determined during the routine tests. If the routine test values for no-load losses exceed the specified no-load losses by more than 10 percent, or the total losses exceed the specified total losses (sum of no-load and load losses) by more than 6 percent, the transformer is unacceptable.

2.1.4 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 D 92 and a dielectric strength not less than 33 kV tested per ASTM D 877. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid" on the nameplate.

(1) 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:

(a) Pour point: ASTM D 97, less than -15 degree C

(b) Aquatic biodegradation: EPA 712-C-98-075, 100 percent

(c) Trout toxicity: OECD Test 203, zero mortality of EPA 600/4-90/027F, pass

2.1.4.1 Liquid-Filled Transformer Nameplates

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

2.1.5 Corrosion Protection

Entire transformer assembly, including tank and radiator, base, enclosure, and metering enclosure shall be fabricated of stainless steel conforming to ASTM A167, Type 304 or 304L. Form enclosure of stainless steel sheets. Paint entire transformer assembly Munsell 7GY3.29/1.5 green. Paint coating system shall comply with IEEE C57.12.28. The Munsell color notation is specified in ASTM D 1535. After the final coating, on the bottom and bottom of sides up to 6 inches, a rubberized or coal tar protective coating at least 1/32 inch thick shall be applied on top of the final coating.

2.2 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 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.

Provide an arc-flash warning label for the enclosure of pad-mounted transformers. Locate this self-adhesive warning label on the outside of the high voltage compartment door warning of potential electrical arc flash hazards and appropriate PPE required. The required detailed label format and associated power system analysis required for determining arc flash hazard shall be in accordance with Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

2.3 GROUNDING AND BONDING

UL 467. Provide grounding and bonding as specified in Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL and Section 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.4 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.

2.5 SOURCE QUALITY CONTROL

2.5.1 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.

2.5.2 Design Tests

IEEE C57.12.00, and IEEE C57.12.90. Section 5.1.2 in IEEE C57.12.80 states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for each of the specified transformer(s). Perform design tests 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.

2.5.3 Routine and Other Tests

IEEE C57.12.00. Routine and other tests shall be performed 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. Cold resistance measurements (provide reference temperature)

b. Phase relation

c. Ratio

d. No-load losses (NLL) and excitation current

e. Load losses (LL) and impedance voltage

f. Dielectric

(1) Impulse

(2) Applied voltage

(3) Induced voltage

g. Leak

h. Dissolved gas analysis (DGA)

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

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02.00 20 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 AWG #4/0 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. Install exothermic welds and compression connectors as specified in Section 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4 Grounding and Bonding Equipment

UL 467 and NFPA 70, 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. 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 three multi-ratio current transformers per power transformer with characteristics as indicated on the drawings. Meters shall be mounted as indicated on the drawings.

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. Place the slab 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.

3.6 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 information with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.

(3) 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.

(4) Verify correct liquid level in tanks.

(5) Perform specific inspections and mechanical tests as recommended

by manufacturer.

(6) Verify correct equipment grounding.

(7) Verify the presence of transformer surge arresters.

b. Electrical tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

(2) Verify that the tap-changer is set at specified ratio.

(3) Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

(4) Perform insulation resistance tests on transformer windings using a 5000 volt test set. Readings shall be conducted every 15 seconds for the first minute and every minute thereafter for 10 minutes. Resistance between phase conductors and ground shall be no less than 125 megohms.

(5) Perform insulation power factor (Doble) tests on transformer windings in accordance with IEEE C57.12.90. Insulation power factor shall not exceed 0.5 percent.

c. Insulating liquid tests

1. Perform dielectric test in accordance with ASTM D 877. Breakdown voltage shall not be less than 33,000 volts.

2. Perform power factor tests per ASTM D 924 at 20 degrees C. Results shall not be greater than 0.5 percent at 20 degrees C.

3.6.1.2 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) 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 required grounding and shorting connections provide good contact.

b. Electrical tests

(1) Perform resistance measurements through all bolted connections

with low-resistance ohmmeter, if applicable.

(2) Perform insulation-resistance test.

(3) Perform a polarity test.

(4) Perform a ratio-verification test.

3.6.1.3 Multi-Function circuit monitor

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. Verify that correct multiplier has been been programmed into the circuit monitor, where applicable.

2. Verify that current transformer secondary circuits are intact.

3.6.1.4 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. Equip the instrument with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.6.2 Follow-Up Verification

Upon completion of acceptance checks 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 TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 24 16.00 40

PANELBOARDS

PART 1 GENERAL

1.1 REFERENCES
1.2 GENERAL REQUIREMENTS
1.3 SUBMITTALS
1.4 PREDICTIVE TESTING AND INSPECTION TECHNOLOGY REQUIREMENTS

PART 2 PRODUCTS

2.1 PANELBOARDS
2.2 CIRCUIT BREAKERS
2.3 DIRECTORY CARD AND HOLDER
2.4 FACTORY TESTING
2.5 PRECAUTIONARY LABEL

PART 3 EXECUTION

3.1 INSTALLATION
3.2 SITE TESTING

-- End of Section Table of Contents --

SECTION 26 24 16.00 40

PANELBOARDS

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.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA PB 1	(2006; Errata 2008) Panelboards

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-595	(Rev C, 2008) Colors Used in Government Procurement

UNDERWRITERS LABORATORIES (UL)

UL 489	(2009) Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 67	(2009; Reprint Sep 2010) Standard for Panelboards

1.2 GENERAL REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to work specified in this section.

Submit Detail Drawings for the panelboards consisting of fabrication and assembly drawings for all parts of the work in sufficient detail to enable the Government to check conformity with the requirements of the contract documents. Include within drawings details of bus layout.

Ensure Outline Drawings for panelboards indicate overall physical features, dimensions, ratings, service requirements, and weights of equipment.

Statements signed by responsible officials of a manufacturer of a product, system, or material attesting that the product, system or material meet specified requirements. Statements must be dated after the award of this contract, name the project, and list the specific requirements which it is intended to address.

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

Submit Detail Drawings and Outline Drawings for panelboards in accordance with paragraph entitled, "General Requirements," of this section.

SD-03 Product Data

Submit manufacturer's catalog data for the following items:

Panelboards

Directory Card and Holder

SD-04 Samples

Ensure that Keys are properly tagged and delivered to the Contracting Officer.

SD-06 Test Reports

Submit test reports for the following tests in accordance with the paragraph entitled, "Site Testing," of this section. Do not energize panelboards until the recorded test data has been submitted to and approved by the Contracting Officer.

Continuity Tests

Insulation Tests

SD-07 Certificates

Submit Statements in accordance with paragraph entitled, "General Requirements," of this section.

SD-08 Manufacturer's Instructions

Submit manufacturer's instructions for Panelboards including special provisions required to install equipment components and system packages. Special notices shall detail impedances, hazards and safety precautions.

1.4 PREDICTIVE TESTING AND INSPECTION TECHNOLOGY REQUIREMENTS

This section contains systems and/or equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure building equipment and systems installed by the Contractor have been installed properly and contain no identifiable defects that shorten the design life of a system and/or its components. Satisfactory completion of all acceptance

requirements is required to obtain Government approval and acceptance of the Contractor's work.

PART 2 PRODUCTS

2.1 PANELBOARDS

Totally enclose power-distribution panelboards and lighting and appliance branch-circuit panelboards in a steel cabinet, dead-front circuit breaker type with copper buses, surface- or flush-mounted as indicated. Ensure panelboards conform to NEMA PB 1 and UL 489. Branch circuit panels shall have buses fabricated for bolt-on type circuit breakers.

An outer door or cover, hinged on one side, shall be provided on surface-mounted panelboards to provide gutter space access. Provide a center door for circuit breaker/switch access only.

Voltage and current rating, number of phases, and number of wires shall be as indicated. Provide four-wire distribution panelboards and lighting and appliance branch-circuit panelboards with an isolated full-capacity neutral bus. Ensure panelboards are rated for 120/208-volt, three-phase and 277/480-volt, three-phase, 60-hertz current.

Provide three-phase, 4-wire and single-phase, 3-wire distribution lighting and branch circuit panelboards with an isolated full-capacity bus providing spaces for single-pole circuit breakers/switches and spaces indicated as spare.

Provide panelboards with a separate grounding bus bonded to the enclosure. Grounding bus shall be a solid bus bar of rectangular cross section equipped with binding screws for the connection of equipment grounding conductors.

Each panelboard, as a complete unit, shall have a short-circuit current rating equal to or greater than the integrated equipment rating shown on the panelboard schedule or as indicated.

Ensure panelboards and main lugs or main breaker have current ratings as shown on the panelboard schedule.

Bus bar connections to the branch circuit breakers shall be the "distributed phase" or "phase sequence" type. Three-phase, four-wire busing shall be such that when any three adjacent single-pole breakers are individually connected to each of the three different phases, two- or three-pole breakers can be installed at any location. Current-carrying parts of the bus assembly shall be plated. Mains ratings shall be as shown.

Mechanical lugs furnished with panelboards shall be cast copper or copper alloys of sizes suitable for the conductors indicated to be connected thereto.

Panelboard enclosures shall be NEMA 250, Type 1. Provide enclosures with hinged fronts and corrosion-resistant steel pin-tumbler cylinder locks. Key locks alike and provide two keys for each enclosure.

Finish panelboards with baked enamel. Finish color is to be No. 61 gray conforming to FED-STD-595.

2.2 CIRCUIT BREAKERS

Circuit breakers shall be the molded-case type as specified in Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES. Frame and trip ratings shall be as indicated.

Interrupting rating of circuit breakers shall be as indicated. If not shown, the interrupting rating for circuit breakers in 120/208-volt panelboards shall be not less than 10,000 amperes rms symmetrical, and that for breakers in 277/480-volt panelboards shall be not less than 65,000 amperes rms symmetrical.

Circuit breakers shall be bolt-on type. Plug-in type is not acceptable.

Provide shunt trips where indicated.

In branch circuit panelboards, branch circuit breakers feeding convenience outlets shall have sensitive instantaneous trip settings of not more than 10 times the trip rating of the breaker to prevent repeated arcing shorts resulting from frayed appliance cords. Single-pole 15- and 20-ampere circuit breakers shall be UL listed as "Switching Breakers" at 120 volts ac. Provide UL Class A (5-milliampere sensitivity) ground fault circuit protection on 120-volt ac branch circuit as indicated. This protection is an integral part of the branch circuit breaker that also provides overload and short-circuit protection for branch circuit wiring. Tripping of a branch circuit breaker containing ground fault circuit interruption is not to disturb the feeder circuit to the panelboard.

Ensure connections to the bus are bolt-on type.

When multiple wires per phase are specified, furnish the circuit breakers with connectors made to accommodate multiple wires.

Ensure circuit breaker spaces called out on the drawings are complete with mounting hardware to permit ready installation of the circuit breakers.

2.3 DIRECTORY CARD AND HOLDER

Mount a directory card on the inside of hinged fronts and doors 0.030-inch thick minimum plastic in a metal frame, with spaces for circuit numbers, outlets controlled, and room numbers. Where hinged fronts or doors are not required, provide the directory card 0.030-inch thick minimum plastic in a metal frame mounted on the left-hand side of the front trim. Directory card shall identify each branch circuit with its respective and numbered circuit breaker.

2.4 FACTORY TESTING

Test complete panelboards in accordance with UL 67.

2.5 PRECAUTIONARY LABEL

To ensure persons are aware of immediate or potential hazard in the application, installation, use, or maintenance of panelboards, each panelboard shall be conspicuously marked on the trim or dead front shield with the text (or equivalent) **DANGER** symbol. If the panel is supplied with a door, ensure the label is visible when the door is in the open position.

PART 3 EXECUTION

3.1 INSTALLATION

Install panelboards as indicated and in accordance with the manufacturer's instructions. Fully align and mount panels so that the height of the top operating handle does not exceed 72-inches above the finished floor.

Directory-card information shall be typewritten in capital letters to indicate outlets controlled and final room numbers served by each circuit and shall be mounted in holders behind protective covering.

3.2 SITE TESTING

Each panelboard enclosure key shall be shown to operate the enclosure locks in the presence of the Contracting Officer.

Panelboards shall be given continuity and insulation tests after the installation has been completed and before the panelboard is energized.

Provide test equipment, labor, and personnel as required to perform the tests as specified. Conduct Continuity tests using a dc device with buzzer.

Conduct insulation tests on 480-volt panelboards using a 1,000-volt insulation-resistance test set. Record readings every minute until three equal and consecutive readings have been obtained. Resistance between phase conductors and between phase conductors and ground shall be not less than 50 megohms.

Conduct insulation tests on panelboards rated 300 volts or less using a 500-volt minimum insulation-resistance test set. Record readings after 1 minute and until the reading is constant for 15 seconds. Resistance between phase conductors and between phase conductors and ground shall be not less than 25 megohms.

Record test data and include the location and identification of panelboards and megohm readings versus time.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 24 19.00 40

MOTOR CONTROL CENTERS

PART 1 GENERAL

1.1 REFERENCES
1.2 SYSTEM DESCRIPTION
1.2.1 Rules
1.2.2 Coordination
1.2.3 Standard Products
1.2.4 Nameplates
1.3 SUBMITTALS
1.4 PREDICTIVE TESTING AND INSPECTION TECHNOLOGY REQUIREMENTS
1.5 DELIVERY, STORAGE, AND HANDLING
1.6 MAINTENANCE
1.6.1 Accessories and Tools
1.6.2 Spare Parts

PART 2 PRODUCTS

2.1 CONNECTIONS
2.2 MOLDED CASE CIRCUIT BREAKERS
2.2.1 Trip Units
2.2.2 480-Volt AC Circuits
2.2.3 120/208-Volt AC Circuits
2.3 WIRING
2.4 TERMINAL BLOCKS
2.4.1 Types of Terminal Blocks
2.4.1.1 Short-Circuiting Type
2.4.1.2 Load Type
2.4.2 Marking Strips
2.5 MOTOR CONTROL CENTERS
2.5.1 Enclosures
2.5.1.1 Unit Compartments
2.5.1.2 Motor Control Center Doors and Covers
2.5.1.3 Sills
2.5.1.4 Shutters
2.5.2 Buses
2.5.2.1 Horizontal Bus
2.5.2.2 Vertical Bus
2.5.2.3 Ground Bus
2.5.2.4 Neutral Bus
2.5.3 Combination Starters
2.5.3.1 Magnetic Contactors
2.5.3.2 Variable Frequency Drives
2.5.3.3 Auxiliary Contacts
2.5.3.4 Overload Relays
2.5.3.5 Individual Control Transformers
2.5.3.6 Voltage Fault Protection

2.5.3.7 Control Circuit Disconnects
2.5.4 Molded Case Circuit Breakers in Unit Compartments
2.5.5 Wiring for Motor Control Centers
2.5.5.1 Contractor's Wiring
2.5.5.2 External Connections
2.5.5.3 Terminal Blocks
2.5.6 Accessories and Control Devices
2.5.6.1 Control Stations
2.5.6.2 LED Indicating Lights
2.5.6.3 Control Relays
2.5.6.4 Timing Relays
2.5.6.5 Elapsed-Time Meters
2.5.7 Feeder Tap Units
2.5.8 Metering Section
2.5.8.1 Instrument Transformers
2.6 PAINTING
2.7 FACTORY TESTS
2.7.1 Motor Control Centers Tests
2.7.1.1 Dielectric Tests
2.7.1.2 Operational Tests
2.7.1.3 Short Circuit Tests

PART 3 EXECUTION

3.1 INSTALLATION
3.2 FIELD TESTING

-- End of Section Table of Contents --

SECTION 26 24 19.00 40

MOTOR CONTROL CENTERS

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 B1.1	(2003; R 2008) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1	(1983; R 2006) Pipe Threads, General Purpose (Inch)

ASTM INTERNATIONAL (ASTM)

ASTM B187/B187M	(2011) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes
ASTM B317/B317M	(2007) Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, and Structural Profiles for Electrical Purposes (Bus Conductor)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C57.13	(2008) Standard Requirements for Instrument Transformers

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(2000; R 2005; R 2008) 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 4	(2010) Terminal Blocks
NEMA ICS 6	(1993; R 2006) Enclosures
NEMA ST 1	(1988; R 1994; R 1997) Specialty

	Transformers (Except General Purpose Type)
NEMA/ANSI C12.11	(2007) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; TIA 11-1; Errata 2011) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1063	(2006) Machine-Tool Wires and Cables
UL 44	(2010) Thermoset-Insulated Wires and Cables
UL 489	(2009) Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 845	(2005; Reprint Aug 2006) Motor Control Centers

1.2 SYSTEM DESCRIPTION

These specifications include the design, fabrication, assembly, wiring, testing, delivery, installation and testing of the items of equipment and accessories and spare parts listed in the Schedule and shown on the drawings.

Within 30 calendar days after date of award, submit for the approval of the Contracting Officer six (6) copies of electrical equipment drawings, including all motor control units and protective devices. Provide a single-line diagram, equipment list and nameplate schedule.

Within 30 calendar days after date of award, submit for the approval of the Contracting Officer six (6) copies of electrical equipment drawings. Include within the NEMA Class II motor control center drawings a connection diagram with wire designations and schematic diagrams to illustrate operation of associated motor unit controls. Submit an individual wiring diagram for each motor control center. Wiring diagrams shall be in a form showing physical arrangement of the control center with interconnecting wiring shown by lines or by terminal designations (wireless). Provide a single-line diagram, equipment list and nameplate schedule for each motor control center.

1.2.1 Rules

The equipment shall conform to the requirements of NFPA 70 unless more stringent requirements are indicated herein or shown. NEMA rated and UL listed equipment has been specified when available. Equipment must meet NEMA and UL construction and rating requirements as specified. No equivalent will be acceptable. Immediately notify the Contracting Officer of any requirements of the specifications or Contractor proposed materials or assemblies that do not comply with UL or NEMA. International Electrotechnical Commission (IEC) rated equipment will not be considered an acceptable alternative to specified NEMA ratings.

1.2.2 Coordination

The general arrangement of the motor control centers is shown on the contract drawings. Any modifications of the equipment arrangement or device requirements as shown on the drawings is subject to the approval of the Contracting Officer. If any conflicts occur necessitating departures from the drawings, details of and reasons for departures shall be submitted and approved prior to implementing any change. Completely assemble all equipment at the factory. The motor control centers may be disassembled into sections, if necessary, for convenience of handling, shipping, and installation.

1.2.3 Standard Products

Material and equipment shall be standard products of a manufacturer regularly engaged in their manufacture and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. All materials shall conform to the requirements of these specifications. Materials are to be of high quality, free from defects and imperfections, of recent manufacture, and of the classification and grades designated. All materials, supplies, and articles not manufactured by the Contractor shall be the products of other recognized reputable manufacturers. If the Contractor desires for any reason to deviate from the standards designated in these specifications, he shall, after award, submit a statement of the exact nature of the deviation, and shall submit, for the approval of the Contracting Officer, complete specifications for the materials which he proposes to use.

1.2.4 Nameplates

Make nameplates of laminated sheet plastic or of anodized aluminum approximately 1/8 inch thick, engraved to provide white letters on a black background. Fasten the nameplates to the equipment in proper positions with anodized round-head screws. Lettering shall be minimum 1/2 inch high. Nameplate designations shall be in accordance with lists on the drawings, and as a minimum provide for the following equipment:

a. Motor Control Centers

b. Individual items of equipment mounted in the Motor Control Centers

Provide equipment of the withdrawal type with nameplates mounted on the removable equipment in locations visible when the equipment is in place.

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

Drawings; G

Shop Drawings; G

Within 30 calendar days after date of award, submit for the approval of the Contracting Officer six (6) copies of outline

drawings of all equipment to be furnished under this contract, together with weights and overall dimensions. Drawings shall show the general arrangement and overall dimensions of the motor control centers. These drawings shall show space requirements, details of any floor supports to be embedded in concrete and provisions for conduits for external cables.

Motor Control Centers; G

SD-03 Product Data

Equipment; G

Within 30 calendar days after date of award submit for approval six (6) copies of such descriptive cuts and information as are required to demonstrate fully that all parts of the equipment will conform to the requirements and intent of the specifications. Data shall include descriptive data showing typical construction of the types of equipment proposed, including the manufacturer's name, type of molded case circuit breakers or motor circuit protectors, performance capacities and other information pertaining to the equipment. Submit six (6) sets of characteristic curves of the individual breaker trip element.

Factory Tests

Submit, within a minimum of 14 days prior to the proposed date of tests, six (6) copies of manufacturer's routine factory test procedures and production line tests for all motor control centers.

SD-06 Test Reports

Factory Tests

Submit six (6) complete reproducible copies of the factory inspection results and six (6) complete reproducible copies of the factory test results in booklet form, including all plotted data curves, all test conditions, a listing of test equipment complete with calibration certifications, and all measurements taken. Contractor's and Contracting Officer's Representatives must sign and date report.

SD-07 Certificates

Motor Control Centers

Submit certification of factory test reports. Certification shall be signed by official authorized to certify on behalf of the manufacturer, attesting that the motor control center meets the specified requirements. The statement must be dated after the award of this contract, must state the Contractors name and address, must name the project and location, and must list the specific requirements which are being certified.

SD-08 Manufacturer's Instructions

Submit manufacturer's instructions for the following including special provisions required to install equipment components and system packages. Detail within special notices hazards and safety

precautions.

Motor Control Units

Protective Devices

1.4 PREDICTIVE TESTING AND INSPECTION TECHNOLOGY REQUIREMENTS

This section contains systems and/or equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure building equipment and systems installed by the Contractor have been installed properly and contain no identifiable defects that shorten the design life of a system and/or its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the Contractor's work..

1.5 DELIVERY, STORAGE, AND HANDLING

Ship the equipment as completely assembled and wired as feasible so as to require a minimum of installation work. Each shipping section shall be properly match marked to facilitate reassembly, and shall be provided with removable lifting channels with eye bolts for attachment of crane slings to facilitate lifting and handling. Any relay or other device which cannot withstand the hazards of shipment when mounted in place on the equipment shall be carefully packed and shipped separately. Mark these devices with the number of the panel which they are to be mounted on and fully identified. All finished painted surfaces and metal work shall be wrapped suitably or otherwise protected from damage during shipment. Prepare all parts for shipment so that slings for handling may be attached readily while the parts are in a railway car or transport truck.

1.6 MAINTENANCE

1.6.1 Accessories and Tools

A complete set of accessories and special tools unique to equipment provided and required for erecting, handling, dismantling, testing and maintaining the apparatus to be furnished by the Contractor.

1.6.2 Spare Parts

Furnish spare parts as specified below. All spare parts shall be of the same material and workmanship, shall meet the same requirements, and shall be interchangeable with the corresponding original parts furnished.

a. 2 - Fuses of each type and size.

b. 1 - Circuit breaker auxiliary switch.

c. 2 - Operating coils for each size ac contactor.

d. 1 - Operating coil for each size dc contactor.

e. 2 - Complete sets of 3-pole stationary and moving contact assemblies for each size ac contactor.

f. 1 - Complete set of 2-pole stationary and moving contact assemblies for

each size dc contactor.

g. 3 - Contactor overload relays of each type and rating, each relay with a complete set of contact blocks.

h. 1 - Spare set of heater elements for each heater rating provided.

i. 2 - Indicating lamp assemblies of each type.

j. 1 - Control transformer of each type and rating.

k. 1 - Control relay of each type and rating.

l. 1 - Contactor auxiliary contact of each type.

m. 4 - One quart containers of finish paint for indoor equipment.

n. 2 - One quart containers of the paint used for the exterior surfaces of outdoor equipment.

o. 4 - Keys for motor control center door lock.

PART 2 PRODUCTS

2.1 CONNECTIONS

All bolts, studs, machine screws, nuts, and tapped holes shall be in accordance with ASME B1.1. The sizes and threads of all conduit and fittings, tubing and fittings, and connecting equipment shall be in accordance with ASME B1.20.1. All ferrous fasteners shall have rust-resistant finish and all bolts and screws shall be equipped with approved locking devices. Manufacturer's standard threads and construction may be used on small items which, in the opinion of the Contracting Officer, are integrally replaceable, except that threads for external connections to these items and meet the above requirements.

2.2 MOLDED CASE CIRCUIT BREAKERS

Molded case circuit breakers shall conform to the applicable requirements of UL 489. The circuit breakers shall be manually-operated, shall be quick-make, quick-break, common trip type, and shall be of automatic-trip type unless otherwise specified or indicated on the drawings. Operate all poles of each breaker simultaneously by means of a common handle. The operating handles shall clearly indicate whether the breakers are in "On," "Off," or "Tripped" position and shall have provisions for padlocking in the "Off" position. Provide personnel safety line terminal shields for each breaker. The circuit breakers shall be products of only one manufacturer, and shall be interchangeable when of the same frame size.

2.2.1 Trip Units

Except as otherwise noted, the circuit breakers, of frame sizes and the trip unit ratings as shown on the drawings, shall be provided with combination thermal and instantaneous magnetic or solid state trip units. The Government reserves the right to change the indicated trip ratings, within frame limits, of the trip devices at the time the shop drawings are submitted for approval. The breaker trip units shall be interchangeable and the instantaneous magnetic trip units shall be adjustable on frame sizes larger than 150 amperes. Nonadjustable instantaneous magnetic trip

units shall be set at approximately 10 times the continuous current ratings of the circuit breakers. Solid state trip units, where indicated, shall also have adjustable long time pick-up and delay, short time pick-up and delay, and ground fault pick-up and delay.

2.2.2 480-Volt AC Circuits

Circuit breakers for 480-volt or 277/480-volt ac circuits shall be rated 600 volts ac, and shall have an UL listed minimum interrupting capacity of 22,000 symmetrical amperes at 600 volts ac.

2.2.3 120/208-Volt AC Circuits

Circuit breakers for 120-volt ac circuits shall be rated not less than 120/208 or 208 volts ac, and shall have a UL listed minimum interrupting capacity of 10,000 symmetrical amperes.

2.3 WIRING

All control wire is to be stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44 or Type MTW meeting UL 1063, and shall pass the VW-1 flame tests included in those standards. Hinge wire shall have Class K stranding. Current transformer secondary leads shall be not smaller than No. 10 AWG. The minimum size of control wire shall be No. 14 AWG. Power wiring for 480-volt circuits and below shall be of the same type as control wiring and the minimum size shall be No. 12 AWG. Give special attention to wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.4 TERMINAL BLOCKS

Control circuit terminal blocks for control wiring shall be molded or fabricated type with barriers, rated not less than 600 volts. The terminals shall be removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts. The terminals are to be no less than No. 10 in size and having sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal. The terminal arrangement is subject to the approval of the Contracting Officer and not less than four (4) spare terminals or 10 percent, whichever is greater, shall be provided on each block or group of blocks. Modular, pull apart, terminal blocks will be acceptable provided they are of the channel or rail-mounted type. Submit data showing that the 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.

2.4.1 Types of Terminal Blocks

2.4.1.1 Short-Circuiting Type

Furnish short-circuiting type terminal blocks for all current transformer secondary leads and shall have provision for shorting together all leads from each current transformer without first opening any circuit. Terminal blocks shall meet the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

2.4.1.2 Load Type

Provide load terminal blocks rated no less than 600 volts and of adequate capacity for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits except those for feeder tap units. The terminals shall be 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, screws shall have hexagonal heads. Conducting parts between connected terminals shall have adequate contact surface and cross-section to operate without overheating. Each connected terminal shall have the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.4.2 Marking Strips

Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations. Make the wire numbers with permanent ink. The marking strips shall be reversible to permit marking both sides, or two marking strips shall be furnished with each block. Marking strips shall accommodate the two sets of wire numbers. Each device to which a connection is made shall be assigned a device designation in accordance with NEMA ICS 1 and each device terminal to which a connection is made shall be marked with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams. 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. Prints of 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.

2.5 MOTOR CONTROL CENTERS

Design each motor control center for operation on 480-volts ac, 3-phase, 60-Hz system, and the ensure that equipment conforms to all the applicable requirements of NEMA ICS 1, NEMA ICS 2, NEMA ICS 4, NEMA ICS 6, UL 845 and NFPA 70. List and label vertical sections and individual units under UL 845 where ever possible. In lieu of the UL listing, certification from any nationally recognized, adequately equipped, testing agency that the individual units and vertical sections have been tested and conform to the UL requirements of that agency will be acceptable when approved by the Contracting Officer. Provide NEMA Class II, Type B, motor control centers in accordance with NEMA ICS 2.

2.5.1 Enclosures

Each motor control center shall consist of the required number of vertical sections of 90 inches nominal height, bolted together, with steel channel sills and suitable for mounting against a wall. Vertical section shall be 20 inches deep and buses, control wiring, control transformers, small power transformers, terminal blocks, line terminals, cable supports, and clamps shall be accessible from the front. Enclosure shall be NEMA Type 12. Fabricate the control centers from smooth select steel sheets shaped and reinforced to form rigid free-standing structures. Metal thickness for enclosures shall be not less than specified in NEMA ICS 6 without exception. Fabricate and bolt vertical edges of sections exposed to view so that the joints will not pass a 1/16 inch gage. Design each structure for addition of future sections required. Isolate individual compartments

from adjacent compartments. Make provisions for leveling the entire assembled motor-control center sections and bolting them together so that they form a contiguous structural enclosure.

Lifting angles shall be 7 gage, and shall be provided on the top of each section, and shall extend the entire width of the section, and shall be capable of supporting the entire weight of the motor-control center section without distortion. Provide base channels with holes to facilitate floor mounting and leveling.

2.5.1.1 Unit Compartments

Each operating unit shall contain equipment as shown on the drawings, mounted in an individual cell. The unit assembly, except main circuit breakers, panelboards and auxiliary control devices, shall be drawout type removed from the front, without rear access or disturbing other units in the control center assembly. All drawout type unit assemblies shall have positive guide rail system to ensure alignment of connection to vertical bus. Units shall be mechanically interlocked with the door to prevent removal while in the energized position. Each removable unit shall have provision for padlocking in a position in which it is disconnected from the vertical bus although not removed from the stationary structure. Provide all ventilating openings with corrosion-resistant insect-proof screens on the inside. Provide bus closing plugs for all unused openings in vertical bus barriers.

Compartments for future combination motor-control units shall be complete with hardware, buses, and hinged doors ready to receive future draw-out units. Compartments for spare combination motor-control units shall be complete with buses, hinged doors, and draw-out units but without load terminal connections. Spare spaces shall be complete with buses and screwed-on front cover plates.

2.5.1.2 Motor Control Center Doors and Covers

Provide each unit compartment, including blank compartments for future use, with either a flange-formed or a rolled-edge door. Mount each door on fully-concealed or continuous full-length piano-type hinges and provide with positive fasteners. Prevent door sag by proper alignment of hinges made of sufficiently strong material. Interlock the door fastenings to prevent opening when the equipment is energized. The external operating handle shall clearly indicate whether the equipment is in an "ON", "OFF" or "TRIPPED" position.

2.5.1.3 Sills

Channel iron foundations, complete with bolts and drilled holes for grouting and anchoring to the floor, shall be furnished for the complete length (front and rear) of each motor control center assembly. The channels shall be designed for flat mounting and maximum channel depth shall be 1-1/2 inches. Additional channel or substantial metal trim shall be provided flush with the end panels to completely enclose the bases across the ends of the equipment assemblies.

2.5.1.4 Shutters

Drawout units shall have shutters which close when the unit is withdrawn to isolate the vertical bus.

2.5.2 Buses

All buses shall be of tinned copper and shall be tin or silver-plated throughout. Copper bars and shapes for bus conductors shall conform to the applicable requirements of ASTM B187/B187M and ASTM B317/B317M. All splices for field assembly shall be bolted with at least two bolts and shall employ the use of "Belleville" washers in the connection. The bus ratings shall be based on a 65 degree Celsius maximum temperature rise in accordance with UL 845 requirements. Bus shall have a short-circuit current rating of not less than 42,000 RMS symmetrical amperes. Support all bus work on wet process porcelain insulators, glass polyester, or suitable molded material.

2.5.2.1 Horizontal Bus

Provide each control center assembly with a three-phase main horizontal bus, with a continuous current rating not less than 800 amperes, located across the top of each vertical section. Drill the ends of horizontal buses for future extensions.

2.5.2.2 Vertical Bus

Provide each vertical section with a three-phase vertical bus with a continuous current rating of 600 amperes connected to the horizontal bus by brazing, welding, or bolting. Where the incoming feeder breakers are located at the bottom of a control center, rate the vertical bus in that section the same as the main horizontal bus. Extend vertical buses from the horizontal bus to the bottom of the lowest available unit mounting space. Isolate the vertical bus from wireways and equipment in compartments.

2.5.2.3 Ground Bus

Provide a tin-plated copper ground bus full width at the bottom of the motor control center line-up. Provide a full clamp-type solderless copper or copper alloy lug for No. 3/0 AWG stranded copper cable at each end of the bus for connection to the station grounding system. Ground bus shall be capable of carrying the rated short-circuit current available in the motor-control center.

2.5.2.4 Neutral Bus

Furnish a half rated neutral bus continuous through the control center. Lugs of appropriate capacity will be furnished.

2.5.3 Combination Starters

Combination motor controller units shall contain molded-case circuit breakers, auxiliary and pilot devices and a magnetic contactor with thermal overload relays and reduced voltage starter where indicated on the drawings. The ratings of air circuit breakers, contactors, motor controllers and other devices shall be as shown on the drawings. All combination motor controller units shall have short circuit ratings equal to 25,000 AIC or greater. Where control push-buttons, indicating lamps, "Hand-Off-Automatic" switches, and similar control devices are associated with a unit, mount them on the unit compartment door. Door-mounted components shall not interfere with access within the compartments. Molded case circuit breakers for use in combination starters shall meet the requirements of paragraph entitled, "Molded Case Circuit Breakers," of this

section.

2.5.3.1 Magnetic Contactors

Magnetic contactors shall be of the NEMA sizes indicated on the drawings. The rating, performance and service characteristics shall conform to the requirements of NEMA ICS 2 for contactors with continuous current ratings for the duty indicated. Contactors for motor control shall be rated for VFDs (Class A controllers). Contactors shall be suitable for at least 200,000 complete operations under rated load without more than routine maintenance. Minimize the interruption arc and flame by suitable arc chutes or other means so that no damage will be done to other portions of the device. The arc chutes, if provided, shall be easily removable without removing or dismantling other parts. The contacts shall be easily removable. All current-carrying contact surfaces shall be silver-surfaced or of other approved material to prevent the formation of high resistance oxides. The contactor shall operate without chatter or perceptible hum while energized. Coils shall be suitable for continuous operation 480-volt ac circuits. Alternating-current contactors shall be three-pole, except where otherwise noted, and shall be insulated for 600 volts ac and of the electrically- operated, magnetically-held type. Direct-current contactors shall be two-pole, suitable for controlling circuits operating at 125 volts dc, insulated for 250 volts dc, electrically-operated, magnetically-held type and adequate for variable frequency drives service.

2.5.3.2 Variable Frequency Drives

Variable frequency drives shall be included in the MCC lineup as indicated in the drawings and shall conform with Section 26 29 23 VARIABLE FREQUENCY DRIVE SYSTEMS UNDER 600 VOLTS.

2.5.3.3 Auxiliary Contacts

Each controller shall be provided with a minimum of three auxiliary contacts which can be easily changed from normally open to normally closed. Where indicated on the drawings, provide a fourth auxiliary contact and red and green indicating lights.

2.5.3.4 Overload Relays

Except as otherwise indicated, each controller shall be provided three NEMA Class 20 thermal overload relays with external manual reset. Prior to shipment of the control centers, the Contracting Officer will furnish the ratings of the heater elements to be installed in the relays by the Contractor.

2.5.3.5 Individual Control Transformers

Where 120 volt ac control of contactors is indicated or required, provide an individual control transformer on the line side of the unit disconnect. The control transformers shall be rated 480-120 volts and shall conform to the requirements for control transformers in NEMA ST 1. Control transformers shall have adequate volt-ampere capacity for the control functions indicated. Install transformers with primary fuses. Except as otherwise indicated on the drawings, provide each control transformer with a fuse in one secondary lead and have the other secondary lead grounded.

2.5.3.6 Voltage Fault Protection

Where shown, provide starters with protection against voltage faults, phase unbalance, phase loss, phase reversal, undervoltage and overvoltage. Upon sensing one of these faults, the protector shall de-energize the starter. The protector shall use a combination of voltage and phase-angle sensing to detect phase loss even when regenerated voltages are present. Connect the protector to the load side of the motor circuit disconnect. The protector shall have an adjustable line voltage trip level, adjustable trip delay, automatic reset and manual reset by an external normally closed push-button, and Double Pull Double Throw (DPDT) output contacts. Protector operation shall have repeatability of +1 percent of set point, maximum, and a dead band of 2 percent maximum. Protector shall have green indicator to show normal status and red indicator to show tripped status. Indicators will be visible through the compartment door, when LED's are used cover the protector with a clear unbreakable cover, when lamps are used they shall have nameplates and be grouped with other indicating lights.

2.5.3.7 Control Circuit Disconnects

Disconnect control circuit power when the unit compartment is opened.

2.5.4 Molded Case Circuit Breakers in Unit Compartments

Molded case circuit breakers for installation in unit compartments shall meet the requirements of paragraph entitled, "Molded Case Circuit Breakers," of this section.

2.5.5 Wiring for Motor Control Centers

All wiring shall meet the requirements of paragraph entitled, "Wiring," of this section. Provide heavy-duty clamp type terminals for terminating all power cables entering the control centers.

2.5.5.1 Contractor's Wiring

Form wiring into groups, suitably bound together, properly supported and run straight horizontally or vertically. There shall be no splices in the wiring. The manufacturer's standard pressure-type wire terminations for connections to internal devices will be acceptable. Add terminal blocks for wiring to devices having leads instead of terminals. Use ring tongue indented terminals on all wires terminated on control terminal blocks for external or interpanel connections and at shipping splits. All stud terminals shall have contact nuts and either locking nuts or lockwashers.

2.5.5.2 External Connections

Power and control cables will enter the control centers at the bottom.

2.5.5.3 Terminal Blocks

Terminal blocks shall meet the requirements of paragraph TERMINAL BLOCKS above. In no case shall the terminals provided for circuit breakers or contactors accommodate less than the number or size of conductors shown on the drawings. Give special attention to wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.5.6 Accessories and Control Devices

Control accessories shall be provided, and shall be suitable for mounting

on the front of, or inside, the control centers as indicated on the drawings. Control accessories shall meet the applicable requirements of NEMA ICS 2. Mount relays and other equipment that mechanical vibration will not cause false operation.

2.5.6.1 Control Stations

Push-button stations and selector switches shall conform to NEMA ICS 2, shall be of the heavy-duty, oil-tight type, rated 600 volts ac, and have a contact rating designation of A600. Provide switches with escutcheon plates clearly marked to show operating positions.

2.5.6.2 LED Indicating Lights

Furnish red and green LED's where shown on the drawings, indicating contact "open" and "closed" position. The LED's shall be accessible and replaceable from the front of the control center through a finished opening in the compartment door. The LED assemblies shall be of the heavy duty oiltight, watertight, and dusttight type.

2.5.6.3 Control Relays

Control relays shall be of the electrically operated, magnetically held, self-reset, open type, suitable for mounting inside the starter compartments, and shall be 120-volt ac. Contacts shall be as indicated on the drawings and shall have a contact rating designation of A600 or N600, as required, in accordance with NEMA ICS 2.

2.5.6.4 Timing Relays

Timers shall be pneumatic type. They shall be suitable for mounting inside the control center and shall be rated 120 volts ac, 60 Hz. Provide instantaneous and time delay contacts as indicated on the drawings, and have a contact rating designation of A600 or N600, as required, in accordance with NEMA ICS 2. Provide means for manual adjustment over a range as indicated on the drawings.

2.5.6.5 Elapsed-Time Meters

Hour-indicating time meters shall have 6- digit registers with counter numbers at least 1/4 inch high. White numbers on black backgrounds shall provide hour indication with the last digit in contrasting colors to indicate tenths of an hour. The enclosure shall be 3-1/2 inches square and dust resistant. Operating voltage shall be 120 volts ac. They shall be of the nonreset type.

2.5.7 Feeder Tap Units

Provide feeder tap units as indicated on the drawings. Feeder tap units shall include externally operable molded-case circuit breakers in combination motor-control unit enclosures for the protection of non-motor loads or remotely located magnetic motor-controllers. Not more than two molded-case circuit breakers shall be contained in feeder tap units.

2.5.8 Metering Section

Provide metering section with instruments as indicated on the drawings.

2.5.8.1 Instrument Transformers

All transformers used for metering shall meet the requirements of NEMA/ANSI C12.11 and IEEE C57.13. Protect voltage transformers with removable primary and secondary fuses. Install fuses in each ungrounded lead and located adjacent to the transformers in an easily accessible place. If cable connections to current transformer primary are required, furnish terminals of an approved solderless type and proper size. If current transformers are connected to buses, furnish proper connections, complete with bolts, nuts, washers and other accessories.

2.6 PAINTING

Interior and exterior steel surfaces of equipment enclosures shall be thoroughly cleaned and then receive a rust-inhibitive phosphatizing or equivalent treatment prior to painting. Exterior surfaces shall be free from holes, seams, dents, weld marks, loose scale or other imperfections. Interior surfaces shall receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice. Prime exterior surfaces, fill where necessary, and give no less than two coats baked enamel with semigloss finish. Equipment located indoors shall be ANSI Light Gray. All touch-up work shall be done with manufacturer's coatings as supplied under paragraph entitled, "Spare Parts," of this section.

2.7 FACTORY TESTS

Each item of equipment supplied under this contract shall be given the manufacturer's routine factory tests and tests as specified below, to insure successful operation of all parts of the assemblies. All tests required herein shall be witnessed by the Contracting Officer unless waived in writing, and no equipment shall be shipped until it has been approved for shipment by the Contracting Officer. Notify the Contracting Officer a minimum of 14 days prior to the proposed date of the tests so that arrangements can be made for the Contracting Officer to be present at the tests. The factory test equipment and the test methods used shall conform to the applicable NEMA Standards, and shall be subject to the approval of the Contracting Officer. Reports of all witnessed tests shall be signed by witnessing representatives of the Contractor and Contracting Officer. Bear the cost of performing all tests and include in the prices bid in the schedule for equipment.

2.7.1 Motor Control Centers Tests

2.7.1.1 Dielectric Tests

Each motor control center shall be completely assembled and given dielectric tests in accordance with NEMA ICS 1.

2.7.1.2 Operational Tests

The correctness of operation of each air circuit breaker and magnetic contactor and of all control devices, accessories and indicating lamps, shall be checked. These checks shall be made at rated voltage with power supplies to the main buses. All magnetic contactors shall also be checked for proper operation with power at 90 percent of rated voltage.

2.7.1.3 Short Circuit Tests

If the unit is not UL labeled for the specified short circuit, the

Contractor may submit design tests demonstrating that satisfactory short-circuit tests, as specified in NEMA ICS 2, have been made on a motor control center of similar type of construction and having the same available short circuit current at the motor terminals, including any motor contributions, as the motor control centers specified to be furnished under these specifications.

PART 3 EXECUTION

3.1 INSTALLATION

Complete assembly shall be electrically and mechanically connected and assembled from coordinated subassemblies shipped in complete sections from the manufacturer. Installation shall be aligned, leveled, and secured to the supporting construction in accordance with the manufacturer's recommendations.

3.2 FIELD TESTING

Motor-control centers shall be subjected to continuity and insulation tests after the installation has been completed and before the motor-control center is energized.

Provide test equipment, labor, and personnel to perform the tests required. Conduct continuity tests using a dc device with bell or buzzer.

Motor-control centers shall be completely isolated from extraneous electrical connections. Substation feeder breakers, circuit breakers in switchboards, and other disconnecting devices shall be used to isolate the motor-control center under test.

Conduct insulation tests on 600-volt motor-control centers using a 1,000-volt insulation-resistance test set. Record readings every 15 seconds for the first minute and every minute thereafter for 10 minutes. Resistance between phase conductors and between phase conductors and ground shall be not less than 50 megohms.

Conduct insulation tests on motor-control centers 480 volts or less using a 500-volt insulation-resistance test set. Record readings every 15 seconds for the first minute and every minute thereafter for 10 minutes. Resistance between phase conductors and between phase conductors and ground shall be not less than 25 megohms.

Prior to final acceptance the motor control center shall be energized and loaded (to the maximum load possible, but not less than 10 percent of expected full load)for a minimum of 10 minutes and the temperature measured, with a non-contact device, to verify connection integrity. The temperature detector shall be accurate within 0.5 degrees C. Each phase temperature of 3 phase circuits and individual connections compared to other similarly loaded connections shall be within 3 degrees C of each other. Temperatures outside these values warrant investigation.

Conduct phase-rotation tests on all three-phase circuits using a phase-rotation indicating instrument. Phase rotation of electrical connections to motors and other connected equipment shall be clockwise.

Record test data and include location and identification of motor-control centers and megohm readings versus time.

Final acceptance shall depend upon the satisfactory performance of the motor-control centers under test. No motor-control center shall be energized until recorded test data have been approved by the Contracting Officer. Provide final test reports to the Contracting Officer. Reports shall have a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 28 01.00 10

COORDINATED POWER SYSTEM PROTECTION

PART 1 GENERAL

1.1 REFERENCES
1.2 SYSTEM DESCRIPTION
1.3 SUBMITTALS
1.4 QUALITY ASSURANCE
1.4.1 System Coordinator
1.4.2 System Installer
1.4.3 Power System Analysis Document Design Reviews

PART 2 PRODUCTS

2.1 Arc-Flash Labels
2.2 COORDINATED POWER SYSTEM PROTECTION
2.2.1 Scope of Analyses
2.2.2 Determination of Facts
2.2.3 Single Line Diagram
2.2.4 Fault Current Analysis
2.2.4.1 Method
2.2.4.2 Data
2.2.4.3 Fault Current Availability
2.2.5 Coordination Study
2.2.6 Study Report

PART 3 EXECUTION

3.1 INSTALLATION
3.2 FIELD TESTING
3.2.1 General
3.2.2 Safety
3.2.3 Molded-Case Circuit Breakers
3.2.4 Power Circuit Breakers
3.2.4.1 General
3.2.5 Protective Relays

-- End of Section Table of Contents --

SECTION 26 28 01.00 10

COORDINATED POWER SYSTEM PROTECTION

PART 1 GENERAL

1.1 REFERENCES

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 242	(2001; Errata 2003) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book
IEEE 399	(1997) Brown Book IEEE Recommended Practice for Power Systems Analysis
IEEE 1584	IEEE Guide for Performing Arc Flash Hazard Calculations

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2009) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI Z535.1	(2006) American National Standard for Safety--Color Code

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; TIA 11-1; Errata 2011) National Electrical Code
NFPA 70E	(2009; Errata 2009) Standard for Electrical Safety in the Workplace

1.2 SYSTEM DESCRIPTION

The power system covered by this specification consists of: Drawing No. 79K38877.

The analysis shall include all new protective devices installed, the first existing upstream supplying protective device, and the first downstream feeder device for all new protective devices installed.

New protective device settings shall be provided for all new low voltage equipment (up to 600 Volts AC). Protective device settings for medium

voltage equipment will be provided by the Government; however, the Contractor shall provide all required protective device data for the Government to analyze and determine the settings required.

The Government will provide the short circuit values for the following connection points on the electrical system:
13.2kV or 13.8kV primary terminals at each existing transformer and LBS/VFI involved in the project.

The Government will provide the existing protective device settings for the following devices on the electrical system:
Each C5 and Orsino substation feeder or existing upstream VFI involved in the project.

The Government will provide the existing protective device time-current curves for the above devices.

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

Fault Current and Arc Flash Analysis
Protective Device Coordination Study

The study along with protective device equipment submittals. No time extensions or similar contact modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed will be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Review and final submittals shall consist of 5 bound copies and a PDF file submitted on Compact Disc (CD). Also provide on a final submittal CD, all power system analysis software data files necessary to restore and edit the model.

Equipment

Data consisting of manufacturer's time-current characteristic curves for individual protective devices, recommended settings of adjustable protective devices, and recommended ratings of non-adjustable protective devices.

System Coordinator

Verification of experience and license number, of a registered Professional Engineer with at least 3 years of current experience in the design of coordinated power system protection. Experience data shall include at least five references for work of a magnitude comparable to this contract, including points of contact, addresses and telephone numbers. This engineer must perform items required by this section to be performed by a

Florida registered Professional Engineer.

Protective Relays

Data including calibration and testing procedures and instructions pertaining to the frequency of calibration, inspection, adjustment, cleaning, and lubrication.

Installation

Procedures including diagrams, instructions, and precautions required to properly install, adjust, calibrate, and test the devices and equipment.

1.4 QUALITY ASSURANCE

1.4.1 System Coordinator

System coordination, recommended ratings and settings of protective devices, and design analysis shall be accomplished by a Florida registered professional electrical power engineer with a minimum of 3 years of current experience in the coordination of electrical power systems.

1.4.2 System Installer

Calibration, testing, adjustment, and placing into service of the protective devices shall be accomplished by a manufacturer's product field service engineer or independent testing company.

1.4.3 Power System Analysis Document Design Reviews

The completed fault current and arc flash analysis and protective device coordination study documents shall be reviewed at a KSC location and implemented as follows:

90 percent document and review meeting at KSC: Study is complete except for disposition of Government comments.

100 percent document: Incorporates approved Government comments and submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES. Setting sheets from this document are to be used to implement protective device settings.

Installation field change document and review meeting at KSC: Required if setting changes in protective devices are required due to discrepancies between the 100 percent setting sheet documents and the available setting selections on the protective device. All applicable portions of the fault current and arc flash analysis and protective device coordination study document shall be changed and annotated to reflect the impacts of the setting changes.

As-Built document: Incorporates as-installed protective device settings Government comments and submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES.

PART 2 PRODUCTS

2.1 Arc-Flash Labels

Provide detailed arc flash warning labels for all electrical equipment as required by NFPA 70 and NFPA 70E, including, medium voltage switches, transformers, switchgear main breakers, switchgear bus-tie breaker, switchgear feeder breakers, switchgear cable compartments, switchboards, panelboards, motor control centers, enclosed breakers, safety switches automatic transfer switches, motor starters, control panels, and other equipment modified or installed by the project that is likely to require examination, adjustment, servicing, or maintenance while energized.

a. Label format is to be NFPA 70E detailed format type and samples will be provided at the time of award. Format includes different colors and formatting per ANSI Z535.1 for different hazard levels and the following information:

i) Flash hazard boundary
ii) Incident energy
iii) Hazard Category and PPE
iv) Shock Voltage
v) Minimum insulated glove rating
vi) Limited approach boundary distance
vii) Restricted approach boundary distance
viii) Prohibited approach boundary distance

b. The arc flash label content shall be based on the operational scenario, fault location, and fault type (arcing or bolted) that results in the highest incident energy.

2.2 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for ratings, coordination, and protection. They shall include a fault current and arc flash analysis, and a protective device coordination study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last 3 years. Provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

Perform short circuit studies, coordination studies, and arc-flash hazard analysis in accordance with NETA ATS and as specified herein.

2.2.1 Scope of Analyses

The fault current and arc flash analysis, and protective device coordination study shall begin at: the existing power supply connection points indicated and extend down to all electrical equipment shown on Drawings indicated in Paragraph 1.2 SYSTEM DESCRIPTION.

2.2.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. Coordinate with the Government Lead Electrical Design Engineer for fault current availability at the site.

Review protective device submittals, perform field surveys, make notations on submittals, and coordinate with equipment vendor as required to obtain all new device data necessary for the coordination study.

2.2.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Location of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating. Include on the single line names of equipment as indicated on the drawings or provide a table cross-referencing node numbers to equipment names on the drawings.

2.2.4 Fault Current Analysis

2.2.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE 242 and IEEE 399.

Analysis shall utilize specialized computer aided engineering software designed for the purpose including the following capabilities.

a. Short circuit analysis with asymmetrical and symmetrical values for different fault times.

b. Time current curve plotting.

c. Arc-flash energy calculation for both arcing and bolted fault current levels.

Analysis shall be performed and separate study reports generated for each operational scenario including:

a. Single-ended substation source operation
b. Double-ended substation source operation
c. Generator source operation

2.2.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedance shall be those proposed. Data shall be documented in the report.

2.2.4.3 Fault Current Availability

Balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

2.2.5 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions.

The study shall include a description of the coordination of the protective devices in this project. A written narrative shall be provided describing: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost damages (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.2.6 Study Report

a. The report shall include a cover sheet and table of contents. Separate sections with all applicable content shall be provided for all operating scenarios.

b. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

c. The report shall include single-line line diagram(s); reference 2.14.3, Single Line Diagram.

d. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, time-current curves, and definition of the fixed or adjustable features of the existing or new protective devices.

e. The report shall document existing power system data including time-current characteristic curves and protective device ratings and settings.

f. The report shall contain fully coordinated composite time-current characteristics curves for each bus in the system, as required to substantiate all protective devices settings and to ensure coordinated power system protection between protective devices or equipment. Provide separate curves for phase and ground fault currents. The report shall include recommended ratings and settings of all protective devices in tabulated form.

g. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided. For all nodes, include phase fault short circuit levels and X/R ratios, ground fault short circuit levels and X/R ratios, load flow levels, arc-flash energy (for both bolted and arcing short circuit current levels), and motor starting study results.

h. The report shall include protective device setting sheets including recommended changes to existing protective device settings and settings for all new protective devices. All information to field install the settings, including settings or features not used or turned off, shall be provided. Setting sheets shall be separate pages, suitable for use by installing technicians, and not include other report analysis and data.

i. The report shall include tabulated arc-flash data for all equipment and

all modified equipment requiring arc-flash warning labels in accordance with IEEE 1584. Label format is to be NFPA 70E (most recent edition) detailed format and include the following information:

Flash Hazard Boundary.
Incident Energy.
Hazard Category and PPE.
Shock Voltage
Limited Approach Boundary Distance
Restricted Approach Boundary Distance
Prohibited Approach Boundary Distance

PART 3 EXECUTION

3.1 INSTALLATION

Install protective device settings in accordance with the manufacturer's published instructions and in accordance with protective device coordination study protective device setting sheets.

Affix detailed arc flash warning labels to all electrical equipment as required by NFPA 70E (most recent edition).

3.2 FIELD TESTING

3.2.1 General

Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL applies to this section, with the additions and modifications specified herein.

3.2.2 Safety

Provide and use safety devices such as arc flash personal protective equipment, electrically insulating rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. Replace any devices or equipment which are damaged due to improper test procedures or handling.

3.2.3 Molded-Case Circuit Breakers

Circuit breakers shall be visually inspected. Current ratings shall be verified and adjustable settings incorporated in accordance with the coordination study.

3.2.4 Power Circuit Breakers

3.2.4.1 General

Visually inspect the circuit breaker and implement settings in accordance with the coordination study.

3.2.5 Protective Relays

Protective relays shall be visually inspected. Relay settings shall be implemented in accordance with the coordination study.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 28 21.00 40

AUTOMATIC TRANSFER SWITCHES

PART 1 GENERAL

1.1 REFERENCES
1.2 SUBMITTALS
1.3 QUALIFICATION TESTING

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION
2.1.1 Design Requirements
2.1.2 Performance Requirements
2.2 FABRICATION
2.2.1 Short Circuit Withstand Current Rating
2.2.2 Self-Test Capability
2.2.3 Enclosures
2.3 COMPONENTS
2.3.1 Contacts
2.3.2 Indicating Lights
2.3.3 Terminal Board
2.4 OPERATION
2.5 ACCESSORIES

PART 3 EXECUTION

3.1 INSTALLATION
3.2 FIELD TESTING

-- End of Section Table of Contents --

SECTION 26 28 21.00 40

AUTOMATIC TRANSFER SWITCHES

PART 1 GENERAL

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to work specified in this section.

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.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2000; R 2005; R 2008) Standard for Industrial Control and Systems: General Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; TIA 11-1; Errata 2011) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1008	(2011) Transfer Switch Equipment
UL 508	(1999; Reprint Apr 2010) Industrial Control Equipment

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-02 Shop Drawings

Connection Diagrams; G

Fabrication Drawings; G

Installation Drawings; G

SD-03 Product Data

Equipment and Performance Data; G

Contacts; G

Indicating Lights; G

Terminal Board; G

Enclosures; G

Accessories; G

SD-06 Test Reports

Qualification Testing; G

Operation Tests; G

SD-07 Certificates

Listing of Product Installations; G

SD-08 Manufacturer's Instructions

Automatic Transfer Switch; G

1.3 QUALIFICATION TESTING

Provide certified independent laboratory test data for the furnished unit or an identical unit. Ensure tests meet the general use requirements of UL 508, Table 22.1. Subject the complete automatic transfer switch to a test as outlined in NEMA ICS 1, paragraph 109.5. One cycle of operation tests under the UL 508 test requirements consists of a transfer of load from the normal source to the emergency source and retransfer to the normal source. After the required number of test cycles, ensure the temperature rise of the contacts has not exceeded 149 degrees F. Test the switch operating time and the sense relay pickup and dropout times.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide a complete automatic transfer switch system for use with engine-generator sets for standby power. Submit the following:

a. Connection diagrams showing the relations and connections of contacts, indicating lights, and terminal board by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another.

b. Fabrication drawings for contacts, indicating lights, terminal board enclosures, and accessories consisting of fabrication and assembly details to be performed in the factory.

c. Installation drawings for automatic transfer equipment in accordance with the paragraph entitled, "Installation," of this section.

d. Equipment and performance data for automatic transfer equipment including life, test, system functional flows, safety features, and mechanical automated details.

2.1.1 Design Requirements

Ensure control and protective devices associated with automatic transfer switches are in accordance with Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

Provide an automatic transfer switch of the two-pole type for single-phase application, and three-pole type for three-phase application. Provide an additional switched neutral pole.

2.1.2 Performance Requirements

Provide an automatic transfer switch capable of transferring the load from the normal power source to emergency power source, and from an emergency source to the normal power source. Locate switch where indicated. Provide a switch that is solenoid-operated, mechanically held, double-throw, rated for continuous duty, capable of transferring in 100 milliseconds or less, and conforming to the applicable requirements of UL 1008 and NFPA 70, Article 700, except as herein modified.

Ensure the automatic transfer switch is capable of being placed in either the normal or the emergency position.

2.2 FABRICATION

2.2.1 Short Circuit Withstand Current Rating

Provide switch with short-circuit current rating of 50,000. Ensure switch is capable of withstanding 54,000 amperes for a period of 3 cycles without damage.

2.2.2 Self-Test Capability

Provide an automatic transfer switch with a control-circuit self-test feature capable of verifying the proper operation of the switch control circuit without moving the main contactor or causing discontinuity of service to the load. Include the following characteristics in the self-test circuit:

a. A key-operated switch that disconnects the main actuator and connects in its place, an indicator light. Design the key-operated switch to prevent removal of the key while the switch is in the self-test mode.

b. A power-failure simulator switch that removes voltage from the voltage-sensing devices so that emergency power activates the test light.

2.2.3 Enclosures

Provide automatic transfer switch enclosures with solid, unventilated, code-gage 14-gage, minimum sheet metal, NEMA 250, Type 3R stainless steel, with manufacturer's standard finish.

2.3 COMPONENTS

2.3.1 Contacts

Provide main contacts with a wiping-action silver alloy that, when rated for operation at 50 amperes or greater, are protected against arcing. Ensure auxiliary contacts and control transfer relay contacts have a

minimum continuous current rating of not less than 10-amperes inductive at 120 volts ac. Provide the following auxiliary contacts:

a. Generator-control contacts, normally open, that close on undervoltage or loss of normal power as specified, remaining closed until transfer back to normal power

b. Emergency-position contacts, normally open when the switch is in the normal position, that close when the switch is in the emergency position

c. Normal position contacts, normally closed when the switch is in the normal position, that open when the switch is in the emergency position

Use two pole auxiliary contacts.

Provide a test automatic transfer switch mounted on door of enclosure with contacts rated for operation at 10 amperes.

Provide automatic transfer switch with overlapping neutral transfer contacts in addition to the two- or three-pole main bus contacts. Normal and emergency neutral are connected together only during the transfer and retransfer operation. They remain connected only until the power source contacts close/open to transfer from one source to the other. Ensure overlapping neutral transfer contacts connection time does not exceed 100 milliseconds.

2.3.2 Indicating Lights

Furnish automatic transfer switch with two indicating lamps. One light to indicate that the switch is operating on normal power, and the other light to indicate that the switch is operating on emergency power. Fuse each indicating circuit.

2.3.3 Terminal Board

Internally wire control devices, indicating lights, auxiliary contacts, and internal control devices or auxiliary switches to a common output terminal board. Wire the internal functions to facilitate remote connections or monitoring.

2.4 OPERATION

Monitor normal source voltage across phase lines by sensing devices. If the normal source voltage in phase drops to 90 percent or less for a timed period, the automatic transfer switch starts the emergency source and transfer the load to the emergency source when voltage and frequency reach rated values or, if the emergency source is on, verify voltage and frequency of the alternate source and transfer the load to the alternate source. Field adjust this time period from 1 to 30 seconds. Provide a voltage and frequency sensor relay to monitor rated values on the emergency side to prohibit transfer until the emergency source voltage and frequency reach at least 95 percent of the required rating. Provide phase failure protection, with 65 to 70 percent drop and 92 to 95 percent voltage pickup ratings.

Furnish the automatic transfer switch with a time-delay feature, field adjustable from 2 to 30 minutes, that operates to delay automatic transfer back to normal power until the normal source voltage and frequency reach at least 95 percent of the rated voltage. However, if the emergency power

fails, and the normal source is again available at 90 percent of the rated voltage, bypass the time-delay circuitry, and the load immediately transferred back to the normal source. Provide capability for manual transfer in either direction. Operate sensing relays without contact chatter or false response during voltage variations between dropout and pickup.

2.5 ACCESSORIES

Incorporate with the automatic transfer switch a 24-volt solid-state, high-and low-rate charger complete with rheostat and ammeter, to maintain the engine-generator cranking batteries in a fully charged condition.

Incorporate an engine-generator exerciser timer with the automatic transfer switch to permit weekly programming of engine-generator set test runs under load.

PART 3 EXECUTION

3.1 INSTALLATION

Install automatic transfer switch as indicated, and in accordance with the manufacturer's installation instructions. Fully align and install wall-mounted enclosures at the indicated mounting height using a minimum of six 3/8-inch bolts. Use of sheet metal screws or small machine screws is not permitted.

Submit listing of product installations for automatic transfer switches showing the manufacturer has successfully manufactured automatic transfer switches of the size specified for a minimum period of 10 years. Include on the list, purchaser, address of installation, service organization, and date of installation.

3.2 FIELD TESTING

Demonstrate the automatic transfer switch operates in accordance with the specification requirements in conjunction with the normal and emergency power sources.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 29 23

VARIABLE FREQUENCY DRIVE SYSTEMS UNDER 600 VOLTS

PART 1 GENERAL

1.1 REFERENCES
1.2 RELATED REQUIREMENTS
1.3 SYSTEM DESCRIPTION
1.3.1 Performance Requirements
1.3.1.1 Electromagnetic Interference Suppression
1.3.1.2 Electromechanical and Electrical Components
1.3.2 Electrical Requirements
1.3.2.1 Power Line Surge Protection
1.3.2.2 Sensor and Control Wiring Surge Protection
1.4 SUBMITTALS
1.5 QUALITY ASSURANCE
1.5.1 Schematic Diagrams
1.5.2 Interconnecting Diagrams
1.5.3 Installation Drawings
1.5.4 Equipment Schedule
1.5.5 Installation instructions
1.5.6 Factory Test Results
1.5.7 Variable Frequency Drives for Booster Pump
1.6 DELIVERY AND STORAGE
1.7 WARRANTY
1.8 MAINTENANCE
1.8.1 Spare Parts
1.8.2 Maintenance Support

PART 2 PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES (VFD)
2.2 ENCLOSURES
2.3 WIRES AND CABLES
2.4 NAMEPLATES
2.5 SOURCE QUALITY CONTROL
2.5.1 VFD Factory Test Plan

PART 3 EXECUTION

3.1 INSTALLATION
3.2 FIELD QUALITY CONTROL
3.2.1 VFD Test
3.2.2 Performance Verification Tests
3.2.3 Endurance Test
3.3 DEMONSTRATION
3.3.1 Training
3.3.1.1 Instructions to Government Personnel
3.3.1.2 Operating Personnel Training Program

3.3.1.3 Engineering/Maintenance Personnel Training

-- End of Section Table of Contents --

SECTION 26 29 23

VARIABLE FREQUENCY DRIVE SYSTEMS UNDER 600 VOLTS

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 519	(1992; R 1993; Errata 2004) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE C62.41.1	(2002; R 2008) IEEE Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2000; R 2005; R 2008) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 3.1	(2009) Guide for the Application, Handling, Storage, Installation and Maintenance of Medium-Voltage AC Contactors, Controllers and Control Centers
NEMA ICS 6	(1993; R 2006) Enclosures
NEMA ICS 7	(2006) Adjustable-Speed Drives

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; TIA 11-1; Errata 2011) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-461	(2007; Rev F) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

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

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 489	(2009) Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508C	(2002; Reprint Nov 2010) Power Conversion Equipment

1.2 RELATED REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODSapplies to this section with additions and modifications specified herein.

1.3 SYSTEM DESCRIPTION

1.3.1 Performance Requirements

1.3.1.1 Electromagnetic Interference Suppression

Computing devices, as defined by 47 CFR 15, MIL-STD-461 rules and regulations, shall be certified to comply with the requirements for class A computing devices and labeled as set forth in part 15.

1.3.1.2 Electromechanical and Electrical Components

Electrical and electromechanical components of the Variable Frequency Drive (VFD) shall not cause electromagnetic interference to adjacent electrical or electromechanical equipment while in operation.

1.3.2 Electrical Requirements

1.3.2.1 Power Line Surge Protection

IEEE C62.41.1 and IEEE C62.41.2, IEEE 519 Control panel shall have surge protection, included within the panel to protect the unit from damaging transient voltage surges. Surge arrestor shall be mounted near the incoming power source and properly wired to all three phases and ground. Fuses shall not be used for surge protection.

1.3.2.2 Sensor and Control Wiring Surge Protection

I/O functions as specified shall be protected against surges induced on control and sensor wiring installed outdoors and as shown. The inputs and outputs shall be tested in both normal mode and common mode using the following two waveforms:

a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation;

submittals not having a "G" designation are for Contractor Quality Control approval. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Schematic diagrams; G

Interconnecting diagrams; G

Installation drawings; G

Submit drawings for government approval prior to equipment construction or integration. Modifications to original drawings made during installation shall be immediately recorded for inclusion into the as-built drawings.

SD-03 Product Data

Variable frequency drives; G

Wires and cables

Equipment schedule

Include data indicating compatibility with motors being driven.

SD-06 Test Reports

VFD Test

Performance Verification Tests

Endurance Test

SD-08 Manufacturer's Instructions

Installation instructions

SD-09 Manufacturer's Field Reports

VFD Factory Test Plan; G

Factory test results

SD-10 Operation and Maintenance Data

Variable frequency drives, Data Package 4

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Provide service and maintenance information including preventive maintenance, assembly, and disassembly procedures. Include electrical drawings from electrical general sections. Submit additional information necessary to provide complete operation, repair, and maintenance information, detailed to the smallest replaceable unit. Include copies of as-built submittals. Provide routine preventative maintenance instructions, and equipment required. Provide instructions on how to modify program settings, and modify the control program.

Provide instructions on drive adjustment, trouble-shooting, and configuration. Provide instructions on process tuning and system calibration.

1.5 QUALITY ASSURANCE

1.5.1 Schematic Diagrams

Show circuits and device elements for each replaceable module. Schematic diagrams of printed circuit boards are permitted to group functional assemblies as devices, provided that sufficient information is provided for government maintenance personnel to verify proper operation of the functional assemblies.

1.5.2 Interconnecting Diagrams

Show interconnections between equipment assemblies, and external interfaces, including power and signal conductors. Include for enclosures and external devices.

1.5.3 Installation Drawings

Show floor plan of each site, with V.F.D.'s and motors indicated. Indicate ventilation requirements, adequate clearances, and cable routes.

1.5.4 Equipment Schedule

Provide schedule of equipment supplied. Schedule shall provide a cross reference between manufacturer data and identifiers indicated in shop drawings. Schedule shall include the total quantity of each item of equipment supplied. For complete assemblies, such as VFD's, provide the serial numbers of each assembly, and a sub-schedule of components within the assembly. Provide recommended spare parts listing for each assembly or component.

1.5.5 Installation instructions

Provide installation instructions issued by the manufacturer of the equipment, including notes and recommendations, prior to shipment to the site. Provide operation instructions prior to acceptance testing.

1.5.6 Factory Test Results

Document test results and submit to government within 7 working days after completion of test.

1.5.7 Variable Frequency Drives for Booster Pump

VFDs shall meet the requirements of this section and shall be selected by the pump manufacturer in accordance with Section 22 11 23.13, PUMP STATION.

1.6 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.7 WARRANTY

The complete system shall be warranted by the manufacturer for a period of one year, or the contracted period of any extended warrantee agreed upon by the contractor and the Government, after successful completion of the acceptance test. Any component failing to perform its function as specified and documented shall be repaired or replaced by the contractor at no additional cost to the Government. Items repaired or replaced shall be warranted for an additional period of at least one year from the date that it becomes functional again, as specified in the FAR CLAUSE 52.246-21.

1.8 MAINTENANCE

1.8.1 Spare Parts

Manufacturers provide spare parts in accordance with recommended spare parts list.

1.8.2 Maintenance Support

During the warranty period, the Contractor shall provide on-site, on-call maintenance services by Contractor's personnel on the following basis: The service shall be on a per-call basis with 36 hour response. Contractor shall support the maintenance of all hardware and software of the system. Various personnel of different expertise shall be sent on-site depending on the nature of the maintenance service required. Costs shall include travel, local transportation, living expenses, and labor rates of the service personnel while responding to the service request. The provisions of this Section are not in lieu of, nor relieve the Contractor of, warranty responsibilities covered in this specification. Should the result of the service request be the uncovering of a system defect covered under the warranty provisions, all costs for the call, including the labor necessary to identify the defect, shall be borne by the Contractor.

PART 2 PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES (VFD)

Provide frequency drive to control the speed of induction motor(s). The VFD shall include the following minimum functions, features and ratings.

a. Input circuit breaker per UL 489 with a minimum of 10,000 amps symmetrical interrupting capacity and door interlocked external operator.

b. A converter stage per UL 508C shall change fixed voltage, fixed frequency, ac line power to a fixed dc voltage. The converter shall utilize a full wave bridge design incorporating diode rectifiers. Silicon Controlled Rectifiers (SCR) are not acceptable. The converter shall be insensitive to three phase rotation of the ac line and shall not cause displacement power factor of less than .95 lagging under any speed and load condition.

c. An inverter stage shall change fixed dc voltage to variable frequency, variable voltage, ac for application to a standard NEMA design B squirrel cage motor. The inverter shall be switched in a manner to produce a sine coded pulse width modulated (PWM) output waveform.

d. The VFD shall be capable of supplying 120 percent of rated full load current for one minute at maximum ambient temperature.

e. The VFD shall be designed to operate from a 480 volt, plus or minus 10 percent, three phase, 60 Hz supply, and control motors with a corresponding voltage rating.

f. Acceleration and deceleration time shall be independently adjustable from one second to 60 seconds.

g. Adjustable full-time current limiting shall limit the current to a preset value which shall not exceed 120 percent of the controller rated current. The current limiting action shall maintain the V/Hz ratio constant so that variable torque can be maintained. Short time starting override shall allow starting current to reach 175 percent of controller rated current to maximum starting torque.

h. The controllers shall be capable of producing an output frequency over the range of 3 Hz to 60 Hz (20 to one speed range), without low speed cogging. Over frequency protection shall be included such that a failure in the controller electronic circuitry shall not cause frequency to exceed 110 percent of the maximum controller output frequency selected.

i. Minimum and maximum output frequency shall be adjustable over the following ranges: 1) Minimum frequency 3 Hz to 50 percent of maximum selected frequency; 2) Maximum frequency 40 Hz to 60 Hz.

j. The controller efficiency at any speed shall not be less than 96 percent.

k. The controllers shall be capable of being restarted into a motor coasting in the forward direction without tripping.

l. Protection of power semiconductor components shall be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controllers to any of the following conditions shall not result in component failure or the need for fuse replacement:

1. Short circuit at controller output

2. Ground fault at controller output

3. Open circuit at controller output

4. Input undervoltage

5. Input overvoltage

6. Loss of input phase

7. AC line switching transients

8. Instantaneous overload

9. Sustained overload exceeding 115 percent of controller rated current

10. Over temperature

11. Phase reversal

m. Solid state motor overload protection shall be included such that current exceeding an adjustable threshold shall activate a 60 second timing circuit. Should current remain above the threshold continuously for the timing period, the controller will automatically shut down.

n. A slip compensation circuit shall be included which will sense changing motor load conditions and adjust output frequency to provide speed regulation of NEMA B motors to within plus or minus 0.5 percent of maximum speed without the necessity of a tachometer generator.

o. The VFD shall be factory set for manual restart after the first protective circuit trip for malfunction (overcurrent,undervoltage, overvoltage or overtemperature) or an interruption of power. The VFD shall be capable of being set for automatic restart after a selected time delay. If the drive faults again within a specified time period (adjustable 0-60 seconds), a manual restart will be required.

p. The VFD shall include external fault reset capability. All the necessary logic to accept an external fault reset contact shall be included.

q. Provide critical speed lockout circuitry to prevent operating at frequencies with critical harmonics that cause resonant vibrations. The VFD shall have a minimum of three user selectable bandwidths.

r. Provide the following operator control and monitoring devices mounted on the front panel of the VFD:

   1. Manual speed potentiometer.

   2. Hand-Off-Auto (HOA) switch.

   3. Power on light.

   4. Drive run power light.

   5. Local display.

s. Provide properly sized NEMA rated by-pass and isolation contactors to enable operation of motor in the event of VFD failure. Mechanical and electrical interlocks shall be installed between the by-pass and isolation contactors. Provide a selector switch and transfer delay timer.

2.2 ENCLOSURES

Provide equipment enclosures conforming to NEMA 250, NEMA ICS 7, NEMA ICS 6.

2.3 WIRES AND CABLES

All wires and cables shall conform to NEMA 250, NEMA ICS 7, NFPA 70.

Conductors installed between VFDs and motors shall be shielded VFD cables for conductor sizes AWG 4/0 and below. VFD cables shall be rated for up to 1,000 V and have cross-linked polyethylene (XLPE) Type XHHW-2 insulation on current-carrying conductors. VFD cables with current-carrying conductors of size No 2 and smaller shall have an insulated grounding conductor. Larger cables may have insulated or bare grounding conductors. VFD cables shall have a braided or tape shield. The outer jacket shall be black sunlight and

oil-resistant PVC. VFD cables shall be rated for 194 degrees F in wet or dry locations and shall be suitable for direct burial. VFD cables shall be designed specifically for use in VFD applications. The Contractor shall install the VFD cables in accordance with the cable manufacturer's and the VFD manufacturer's recommendations. VFD cables shall be manufactured by Belden, or approved equal.

2.4 NAMEPLATES

Nameplates external to NEMA enclosures shall conform with the requirements of Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS. Nameplates internal to enclosures shall be manufacturer's standard, with the exception that they must be permanent.

2.5 SOURCE QUALITY CONTROL

2.5.1 VFD Factory Test Plan

To ensure quality, each VFD shall be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test plans and test reports.

PART 3 EXECUTION

3.1 INSTALLATION

Per NEMA ICS 3.1, install equipment in accordance with the approved manufacturer's printed installation drawings, instructions, wiring diagrams, and as indicated on project drawings and the approved shop drawings. A field representative of the drive manufacturer shall supervise the installation of all equipment, and wiring.

3.2 FIELD QUALITY CONTROL

Specified products shall be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. Contractor shall conduct performance verification tests in the presence of Government representative, observing and documenting complete compliance of the system to the specifications. Contractor shall submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.2.1 VFD Test

A proposed test plan shall be submitted to the contracting officer at least 28 calendar days prior to proposed testing for approval. The tests shall conform to NEMA ICS 1, NEMA ICS 7, and all manufacturer's safety regulations. The Government reserves the right to witness all tests and review any documentation. The contractor shall inform the Government at least 14 working days prior to the dates of testing. Contractor shall provide video tapes, if available, of all training provided to the Government for subsequent use in training new personnel. All training aids, texts, and expendable support material for a self-sufficient presentation shall be provided, the amount of which to be determined by the contracting officer.

3.2.2 Performance Verification Tests

"Performance Verification Test" plan shall provide the step by step

procedure required to establish formal verification of the performance of the VFD. Compliance with the specification requirements shall be verified by inspections, review of critical data, demonstrations, and tests. The Government reserves the right to witness all tests, review data, and request other such additional inspections and repeat tests as necessary to ensure that the system and provided services conform to the stated requirements. The contractor shall inform the Government 14 calendar days prior to the date the test is to be conducted.

3.2.3 Endurance Test

Immediately upon completion of the performance verification test, the endurance test shall commence. The system shall be operated at varying rates for not less than 192 consecutive hours, at an average effectiveness level of .9998, to demonstrate proper functioning of the complete PCS. Continue the test on a day-to-day basis until performance standard is met. During the endurance test, the contractor shall not be allowed in the building. The system shall respond as designed.

3.3 DEMONSTRATION

3.3.1 Training

Coordinate training requirements with the Contracting Officer.

3.3.1.1 Instructions to Government Personnel

Provide the services of competent instructors who will give full instruction to designated personnel in operation, maintenance, calibration, configuration, and programming of the complete control system. Orient the training specifically to the system installed. Instructors shall be thoroughly familiar with the subject matter they are to teach. The Government personnel designated to attend the training will have a high school education or equivalent. The number of training days of instruction furnished shall be as specified. A training day is defined as eight hours of instruction, including two 15-minute breaks and excluding lunch time; Monday through Friday. Provide a training manual for each student at each training phase which describes in detail the material included in each training program. Provide one additional copy for archiving. Provide equipment and materials required for classroom training. Provide a list of additional related courses, and offers, noting any courses recommended. List each training course individually by name, including duration, approximate cost per person, and location of course. Unused copies of training manuals shall be turned over to the Government at the end of last training session.

3.3.1.2 Operating Personnel Training Program

Provide one 2 hour training session at the site at a time and place mutually agreeable between the Contractor and the Government. Provide session to train 4 operation personnel in the functional operations of the system and the procedures that personnel will follow in system operation. This training shall include:

a. System overview

b. General theory of operation

c. System operation

d. Alarm formats

e. Failure recovery procedures

f. Troubleshooting

3.3.1.3 Engineering/Maintenance Personnel Training

Accomplish the training program as specified. Training shall be conducted on site at a location designated by the Government. Provide a one day training session to train 4 engineering personnel in the functional operations of the system. This training shall include:

a. System overview

b. General theory of operation

c. System operation

d. System configuration

e. Alarm formats

f. Failure recovery procedures

g. Troubleshooting and repair

h. Maintenance and calibration

i. System programming and configuration

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 32 13.00 20

SINGLE OPERATION GENERATOR SETS

PART 1 GENERAL

1.1 REFERENCES
1.2 RELATED REQUIREMENTS
1.3 SYSTEM DESCRIPTION
1.3.1 Engine-Generator Set Data
1.3.2 Engine-Generator Set Efficiencies
1.3.3 Diesel Engine Data
1.3.4 Generator and Exciter Data
1.3.5 Capacity Calculations for Engine-Generator Set
1.3.6 Calculations for Brake Mean Effective Pressure (BMEP)
1.3.7 Torsional Vibration Stress Analysis Computations
1.3.8 Capacity Calculations for Batteries
1.3.9 Turbocharger Load Calculations
1.4 SUBMITTALS
1.5 QUALITY ASSURANCE
1.5.1 Drawing Requirements
1.5.1.1 Engine-Generator Set and Auxiliary Equipment
1.5.1.2 Auxiliary Systems
1.5.2 Vibration Isolation System Certification
1.5.3 Fuel System Certification
1.6 DELIVERY, STORAGE, AND HANDLING
1.7 SITE CONDITIONS
1.8 MAINTENANCE
1.8.1 Extra Materials
1.8.1.1 Paint
1.8.1.2 Filters
1.8.2 Posted Operating Instructions

PART 2 PRODUCTS

2.1 DIESEL ENGINE-GENERATOR SET
2.1.1 Engine-Generator Set Ratings and Performance
2.1.1.1 Diesel Engine Capacity
2.1.1.2 Performance Class
2.1.1.3 Load Profile
2.1.2 Diesel Engines and Accessories
2.1.2.1 Subbase Mounting
2.1.2.2 Assembly
2.1.2.3 Turbocharger
2.1.2.4 Intercooler
2.1.2.5 Crankcase Protection
2.1.2.6 Engine Lubricating Oil System
2.1.2.7 Engine Cooling System
2.1.2.8 Engine Fuel System
2.1.2.9 Engine Intake Filter

2.1.2.10 Engine Starting System
2.1.2.11 Jacket Coolant Heating System
2.1.2.12 Engine Protective (Shutdown) Devices
2.1.2.13 Engine Alarm Devices
2.1.2.14 Miscellaneous Engine Accessories
2.1.2.15 Engine Speed Governor System
2.1.3 Generator and Excitation System
2.1.3.1 Generator
2.1.3.2 Excitation System
2.2 ENGINE-GENERATOR SET AUXILIARY SYSTEMS AND EQUIPMENT
2.2.1 Vibration Isolation System
2.2.2 Exhaust System
2.2.2.1 Exhaust Silencers
2.2.3 Cooling System
2.2.3.1 Radiators
2.2.4 Diesel Fuel System
2.2.4.1 Diesel Fuel Piping System
2.2.4.2 Flanged End Connections
2.2.4.2.1 Flanges
2.2.4.2.2 Flange Gaskets, Non-Isolating
2.2.4.2.3 Flange Gaskets, Electrically Isolating
2.2.4.2.4 Flange Bolts, Nuts, and Washers
2.2.4.3 Pipe
2.2.4.3.1 Carbon Steel Pipe
2.2.4.3.2 Fittings 2 Inches and Smaller
2.2.4.3.3 Welded Nipples
2.2.4.3.4 Steel Couplings
2.2.4.3.5 Threaded Unions
2.2.4.3.6 Threaded End Connections
2.2.4.3.7 Joint Compound
2.2.4.4 Piping Components
2.2.4.4.1 Flexible Pipe Connector
2.2.4.4.2 Strainer
2.2.4.4.3 Vent Cap
2.2.4.5 General Valves
2.2.4.5.1 Ball Valve
2.2.4.5.2 Pressure Relief Valve
2.2.4.6 Finishes
2.2.4.6.1 Exterior Coating, Aboveground Piping
2.2.4.6.2 New Equipment and Components
2.2.4.7 Pipe Hangers and Supports
2.2.4.7.1 Pipe Tightness Testing
2.2.4.7.1.1 Preliminary Pneumatic Piping System Test
2.2.4.7.1.2 Final Pneumatic Piping System Test
2.2.5 Diesel Fuel System
2.2.5.1 Diesel Fuel Piping System
2.2.5.2 Diesel Fuel Day Tank System
2.2.5.3 Fuel Transfer Pump
2.2.5.4 Fuel Oil Solenoid Valve
2.2.6 Remote Fuel Storage
2.2.6.1 Labeling
2.2.6.2 Tank Manufacturer's Tests
2.2.7 Starting Battery System
2.2.7.1 Engine Starting Battery
2.2.7.2 Starting Battery Charger
2.2.8 Engine-Generator Control Panel
2.2.8.1 Control Panel Mounted Devices
2.2.8.2 Crank Cycle/Terminate Relay
2.2.8.3 Engine Cooldown Relay

2.2.9 Remote Alarm Annunciator
2.2.9.1 Storage Battery
2.2.10 Generator Circuit Breaker
2.2.11 Electrical Support Equipment
2.2.12 Sound Attenuated Weatherproof Enclosure
2.3 SPECIAL WRENCHES AND TOOLS
2.4 IDENTIFICATION OF EQUIPMENT
2.4.1 Materials
2.4.2 Control Devices and Operation Indicators
2.4.3 Equipment
2.5 ASSEMBLED OPERATION AND MAINTENANCE MANUALS
2.6 SOURCE QUALITY CONTROL
2.6.1 Engine Tests
2.6.2 Generator Tests
2.6.2.1 Routine Tests
2.6.2.2 Design Tests
2.6.3 Assembled Engine-Generator Set Tests
2.6.3.1 Initial Stabilization Readings
2.6.3.2 Regulator Range Test
2.6.3.3 Frequency Range Test
2.6.3.4 Transient Response Test

PART 3 EXECUTION

3.1 INSTALLATION
3.2 GROUNDING
3.2.1 Grounding Electrodes
3.2.2 Engine-Generator Set Grounding
3.2.3 Connections
3.2.4 Grounding and Bonding Equipment
3.3 START-UP ENGINEER
3.4 PREREQUISITES FOR FUNCTIONAL ACCEPTANCE TESTING
3.4.1 Testing
3.4.1.1 Generator Sets
3.4.1.2 Automatic Transfer Switches
3.4.2 Preliminary Operations
3.4.3 Preliminary Assembled Operation and Maintenance Manuals
3.4.4 Functional Acceptance Test Procedure
3.4.5 Test Equipment
3.5 FIELD QUALITY CONTROL
3.5.1 Acceptance Checks and Tests
3.5.1.1 Circuit Breakers - Low Voltage Insulated Case/Molded Case
3.5.1.2 Current Transformers
3.5.1.3 Metering and Instrumentation
3.5.1.4 Battery Systems
3.5.1.5 Engine-Generator Set
3.5.1.6 Grounding System
3.5.2 Functional Acceptance Tests
3.6 DEMONSTRATION
3.6.1 Instructor's Qualification Resume
3.6.2 Training Plan
3.6.2.1 Operating Personnel Training
3.6.2.2 Maintenance Personnel Training

-- End of Section Table of Contents --

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.

AMERICAN PETROLEUM INSTITUTE (API)

API RP 2003	(2008) Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents
API RP 540	(1999; R 2004) Electrical Installations in Petroleum Processing Plants
API Spec 5L	(2007; Errata 2009) Specification for Line Pipe
API Spec 6D	(2008; Errata 2008; Errata 2008; Errata 2009; Addendum 2009; Errata 2010) Specification for Pipeline Valves
API Spec 6FA	(1999; R 2006; Errata 2006; Errata 2008) Specification for Fire Test for Valves

ASME INTERNATIONAL (ASME)

ASME B1.1	(2003; R 2008) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B16.1	(2005) Gray Iron Threaded Fittings; Classes 25, 125 and 250
ASME B16.11	(2009) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.34	(2009; Supp 2010) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2009) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.5	(2009) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2007) Standard for Factory-Made Wrought

	Steel Buttwelding Fittings
ASME B18.2.1	(2010) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2010) Standard for Square and Hex Nuts
ASME B31.3	(2010) Process Piping

ASTM INTERNATIONAL (ASTM)

ASTM A 105/A 105M	(2010) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A 182/A 182M	(2010a) Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A 216/A 216M	(2008) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A 234/A 234M	(2010) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A 307	(2007b) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A 312/A 312M	(2011) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A 53/A 53M	(2010) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 563	(2007a) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A 733	(2003e1; R 2009) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM B 117	(2009) Standing Practice for Operating Salt Spray (Fog) Apparatus
ASTM B 687	(1999; R 2005e1) Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples
ASTM D 229	(2009b) Rigid Sheet and Plate Materials Used for Electrical Insulation
ASTM D 975	(2010a) Standard Specification for Diesel Fuel Oils

ASTM F 844	(2007a) Washers, Steel, Plain (Flat), Unhardened for General Use

FLORIDA ADMINISTRATIVE CODE (FAC)

FAC 62-762	(2005) Aboveground Storage Tank
FAC 62-762.851	(2004) Alternative Requirements and Equipment Approvals

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	(2007; Errata 06-1; TIA 07-1; TIA 07-2; TIA 07-3; Errata 07-2; TIA 08-4; TIA 08-5; TIA 08-6; TIA 08-7; TIA 08-8; TIA 08-9; TIA 08-10; TIA 08-11; TIA 09-12; TIA 09-13; TIA 09-14; Errata 09-3; TIA 09-15; TIA 09-16; TIA 10-17) National Electrical Safety Code
IEEE C50.12	(2005) Standard for Salient Pole 50 HZ and 60 Hz Synchronous Generators and Generation/Motors for Hydraulic Turbine Applications Rated 5 MVA and above

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2009) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C50.10	(1990) Rotating Electrical Machinery - Synchronous Machines
NEMA ICS 6	(1993; R 2006) Enclosures
NEMA MG 1	(2009) Motors and Generators
NEMA PB 1	(2006; Errata 2008) Panelboards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2008; Errata 08-1) Flammable and Combustible Liquids Code
NFPA 37	(2010; TIA 10-1) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 407	(2007; Errata 2007; AMD 1 2007; AMD 2 2008) Standard for Aircraft Fuel Servicing
NFPA 70	(2011; TIA 11-1; Errata 2011) National Electrical Code
NFPA 704	(2006) Identification of the Hazards of Materials for Emergency Response
NFPA 77	(2006) Recommended Practice on Static Electricity
NFPA 780	(2007) Standard for the Installation of Lightning Protection Systems

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS W-C-375	(Rev D) Circuit Breakers, Molded Case, Branch Circuit and Service
FS W-P-115C	(2001) Panel, Power Distribution

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC PA 1	(2000; E 2004) Shop, Field, and Maintenance Painting

UNDERWRITERS LABORATORIES (UL)

UL 1236	(2006; R 2009; R 2010) Standard for Battery Chargers for Charging Engine-Starter Batteries
UL 142	(2006; Rev thru Dec 2007) Steel Aboveground Tanks for Flammable and Combustible Liquids
UL 2085	(2006; R 2010) Protected Aboveground Tanks for Flammable and Combustible Liquids
UL 429	(2009; Rev 2010) Electrically Operated Valves
UL 467	(2007) Grounding and Bonding Equipment
UL 489	(2009) Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 67	(2009; Reprint Sep 2010) Standard for Panelboards

1.2 RELATED REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies 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. x 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' + bhp".

j. BMEP psi: (792,000 x bhp)/(rpm x 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.

1.3.9 Turbocharger Load Calculations

When the proposed exhaust system layout is different from that shown on the contract drawings, submit calculations showing that the external loads from the exhaust system such as weight and thermal expansion do not exceed the engine manufacturer's maximum allowed forces and moments on the turbocharger.

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

Generator control panel

Auxiliary systems

SD-03 Product Data

Engine-generator set data

Engine-generator set efficiencies

Diesel engine data

Generator and exciter data

Diesel engine-generator set

Auxiliary systems and equipment

Remote alarm annunciator

Generator control panel

Carbon steel pipe

Ball valve

Pressure relief valve

SD-05 Design Data

Capacity calculations for engine-generator set

Calculations for brake mean effective pressure

Torsional vibration stress analysis computations

Capacity calculations for batteries

Turbocharger load calculations

SD-06 Test Reports

Acceptance checks and tests

Functional acceptance tests

Functional acceptance test procedure

SD-07 Certificates

Vibration isolation system certification

Fuel system certification

Start-up engineer qualification resume

Instructor's qualification resume

SD-09 Manufacturer's Field Reports

Engine tests

Generator tests

Assembled engine-generator set tests

SD-10 Operation and Maintenance Data

Diesel engine-generator set, Data Package 4

Auxiliary systems and equipment, Data Package 4

Preliminary assembled operation and maintenance manuals

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

Training plan

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, interior lighting, 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, interior lighting, and other auxiliary equipment not integral with the engine-generator set.

1.5.1.2 Auxiliary Systems

Submit drawings showing floor plan arrangement of weatherproof enclosure, exhaust, air intake, fuel oil cooler, and jacket coolant water systems including arrangement of piping and pipe sizes.

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: Kennedy Space Center (KSC), Florida

b. Site Elevation: 10 feet above mean sea level

c. Ambient Temperatures:

1. Maximum 104 degrees F.

2. Minimum 0 degrees F.

d. Design Wind Velocity: 140 mph.

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 250 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 D 975, 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.

Engine speed, rpm: 1800

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 G3.

2.1.1.3 Load Profile

The diesel engine-generator set shall be of adequate capacity necessary for the following load profile:

a. Lighting 40 kW

b. Variable frequency drives (VFD) 206 kVA, 6 pulse

c. Motor starting sequence

Starting Order	Size (hp)	Locked Rotor NEMA Code	Starting Method	Maximum Voltage Dip
1	60	F	VFD	10 Percent
2	60	F	VFD	10 Percent

f. Other load: 75 kW at 0.8 p.f.

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, 120 volts ac, 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, coupled type, synchronous generator conforming to NEMA MG 1, Part 16, NEMA C50.10, and IEEE C50.12. Generator shall be rated for standby 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 10-12 lead reconnectable coils.

b. Rotor: The rotor shall have connected amortisser 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 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. 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.

2.2 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. The Contractor shall furnish and install, according to the manufacturer's recommendations, silencers, wall thimbles, stainless steel flexible corrugated exhaust connections, flanges, hangers and supports, pipe and fittings, and insulation as specified in this section or as indicated on the drawings to provide a complete and operable exhaust system.

b. Silencers shall be residential grade, Maxim M-41 or equal, and shall have bolted flange connections. The silencer shall be mounted so that

the engine does not support its weight nor will thermal expansion be imposed on the engine. The silencer shall be mounted outside the generator enclosure.

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 104 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.

b. Engine Mounted Radiator Construction: Radiator fan shall direct airflow from the engine outward through the radiator. Fan shall be V-belt driven directly from the engine crankshaft. Fan static capacity shall be adjusted to suit the ductwork furnished. Cooling section shall have a tube and fin-type core consisting of copper or copper base alloy tubes with nonferrous fins. Select engine-driven fans for quiet vibration-free operation. Make provision for coolant expansion either by self-contained expansion tanks or separately mounted expansion tanks, as standard with the manufacturer. Provide suitable guards for each fan and drive.

c. Coolant solution 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 Flanged End Connections

2.2.4.2.1 Flanges

Provide flanged end connections on equipment, fittings, piping, piping

components, adapters, couplers,and valves that conform to ASME B16.5, Class 150.

a. Carbon Steel

Carbon steel flanges shall conform to ASTM A 105/A 105M.

2.2.4.2.2 Flange Gaskets, Non-Isolating

Provide flange gaskets that are 1/8 inch thick and that conform to ASME B16.21, raised-face type unless otherwise indicated. Gaskets shall be constructed of Buna-N.

2.2.4.2.3 Flange Gaskets, Electrically Isolating

Flange gaskets shall conform to ASTM D 229 and shall provide an electrical insulating material of 1000 ohms minimum resistance. Provide gasket material that is chemically compatible with the fuel to be handled. Provide gaskets that are the full face type. Provide flanges that have a full surface 0.03 inch thick, spiral-wound mylar insulating sleeves between the bolts and the holes in the flanges. Bolts may have reduced shanks of a diameter not less than the diameter at the root of the threads. Provide high-strength 1/8 inch thick phenolic insulating washers next to the flanges with flat circular stainless steel washers over the insulating washers and under bolt heads and nuts. Provide bolts long enough to compensate for the insulating gaskets and stainless steel washers.

2.2.4.2.4 Flange Bolts, Nuts, and Washers

Bolts and nuts for pipe flanges, flanged fittings, valves and accessories shall conform to ASME B18.2.1 and ASME B18.2.2, except as otherwise specified. Bolts shall be regular hexagonal type. Bolts shall be threaded in accordance with ASME B1.1, Class 2A fit, Coarse Thread Series, for sizes 1 inch and smaller and Eight-Pitch Thread Series for sizes larger than 1 inch. Nuts shall be the hexagonal, heavy series type. Nuts shall be threaded in accordance with ASME B1.1, Class 2B fit, Coarse Thread Series for sizes 1 inch and smaller and Eight-Pitch Thread Series for sizes larger than 1 inch. Bolts shall be of sufficient length to obtain full bearing on the nuts and shall project no more than two full threads beyond the nuts with the bolts tightened to the required torque.

a. Carbon Steel Materials

Bolts shall conform to ASTM A 307, Grade B, hot-dipped galvanized. Nuts shall conform to ASTM A 563, Grade A, hex style, hot-dipped galvanized. Washers shall conform to ASTM F 844, hot-dipped galvanized.

2.2.4.3 Pipe

Pipe shall meet the material, fabrication and operating requirements of ASME B31.3, except as modified herein.

2.2.4.3.1 Carbon Steel Pipe

Provide carbon steel pipe that complies with one of the following:

a. Pipe shall conform to ASTM A 53/A 53M, Type E or S, Grade B, seamless or electric welded. Pipe smaller than 2-1/2 inches shall be Schedule 80. Pipe 2-1/2 inches and larger shall be Schedule 40.

b. Pipe shall conform to API Spec 5L, Product Specification Level (PSL) 1, Grade B, seamless or electric welded.

End connections for pipe or fittings smaller than 2-1/2 inches shall be forged, socket weld type conforming to ASTM A 182/A 182M and ASME B16.11, unless indicated otherwise. End connections for pipe or fittings 2-1/2 inches and larger shall be buttweld type conforming to ASTM A 234/A 234M, Grade WPB and ASME B16.9 of the same wall thickness as the adjoining pipe.

2.2.4.3.2 Fittings 2 Inches and Smaller

Socket welded type fittings, unless indicated otherwise, shall conform to ASME B16.11. Fitting materials shall be stainless steel that conforms to ASTM A 182/A 182M, Type F304L.

2.2.4.3.3 Welded Nipples

Nipples shall conform to ASTM A 733 or ASTM B 687 and be constructed of the same material as the connecting pipe.

2.2.4.3.4 Steel Couplings

Coupling shall conform to API Spec 5L, seamless, extra heavy, wrought steel with recessed ends.

2.2.4.3.5 Threaded Unions

Unions shall conform to ASME B16.39, Class 150. Union materials shall conform to ASTM A 312/A 312M, Grade 304 or 316. Dielectric unions shall conform to dimensional, strength, and pressure requirements of ASME B16.39, Class 150. Steel parts shall be galvanized or plated. Union shall have a water-impervious insulation barrier capable of limiting galvanic current to one percent of the short-circuit current in a corresponding bimetallic joint. When dry, union shall be able to withstand a 600-volt breakdown test.

2.2.4.3.6 Threaded End Connections

Provide threaded end connections only on piping 2 inches in nominal size or smaller and only where indicated on the drawings. Provide threaded connections with thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is tightened.

2.2.4.3.7 Joint Compound

Joint compounds shall be resistant to water and be suitable for use with fuel containing 40 percent aromatics. Threading compound shall be Locktite 5, 6, 7, Gasoila PLS2 or approved equivalent. PTFE tape should not be used.

2.2.4.4 Piping Components

Provide piping components that meet the material, fabrication and operating requirements of ASME B31.3, except as modified herein. Pressure design class for piping components shall be Class 150 as defined in ASME B16.5.

2.2.4.4.1 Flexible Pipe Connector

Connector shall be the flexible, close pitch, metal hose type that is constructed with exterior annular corrugations and provided with a single

layer of braided wire sheath covering. Connectors shall be constructed entirely of stainless steel and be rated for the system working pressure and temperature. Provide threaded end connections for connectors smaller than 2-1/2 inches. Provide flanged end connections for connectors 2-1/2 inches and larger.

2.2.4.4.2 Strainer

Strainer shall be the in-line, cleanable, simplex basket type configured in either an "S" or "T" pattern. Strainer type shall be RACOR™ 75/900 series fuel filter/water separator or approved equivalent. Strainer shall be installed within generator enclosure adjacent to the daytank in accordance with the manufacturer instructions.

2.2.4.4.3 Vent Cap

Provide atmospheric, updraft type cap. Cap shall be constructed of aluminum or carbon steel. Cap shall have an internal brass or bronze insect screen, minimum 40-mesh. Cap shall prevent rain, snow, or ice from entering the vent piping.

2.2.4.5 General Valves

Provide valves that meet the material, fabrication and operating requirements of ASME B31.3, except as modified herein. Valves shall have flanged end connections and conform to ASME B16.34, Class 150 except as modified herein. Provide stainless steel stem and trim for each valve. Valves shall have a weatherproof housing. Seats, body seals, and stem seals shall be Viton or Buna-N.

a. Carbon Steel Piping. Provide valves with bodies, bonnets, and covers constructed of cast steel conforming to ASTM A 216/A 216M.

2.2.4.5.1 Ball Valve

Valve shall be the non-lubricated, double seated, ball type that conforms to API Spec 6D. Valve shall meet the fire test requirements of API Spec 6FA. Valve shall operate from fully open to fully closed with 90 degree rotation of the ball. Valve shall be capable of 2-way shutoff. For valves 2 inches and larger, provide full bore type. Valves smaller than 2 inches shall have one piece bodies and shall have a minimum bore not less than 55 percent of the internal cross sectional area of a pipe of the same nominal diameter.

2.2.4.5.2 Pressure Relief Valve

Valve shall be the fully enclosed, spring loaded, angle pattern, ball seated type with lift lever. Valve shall have corrosion-resistant valve seats. Valve stem shall be fully guided between the fully opened and fully closed positions. Valve shall be factory set to open at the indicated pressure (plus or minus ten percent deviation). Valve setpoint shall be field adjustable within a minimum range of plus or minus 20 percent of the indicated setpoint.

2.2.4.6 Finishes

Ship, store, and handle coating materials as well as apply and cure coatings in accordance with SSPC PA 1.

2.2.4.6.1 Exterior Coating, Aboveground Piping

Coat the exterior of aboveground steel piping, flanges, fittings, nuts, bolts, washers, valves, and piping components, as defined in this specification.

2.2.4.6.2 New Equipment and Components

a. Factory Coating

Unless otherwise specified, provide equipment and components fabricated from ferrous metal with the manufacturer's standard factory finish. Each factory finish shall withstand 125 hours exposure to the salt spray test specified in ASTM B 117. For test acceptance, the test specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch mark immediately after completion of the test. For equipment and component surfaces subject to temperatures above 120 degrees F, the factory coating shall be appropriately designed for the temperature service.

b. Field Painting

Do not paint stainless steel and aluminum surfaces. Do not coat equipment or components provided with a complete factory coating. Prior to any field painting, clean surfaces to remove dust, dirt, rust, oil, and grease.

2.2.4.7 Pipe Hangers and Supports

Provide and install pipe hangers and support in accordance with Section 33 11 00.

2.2.4.7.1 Pipe Tightness Testing

2.2.4.7.1.1 Preliminary Pneumatic Piping System Test

Apply a 25 psig pneumatic test to product piping. Maintain the pressure while soapsuds or equivalent materials are applied to the exterior of the piping. While applying the soapsuds, visually inspect the entire run of piping, including the bottom surfaces, for leaks (bubble formations). If leaks are discovered, repair the leaks accordingly and retest.

2.2.4.7.1.2 Final Pneumatic Piping System Test

Following the preliminary pneumatic test, apply a 50 psig pneumatic test to all product piping and hold for a period of not less than 2 hours. During the test period, there shall be no drop in pressure in the pipe greater than that allowed for thermal expanse and contraction. Disconnect the pressure source during the final test period. If leaks are discovered, repair the leaks accordingly and retest. Documentation of successful tightness test shall be provided to the Contracting Officer in accordance with the submittal schedule.

2.2.5 Diesel Fuel System

NFPA 30 and NFPA 37 and the requirements herein.

2.2.5.1 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.

2.2.5.2 Diesel Fuel Day Tank System

Provide 120 volt ac diesel fuel day tank system. Include necessary equipment, piping, controls, wiring, and accessories.

Day Tanks: UL 142. Provide free standing double-wall (110 percent containment) diesel fuel day tanks with a 75- to 100-gallon capacity. Epoxy coat day tanks inside and prime and paint outside. Tanks shall be doubled-walled anti-siphon. Construct tanks of not less than 3/16-inch steel plate with welded joints and necessary stiffeners on exterior of tank. Provide overflow return. Provide a brace 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.

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-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 that remote 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 remote 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, Type 3R, 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 Gauges: Provide buoyant force type gauges 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.

2.2.5.3 Fuel Transfer Pump

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."

2.2.5.4 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 150 psig 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.

2.2.6 Remote Fuel Storage

The remote fuel storage shall be an aboveground tank having a capacity of 1500 gallons with integral secondary containment. Where applicable, storage tank components shall be approved for use in the State of Florida in accordance with Florida Administrative Code FAC 62-762.851.

The aboveground storage tank shall be horizontal, rectangular, consisting of a steel primary tank, a secondary containment, and concrete encasement.

a. The primary tank shall be fabricated and tested to UL 142 standards. The tank shall be constructed of 1/4-inch-thick (minimum) carbon steel and shall have continuous welds on all sides, inside and outside, conforming to the AWS standard for continuous weld. All exposed steel shall be powder-coated to inhibit corrosion. The tank shall be warranted for 30 years.

b. The secondary containment shall consist of an impervious barrier of 30-mil high-density polyethylene to contain leaks from the primary tank. A leak-detection tube shall be provided between the primary tank and the secondary containment. The design shall permit leaked fluid to flow freely to the detection tube. The tube shall allow manual or automatic monitoring. The tube shall be provided with a special cap with 2-inch female NPT fitting for connection of the automatic sensor.

c. The concrete encasement shall be 6 inches thick with a minimum design strength of 3,000 psi and shall be steel reinforced. The encasement shall comply with UL 2085 and be listed. The Contractor shall provide an aluminum hand rail and access ladder around the concrete-vaulted encasement. The encasement shall be of a continuous monolithic pour on top, bottom, and sides and contain no cold joints or heat transfer

points on bottom and sides. The encasement shall have concrete support legs of unitized monolithic construction to provide visual inspection capability. Thermal insulation shall be incorporated to protect against temperature extremes and corrosion. No steel or insulating spacers shall come into direct contact with the concrete.

d. A leak-detection system shall be provided and shall be a microprocessor-based detector with a remote sensor designed to fit the detection tube. The detector shall be equipped with lights to indicate normal operation (green), oil (red), and water (amber) and shall include a test button and a reset button. The sensor shall be the capacitance type which will differentiate between air, water, and hydrocarbons in the environment. The detector shall be NEMA 4, wall-mounted in the generator room, and suitable for operation on a 120-volt 60-hertz single-phase power supply and shall provide a dry contact for remote annunciation. The leak-detection system shall be Pneumercator or approved equal.

e. Tank nipples shall be provided on top of the tank as follows:

Size	Type	Comments
4-inch	Threaded	Fill (lockable)
4-inch	Threaded	Spare
6-inch	Threaded	Emergency Vent
2-inch	Threaded	Normal Vent
2-inch	Threaded	Outlet (suction)
2-inch	Threaded	Level Gauge
1-1/2-inch-by-1-1/2-inch	-----	Lead-Detection Tube

f. Provide a 7-gallon overfill/spill containment surrounding the fill pipe with a normally closed valve to release spilled fuel into the primary tank.

g. Provide a 5-gallon minimum overfill/spill containment surrounding the fill pipe fueling connection. The fill port containment shall be mounted on the tank side as a remote fill box and have a 3-inch-by-2-inch reducing bushing with a cam lock style debris cap.

h. The fuel fill line drop tube shall be equipped with an internal overfill protection device capable of automatic shut-off at the 90 percent full level.

i. All nipples shall be capped during shipping. Caps shall remain on nozzles which do not receive fittings.

j. The aboveground tank shall be designed and tested to provide a 2-hour fire protection for the primary tank. The aboveground tank shall have epoxy-coated concrete exterior to resist weathering, reflect sunlight,

and inhibit corrosion and shall be UL labeled. Tank shall be Con Vault or approved equal.

k. The concrete vault encasement shall be equipped with factory installed, OSHA approved ladder and a handrail system around the entire tank top to allow for physical inspection of system and appurtenances.

l. Remote fuel tank and daytank shall each be grounded in accordance with NFPA 70, NFPA 77, NFPA 407, NFPA 780, API RP 540, and API RP 2003. Provide jumpers on piping and components to overcome insulating effects of gaskets paints or non-metallic components.

2.2.6.1 Labeling

Provide labeling to tank exterior to include NO SMOKING signage, product stored, tank storage capacity, and an NFPA fire diamond placecard. NFPA numbering and classification information are found on the material safety data sheet for the commodity stored. Labeling and marking shall be done in accordance with requirements in NFPA 704.

2.2.6.2 Tank Manufacturer's Tests

Manufacturer's tank tightness tests certification is required by UL 142 and FAC 62-762. Documentation of test and repair of leaks discovered during the tests in accordance with manufacturer's instructions shall be provided. Provide manufacturer tightness test result to the Contracting Officer before start-up and final regulatory inspection.

2.2.7 Starting Battery System

Provide a 24-volt dc starting battery installation for starting of each engine-generator set utilizing an electric cranking system.

2.2.7.1 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.

2.2.7.2 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, Type 3R. 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

2.2.8 Engine-Generator Control Panel

Provide NEMA ICS 6, Type 3R, enclosed control panel mounted on the engine-generator set with vibration isolators. Provide external serial communication using mod-bus. Provide the following control panel mounted devices and control features.

2.2.8.1 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.

2.2.8.2 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).

2.2.8.3 Engine Cooldown Relay

Provide cooldown relay with adjustable cool down time of 0 to 30 minutes (initially set at engine manufacturer's recommended time).

2.2.9 Remote Alarm Annunciator

Provide NEMA ICS 6, Type 3R, enclosed remote alarm annunciator powered by the engine starting battery system. 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

2.2.9.1 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.

2.2.10 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, Type 3R enclosure mounted on the engine-generator set.

2.2.11 Electrical Support Equipment

Furnish with respective pieces of equipment. Motors, controllers, contactors, and disconnects shall conform to Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL. Provide electrical connections under Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL. 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.

2.2.12 Sound Attenuated Weatherproof Enclosure

Standby generator set located outdoors shall be enclosed in a modular, weatherproof, corrosion-resistant, walk-in enclosure. The enclosure shall be constructed with removable side and end panels. Louver-access doors and top panels shall be made out of 14-gauge steel with 12-gauge steel corner and side supports (10-gauge for generator sets above 175 kW), and 16-gauge steel solid access doors minimum. The enclosure shall have continuous hinged doors on each side and at the control end and shall be equipped with key locks for ease of engine maintenance and a three-point latch system. There shall be expanded metal grating or radiator core guard in front for the radiator grill and fixed punched louvered air intake ports on the enclosure sides and rear for proper air circulation within the housing. Provide sleeves for wall penetrations of enclosure with enough annulus space to visually inspect the piping. The complete generator set and housing shall be prime painted and have two finish coats of protective enamel paint. Provide lifting eyes and spreader bar reinforcement for crane unloading.

The enclosure shall be sized to house the generator breaker, generator control panel, annunciator, load center, rack-mounted batteries, battery charger, and accessories. Control wire connection between starting and safety circuits shall be preconnected before the standby generator set is delivered. A thermostatically controlled exhaust fan shall be provided. Space heater(s) shall be provided as recommended by the generator set manufacturer. A 120/208-VAC load center shall be provided to supply power to the jacket water heaters, battery charger, exhaust fan, space heaters, etc. Enclosures for electrical equipment shall be NEMA 3R. The load center shall be Type 1, Class 2 circuit-breaker type, conforming to FS W-P-115C. Load center shall be dead-front safety type equipped with main and branch circuit breakers. Main breaker and bus shall be rated a

minimum of 125 percent of the connected load plus 25 percent spare capacity. All current-carrying parts of the bus assembly shall be plated copper. The load center shall be enclosed in a steel cabinet for surface mounting. Wiring gutters and steel gauge shall be in accordance with NEMA PB 1 and UL 67 for electric panelboards. The enclosure shall be fabricated from galvanized steel or equivalent rust-resistant steel and shall be coated with a rust-inhibiting primer and baked-enamel finish. The load center shall be equipped with a neutral bus bar and separate equipment grounding bar. The circuit breakers shall be quick-make, quick-break thermal magnetic-molded case type with trip indicated by handle taking a position between ON and OFF when tripped. Circuit breakers shall comply with FS W-C-375B/GEN(1). The load center shall have an integrated equipment fault current interrupting rating equal to the available fault with a minimum rating of 10,000 A/C. The load center shall be listed by UL and bear the UL label. Load center shall be as manufactured by Square D, General Electric, Cutler-Hammer/Westinghouse, or approved equal.

Engine oil and radiator drain lines shall be brought to the outside of the enclosure. A globe-type shut-off valve shall be installed in each drain line inside the enclosure for security.

An exhaust silencer shall be mounted on top of the unit. Silencers shall be critical grade and shall have bolted flange connections. The silencer shall be mounted so that the engine shall not be supporting its weight nor will thermal expansion be imposed on the engine. A top-mount unit shall be secured in position at no fewer than four points. The silencer shall be supported by an angle-iron cradle welded to the silencer and bolted to the angle-iron roof support members mounted inside the roof of the enclosure. The silencer shall be of the side-inlet type. The exhaust side of the silencer shall have a length of black iron pipe extending beyond the radiator end of the enclosure by minimum of 10 inches and cut back on a 45-degree angle. The intake of the silencer shall connect to a flexible exhaust connection. Route exhaust pipe to penetrate the enclosure roof through a metal thimble. The flash penetration area is to be weatherproof. Size as required by the engine manufacturer. The flexible exhaust connection as specified shall mount directly on the exhaust manifold and shall be mounted so that no weight is exerted on the manifold at any time. Provide sleeves in the side of the generator enclosure for fuel line piping. Provide enough annular space to enable visual inspection of the fuel line piping.

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 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS.

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, 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. Megger 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 10 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL. 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 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL

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 Testing

The Contractor shall operate the standby generator(s) under full-load conditions for a continuous period of 4 hours with loading provided by a Contractor-furnished load bank.

a. Load bank testing shall be done in the presence of the Contracting

Officer's appointed representative after the unit is permanently installed in accordance with the drawings and specifications.

b. Before acceptance any defects which become evident during this test shall be corrected at no expense to the Government.

c. The Contractor will provide fuel for load bank testing.

The services of a factory-trained service engineer who is specifically trained on the type of equipment specified in this Section shall be provided to fully inspect the installation, calibrate the equipment, and supervise testing.

Upon completion of testing, the services of the service engineer shall be provided for instruction of the Government's operating and maintenance personnel. The instructions shall include operating and maintenance procedures specifically written for the equipment installed and not generally written to cover all options available.

The transfer switch shall be operationally tested as part of the complete system to verify satisfactory operation under the worst-case conditions to be provided by the electrical system.

After testing is complete, the Contractor shall fill all fuel storage tanks to full capacity with #2 diesel fuel. The cost for filling the storage tanks with fuel shall be included in the Contract bid amount.

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 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS.

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 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. Six 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.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 41 00.00 40

LIGHTNING PROTECTION SYSTEM

PART 1 GENERAL

1.1 REFERENCES
1.2 RELATED REQUIREMENTS
1.2.1 Verification of Dimensions
1.2.2 System Requirements
1.3 SUBMITTALS
1.4 QUALITY ASSURANCE
1.4.1 Installation Drawings
1.5 SITE CONDITIONS

PART 2 PRODUCTS

2.1 MATERIALS
2.1.1 Main and Bonding Conductors
2.1.2 Copper
2.1.3 Aluminum
2.2 COMPONENTS
2.2.1 Air Terminals
2.2.2 Ground Rods
2.2.3 Connections and Terminations
2.2.4 Connector Fittings
2.2.5 Lightning Protection Components
2.3 MAIN AND SECONDARY CONDUCTORS
2.4 CLAMP-TYPE CONNECTORS
2.5 LIGHTNING PROTECTION COMPONENTS

PART 3 EXECUTION

3.1 INTEGRAL SYSTEM
3.1.1 Air Terminals
3.1.2 Roof Conductors
3.1.3 Down Conductors
3.1.4 Interconnection of Metallic Parts
3.1.5 Ground Connections
3.1.6 Grounding Electrodes
3.2 APPLICATIONS
3.2.1 Steel Frame Building
3.3 INTERFACE WITH OTHER STRUCTURES
3.3.1 Exterior Pipe Lines
3.4 SEPARATELY MOUNTED SHIELDING SYSTEM
3.5 RESTORATION
3.6 FIELD QUALITY CONTROL
3.6.1 Grounding System Test
3.6.2 Lightning Protection System Inspection
3.7 INSPECTION

-- End of Section Table of Contents --

SECTION 26 41 00.00 40

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 Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)Normal Measurements

JOHN F. KENNEDY SPACE CENTER (KSC)

KSC-STD-E-0012E	(Rev E; 2001) Standard for Facility Grounding and Lightning Protection

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; TIA 11-1; Errata 2011) National Electrical Code
NFPA 780	(2007) Standard for the Installation of Lightning Protection Systems

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS A-A-52913	Splice Connectors

UNDERWRITERS LABORATORIES (UL)

UL 467	(2007) Grounding and Bonding Equipment
UL 96	(2005) Standard for Lightning Protection Components
UL 96A	(2007) Standard for Installation Requirements for Lightning Protection 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.

1.2.1 Verification of Dimensions

Contractor shall become familiar with all details of work, verify all dimensions in field, and shall advise Contracting Officer of any

discrepancy before performing work. Make no departures without prior approval of Contracting Officer.

1.2.2 System Requirements

Materials shall consist of standard products of a manufacturer regularly engaged in production of lightning protection systems and manufacturer's latest UL approved design. Lightning protection system and materials shall conform to NFPA 70, NFPA 780, UL 96 and UL 96A.

Comply with KSC-STD-E-0012E

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-03 Product Data

Submit manufacturer's catalog data for the following items:

Air Terminals

Main and Secondary Conductors

Ground Rods

Clamp-Type Connectors

Lightning Protection Components

Hardware

Accessories

SD-06 Test Reports

Grounding system test; G

Lightning protection system inspection; G

1.4 QUALITY ASSURANCE

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" 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

a. Submit installation shop drawing for the overall lightning protection system. Drawings shall include physical layout of the equipment, dimensions, mounting details, relationship to other parts of the work, and wiring diagram.

b. Submit detail drawings for each major component to include manufacturer's descriptive and technical literature, catalog cuts, and installation instructions.

1.5 SITE CONDITIONS

Contractor will become familiar with details of the work, verify dimensions in the field, and advise Contracting Officer of discrepancies before performing work. Deviations from contract drawings will not be made without prior approval of Contracting Officer.

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 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 tinned coatings. Where a mechanical hazard is involved, increase the conductor size to compensate for the hazard or protect conductors by covering them with molding or tubing made of wood or nonmagnetic material. 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).

Lightning protection equipment, Accessories, and Hardware shall conform to NFPA 70, NFPA 780, and UL 96.

2.1.1 Main and Bonding Conductors

NFPA 780 and UL 96 Class I, Class II, or Class II modified materials as applicable.

Size of conductors shall not be less than specified in NFPA 780.

2.1.2 Copper

For Class I materials (structures not exceeding 75 ft in height), provide copper main conductors that do not weigh less than 187 pounds per thousand feet, have a cross section area of not less than and minimum strand size of not less than 17 AWG. Provide loop conductors that are comprised of copper conductors not smaller than No. 4/0 AWG.

2.1.3 Aluminum

For Class I materials (structures not exceeding 75 ft in height), provide aluminum main conductors that do not weigh less than 95 pounds per thousand feet, have a cross section area of not less than and minimum strand size of not less than 14 AWG.

Do not allow aluminum to contact the earth and do not use in any other manner that will contribute to rapid deterioration of the metal. Observe

appropriate precautions at connections with dissimilar metals in accordance with NFPA 70 Article 110-14. Provide aluminum cable conductors for bonding and interconnecting metallic bodies to main cable that are at least equivalent to strength cross-sectional area of a No. 4 AWG aluminum wire.

2.2 COMPONENTS

2.2.1 Air Terminals

Provide terminals in accordance with UL 96, except provide Class II for Class I and Class II applications. Support air terminals more than 24 inches in length by suitable brace, with guides, not less than one-half the height of the terminal.

Air terminals shall be 5/8-inch aluminum with length and location as indicated. Fasten air terminals to an aluminum connector with a male threaded stud on which the female threaded air-terminal shaft shall be mounted

Air terminals shall be not less than 24-inches high above the object to protect, tapered to a point. Separate points are not required on top of air terminals, but if used, the points shall be of substantial construction and securely attached by screw or slip joints. Air terminals more than 24-inches high shall be supported by a suitable brace with guide(s) not less than one-half the height of the air terminal.

2.2.2 Ground Rods

Provide ground rods made of solid copper conforming to UL 467. Provide ground rods that are not less than 3/4 inch in diameter and 20 feet in length. Do not mix ground rods of copper-clad steel, stainless steel, galvanized ferrous, or solid copper on the same 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 of corrosion-resistant material (bimetallic) affording protection against electrolysis when joining dissimilar metals. Only use clamp-type connectors for the connection of the roof conductor to the air terminal and to the guttering. All other connections, bonds, and splices shall be done by exothermic welds or by high compression fittings. List the exothermic welds and high compression fittings for the purpose. The high compression fittings shall be the type which require a hydraulically operated mechanism to apply a minimum of 10,000 psi.

2.2.4 Connector Fittings

Provide connector fittings for "end-to-end", "Tee", or "Y" splices that conform to NFPA 780.

2.2.5 Lightning Protection Components

Provide bonding plates, air terminal supports, clips, and fasteners that conform to UL 96 classes as applicable.

2.3 MAIN AND SECONDARY CONDUCTORS

Conductors shall be in accordance with NFPA 780 and UL 96 for Class I. Materials shall be aluminum.

Weight of copper conductors shall be not less than 187.5 pounds per thousand feet, and the size of any wire of this cable shall be not less than AWG No. 17. Copper tube or solid-section conductors of copper shall weigh not less than 187.5 pounds per thousand feet, and no tube wall shall be less than AWG No. 20. Thickness of any copper ribbon or strip shall be not less than AWG No. 16. Copper conductors used for counterpoise shall be not smaller than AWG No. 4/0.

Do not allow aluminum to contact or touch the earth, dissimilar metals, or constructions where rapid deterioration of the metal could result. Observe precautions at connections with dissimilar metals. Aluminum cable conductors shall be electrical conductor-grade aluminum and weigh not less than 95 pounds per thousand feet. Size of any wire of the cable shall be not less than AWG No. 14. Aluminum conductors for bonding and interconnecting metallic bodies to the main cable shall be at least equivalent to strength and cross-sectional area of a AWG No. 4 aluminum wire. Aluminum strip conductors for interconnecting metallic bodies to the main conductor cable, when void of perforations, shall be not less than 14 gauge and at least 1/2-inch wide. When perforated, the total cross-sectional area shall not be reduced from that of an unperforated conductor.

Rooftop conductors shall be aluminum. Transition down conductors from aluminum to copper via a bi-metallic conductor after the down conductor leaves the roof.

2.4 CLAMP-TYPE CONNECTORS

Clamp connectors for splicing conductors shall conform to UL 96 and FS A-A-52913, Class 2 noninsulated, style and size as required for the installation. Connectors shall be of corrosion-resistant material and shall afford protection against electrolysis.

2.5 LIGHTNING PROTECTION COMPONENTS

Lightning protection components, such as bonding plates, air terminal supports, clips, and fasteners shall conform to UL 96, classes as applicable.

PART 3 EXECUTION

3.1 INTEGRAL SYSTEM

Lightning protection system consists of air terminals, roof conductors, down conductors, ground connections, grounding electrodes and ground loop conductor. Electrically interconnect lightning protection system to form the shortest distance to ground. Do not use nonconducting parts of the structure as part of the building's lightning protection system. Expose conductors on the structures except where conductors are required to be in protective sleeves. Interconnect secondary conductors with grounded metallic parts within the building. Make interconnections within side-flash distances at or above the level of the grounded metallic parts.

3.1.1 Air Terminals

Provide air terminal design and support conforming to NFPA 780. Rigidly

connect terminals to, and make electrically continuous with, roof conductors by means of pressure connectors or crimped joints of T-shaped malleable metal. Provide pressure connector or crimped joint with a dowel or threaded fitting to connect ground rod conductor with air terminal. Set air terminals at ends of structures not more than 2 feet from ends of ridges and corners of roofs. Do not exceed 25 feet in spacing of 2 foot high or greater air terminals on ridges, parapets, and around perimeter of building with flat roofs or 20 feet in spacing of air terminals less than 2 feet high. When necessary to exceed this spacing, use taller air terminals and the rolling sphere method. On large flat, or gently sloping roofs, as defined in NFPA 780, place air terminals at points of the intersection of imaginary lines dividing the surface into rectangles having sides not exceeding 50 feet in length. Secure air terminals against overturning either by attachment to the object to be protected or by means of a substantial tripod or other braces which are permanently and rigidly attached to the building or structure.

Air terminal tips on buildings used for manufacturing, processing, handling, or storing explosives, ammunition, or explosive ingredients shall be a minimum of 2 feet above the ridge parapet, ventilator or perimeter.

Air terminals shall be a minimum of 5 feet above the opening on open or hooded vents emitting explosive dusts or vapors under natural or forced draft.

Air terminals shall extend a minimum of 15 feet above vent opening on open stacks emitting explosive dusts, gases, or vapor under forced draft.

3.1.2 Roof Conductors

Connect roof conductors directly to the roof or ridge roll. Avoid sharp bends or turns in conductors. Do not make turns of less than 8 inches radius. Preserve horizontal or downward course on conductors. Rigidly fasten conductors every 3 feet along the roof and down the building to the ground. Make connections electrically continuous. Course roof conductors along contours of flat roofs, ridges, parapets, and edges; and where necessary, over flat surfaces, in such a way as to join each air terminal to all the rest. Connect roof conductors surrounding tank tops, decks, flat surfaces, and flat roofs to form a closed loop.

3.1.3 Down Conductors

All down conductors shall wrap around the eave of the building. No penetrations of the roofing material shall be allowed.

Make down conductors electrically continuous from roof conductors to grounding electrodes. Course down conductors over outer extreme portions of the building, such as corners, with consideration given to location of ground connections and air terminals. Provide each building or structure not less than two down conductors located as widely separated as practicable, such as at diagonally opposite corners. Structures exceeding 250 feet in perimeter, provide at least one additional down conductor for each 100 feet of perimeter or fraction thereof. Provide enough conductors so that the average distance between them along the perimeter is not greater than 100 feet. Structures exceeding 50 feet in height, provide at least one additional down conductor for each additional 60 feet of height or fraction thereof, except that this application will not cause down conductors to be placed about the perimeter of the structure at intervals of less than 50 feet. Install additional down conductors when necessary to

avoid "dead ends" or branch conductors ending at air terminals, except where the air terminal is on a roof below the main protected level and the "dead end" or branch conductor is less than 16 feet in length and maintains a horizontal or downward coursing. Equally and symmetrically spaced down conductors about the perimeter of the structure. Protect conductors where necessary, to prevent physical damage or displacement to the conductor. Protect down conductors by placing in Schedule 80 PVC conduit for a minimum distance of 72 inch above finished grade level.

3.1.4 Interconnection of Metallic Parts

Connect metal doors, windows, and gutters directly to ground or down conductors using not smaller than No. 6 copper conductor, or equivalent. Where there is probability of unusual wear, mechanical injury, or corrosion, provide conductors with greater electrical capacity than normal or protect the conductor. Provide mechanical ties or pressure connectors between grounds and metal doors and windows.

3.1.5 Ground Connections

Securely connect conductor forming continuations of down conductors from structure to grounding electrode in a manner to ensure electrical continuity between the two. Provide welds (including exothermic) for continuation. Provide a ground connection for each down conductor. Attach down conductors to ground rods by welding (including exothermic), brazing, or clamping. Provide clamps suitable for direct burial. Protect ground connection from mechanical injury. Bond metal water pipes and other large underground metallic objects together with all grounding mediums. In making ground connections, take advantage of all permanently moist places where practicable, although avoid such places when area is wet with waste water that contains chemical substances, especially those corrosive to metal.

3.1.6 Grounding Electrodes

Provide grounding electrode for each down conductor. Extend driven ground rods into the existing undisturbed earth for a distance of not less 20 feet. Set ground rods not less than 2 feet nor more than 10 feet, from the structure. After the completed installation, measure the total resistance to ground using the fall-of-potential method described in IEEE Std 81. Maximum resistance of a driven ground rod shall be 10 ohms, under normally dry conditions. For ground loop, provide continuous No. 4/0 bare stranded copper cable or equivalent material having suitable resistance to corrosion. Lay ground loop around the perimeter of the structure in a trench not less than 18 inches below grade, at a distance not less than 2 feet nor more than 10 feet from the nearest point of the structure. Install a ground loop 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. Make connections between ground conductors and grounds or ground loop, and between ground loop and grounds electrically continuous.

3.2 APPLICATIONS

3.2.1 Steel Frame Building

Make the steel framework of the building electrically continuous. Electrical continuity may be provided by bolting, riveting, or welding unless another specific method is indicated. Connect air terminals to the

structural steel framework at the ridge. Provide short runs of conductors to join air terminals to the metal framework so that proper placing of air terminals is maintained. Separate down conductors from air terminals to ground connections are not required. Where water system enters the building, securely connect structural steel framework and water system at point of entrance by a ground connector. Make connections to pipes by means of ground clamps with lugs. Make connections to structural framework by welding. Make connections between columns and ground connections at bottom of steel columns. Make ground connections to grounds or ground loop runs from not less than one-half of the columns distributed equally around perimeter of structure at intervals averaging not more than 60 feet. Bond all metal piping entering and exiting the building. Bond all underground concrete reinforcing steel. Bond metal doors, windows, gutters, and similar metal installation to steel work of the building. Provide a grounding electrode for each ground connection.

3.3 INTERFACE WITH OTHER STRUCTURES

3.3.1 Exterior Pipe Lines

Bond all pipes and conduits that enter the building, preferably to building grounds at points where pipes enter the building. Where a separate ground is provided, bond the pipes to the building ground at points where the pipes are closest to the ground connections. In addition, bond pipes to any metallic masses that are within 6 feet of the pipe.

3.4 SEPARATELY MOUNTED SHIELDING SYSTEM

3.5 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. Include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging or mulching in any restoration. Maintain disturbed surfaces and replacements until final acceptance.

3.6 FIELD QUALITY CONTROL

3.6.1 Grounding System Test

Test the grounding system to ensure continuity and that resistance to ground is not in excess of 10 ohms. 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 ground rods, resistance, and soil conditions at the time that measurements were made. Submit results of each test to the Contracting Officer.

3.6.2 Lightning Protection System Inspection

Make visual inspections to verify that there are no loose connections which may result in high resistance joints, and that conductors and system components are securely fastened to their mounting surfaces and are protected against accidental mechanical displacement.

3.7 INSPECTION

The lightning protection system will be inspected by the Contracting Officer to determine conformance with the requirements of this specification. No part of the system shall be concealed until so authorized by the Contracting Officer.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 43 00.00 99

SURGE PROTECTIVE DEVICE (SPD)

PART 1 GENERAL

1.1 REFERENCES
1.2 GENERAL REQUIREMENTS
1.3 SUBMITTALS

PART 2 PRODUCTS

2.1 SURGE PROTECTIVE DEVICE (SPD) COMPONENTS
2.1.1 REQUIRED SUPPRESSOR LOCATIONS
2.1.2 LEVEL "I"
2.1.3 LEVEL "II"
2.1.4 LEVEL "III"
2.2 DOCUMENTATION

PART 3 EXECUTION

3.1 INSTALLATION
3.2 SPDs

-- End of Section Table of Contents --

SECTION 26 43 00.00 99

SURGE PROTECTIVE DEVICE (SPD)

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this section to the extent referenced:

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41	(1991; R 1995) Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits

UNDERWRITERS LABORATORIES (UL)

UL 1449	(2006; Rev thru Sep 2009) Surge Protective Devices

1.2 GENERAL REQUIREMENTS

Section 26 00 00.00 20, BASIC ELECTRICAL MATERIALS AND METHODS applies to work specified in this section.

1.3 SUBMITTALS

The following shall be submitted in sufficient detail to show full compliance with the specification:

SD-03 Product Data

Manufacturer's Catalog Data shall be submitted for the following items:

Surge Protective Device (SPD) Components; G
UL Documentation

PART 2 PRODUCTS

2.1 SURGE PROTECTIVE DEVICE (SPD) COMPONENTS

All SPDs shall be manufactured by a company engaged in the design, development, and manufacture of such devices for electrical and electronics systems equipment. The said firm shall offer a five-year warranty.

The surge protective manufacturer shall offer technical assistance through support by a factory representative and local stocking distributor or local direct factory distribution warehouse and coordinate with the panelboard manufacturer for installation into the panelboards.

Suppressors shall be listed in accordance with UL 1449. Protective modes shall be as follows: Wye = L-N, L-G, N-G; Delta = L-G, L-L.

Suppressors shall be tested with Category C3 high exposure waveform (20KV, 10 KA, 9/200 usec. waveform) per IEEE C62.41.

Surge protective devices shall be installed in all new panelboards installed flush in walls and surface-mounted in shop and mechanical spaces in accordance with requirements of all National Fire Protection Association (NFPA) codes.

Provide Level One, Level Two or Level Three SPDs where indicated. SPD shall have seven(7) mode protection for 3-phase, wye configuration and four (4) mode protection for 3-phase delta configurations. SPD shall be an integral part of the panel and mounted directly to the bus. SPD provided for new switchgear shall be an integral part of the switchgear and mounted in the auxiliary compartment, dead-front design and front accessible.

SPD shall be installed internal to the new equipment being protected. The mounting position of the SPD shall permit a straight and short lead length connection between the SPD and the point of connection to the equipment. The interconnecting leads between the SPD and the point of connection to the bus should be kept as short as possible, 0.5 m (20 in) or less, and should be twisted to minimize lead reactances. Bends should be avoided if possible. Provide overcurrent protection as recommended by the SPD manufacturer.

All SPD units shall be equipped with an audible alarm which shall actuate when any one of the surge current modules has failed. An alarm on/off switch shall be provided to silence the alarm and an alarm push-to-test switch shall be provided to test the alarm. Both switches and audible alarm shall be located on the front cover of the panelboard.

2.1.1 REQUIRED SUPPRESSOR LOCATIONS

In service entrance panelboards.

In distribution and branch circuit panels as indicated on the drawings.

2.1.2 LEVEL "I"

SPD shall meet or exceed the following criteria.

1) Maximum single impulse current rating: 100,000 amperes per mode(8X20 usec current waveform).

2) Pulse life rating (IEEE C62.41-1991, Table 4, Category C3 transient): 1000 occurrences min./mode, based on the highest voltage mode of the device. (20KV/10KA - 8X20usec/1.2X50usec waveform)

Suppression Voltage Ratings (SVR): The maximum UL 1449, Second Edition SVR for the device should not exceed the following:

Nominal Voltage	Configuration	L-N	N-G	L-G	L-L
120/240	Grd. Neutral	400	400	400	700
120/208	Grd. Wye	400	400	400	700
277/480	Grd. Wye	800	800	800	1500
240	Delta			700	700
480	Delta			1500	1500

2.1.3 LEVEL "II"

SPD shall meet or exceed the following criteria.

1) Maximum single impulse current rating: 50,000 amperes per mode (8x20 usec current waveform).

2) Pulse life rating (IEEE C62.41-1991, Table 4, Category C3 transient): 1000 occurrences minimum per mode, based on the highest voltage mode of the device. (6KV/3KA - 8X20usec/1.2X50usec waveform)

Suppression Voltage Ratings (SVR): The maximum UL 1449, Second Edition SVR for the device should not exceed the following:

Nominal Voltage	Configuration	L-N	N-G	L-G	L-L
120/240	Grd. Neutral	400	400	400	700
120/208	Grd. Wye	400	400	400	700
277/480	Grd. Wye	800	800	800	1500
240	Delta			700	700
480	Delta			1500	1500

2.1.4 LEVEL "III"

Suppressors shall be listed in accordance with UL 1449.

For 3 phase, 4-wire configurations, suppressors shall provide suppression elements between each phase conductor and the system neutral, between each phase conductor and the system ground, and between the neutral conductor and ground, for a total of seven suppression modes.

Visible indication of proper suppressor connection and operation shall be provided.

Suppressors shall be designed for a straight and short lead length connection between the suppressor and the point of connection to the panelboard. Other suppressor connections will not be acceptable.

Suppressors shall meet or exceed the following criteria:

1. Maximum single impulse current rating: 80,000 amperes per phase (8/20 usec. waveform).

Note: If the suppressor utilizes internal fuses, the maximum single impulse current cannot exceed the rating of the fuse.

2. Pulse life rating: Category C (8/20 usec. waveform): 2,000 occurrences, with no clamping drift.

3. UL Clamping voltage shall not exceed the following:

Voltage	L-N	N-G	L-G
120/208	400	400	400

Suppressors shall have turn-on and turn-off times of less than one nanosecond.

Suppressors shall be of the solid-state componentry and shall operate

bidirectionally.

2.2 DOCUMENTATION

Submit UL Documentation verifying listing for UL 1449 sections 34, 35,36, 37, 38, 39, 40.

PART 3 EXECUTION

3.1 INSTALLATION

Arresters and SPD units shall be installed and connected in accordance with the manufacturer's installation instructions.

Ground connection shall be made to a driven ground rod, counterpoise, or station grounding system.

Lightning arresters shall be connected as close as practicable to the apparatus being protected.

3.2 SPDs

Install the proper "level" of suppressor at each switchboard/panelboard as indicated on the power one-line diagram and panelboard schedules.

Suppressor shall be installed in the equipment to be protected, per the manufacturer's installation instructions.

Conductors between suppressor and point of attachment to the panelboard shall be kept as short and straight as possible.

Suppressor's ground shall be bonded to the service entrance ground or point of ground for the respective panelboard.

Include the costs for the manufacturer's certified representative to inspect and approve the installation upon completion of the project.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 60 13.00 40

LOW-VOLTAGE MOTORS

PART 1 GENERAL

1.1 REFERENCES
1.2 GENERAL REQUIREMENTS
1.3 SUBMITTALS
1.4 DESIGN REQUIREMENTS

PART 2 PRODUCTS

2.1 EQUIPMENT
2.1.1 Efficiency
2.2 MOTOR TYPES
2.3 SIZES OF MOTORS
2.3.1 Motors
2.3.2 Electrically Driven Equipment
2.4 VOLTAGE RATINGS
2.5 TEMPERATURE RATING AND INSULATION
2.6 MOTOR ENCLOSURES
2.7 SERVICE FACTOR
2.8 FACTORY TESTS

PART 3 EXECUTION

3.1 INSTALLATION
3.2 ALIGNMENT
3.3 ELECTRICAL TESTS

-- End of Section Table of Contents --

SECTION 26 60 13.00 40

LOW-VOLTAGE MOTORS

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 BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11	(1990) Load Ratings and Fatigue Life for Roller Bearings
ABMA 9	(1990; R 2008) Load Ratings and Fatigue Life for Ball Bearings

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 112	(2004) Standard Test Procedure for Polyphase Induction Motors and Generators

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2009) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems
NETA MAINT	(2011) Standard for Maintenance Testing Specifications for Electric Power Distribution Equipment and Systems

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1	(2003; Corrigendum 2005) Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerance - International Restrictions

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2009) Motors and Generators

U.S. DEPARTMENT OF ENERGY (DOE)

DOE CI-1	(2001) How to Buy a Premium Energy-Efficient Electric Motor

1.2 GENERAL REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to

work specified in this section.

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

Outline drawings for Motors shall indicate overall physical features, dimensions, ratings, service requirements, and weights of equipment.

SD-03 Product Data

Equipment and performance data shall be submitted for Motors consisting of use life, system functional flows, safety features, and mechanical automated details. Curves indicating tested and certified equipment response and performance characteristics shall also be submitted.

Submit Manufacturer's Catalog Data in accordance with paragraph entitled, "Equipment," of this section

For Electric Motors rated over 25 and those specified to meet a special vibration class in accordance with NEMA MG 1 indicate number of:

Rotor Bars
Stator Slots
Rotational Speed
Cooling Fan Blades
Bearing Manufacturer
Bearing Style
Bearing Type
Balls/Elements
Commutator Bars
Commutator Brushes
SCR Firing Frequencies (for variable speed motors)

SD-07 Certificates

Certificates shall be submitted for the following tests showing conformance with the referenced standards contained in this section. Certified copies of previous test reports on identical motors may be submitted in lieu of factory test reports.

Factory Test Results
Efficiency
Power-Factor
Service Factor
Temperature Rating
Noise
Full-Load
Locked-Rotor
Insulation Resistance
Winding Resistance

High-Potential Tests

SD-08 Manufacturer's Instructions

Manufacturer's Instructions shall be submitted for Motors including special provisions required to install equipment components and system packages. Special notices shall detail impedances, hazards and safety precautions.

1.4 DESIGN REQUIREMENTS

The following motor design data shall be provided prior to final turnover-number of motor rotor bars, Stator slots, rotational speed; number of cooling fan blades; RPM of motor; bearing manufacturer, bearing type, bearing style and number of balls/elements; number of commutator bars and commutator brushes; and SCR firing frequencies.

PART 2 PRODUCTS

2.1 EQUIPMENT

Submit manufacturer's catalog data for motors and enclosures.

Design, fabrication, testing, and performance of motors shall be in accordance with NEMA MG 1 and ISO 1940-1 and shall meet or exceed the requirements as specified herein.

Testing and performance of polyphase induction motors shall be in accordance with IEEE 112, Method B.

Efficiency labeling shall be in accordance with NEMA MG 1.

Allowable balance limits shall be in accordance with ISO 1940-1, Table 1

2.1.1 Efficiency

Motors shall have efficiencies in accordance with the recommended levels specified in DOE CI-1.

2.2 MOTOR TYPES

Motor shall be marked to show the index letter, which shall be the letter shown or a letter that indicates a higher efficiency.

Motors shall be of the following types:

1/3 HP and smaller, single phase - capacitor start

1/2 HP and larger, three-phase - induction squirrel-cage type, NEMA Design B, having normal starting torque and low starting current

Motors for variable-speed applications shall be designed for operation at the rated maximum speed and at reduced speed throughout the variable-speed range without overloading. Motors for variable-speed operation shall be inverter duty rated and compatible with the associated variable-speed control equipment and operating conditions, including the effects of harmonic current and voltage distortion. Motors for variable-speed operation shall be equipped with a normally closed automatic reset winding thermostat in addition to all accessory equipment recommended by the

variable-speed equipment manufacturer. Thermostat leads shall be brought to the motor connection box.

Motors shall have factory-sealed ball bearings with an L-10 rated life of not less than 80,000 hours in accordance with ABMA 9 or ABMA 11.

2.3 SIZES OF MOTORS

2.3.1 Motors

Motors shall be of a sufficient size for the duty to be performed and shall not exceed the full-load rating when the driven equipment is operating at specified capacity under the most severe loading conditions.

2.3.2 Electrically Driven Equipment

When electrically driven equipment differs from that indicated, adjustments shall be made to the motor size, wiring and conduit systems, disconnect devices, and circuit protection to accommodate the equipment actually installed, at no additional cost to the Government. Control and protective devices shall be in accordance with Section 26 05 71.00 40.00 40 LOW-VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

2.4 VOLTAGE RATINGS

Motors shall have the following minimum voltage ratings:

MOTOR SIZE			MOTOR
MOTOR TYPE	HORSEPOWER	SERVICE	VOLTAGE RATING
Fractional horsepower, single-phase	1/3 and smaller	120/208-volt, 3-phase, 4-wire	115-volt, 60-hertz
Fractional and integral horsepower, 3-phase	1/2 and larger	120/208-volt, 3-phase, 4-wire	200-volt, 3-phase 60-hertz
Fractional and integral horsepower, 3-phase	1/2 and larger	480-volt, 3-phase, 3-wire	230/460-volt, 3-phase, 60-hertz

2.5 TEMPERATURE RATING AND INSULATION

Motors shall be designed for continuous operation at the rated full load in an ambient temperature of 104 degrees F.

Insulation level shall be at least Class F.

2.6 MOTOR ENCLOSURES

Motors installed in indoor, nonhazardous locations where it is necessary to protect the motor from dirt, moisture, chemical fumes, or other harmful ingredients in the surrounding atmosphere shall be the totally enclosed type, with either of the following:

Totally enclosed fan-cooled enclosures for exterior cooling by means of

a fan or fans integral with the machine but external to the enclosing parts.

Motors installed in outdoor, nonhazardous locations shall have waterproof enclosures.

2.7 SERVICE FACTOR

Service factor of general purpose and other open ac motors shall be in accordance with NEMA MG 1.

Totally enclosed ac motors shall have a service factor of 1.15.

2.8 FACTORY TESTS

Factory test all motors in accordance with the requirements of NEMA MG 1. Polyphase induction motors shall be factory-tested in accordance with IEEE 112, Method B. Tests shall consist of measurements of voltage, frequency, speed, and current under no-load conditions; voltage, frequency, and current under locked-rotor conditions; and efficiency, noise, power factor, and thermal protection. Routine tests on wound-rotor induction motors shall include the measurement of wound-rotor open-circuit voltage across the slip rings under locked-rotor conditions. Electrical tests shall consist of winding resistance, insulation resistance, and high-potential tests. Submit certified copies of factory test results for approval prior to shipment from the factory. Previous test reports on identical motors are not acceptable for these tests.

PART 3 EXECUTION

3.1 INSTALLATION

Motors shall be installed, aligned, and connected in accordance with the equipment manufacturer's instructions.

Motors shall be bolt mounted. Motor feet shall be coplanar within 0.001 inch. Base mounting points shall be accessible and adjustable to enable machine alignment. Motors over 25 hp shall have alignment jack bolts installed to enable alignment.

Alignment of motors shall be rechecked and adjusted as required after the motor has been in operation for not less than 48 hours.

3.2 ALIGNMENT

Before attempting alignment, the contractor will demonstrate that the load does not have any load/force imposed by the piping system. Minimum alignment values (below) are for motor and load at normal running temperatures. Values must be compensated for thermal growth. Limited movement of the motor or load (commonly known as bolt-bound) must be corrected to ensure alignment capability. Hold down bolts shall not be undercut in order to perform adjustment.

Shims shall be commercially die-cut, without seams or folds, and be made of corrosion resistant stainless steel. No more than four shims shall be used at any single point.

Motor and load shall be aligned to the following minimum specifications:

Speed(RPM)	Close-Coupled Offset (mils)	Close-Coupled Angle(mils/in.)	Spool Piece Angle (mils/in. @ coupling pt.)
600	6.0	2.0	3.0
900	5.0	1.5	2.0
1200	4.0	1.0	1.5
1800	3.0	0.5	1.0
3600	1.5	0.4	0.5
7200	1.0	0.3	0.4

Motor/load alignment shall be performed under the direction of the manufacturer's representative.

Final alignment settings shall be provided as part of the final test data.

3.3 ELECTRICAL TESTS

Perform continuity test on all phases.

Perform insulation resistance and polarization index test on each phase of motor. Insulation tests on 480-volt and 600-volt motors shall be conducted using a 1000-volt insulation test set. Insulation tests on motors rated less than 480-volts shall be conducted using 500-volt insulation test set.

Test data shall include the location and identification of motors and megohm readings versus time. Test data shall be recorded at 15, 30, 45 seconds, and in 1 minute increments thereafter up to 10 minutes. Megohm readings shall not be less than 25 megohms for each phase and each phase reading shall be within 10 percent of the other two.

Perform inspections and test procedures on all motors in accordance with NETA ATS and NETA MAINT 7.15.1 for rotating machinery, AC motors.

Calculate the polarization index of each phase by dividing the 10 minute reading by the 1 minute reading. The polarization index shall be greater than 1.25. Any values lower shall be rejected and the motor returned to the factory.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 27 - COMMUNICATIONS

SECTION 27 13 23.00 40

COMMUNICATIONS OPTICAL BACKBONE CABLING

PART 1 GENERAL

1.1 REFERENCES
1.2 GENERAL REQUIREMENTS
1.3 SUBMITTALS
1.4 QUALITY ASSURANCE PLAN
1.4.1 Fiber Optic System
1.4.2 Fiber Optic Cable Installer and Splicer Qualifications
1.4.3 Fiber Optic Field Tests Plan
1.5 DELIVERY, STORAGE, AND HANDLING
1.6 RELATED REQUIREMENTS

PART 2 PRODUCTS

2.1 FIBER OPTIC CABLE DESIGN
2.1.1 Fiber Optic Media Types
2.1.1.1 Multi-Mode Fiber Media
2.1.1.2 Single-Mode Fiber Media
2.1.2 Cable Length
2.1.3 Materials and Construction
2.1.3.1 Central Core Member
2.1.3.2 Optical Fibers
2.1.3.3 Fiber Primary Protective Coating
2.1.3.4 Optical Fiber Color-Code Coating
2.1.3.5 Loose Tube Buffering
2.1.3.6 Colorants
2.1.3.7 Number of Fibers Per Tube Per Cable
2.1.3.8 Inner Jacket
2.1.3.9 Pulling Strength Member
2.1.3.10 Cable Outer Jacket
2.1.3.11 Metallic Armor
2.2 CABLE IDENTIFICATION SYMBOL
2.3 REPLACEMENT CABLE
2.4 SPLICE TRAYS AND ORGANIZERS
2.5 PRE-CONNECTED CABLE ASSEMBLY
2.6 OPTICAL AND MECHANICAL PERFORMANCE REQUIREMENTS
2.6.1 Optical Performance
2.6.1.1 Multi-Mode Fibers in the Cable
2.6.1.2 Single-Mode Fibers in the Cable
2.6.2 Mechanical Performance
2.6.2.1 Minimum Bend Radius
2.6.2.2 Tensile Strength
2.6.2.3 Flexing or Bending Cycles
2.6.2.4 Crush Resistance
2.6.2.5 Impact Resistance
2.6.2.6 Fluid Penetration

2.7 TEMPERATURE ENVIRONMENT
2.8 SPLICE COMPATIBILITY TEST
2.9 FIBER OPTIC TERMINATIONS AND CONNECTORS
2.10 PREPARATION FOR DELIVERY
2.11 FACTORY REEL TEST
2.12 MISCELLANEOUS ITEMS
2.12.1 FO Media Tags
2.12.2 Buried Warning and Identification Tape
2.12.3 Grounding Braid

PART 3 EXECUTION

3.1 FIBER SPLICES
3.2 INSTALLATION
3.2.1 Contractor Damage
3.3 BURIED CABLE INSTALLATION
3.3.1 Location
3.3.2 Field Staking
3.3.3 Method of Cable Placement
3.3.3.1 Open Trench Method
3.3.3.2 Direct Plow Method
3.3.4 Compaction
3.4 UNDERGROUND CABLE INSTALLATION
3.4.1 Securing Cable
3.4.2 Bending
3.4.3 Pulling
3.4.4 Lubricant
3.4.5 Damage and Defects
3.4.6 Seal
3.5 CABLE INSTALLATION IN CABLE TRAYS
3.6 GROUNDING SYSTEMS
3.7 DIRECT BURIAL SYSTEM INSTALLATION
3.7.1 Media Placement
3.7.2 Identification Slabs (Markers)
3.8 RECONDITIONING OF SURFACES INSTALLATION
3.8.1 Unpaved Surface Treatment
3.9 CABLE PULLING
3.9.1 FO Media Tensions
3.9.2 Pulling Eyes
3.9.3 Installation of Media in Maintenance Manholes, Handholes, and Vaults
3.10 GROUNDING
3.11 HOUSEKEEPING
3.12 CABLE DELIVERY
3.13 TESTING
3.13.1 Field Reel Tests
3.13.1.1 Reel Test Results
3.13.2 Final Acceptance Tests
3.13.2.1 Test Results
3.14 TEST REQUIREMENTS
3.14.1 Single-mode and Multi-mode OTDR Test
3.14.2 End-to-End Attenuation Tests
3.14.3 End-to-End Bandwidth Tests

-- End of Section Table of Contents --

SECTION 27 13 23.00 40

COMMUNICATIONS OPTICAL BACKBONE CABLING

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 C 338	(1993; R 2008) Standard Test Method Softening Point of Glass
ASTM D 4976	(2006) Standard Specification for Polyethylene Plastics Molding and Extrusion Materials

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 455-25C	(2002) FOTP-25 Repeated Impact Testing of Single-Mode Fiber Optic Cables and Cable Assemblies
EIA 455-33B	(2005) FOTP-33 Fiber Optic Cable Tensile Loading and Bending Test
EIA 455-41A	(1993; R 2001) FOTP-41 Compressive Loading Resistance of Fiber Optic Cables
EIA 455-80C	(1998) FOTP-80 Cutoff Wavelength of Un-cabled Single-Mode Fiber by Transmitted Power
EIA 455-82B	(1992) FOTP-82 Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2007; Errata 06-1; TIA 07-1; TIA 07-2; TIA 07-3; Errata 07-2; TIA 08-4; TIA 08-5; TIA 08-6; TIA 08-7; TIA 08-8; TIA 08-9; TIA 08-10; TIA 08-11; TIA 09-12; TIA 09-13; TIA 09-14; Errata 09-3; TIA 09-15; TIA 09-16; TIA 10-17) National Electrical Safety Code

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-87-640	(2006) Fiber Optic Outside Plant Communications Cable

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; TIA 11-1; Errata 2011) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

EIA/TIA 455-165A	(1993) Standard for Mode-Field Diameter Measurement by Near-Field Scanning Technique
TIA-455-104-A	(1993; R 2005) Standard for FOTP-104 Fiber Optic Cable Cyclic Flexing Test
TIA-455-175-B	(2003) FOTP-175 IEC-60793-1-42 Optical Fibres - Part 1-42: Measurement Methods and Test Procedures - Chromatic Dispersion
TIA-455-177-B	(2003) FOTP-177 IEC-60793-1-43 Optical Fibres - Part 1-43: Measurement Methods and Test Procedures - Numerical Aperture
TIA-455-78	(2002B) FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures - Attenuation
TIA-526-14-A	(1998) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
TIA-526-7	(2002; R 2008) Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant OFSTP-7
TIA-568-C.1	(2009) Commercial Building Telecommunications Cabling Standard
TIA-568-C.3	(2008e1) Optical Fiber Cabling Components Standard
TIA-590-A	(1997) Standard for Physical Location and Protection of Below Ground Fiber Optic Cable Plant
TIA-758-A	(2004) Customer-Owned Outside Plant Telecommunications Cabling Standard
TIA/EIA-472DAAA	(1993) Detail Specification for All Dielectric Fiber Optic Communications Cable for Outside Plant Use Containing Class 1a 62.5 Um Core Diameter/125 um Cladding Diameter/250 um Coating Diameter Fiber(s).
TIA/EIA-4750000-C	(1996) Generic Specifications for Fiber Optic Connectors (ANSI)
TIA/EIA-526-14A	(1998) Optical Power Loss Measurements of Installed Multimode Fiber Cable

TIA/EIA-598-B	(2001) Optical Fiber Cable Color Coding
TIA/EIA-604-3A	(2000) FOCUS 3 Fiber Optic Connector Intermateability Standard

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-188-176	(Notice 1) Standardized Profile for Asynchronous Transfer Mode (ATM)
MIL-STD-2042	(Rev B; Notice 1) Fiber Optic Cable Topology Installation Standard Methods for Naval Ships

1.2 GENERAL REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to work specified in this section.

Fiber optic cable shall consist of optical fibers, strength members, and jacketing. Associated components shall include optical fiber connectors, optical patch panels, terminal bay cabinets, and splice closures as indicated. Install fiber optic cables in inner duct in the existing cable duct and manhole system and/or directly buried to the facility. Locate fiber optic terminal in existing facility buildings.

References in this section to cable shall refer to fiber optic cable.

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

Submit the following preconstruction submittals to the Contracting Officer for approval and approved 30 calendar days prior to installation.

Quality Assurance Plan

SD-02 Shop Drawings

Fiber Optic System; G

Identify the length, number of fibers, splice tray and termination panel locations, and the general routing for each application.

SD-03 Product Data

Submit manufacturer's product data for the following items. Data shall include a complete list of parts, special tools, and supplies with current unit prices and source of supply.

Fiber Optic Cable, including Media Types; G

Pre-Connected Cable Assembly

Splice Trays and Organizers; G

Fiber Optic Terminations and Connectors Material Data; G

SD-06 Test Reports

Submit contractor test reports for approval to the Contracting Officer not later than 14 calendar days after the completion of each test.

Single-mode and Multi-mode OTDR Test

End-to-End Attenuation Tests

End-to-End Bandwidth Tests

1.4 QUALITY ASSURANCE PLAN

Contractor shall prepare and submit a quality assurance plan which provides a detailed outline of all testing to be accomplished. Quality assurance plan shall address whether cladding modes have been stripped prior to testing, source wavelength (peak), spectral width full width/half maximum (FWHM), mode structure, fiber end preparation, and bandwidth measurements of fiber links both greater and less than 1 kilometer. Quality assurance plan shall include, as a minimum, a schedule of when tests will be performed relative to installation milestones, specific test procedure that will be used, a list of test equipment that will be used including manufacturer, model number, range, resolution accuracy and shall conform to the specified requirements.

Submit the test plan to the Contracting Officer for approval at least 30 calendar days before the start of testing.

1.4.1 Fiber Optic System

Provide drawings for the fiber optic cable and pathway system. Provide single line schematic details of the fiber optic and pathway media, splices, and associated construction materials. Drawings shall be in AUTOCAD.DXF or compatible format. Provide Registered Communications Distribution Designer (RCDD) approved drawings of the fiber optic system. Include drawing details of fiber optic terminations. System drawings shall show final configuration, including location, fiber pair count, pathway innerduct arrangement, and pathway assignment of outside plant. FO system shall be compatible with MIL-STD-188-176. Design Pier FO systems for compatibility with MIL-STD-2042 and NAVSEA drawings.

1.4.2 Fiber Optic Cable Installer and Splicer Qualifications

Technicians installing FO media, splices and performing system tests shall be certified and trained in accordance with an approved manufacturers training program. Technicians shall have a minimum of 5 years FO experience in installing equivalent FO systems. Submit FO technician qualifications for approval 30 days before splices are to be made on the cable. Certification shall include the training, and experience of the individual on specific type and classification of FO media to be provided under this contract.

1.4.3 Fiber Optic Field Tests Plan

Prepare and provide technicians and test equipment for field tests of FO media. Conduct OTDR reel tests at the job site prior to installation. Perform OTDR and end to end tests of all installed media. Conduct tests on single-mode fiber in accordance with TIA-526-7 for single-mode fiber and TIA/EIA-526-14A for multi-mode fiber.

1.5 DELIVERY, STORAGE, AND HANDLING

Ship media to job site on factory reels or in factory cartons. Radius of the reel drum shall not be smaller than the minimum bend radius recommended by the manufacturer for the media. Wind cable on the reel so that unwinding can be done without kinking the cable. Two meters of cable at each end of the reel must be readily accessible for testing. Provide a permanent label on each reel showing length, media, identification number, and date of manufacture. Provide water resistant label and ink on the labels. Apply end seals to each end of the media after testing and before terminating to prevent moisture from entering the cable while stored at the job site. 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 zero to 100 percent. Equipment, other than FO media, delivered and placed in storage shall be stored with protection from weather, humidity and temperature variation, dirt and dust, or other contaminants.

Exercise care in handling materials during construction. Contractor shall ensure that the buried cable is fed through the plow into the ground at zero tension. Do not allow tension to develop in the cable.

Whenever the plow is stopped, sufficient cable shall be unreeled to guard against sudden jerks when the plow is started.

Exercise caution to ensure that the plow is not backed up while the blade is in the ground. Cable can be severely damaged by the plow backing up even a slight amount. During the plowing operation, the plow may strike a buried object or rock that would stop the equipment and necessitate removal of the plow from the ground. When this occurs, remove the plow carefully without backing up. When it is necessary to back the plow, uncover the cable a sufficient distance back from the plow for inspection by the Contracting Officer to determine if there is any damage. Immediately report any damage to the Contracting Officer. Repair or replace damages as directed by the Contracting Officer.

1.6 RELATED REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to this section with additions and modifications specified herein.

PART 2 PRODUCTS

2.1 FIBER OPTIC CABLE DESIGN

2.1.1 Fiber Optic Media Types

FO media shall meet all performance requirements of TIA-568-C.1, TIA-568-C.3 and the physical requirements of ICEA S-87-640 and TIA/EIA-598-B.

2.1.1.1 Multi-Mode Fiber Media

Provide FO media with outer sheath jacket, strength member, ripcords, water blocking material, core tube, and core fibers as installed in a permanent underground pathway system as shown on the construction drawings. FO media shall have an all glass, graded index material with a nominal core diameter of 62.5 microns. Provide a cladding material for the fiber which is compatible with the core. Media transmission window shall be centered at 850 and 1300 nanometer wavelengths, attenuation at 1300 nanometers shall be less than 2.0 dB per kilometer. Minimum bandwidth shall be 500 mHz-Km.

2.1.1.2 Single-Mode Fiber Media

Provide FO single-mode media with outer sheath jacket, strength member, ripcords, water blocking material, core tube, and core fibers as installed in a permanent underground pathway system as shown on the construction drawings. Media shall have all glass, dual window, graded index material with a core diameter of 8.7 microns. Coat fiber with a cladding material which is concentric with the core. Fiber cladding diameter shall be nominal 125 microns. Media shall have a transmission window centered at 1300 and 1550 nanometer wavelengths, attenuation at 1550 nanometers shall be less than 0.5 dB per kilometer. FO media shall comply with TIA/EIA-472DAAA,and TIA-758-A.

2.1.2 Cable Length

Cable shall be manufactured continuous with no factory splices.

2.1.3 Materials and Construction

Materials used within a given cable shall be compatible with all other materials used in the same cable when such materials come into intimate contact. All cable components used shall have no adverse effect on optical transmission or on the mechanical integrity characteristics of the fiber placed in the cable. All materials used shall be non-toxic, non-corrosive, and present no dermal hazard.

Minimum required material components applied to fiber optic cable construction shall be central core member, color-coded optical fiber, color-coded loose tube buffer, with gel-free waterstop, inner jacket, pulling strength members, and outer jacket. Variations in sequence and construction structural components will be considered when necessary.

2.1.3.1 Central Core Member

Include a central core member to serve as a cable core foundation to reduce strain on the fibers but not to serve as a pulling strength member. Material of the central core member shall be non-metallic.

2.1.3.2 Optical Fibers

The cable may contain one of two types of optical fibers, single-mode fiber and multi-mode fiber, as specified. The optical fibers shall be as follows:

Single-Mode (SM) fiber must be the equivalent step index optical glass. Core diameter of the fiber shall be approximately 8.7 micrometer. Cladding diameter shall be 125 plus or minus 3 micrometer. Core cladding offset shall be less than 1 micrometer. Minimum tensile strength of the fiber after primary protective coating shall be greater than 50,000 psi. Softening point of the clad material of the optical fiber shall be 1630 degrees C plus or minus 50 degrees C in accordance

with ASTM C 338, or the optical fiber shall meet the requirements in paragraph entitled, "Splice Compatibility Test."

Multi-Mode (MM) fiber shall be the graded index optical glass. Core diameter of the fiber shall be 62.5 plus or minus 3 micrometer. Cladding diameter shall be 125 plus or minus 3 micrometer. Core-cladding offset shall be less than 3 micrometer. Minimum tensile strength of the fiber after primary protective coating shall be greater than 50,000 psi. Softening point of the clad material of the optical fiber shall be 1630 degrees C plus or minus 50 degrees C in accordance with ASTM C 338, or the optical fiber shall meet the requirements in paragraph entitled, "Splice Compatibility Test."

2.1.3.3 Fiber Primary Protective Coating

Coat optical fiber with suitable material to preserve the intrinsic high tensile strength of the glass fiber. Outside diameter of the coated optical fiber shall be 250 plus or minus 15 micrometer. Coating material shall be readily removable, mechanically or chemically, without damaging the optical fibers when the removal is desired.

2.1.3.4 Optical Fiber Color-Code Coating

Primary protective coated Single-Mode and Multi-Mode fibers shall be coated with a color-code coating for individual fiber identification. Maximum outside diameter of color-code coated fiber shall be less than 300 micrometer.

2.1.3.5 Loose Tube Buffering

Surround color-code coated fibers with a loose tube buffering for protection from external mechanical and environmental influences. Provide with gel-free waterstop material to prevent water migration. Color code loose tube buffering for the tube identification. Material of the buffering tube shall be PVC.

2.1.3.6 Colorants

Color concentrates or inks used to color code the optical fibers and the loose buffer tube shall not be susceptible to migration and chemical reaction with gel filling compound.

2.1.3.7 Number of Fibers Per Tube Per Cable

Unless otherwise indicated on the drawings, all cable shall contain 12-count of multi-mode fiber.

12-count cable shall be comprised of one loose buffer tube containing twelve fibers. The fibers shall be color coded using the standard Munsell color code, Blue, Orange, Green, Brown, Slate, White, Red, Black, Yellow, Violet, Rose, and Aqua.

2.1.3.8 Inner Jacket

Locate buffer tubes concentrically around the cable central core member and covered with a polyethylene inner jacket. Polyethylene inner jacket shall be high density polyethylene in accordance with ASTM D 4976. Space between the buffer tubes and inner jacket shall be filled with a gel-free compound to prevent air, moisture, or water intrusion in the inner jacket.

2.1.3.9 Pulling Strength Member

Use a dielectric type material as pulling strength members in the cable to provide pulling strength of at least 400 pounds for the cable during installation.

2.1.3.10 Cable Outer Jacket

Black high density, high-molecular weight, polyethylene materials in accordance with ASTM D 4976 shall be applied longitudinally over all the inner jacket and sheathing strength member to form the cable outer jacket. Outer jacket shall be smooth, concentric, non-nutrient to fungus, and free from holes, splits, blisters, or other imperfections. Overall outside cable diameter shall not exceed 0.75 inch.

2.1.3.11 Metallic Armor

Provide a metallic armor shield for direct buried cable for additional tensile strength, rodent protection, and high crush and moisture resistance. Material of the metallic armoring shall be metallic tube or steel corrugation-coated with anti-corrosion material, sealed at the longitudinal overlap.

2.2 CABLE IDENTIFICATION SYMBOL

First of three lines on the ID symbol employ 5 characters.

First and second characters, from left to right, shall denote the number of active optical fibers in the cable.

Third character shall be a slash.

Fourth and fifth characters shall denote optical transmission windows which the optical fiber can support. These windows are defined herein as follows:

Fourth character shall be an "A" or an "O." The "A" denotes a window at a wavelength of 850 nanometers (nm) with an attenuation of 4 dB/kilometer (km) and a bandwidth of 800 MHz-km. Character shall be an "O" if these requirements are not met.

Fifth character shall be a "B" or an "O." The "B" denotes a window at a wavelength of 1,300 nanometer (nm) with an attenuation of 1.0 dB/km and a bandwidth of 1,000 MHz-km. Character shall be an "O" if these requirements are not met.

Two lower lines of the cable ID symbol indicate multi-mode or single-mode fibers, the cable number and the fiber count:

Example: 72/OB	Identifies the number of optical fibers (72) and the optical transmission window (OB - See preceding paragraph).
FM05 : 61-120	Identifies Multi-Mode Fiber Cable 05 with MM Fibers 61 through 120.
and FS05 : 13-24	Identifies Single-Mode Fiber Cable 05 with SM Fibers 13 through 24.

2.3 REPLACEMENT CABLE

In addition to the cable sections indicated, a reel of each size and type of the manufacturer's furnished cable, provide not less than 0.5 kilometers.

2.4 SPLICE TRAYS AND ORGANIZERS

Single-mode or multi-mode fibers shall be fusion spliced with a protective sleeve covering and stored in an organizer with a minimum of 18 inches spare coiled buffer tubing. Single-mode fibers shall be spliced last in the splice tray.

Complete fiber splice of all fibers in the cable in an outer closure. Provide organizer assembly to hold the splice trays, each tray containing 12 fusion splices.

Fill space between the inner and outer closures with encapsulating fluid. Factory drill end plates to fit the cable(s) outer diameter.

2.5 PRE-CONNECTED CABLE ASSEMBLY

Contractor shall supply factory assembled pre-connectorized cable assembly to interface with the patch panel bulkhead feed-through receptacle. Contractor shall supply and install dust caps for all terminated fibers.

Multi-mode fiber optic cable assembly shall be comprised of a single fiber connector, terminated on three (3) meter length of single fiber, multi-mode cable. Single fiber cable shall contain a buffered optical fiber and be the same as that provided in the multi-fiber cable.

Single-mode fiber optic cable assembly shall be comprised of a single fiber connector terminated on the three (3) meter length of single fiber, single-mode cable. Single fiber cable shall contain a buffered optical fiber and be the same as that provided in the multi-fiber cable. Return loss for single-mode connectors shall be a minimum of minus 30dB.

Connector/cable interface on both the single and multi-mode cable assemblies shall be able to withstand a tensile force of 25 pounds without detrimental affects on the connector loss characteristics.

Each connectorized cable assembly shall have a loss of less than or equal to 0.5 dB.

2.6 OPTICAL AND MECHANICAL PERFORMANCE REQUIREMENTS

Fiber optical cable shall comply with the following optical and mechanical test requirements.

2.6.1 Optical Performance

2.6.1.1 Multi-Mode Fibers in the Cable

Optical attenuation of each optical fiber in the cable (reeled) shall be no greater than 1.0 dB/Km at 1300 plus or minus 50 nm optical spectrum window. Measure attenuation on completed cable reel length, and normalized linearly to 1 Km.

Bandwidth at minus 3 dB optical power of each optical fiber in the cable

(reeled) shall be a bandwidth length product, gamma equals 1, greater than 1 GHz-Km at 1300 plus or minus 50 nm optical spectrum window.

Numerical aperture of each optical fiber shall be 0.2 plus or minus 0.015 at 1300 nm optical spectrum window. Method of numerical aperture measurement shall be in accordance with TIA-455-177-B, at central wavelength 1300 nm nominal. When this requirement is not met, apply the fusion splice compatibility test.

2.6.1.2 Single-Mode Fibers in the Cable

Optical attenuation of each optical fiber in the cable (reeled) shall be no greater than 0.5 dB/Km at 1300 plus or minus 50 nm optical spectrum window. Measure attenuation on completed cable reel length, and normalized linearly to 1 Km. Measurement method shall be in accordance with TIA-455-78, at central wavelength 1300 nm nominal.

Pulse dispersion of each optical fiber in the cable (reeled) shall be no greater than 3.5 picosecond/nm-Km within the emissive region of 1285-1330 nm. Measurement method shall be in accordance with TIA-455-175-B.

Mode field diameter at 1300 nm optical spectrum window shall be within 10 plus or minus 1 micrometer. Measurement method shall be in accordance with EIA/TIA 455-165A at central wavelength 1300 nm nominal. When this requirement is not met, apply the fusion splice compatibility test.

Cut-off wavelength for 1300 nm optical spectrum window shall be within 1200 plus or minus 70 nm. Measurement method shall be in accordance with EIA 455-80C.

2.6.2 Mechanical Performance

2.6.2.1 Minimum Bend Radius

Cable shall be able to withstand bending to a minimum radius of 10 times the cable outer diameter without tensile load applied, and of 20 times the cable outer diameter with maximum tensile load applied (during installation), without damage to cable components or degradation of the optical fiber performance at room temperature.

2.6.2.2 Tensile Strength

Fiber optical cable shall withstand a pull force of at least 400 pounds to be applied to the pulling strength member during the installation, and a tensile load of at least 300 newtons during operation without incurring any damage or detriment to fiber optical cable and optical performance. Tensile strength test shall be in accordance with EIA 455-33B.

2.6.2.3 Flexing or Bending Cycles

Fiber optical cable shall withstand at least 20 bending cycles at minimum bend radius without damage to the fiber optic cable components or degrading optical performance. Cyclic flexing test shall be in accordance with TIA-455-104-A.

2.6.2.4 Crush Resistance

Minimum crush resistance of the fiber optical cable shall be greater than 650 newton/centimeter (cm) without damage to cable components or degrading

optical performance. Crush resistance test shall be in accordance with EIA 455-41A.

2.6.2.5 Impact Resistance

Fiber optical cable shall be capable of withstanding 20 impacts, at five newton-meters force, without damage to cable components, or degradation of optical performance. Impact resistance test shall be in accordance with EIA 455-25C.

2.6.2.6 Fluid Penetration

Optical cable shall be capable of preventing the entry and axial migration of pressurized water when subjected to fluid penetration testing in accordance with EIA 455-82B.

2.7 TEMPERATURE ENVIRONMENT

Fiber optical cable shall comply with the mechanical performance requirements herein while used in duct applications where the temperature varies from minus 8 degrees C to plus 38 degrees C. Optical performance degradation shall be less than five percent of the optical performance requirements in the temperature range of minus 20 degrees C to plus 60 degrees C. Do not damage fiber optical cable in storage where the temperature may vary from minus 40 degrees C to plus 65 degrees C.

2.8 SPLICE COMPATIBILITY TEST

When the material of the optic fiber is different from Cornings' Class Code No. 1517 for multi-mode graded index fiber and No. 1528 for single-mode fiber, perform and document the Splice Compatibility Test as follows:

Vendor shall select fiber samples from a minimum of 3 different production lots of the fiber type proposed for the job.

Vendor shall fabricate and measure a minimum of 10 fusion splices using fiber from the different production lots and a sample of Corning fiber, Class Code No. 1517 and No. 1528, supplied by the Government.

Measure fusion splices using an Optical Time Domain Reflectometer (OTDR) operating in the region of 1250 through 1350 nm. The insertion loss of the fusion splice shall be the average of two OTDR measurements, one taken with the OTDR installed on the Corning fiber, and the other with the OTDR installed on the vendor's fiber. Vendor's fiber and the Corning fiber shall each be a minimum of 1 Km in length throughout the testing.

Consider vendor's fiber compatible with the Corning fiber if the maximum splice insertion loss of each of 10 fusion splices tested measures less than 0.2 dB.

Vendor shall be allowed a maximum of three retries on any one splice to obtain a loss of 0.2 dB or less.

Perform these tests under Government supervision.

2.9 FIBER OPTIC TERMINATIONS AND CONNECTORS

FO connectors shall be ST type and comply with TIA/EIA-4750000-C and

TIA/EIA-604-3A.

2.10 PREPARATION FOR DELIVERY

Ship media on reels. Provide 6 1/2 feet pigtails on each end of media accessible for testing. Reel drum shall comply with manufacturers recommended bend radius for the media. Wind media on reel so that unreeling can be done without kinking the media. Attach a permanent waterproof label with indelible text on reel showing the length, media type, bandwidth, attenuation, and date of manufacture.

2.11 FACTORY REEL TEST

Test 100 percent OTDR test of FO media at the factory prior to shipment in accordance with TIA-568-C.1 and TIA-568-C.3. Use TIA-526-7 for single-mode fiber and EIA TIA/EIA-526-14A Method B for multi-mode fiber measurements. Calibrate OTDR to show anomalies of 0.2 dB minimum. Provide digitized or photographic traces to the Contracting Officer.

2.12 MISCELLANEOUS ITEMS

2.12.1 FO Media Tags

Provide stainless steel, 1 5/8 inches in diameter 1/16 inch thick, and circular in shape.

2.12.2 Buried Warning and Identification Tape

Provide color, type and depth of tape as specified in paragraph "Buried Warning and Identification Tape" in Section 31 00 00 EARTHWORK, FO media must be marked and protected as required by TIA-590-A.

2.12.3 Grounding Braid

Grounding braid shall provide low electrical impedance connections for dependable shield bonding. Make braid from flat tin-plated copper.

PART 3 EXECUTION

3.1 FIBER SPLICES

Outside plant fiber splices shall be fusion type and made along the fiber route. Splices shall exhibit an insertion loss not greater than 0.2 dB. Make all splice measurements at 1300 nm, plus or minus 5 nm. Mount all splices in trays. Do not increase number of splices.

Cover completed splice with a protective sleeve heat shrink type to restore the protective properties of the fiber coating and buffering. Deviations to the splice, location and pulling plan will be permitted, upon approval by the Contracting Officer, and shall be provided at no additional cost to the Government.

All fiber colors shall be continuous from end to end. No switching or staggering of color scheme within the cable at splice points shall be allowed. Splice fibers in order with multi-mode fibers identified first and single-mode fibers at the end.

Bring cables out of the manhole in a controlled environment to perform the fiber fusion splice operation. Complete splice by returning the cable to

the manhole such that the excess cable does not impede future entrance and utilization. Secure cable at regular intervals.

3.2 INSTALLATION

Install and test the FO media in accordance with contract drawings, specifications, IEEE C2, NFPA 70, and TIA-590-A. Provide all necessary power, utility services, technicians, test equipment, calibration equipment as required to perform reel and final acceptance tests of the media. All media which fail the factory or reel tests or final acceptance field tests shall be replaced and re-tested at the contractors expense. Splices are not permitted unless shown on the construction drawings. Field test splices within 24 hours after splice installation. Test splices to demonstrate a maximum 0.2 dB loss. Provide a splice box for each field splice. Provide a minimum of 2 meters for routing and testing media. Protect media ends of unspliced FO media during splicing operations.

3.2.1 Contractor Damage

Promptly repair indicated utility and communications lines or systems damaged during site preparation and construction. Damage 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 non-indicated 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.

3.3 BURIED CABLE INSTALLATION

3.3.1 Location

Location of the cable splice overlaps shall be as indicated. Contractor shall ensure that all cable ends are sufficiently long before cutting.

3.3.2 Field Staking

When staking the cable plow or trench line, place stakes at least every 100 feet in level country and more frequently in rolling country or in dense vegetation, so that the construction force can sight at least two successive stakes at all times. Stakes should be placed at changes in direction, the beginning and end of all turns should be staked clearly. Where existing buried cable is encountered within 2 feet of the proposed line, decrease the distance between stakes to a minimum of 10 feet. When possible, stakes should project above the vegetation along the line. When a road or other crossings are involved, stakes should be placed at both extremes of the right-of-way.

A stake, with the appropriate number or explanation noted on it, should be used to show the location of each caution point, such as underground utility crossings and culverts; miscellaneous points, such as physical cable protection; and buried cable warning sign locations.

3.3.3 Method of Cable Placement

All direct buried cable shall have a warning tape placed above it as indicated.

Depth of buried cable in soil measured from the top of the cable to the

surface of the ground shall be a minimum of 36 inches. When existing utilities are crossed, use hand excavation at a distance of no less than 4 feet on each side of the utility.

3.3.3.1 Open Trench Method

Contractor shall observe the following when placing cable by the open trench method:

Trench shall be free of all rock and debris.

Pull cable from cable reel truck or dolly and place in the trench by hand.

Place cable in trench as soon as practical and backfilled immediately to avoid cave-in, and ensure safe operational conditions.

An inspector shall walk closely behind the cable reel dolly and ensure that the cable lies flat on the trench bottom, and is placed at the required minimum depth.

Pull cable by hand on each end simultaneously, to remove excess slack, prior to backfilling.

Backfill trench in 6-inch lifts to ensure proper fill. Each backfill lift shall be compacted with hand tamp tools. First lift shall be hand tamped prior to placing the cable.

3.3.3.2 Direct Plow Method

Contractor shall observe the following when placing cable by the direct plow method:

Plow shall be clear of any obstruction which may damage cable and ensure that all rollers on the tractor and on the plow turn freely and are properly located.

Cable shall be hand fed off the reel at all times to ensure that no damage is done to the cable due to excess tension.

An inspector shall walk closely behind the plow and inspect the cable for any blemish or damage, and ensure a free and continuous flow of the cable from the reel to the plow. Inspector shall ensure that the cable is plowed at the minimum required depth.

3.3.4 Compaction

Plow slot shall be compacted following the plowing in or trenching of wire or cable.

3.4 UNDERGROUND CABLE INSTALLATION

Inner duct assignment of individual cables shall be as indicated. Do not place cables in ducts other than those specified.

Exercise adequate care when handling and storing reels of cable to prevent damage to the cable. Cable with dents, flat spots, or other sheath distortions shall not be installed.

3.4.1 Securing Cable

Immediately after cable placement, attach a permanent identification tag as indicated to visible cable sections. Check cables to ensure that the markings are intact.

Support and secure cables and equipment as indicated. Where the specific method of support is not shown, supports and fasteners shall be used to secure cables and equipment in position. Metallic supports and fasteners shall have a corrosion resistant finish. Rout all cables along the interior sides of manholes.

Two or more cable hooks shall be required per manhole.

Use clamps and straps as necessary to properly secure the cable.

3.4.2 Bending

Use caution when bending cable to avoid kinks or other damage to the sheath. Bend radius shall be as large as possible with a minimum of 10 inches. Increase minimum radius when necessary to meet cable manufacturer's recommendation. Do not rest cables against any sharp edges.

Pull and splice cable in the manner and at the locations shown.

3.4.3 Pulling

Attach pulling lines to both cable ends when cable is destined for bi-directional pull, and fitted with factory-installed pulling eyes. Cables not equipped with a pulling eye shall have the pulling line attached to the cable end by means of a cable grip. Do not use core hitches.

Locate and align cable reels so that the cable is paid out from the top of the reel into the duct or conduit in a long, smooth bend without twisting. Do not pull cable from the bottom of the reel. Use a cable feeder guide of proper dimensions at the mouth to guide the cable into the duct or conduit.

Rigging shall be set up at the pulling end so that the pulling line and cable exit on a line parallel with the duct or conduit to prevent either from rubbing against the edge or mouth. Do not pull cable ends around sheave wheels. When the sheave or pulley cannot be positioned to obtain sufficient cable end slack for proper racking and splicing with the pulling line attached to the end of the cable, a split cable grip may be used to obtain the necessary slack.

3.4.4 Lubricant

Pulling lubricant shall be used to minimize pulling tension and prevent sheath damage when pulling cables into ducts and conduits. Apply lubricant to the cable sheath with a lubricator. When pulling has been completed, the exposed cable ends shall be wiped clean of lubricant.

Lubricants shall be compatible with and intended for use with plastic-sheathed cables. Do not allow soap and grease type lubricants.

All equipment and the pulling set shall be checked to minimize interruptions once pulling begins. Pull cable without stopping until the required amount of the cable has been placed. When the pulling operation is halted before the pull is completed, the tension of the pulling line

shall not be released. When pulling is resumed, the inertia of the cable shall be overcome by increasing the tension in small steps a few seconds apart until the cable is in motion. Cable shall be paid from the top of the reel by rotating the reel in the feed direction at the rate of pull. Cable shall not be stripped off the reel by pulling.

3.4.5 Damage and Defects

Contractor shall use a tension monitoring device to ensure that the maximum pulling tension that may be applied to the cable to be pulled into a conduit section is not exceeded. Any damage to the cable due to exceeding the maximum tension will require a new cable furnished by the Contractor.

Carefully inspect cable for sheath defects or other irregularities as it is paid out form the reel. When defects are detected, pulling shall stop immediately and the cable section shall be repaired or replaced at the discretion of the Contracting Officer. Maintain a system of communications between pulling and feed locations so that pulling can be stopped instantly, when required.

Hand guide cable through intermediate manholes and into the next duct section when making pull-throughs. Use proper rigging in the intermediate manhole to keep the pulling line and cable aligned with the exit duct to prevent the line or cable from rubbing against the edge of the duct. Cables in pull-through manholes shall be set up and racked before the cable ends in adjacent manholes are set up and racked.

Cable ends pulled into manholes, vaults, or terminal locations that are not to be racked or otherwise permanently positioned immediately shall be tied in fixed positions to prevent damage to the cables and provide adequate working space.

3.4.6 . Seal

Ducts or innerduct in which cable is placed shall be sealed with urethane foam duct seal. Insert this material between the cable and the duct or innerduct of which it is in, between the innerduct and the duct, and in all unused innerduct, in order to prevent damage to the cable sheath and to prevent the entrance of dirt or water into the manhole or vault.

Provide cables in continuous lengths as required to accomplish the required installation without splices from termination to termination, except where field splices are specifically shown.

3.5 CABLE INSTALLATION IN CABLE TRAYS

Do not install communication cables in the same cable tray with ac power cables.

Cables placed in cable trays shall be installed in a neat and orderly manner and shall not cross or interlace other cables except at breakout points.

Individually retain cables in vertical trays with straps at a maximum of 6 feet on center.

3.6 GROUNDING SYSTEMS

Ground cables at each termination point or as indicated.

3.7 DIRECT BURIAL SYSTEM INSTALLATION

Installation shall be in accordance with TIA-590-A. Under railroad tracks, paved areas, and roadways install cable in conduit encased in concrete. Slope ducts to drain. Excavate trenches by hand or mechanical trenching equipment. Provide a minimum cable cover of 24 inches below finished grade. Trenches shall be not less than 6 inches wide and in straight lines between cable markers. Do not use cable plows. Bends in trenches shall have a radius of not less than 36 inches. Where two or more cables are laid parallel in the same trench, space laterally at least 3 inches apart. When rock is encountered, remove it to a depth of at least 3 inches below the cable and fill the space with sand or clean earth free from particles larger than 1/4 inch. Do not unreel and pull cables into the trench from one end. Cable may be unreeled on grade and lifted into position. Provide color, type and depth of warning tape as specified in Section 31 00 00 EARTHWORK.

3.7.1 Media Placement

a. Separate FO media crossing other cables or metal piping from the other cables or pipe by not less than 3 inches of well tamped earth. Do not install FO media under or above traffic signal loops.

b. Media shall be in one continuous length without splices except where splices are shown on the drawings.

c. Do not allow bends in media which exceed the manufacturers minimum recommended radii. Do not bend media to a radius less than 10 times the outside diameter of the media.

d. Leave a horizontal slack of approximately 3 feet in the ground on each end of cable runs, on each side of connection boxes, and at points where connections are brought above ground. Where cable is brought above ground, leave additional slack to make necessary connections.

3.7.2 Identification Slabs (Markers)

Provide a marker at each change of direction of the cable, over the ends of ducts or conduits which are installed under paved areas and roadways and over each splice. Identification markers shall be of concrete, approximately 20 inches square by 150 mm 6 inches thick and stake mounted warnings meeting the requirements of REA.

3.8 RECONDITIONING OF SURFACES INSTALLATION

3.8.1 Unpaved Surface Treatment

Restore unpaved surfaces disturbed during the installation of direct burial cable to their original elevation and condition. Carefully preserve existing sod and topsoil and replace after the back-filling is completed. Replace damaged sod with sod of quality equal to that removed. Where 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.

3.9 CABLE PULLING

Test duct lines with a mandrel and swab out to remove foreign material before the pulling of FO media. Avoid damage to cables in setting up pulling apparatus or in placing tools or hardware. Do not step on media when entering or leaving the maintenance holes. Do not place media 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 media reels on the same side of the maintenance hole as the pathway section in which the media is to be placed. Level the reel and bring into proper alignment with the pathway section so that the media pays off from the top of the reel in a long smooth bend into the duct without twisting. Under no circumstances shall the media be paid off from the bottom of the reel. Check the equipment set up prior to beginning the media cable pulling to avoid an interruption once pulling has started. Use a cable feeder guide of suitable dimensions between media reel and face of duct to protect media and guide cable into the duct as it is paid off the reel. As media is paid off the reel, lubricate and inspect media for sheath defects. When defects are noticed, stop pulling operations and notify the Contracting Officer to determine required corrective action. Stop media pulling if reel binds or does not pay off freely. Rectify cause of binding before resuming pulling operations. Provide media lubricants recommended by the cable manufacturer. Provide 3.3 feet of spare media in all manholes and enclosures for final termination and testing.

3.9.1 FO Media Tensions

Install FO media as shown on construction drawings. Provide devices to monitor media tension during installation. Do not exceed manufacturers recommended maximum FO tensions and bending radii during installation.

3.9.2 Pulling Eyes

Equip media 1-1/4 inches in diameter and larger with cable manufacturer's factory installed pulling-in eyes. Provide media with diameter smaller than 1-1/4 inches with heat shrinkable type end caps or seals on cable ends when using cable pulling grips. Do not beat rings to prevent grip from slipping into the cable sheath. Use a swivel grip of 3/4 inch links between pulling-in eyes or grips and pulling strand.

3.9.3 Installation of Media in Maintenance Manholes, Handholes, and Vaults

Do not install media 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 media on brackets and cable insulators at a maximum of 4 feet. In existing maintenance manholes, handholes, and vaults where new ducts are to be terminated, or where new media are to be installed, modify the existing installation of media, cable supports, and grounding as required with cables arranged and supported as specified for new media.

3.10 GROUNDING

Ground exposed non current carrying metallic parts of telephone equipment, media sheaths, media splices, and terminals.

3.11 HOUSEKEEPING

The Contractor shall be responsible for cleaning up work area and

maintaining the work area in orderly condition.

3.12 CABLE DELIVERY

Deliver replacement cable reels to the Government as directed by the Contracting Officer.

3.13 TESTING

As a minimum, the Contractor shall test each fiber cable before and after installation for any faults or attenuations using an Optical Time Domain Reflectometer (OTDR). End-to-end attenuation tests shall also be conducted after complete installation.

All test equipment, test procedures, and testing techniques shall be specified in the quality assurance plan and will require approval prior to execution. Tests shall be conducted by the Contractor in accordance with the approved Quality Assurance Plan. Field tests shall be witnessed by the Contracting Officer. Contracting Officer shall be given at least 20 calendar days notice prior to performing each test.

Each test sheet shall have a sign-off blank for the Contractor as well as the Contracting Officer. Deliver copies of the completed test forms and test results as indicated.

Sequential cable markings along the cable, prior to and after each end of splice point, shall be recorded on the sequential cable form and submitted for approval.

Submit test results on all installed fiber cabling before and after each pre-connectorized cable assembly splice is completed.

Contractor shall maintain an accurate test record during all field tests.

3.13.1 Field Reel Tests

Perform the following tests on FO media at the job site before it is removed from the cable reel. For cables with factory installed pulling eyes, perform these tests at the factory and certified test results shall accompany the media. Perform OTDR tests with media on reels and compare factory and field test data.

3.13.1.1 Reel Test Results

Provide results of reel tests to the Contracting Officer at least 5 working days before installation is to commence. Results shall indicate reel number of the media, manufacturer, type and number of fiber tested, and recorded readings. When reel tests indicate that the media does not comply with factory reel test results remove the media from the job site and replace with compliant media.

3.13.2 Final Acceptance Tests

Perform end-to-end tests including power meter light source and OTDR tests. Perform OTDR measurements as required by TIA-568-C.1 and TIA-568-C.3. Test single-mode fiber in accordance with TIA-526-7 (Optical Power Loss). Test multi-mode fiber in accordance with TIA-526-14-A(Optical Power Loss).

3.13.2.1 Test Results

Provide results of final acceptance tests (attenuation tests, OTDR traces, etc.), to the Contracting Officer at least 5 working days after completion of tests.

3.14 TEST REQUIREMENTS

Test equipment used for verifying installation testing shall be calibrated by a certified testing company within 3 weeks of use.

3.14.1 Single-mode and Multi-mode OTDR Test

The Optical Time Domain Reflectometer (OTDR) shall conform to the following minimum requirements:

Operating wavelengths: 1,300 plus or minus 20 nanometers

Attenuation Range (one way): minimum 15 dB at 1,300 nm

Attenuation Resolution: 0.01 dB

Accuracy: plus 0.5 dB.

OTDRs shall have digital readout capability and shall have a means of providing a permanent record in the form of a strip chart.

3.14.2 End-to-End Attenuation Tests

An attenuation measurement test set shall consist of an optical power meter and an optical power source. Attenuation measurement test set shall be in accordance with the applicable National Bureau of Standards (NBS) standards for a stable optical source.[6] Meter may be analog or digital. Include end-to-end attenuation test reading on the test reference loss. Measurement test set shall conform to the following minimum requirements:

Operating wavelengths: 1,300 plus or minus 10 nanometers

Attenuation Range: at least 30 dB at 1,300 nm

Attenuation Resolution: 0.01 dB

Accuracy: The accuracy of the attenuation measurement test set shall be plus or minus 5 percent.

Optical source shall be capable of coupling sufficient power into the fiber so that the light received at the meter is within the meter delectability limits.

3.14.3 End-to-End Bandwidth Tests

Bandwidth test shall conform to the following minimum requirements:

Operating wavelengths: 1,300 plus or minus 10 nanometers

Bandwidth range: minimum 1000 megahertz

Bandwidth Resolution: 1 megahertz

Accuracy: plus or minus 0.5 megahertz

Measurement Method: Swept Frequency

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 28 - ELECTRONIC SAFETY AND SECURITY

SECTION 28 05 26.00 40

GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY

PART 1 GENERAL

1.1 REFERENCES
1.2 GENERAL REQUIREMENTS
1.3 SUBMITTALS
1.4 DRAWINGS

PART 2 PRODUCTS

2.1 GROUND RODS
2.2 GROUND WIRES
2.3 CONNECTORS AND FASTENERS

PART 3 EXECUTION

3.1 BONDING AND GROUNDING
3.2 GROUNDING ELECTRODES
3.3 GROUND GRIDS
3.4 BUILDING GROUNDS
3.5 EQUIPMENT GROUNDING
3.6 GROUNDING CONNECTIONS
3.7 BONDING
3.7.1 Type of Bonds
3.7.1.1 Brazing
3.7.1.2 Welding
3.7.1.3 Clamping
3.7.1.4 Structural Joining Methods
3.7.2 Cleaning of Bonding Surfaces
3.7.3 Bonding Straps and Jumpers
3.7.4 Equipment and Enclosure Bonding
3.7.5 Bonding of Conduit and Raceway Systems
3.7.5.1 Rigid Metal Conduit and Terminations
3.7.5.2 Flexible Metal Conduit
3.7.6 Cable Tray Bonding
3.7.7 Protection of Finished Bonds
3.8 FIELD TESTS
3.8.1 Bond Resistance Test
3.8.2 Ground Resistance Tests
3.8.3 Ground Isolation Test
3.8.4 Continuity Isolation Test

-- End of Section Table of Contents --

SECTION 28 05 26.00 40

GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2004) Specification for Filler Metals for Brazing and Braze Welding

ASTM INTERNATIONAL (ASTM)

ASTM B3	(2001; R 2007) Standard Specification for Soft or Annealed Copper Wire

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; TIA 11-1; Errata 2011) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-889	(1988; Rev B; Notice 2 1988; Notice 3 1993) Dissimilar Metals

UNDERWRITERS LABORATORIES (UL)

UL 467	(2007) Grounding and Bonding Equipment

1.2 GENERAL REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to work specified in this section.

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

Submit material, equipment, and fixture lists for Grounding Systems including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

SD-02 Shop Drawings

Submit Record Drawings in accordance with paragraph entitled, "Drawings," of this section.

SD-03 Product Data

Submit equipment and performance data for the following items including life, test, system functional flows, safety features, and mechanical automated details.

Submit Manufacturer's catalog data for the following items:

Ground Rods

Ground Wires

Connectors and Fasteners

Bonding

SD-06 Test Reports

Submit Test Reports for the following tests on grounding systems in accordance with the paragraph entitled, "Field Tests," of this section. Within the report include certified record of ground-resistance tests on each driven ground rod, ground rod assembly, and other grounding electrodes. Include within the record the number of rods driven and their depth at each location to meet the required resistance-to-ground measurements specified. Include a statement describing the condition of the soil at the time of measurement.

Bond Resistance Test

Ground Resistance Tests

Ground Isolation Test

Continuity Isolation Test

SD-08 Manufacturer's Instructions

Submit Manufacturer's instructions for the Grounding Systems including special provisions required to install equipment components and system packages. Within special notices, detail impedances, hazards and safety precautions.

1.4 DRAWINGS

Record Drawings must indicate the location of ground rods, mats, grids, building ground bus, supplementary grounding electrodes, steel building columns, and other metal structures connected to the grounding system.

Identify the location of each ground rod and ground-rod assembly and other grounding electrodes by letter in alphabetical order and keyed to the record of ground-resistance tests.

PART 2 PRODUCTS

2.1 GROUND RODS

Ground rods must conform to the requirements of NFPA 70.

Ground rods must be copper-clad steel rods not less than 3/4 inch in diameter and not less than 10-feet long per section. Ground rods must be clean and smooth and have a cone-shaped point on the first section and be die-stamped near the top with the name or trademark of the manufacturer and the length of the rod in feet.

2.2 GROUND WIRES

Ground wires must be in accordance with Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL.

Ground and bond wires for substations, main panels and distribution points, and ground rod connections must be annealed bare copper conforming to ASTM B3, stranded, with 98 percent conductivity. Wire size must be in accordance with the grounding requirements of NFPA 70.

Ground wires for equipment receptacles for noncurrent carrying hardware, installed in conduit must be soft drawn copper, in accordance with ASTM B3, stranded, with green insulation. Note wire size.

2.3 CONNECTORS AND FASTENERS

Grounding and bonding fasteners and connectors must conform to the requirements of UL 467, and Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL.

Grounding and bonding fasteners must be copper.

Bonding straps and jumpers must be copper and have a cross-sectional area of not less than No. 6 AWG.

PART 3 EXECUTION

3.1 BONDING AND GROUNDING

Bonding and grounding requirements must be in accordance with NFPA 70.

3.2 GROUNDING ELECTRODES

Grounding electrodes must include ground rods installed expressly for grounding systems.

Minimum ground rod section must be 10 feet. Thread sections together and exothermically fusion weld.

Install ground rods so that the top of the rod is not less than 18 inches below finished grade.

3.3 GROUND GRIDS

Ground grids must consist of a series of ground rods installed with interconnecting grounding conductors between ground rods. Space ground rods as noted.

Do not bury ground grid less than 18 inches below the finish grade. Grounding conductors must not be less than No. 4/0 AWG and must be exothermically fusion welded together at crossover points and to ground rods.

3.4 BUILDING GROUNDS

Steel framework of the building must be grounded with a driven ground rod at the base of every corner column and intermediate exterior columns at distances not greater than 60-feet apart. Electrically connect grounding conductor to each ground rod and to each steel column and extend around the perimeter of the building. Grounding-conductor loop around the perimeter of the building must not be less than No. 4/0 AWG. Tap connections from the ground loop to the building steel must not be less than No. 4/0 AWG.

Bury building ground no less than 18 inches below grade and 2 feet from the building foundation. Interconnecting grounding conductor between ground grid and building grounds must not be less than No. 4/0 AWG.

3.5 EQUIPMENT GROUNDING

Metallic raceway systems must have electrical continuity with equipment individually and be directly connected to the building ground, independent of the raceway system.

Individually and directly connect enclosures for panelboards to the building ground. Grounding conductor must not be less than No. 2 AWG and be connected from the building ground to a copper ground-bus terminal strip located in each panelboard.

Polarized receptacles, lighting fixtures, and equipment enclosures must be grounded with an identified (green color) insulated conductor, not smaller than No. 12 AWG, connected to the branch circuit ground-bus terminal strip. Ground-bus terminal strip in each panelboard enclosure must be isolated and independent of the system neutral terminal strip.

Indoor transformers, motors, motor control centers, air compressors, air handlers, and generators must be individually and directly connected to the building ground. Current-carrying capacity of the grounding conductor must be the same as the current-carrying capacity of the power conductors for circuits utilizing power lines size No. 2 AWG and smaller. For circuits with power wiring larger than No. 2 AWG, the grounding conductor must be in accordance with NFPA 70, except that the grounding conductor must not be smaller than No. 2 AWG.

Noncurrent carrying metallic parts of electrical equipment, including metallic cable sheaths, conduit, raceways, and electrical structural members, must be bonded together and connected to the ground grid or ground connection rods.

Install secure ground systems for power and instrumentation. Independently connect each system to the building counterpoise as shown.

Secure ground systems must consist of unspliced ground wires in individual

welded or epoxied conduit runs from the secure area to the building counterpoise. Welding and epoxying must conform to Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL.

3.6 GROUNDING CONNECTIONS

Ground connections must be bonded connections in accordance with paragraph entitled, "Bonding," of this section.

Weld ground connections that are buried or in inaccessible locations.

Bolt connections in accessible locations. Connections to steel building columns in accessible locations must be cast-copper-alloy clamp lugs exothermically fusion-welded to the structure.

Clean, grease, and remove foreign matter from ground connection surfaces. Do not penetrate clad material in the cleaning process. Make connection between like metals where possible. Where dissimilar metals are welded, brazed, or clamped, follow the weld kit manufacturer's instructions. Connections between dissimilar metals must not produce galvanic action in accordance with MIL-STD-889.

3.7 BONDING

3.7.1 Type of Bonds

Accomplish bonding of metal surfaces by welding.

3.7.1.1 Brazing

Brazing solder must conform to AWS A5.8/A5.8M.

3.7.1.2 Welding

Welding must be by the exothermic process. Within the welding procedure, include the proper mold and powder charge and conform to the manufacturer's recommendations.

Welding processes must be of the exothermic fusion type that will make a connection without corroding or loosening. Process must join all strands and not cause the parts to be damaged or weakened. Completed connection or joint must be equal or larger in size than the conductors joined and have the same current-carrying capacity as the largest conductor. Paint buried ground connections with a bitumastic paint.

3.7.1.3 Clamping

In external locations, use clamping only where a disconnect type of connection is required. Connection device may utilize threaded fasteners. Construct device such that positive contact pressure is maintained at all times. Use machine bolts with tooth-type lockwashers.

3.7.1.4 Structural Joining Methods

Consider joints made with high-strength structural bolts, and clean unpainted faying surfaces sufficiently bonded. Install a jumper across the joint in the form of a No. 4 AWG bare copper wire exothermically welded at each end to the surfaces involved spanning the connection wire jumpers used across joints employing miscellaneous machine bolts.

3.7.2 Cleaning of Bonding Surfaces

Thoroughly clean surfaces that comprise the bond before joining. Apply an appropriate abrasive with gentle and uniform pressure to ensure a smooth and uniform surface. Do not remove excessive metal from the surface. Clean clad metals in such a manner that the cladding material is not penetrated by the cleaning process. Then clean bare metal with an appropriate solvent to remove any grease, oil, dirt, corrosion preventives, and other contaminants. Bond to the cleaned area must be made within one hour after cleaning. Seal joint and refinish the exposed surfaces within two hours of exposure to prevent oxidation. When additional time is required, apply a corrosion preventive compound until the area can be refinished.

3.7.3 Bonding Straps and Jumpers

Install jumpers such that the vibration by the shock-mounted device will not change its electrical characteristics.

Weld bonds for outdoor locations unless a disconnect type of connection is required. When a disconnect is required, use clamping with bolts. Insert a tooth-type lockwasher between the strap and metallic member for each bolt.

Bond straps directly to the basic structure and do not penetrate any adjacent parts. Install straps in an area that is accessible for maintenance.

Use single straps for the bonds and install such that they will not restrict movement of structural members. Do not connect two or more straps in series.

Install straps such that they will not weaken structural members to which they are attached.

3.7.4 Equipment and Enclosure Bonding

Each metallic enclosure and all electrical equipment must be bonded to ground. At least one copper connection must be made from the system ground point to one or more enclosures in the area such that all enclosures and equipment provide a low-impedance path to ground when properly bonded together.

3.7.5 Bonding of Conduit and Raceway Systems

Bond all metal conduit, fittings, junction boxes, outlet boxes, armored and metal sheathed cable, and other raceways. Take care to ensure adequate electrical contact at the joints and terminations.

3.7.5.1 Rigid Metal Conduit and Terminations

Threaded connections must be wrench-tight and there must be no exposed threads. Ream all ends of the conduit to remove burrs and rough edges. Conduits entering boxes and enclosures must be bonded to the box with locknuts and grounding-type bushings. Locknuts that gouge into the metal box when tightened are not acceptable.

Conduit systems that are interrupted by PVC dielectric links must be bonded separately on either side of the link. Dielectric link must not be

jumpered.

3.7.5.2 Flexible Metal Conduit

Flexible conduit must have an integral grounding conductor.

3.7.6 Cable Tray Bonding

Bond cable tray sections together. Cable tray sections in tandem assembly must be considered as having electrical continuity when these sections are bonded with the appropriate bolts. Install bond straps across expansion joints. Bond cable trays to the building ground system.

3.7.7 Protection of Finished Bonds

Protect finished bonds by painting to match the original finish after the bond is made.

3.8 FIELD TESTS

Perform the following tests in the presence of the Contracting Officer.

3.8.1 Bond Resistance Test

Resistance of any bond connection must not exceed 0.5 milliohm. Rework bonds that exceed this resistance at no additional cost to the Government.

3.8.2 Ground Resistance Tests

Test Grounding systems for ground resistance. Total resistance from any point on the ground network to the building counterpoise must not exceed 50 milliohms.

Ground resistance and counterpoise tests must be made during dry weather, and no sooner than 48 hours after rainfall. Conduct tests using the ratio method that measures the ratio of the resistance to earth of an auxiliary test electrode to the series resistance of the electrode under test and a second auxiliary electrode. Perform measurements in accordance with IEEE 81.

Indicating instrument must be self-contained and include a direct-current generator, synchronized current and potential reversers, crossed-current and potential coils, direct-reading ohmmeter, series resistors, and range-selector switch. Calibrate direct-reading ohmmeter for ranges of 0 to 20 ohms and 0 to 200 ohms.

Place auxiliary grounding electrodes in accordance with instrument manufacturer's recommendations but not less than 50 feet apart, in accordance with IEEE 81.

3.8.3 Ground Isolation Test

Test ground systems for isolation from other ground systems.

3.8.4 Continuity Isolation Test

Perform continuity test on all power receptacles to ensure that the ground terminals are properly grounded to the facility ground system.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 28 - ELECTRONIC SAFETY AND SECURITY

SECTION 28 31 00.00 98

FIRE DETECTION AND ALARM

PART 1 GENERAL

1.1 REFERENCES
1.2 SUBMITTALS
1.3 GENERAL REQUIREMENTS
1.4 SYSTEM REQUIREMENTS
1.5 QUALITY ASSURANCE PLAN
1.6 SERVICES OF A CERTIFIED FIRE ALARM SPECIALIST

PART 2 PRODUCTS

2.1 FIRE ALARM CONTROL PANEL
2.2 CRMS REPORTING EQUIPMENT
2.2.1 FACP Reporting
2.2.2 Radio Based FACP Reporting
2.3 SMOKE DETECTORS
2.4 MANUAL ALARM STATIONS
2.5 ALARM BELLS
2.6 STROBE UNITS
2.7 WATER FLOW ALARM DEVICES
2.8 VALVE TAMPER SWITCHES
2.9 REMOTE AUXILIARY CONTROL RELAYS
2.10 POWER SOURCE
2.11 WIRING
2.12 SURGE SUPPRESSORS
2.12.1 Line Voltage Surge Suppressors
2.12.2 Low Voltage Surge Suppressors

PART 3 EXECUTION

3.1 SYSTEM SEQUENCE OF OPERATION
3.1.1 Normal Operation
3.1.2 Supervisory Condition
3.1.3 Trouble Condition
3.1.4 Alarm Condition
3.2 INSTALLATION
3.2.1 Fire Alarm Control Panel(s) and Reporting Equipment
3.2.2 Smoke Detectors
3.2.3 Manual Pull Stations (Fire Alarm Boxes)
3.2.4 Alarm Bells
3.2.5 Strobe Units/Combination Audio Visual
3.2.6 Auxiliary Control Relays
3.2.7 Wiring (Wire and Multi-Conductor Cable)
3.2.7.1 60-Hertz Power
3.2.7.2 Installation in Cabinets and Boxes
3.2.8 Conduit and Raceways

3.3 FIELD TESTING
3.3.1 External System Wiring
3.3.2 Fire Alarm System Acceptance Test Procedures (For Both Preliminary and Final Tests)
3.4 OPERATION AND MAINTENANCE MANUALS
3.5 PAINTING

-- End of Section Table of Contents --

SECTION 28 31 00.00 98

FIRE DETECTION AND ALARM

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S1.4a	(2006) American National Standard Specification for Sound Level Meters
ANSI S3.41	(2008) American National Standard Audible Emergency Evacuation Signal

FM GLOBAL (FM)

FM P7825	(2009) Approval Guide

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41	(1991; R 1995) Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits

JOHN F. KENNEDY SPACE CENTER (KSC)

KSC-STD-F-0004F	(2010) Fire Protection Design, Standard for

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2012; Amd 09-1 & 09-2) Life Safety Code
NFPA 70	(2011; TIA 11-1; Errata 2011) National Electrical Code
NFPA 72	(2010; TIA 10-4) National Fire Alarm and Signaling Code
NFPA 75	(2009) Standard for the Protection of Information Technology Equipment
NFPA 90A	(2012) Standard for the Installation of Air Conditioning and Ventilating Systems

NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES (NICET)

NICET 1016-2	(2007) Program Detail Manual Fire Alarm Systems, 8th Edition

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-595	(Rev C, 2008) Colors Used in Government Procurement

UNDERWRITERS LABORATORIES (UL)

UL 1449	(2006; Rev thru Sep 2009) Surge Protective Devices
UL 1971	(2002; Rev thru Oct 2008) Signaling Devices for the Hearing Impaired
UL 268	(2009) Standard for Smoke Detectors for Fire Alarm Signaling Systems
UL 346	(2005) Waterflow Indicators for Fire Protective Signaling Systems
UL 38	(2008; Rev thru Dec 2008) Standard for Signaling Boxes for Fire Alarm Systems
UL 464	(2009) Standard for Audible Signal Appliances
UL 497B	(2004; Rev thru Oct 2008) Protectors for Data Communication and Fire Alarm Circuits
UL 2196	(2006) UL Standard for Tests for Fire Resistive Cables, 1st Edition
UL Fire Prot Dir	(2011) Fire Protection Equipment Directory

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-01 Preconstruction Submittals

Submit Evidence of the Contractor's State Certification to the Contracting Officer for approval, prior to any work being started on the Fire Alarm System, in accordance with paragraph entitled "Services of a Certified Fire Alarm Specialist".

SD-02 Shop Drawings

Submit the following in accordance with the paragraph entitled, "General Requirements," of this section:

Connection Drawings; G

Module Schematic Drawings

Software Programs

As-Built Record Drawings (hard copy and AutoCAD)

Fire Alarm System Acceptance Test Procedures

Fire Service Floor Plans

SD-03 Product Data

Where multiple types of the same item are required (Example: indoor, weatherproof, and explosion-proof types) provide separate Catalog Data for each type of device. Submit Manufacturer's Catalog Data for the following items:

Fire Alarm Control Panel; G

CRMS Reporting Equipment; G

Smoke Detectors; G

Manual Alarm Stations; G

Alarm Bells; G

Strobe Units; G

Water Flow Alarm Devices

Valve Tamper Switches

Remote Auxiliary Control Relays

Power Source

Line Voltage Surge Suppressors

Low Voltage Surge Suppressors

Wiring (Wire and Multi-Conductor Cable)

Paint

Indicate VOC content for each product used.

SD-05 Design Data

Design Analysis and Battery Calculations G

Submit list of parts and components for the installed system by manufacturer's name, part number, and nomenclature, and recommended stock level required for normal maintenance and unscheduled repairs.

SD-07 Certificates

Submit Quality Assurance Plan G consisting of the following in accordance with the paragraph entitled, "Quality Assurance Plan," of this section:

Submit listing and/or approval documentation G that all components

are Underwriter Laboratory (UL) UL Fire Prot Dir listed or Factory Mutual (FM) FM P7825 approved for their intended use and function.

SD-10 Operation and Maintenance Data

Submit Operation and Maintenance Manuals G bound in manual format and grouped by technical sections consisting of manufacturer's standard brochures, schematics, procedures, recommended spare parts, recommended test equipment, and safety precautions. Submit this information prior to acceptance tests being performed. Provide one single .pdf format of the O&M Manual on a single CD.

1.3 GENERAL REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS apply to work specified in this section.

Submit submittals for approval in the following sequence with each approved prior to the next submittal:

a. Sign and submit the KSC Transfer of Responsibility form no later than 30 days before starting work.

b. Submit Product Data (Catalog Data), Contractor's Certifications, and Quality Assurance Plan, within 30 days before starting work.

c. Submit connection drawings, module schematic drawings, design analysis and battery calculations within 30 days before starting work.

d. Submit new and revised Fire Alarm Control Panel (FACP) and Network Software Program information no later than 60 days prior to the scheduled preliminary test. Provide two completed sets minimum of the r ecord drawings and documentation and make available for reference at the preliminary test.

e. Submit Acceptance Test Procedures no later than 60 days prior to the scheduled preliminary test.

f. Sign and submit the Readiness Affirmation form no later than 5 days prior to the scheduled preliminary test.

g. Submit record shop drawings, panel and network software programs, and b attery calculations for approval no later than 30 days prior to the scheduled final acceptance test. Provide two completed sets minimum of the record drawings (as-built condition) and documentation and the NFPA 72 Fire Alarm System Record of Completion Form and make available for reference at the final test. Include submittal of listing and/or approval documentation

h. Submit Operation and Maintenance Manuals 14 days after the final test has been complete and approved.

i. Include in the record drawing submittal all shop drawings, panel and n etwork software programs, battery calculations, completed final test p rocedures, NFPA 72 fire alarm system record of completion form and submit within 14 days after completion of the final acceptance test. Include in this submittal two (2) sets of CD ROM digital media of all the record drawings, design analysis, battery calculations and program software information.

Prepare and submit all drawings generated by computer aided design (CAD). Include in digital media compact disc (CD) submittals .DWG or .DXF format files for all drawings: connection diagrams, module schematics, battery c alculations, floor plans and fire service floor plans. Also on this CD provide a complete copy of the aforementioned drawings in PDF format.

Provide Connection drawings consisting of point-to-point wiring diagrams of internal and external wiring including, but not limited to, all fire alarm field devices, panel wiring, and interconnection between other building systems and components and the fire alarm system. Indicate wire label designations matching the field installation on these drawings.

Include in connection drawings floor plan drawings that indicate equipment locations, device locations, and conduit/wiring routing from the FACP(s) to all field devices including looped Class A circuit routing requirements. Also include typical mounting requirements for each type of initiation, signaling, notification and control device. Show on record drawings (as-built) for installations with flame detectors horizontal and vertical field of views for each detector and aiming point of detector with clear dimensions from fixed and readily identifiable structural references. Include riser diagram and sequence of operations in an input/output matrix format that clearly shows interaction of system components.

Provide Module schematic drawings (minimum size 8-1/2 by 11 inch prior to system acceptance testing.

Include in record drawings connection drawings, floor plan drawings, module schematics, software programs, fire service floor plans, design and battery calculations, and all other data required to fully document the completed system. After final testing is complete, submit record drawings including digital media and hard copies of all new and revised software, drawings, and analysis/calculations incorporating approved comments and any changes. Document final system configuration in record drawings including, but not limited to, geographic monitor zone boundaries, location of the FACP, all initiating and auxiliary control devices, signaling line devices, notification appliances, additional cabinets, dry pipe sprinkler risers, and all other equipment associated with the fire alarm system(s). Also, annotate deviations from and amendments to the record drawings, and field installation changes, concealed and visible.

Provide software programs, both hard copy and compact disc, for all new and/or existing programmable FACP(s) affected by the project. Provide system executable file and report file on the compact disc. Program information for FACP including program listings, system point summary, and device switch settings. Include in corrected program information panel and network programs and sequence of operations in matrix format that clearly shows interaction of system components.

Conduct tests in accordance with approved Fire Alarm System Acceptance Test Procedures, and in accordance with the paragraph entitled "Field Testing" in this specification. Prepare a test procedure and test record form for conducting complete tests on control panels, reporting systems, wiring systems, and field devices installed in accordance with the manufacturer's requirements and these specifications. Identify each device and circuit to be tested in the test procedure, describe the initial condition, each step or function in the test, required test result, and equipment to be employed. Test procedures are to be written to minimally disrupt facility operations (minimize activation of evacuation notification appliances, AHU

shutdown, etc.) in support of testing requirements. Ensure test forms have suitable space for recording test results on all equipment, devices, and wiring to be tested. Provide test record forms with identified spaces for verification signatures of official witnesses and dates of the test.

Clearly indicate on fire service floor plans the location of the FACP, all initiating and auxiliary control devices, signaling line devices, notification appliances, additional cabinets, detection systems, dry pipe sprinkler risers, and all other equipment associated with the fire alarm system(s). Do not place borders or title blocks on the Fire Service Floor Plan. Provide a symbol legend, which clearly identifies each device shown on the Fire Service Floor Plan. Install a copy of the Fire Service Floor Plan, minimum size 18 by 24 inch in a painted metal frame with a Plexiglas cover. Submit the floor plan and it's location for approval, to the Contracting Officer, prior to installation.

Submit Design Analysis and Battery Calculations for approval for the Fire Alarm and Detection Systems consisting of the battery capacity and loading calculations in accordance with the paragraph entitled "Fire Alarm Control Panel" of this section.

Submit list of parts and components in accordance with the paragraph entitled "System Requirements," of this section.

1.4 SYSTEM REQUIREMENTS

Provide a non-addressable, modular type, microprocessor based, supervised, non-coded electrical fire alarm system with NFPA 72 Class A initiating device circuits,notification appliance circuits, and auxiliary control circuits. Provide NFPA 72 Class A signaling line circuits, Style 6, and Central Radio Monitoring System (CRMS) network reporting circuits, Style 7. Ensure all styles of Class A initiating device, signaling line, network, notification appliance, and control circuits use diverse routing in accordance with NFPA 72. Do not run the outgoing and return redundant circuit conductors in the same cable assembly, enclosure or raceway.

Electrically connect the fire alarm system to report alarm, trouble, and supervisory signals to the CRMS; to sound the general alarm continuously; and to control auxiliary equipment such as dampers, air handling units, etc., upon operation of one or more initiating devices. For initiating, notification, signal, and auxiliary control circuits, use 24 V(DC).

Ensure the system conforms to all the applicable requirements of NFPA 70, NFPA 72, NFPA 75, NFPA 90A, NFPA 101, and KSC-STD-F-0004F.

Ensure fire alarm systems contain all of the equipment, devices, programming and circuits required for system operation in accordance with NFPA Codes and KSC requirements, including remote reporting to and remote control from existing equipment.

Provide all additional equipment, cabinets, conduit, and labor to meet the requirements and intent of this specification.

Components installed under this contract can not be more than one (1) year older than the date of installation.

1.5 QUALITY ASSURANCE PLAN

Provide manufactured fire-alarm equipment which meets the requirements of

the paragraph entitled, "System Requirements," of the latest standard design, and listed by Underwriters' Laboratories or approved by Factory Mutual and be suitable for it's intended service. Ensure all devices installed function with the control panel without interference of the operation of the control panel.

1.6 SERVICES OF A CERTIFIED FIRE ALARM SPECIALIST

Provide services of a Certified Specialist thoroughly experienced in fire detection and alarm work on site, to perform or directly supervise the installation, make all necessary adjustments, and perform all tests on the fire alarm system at the site.

A fire alarm specialist is considered certified when the specialist holds a valid Fire Alarm System, Level III Certification from the National Institute for Certification in Engineering Technologies NICET 1016-2; or a valid Level III Fire Alarm Engineering Technician Certification from the International Municipal Signal Association (IMSA); or is licensed by the State of Florida as a Fire Alarm Contractor I in accordance with Florida State Statute, Chapter 489, Part II.

Certification of other recognized agencies with equivalent requirements will be considered. Provide Evidence of the Contractor's State Certification and the basis of certification to the Contracting Officer and secure Contracting Officer approval prior to any work being performed at Kennedy Space Center.

PART 2 PRODUCTS

2.1 FIRE ALARM CONTROL PANEL

Provide non-addressable FACP, of modular construction with solid state, microprocessor based electronics. Include non-volatile programmable operating system memory for all operating requirements in the panel.

Ensure FACP contains power-on, alarm, supervisory, and trouble indicating lights plainly visible when the cabinet is closed; and also contains the following functions accessible only by unlocking and opening the unit:

Alarm Silence
Trouble Silence
Supervisory Silence
Power On-Off (If standard by the manufacturer)
Alarm/Trouble Acknowledge
Auxiliary Devices (AHU shutdown relay) Maintenance By-pass Switches
System Reset

Ensure FACP contains all components necessary to monitor and supervise all initiating device circuits, and when any detector, manual alarm station (pull box), water flow switch, pressure switch, etc., connected to the FACP is activated, the control panel's visual alarm, alarm indicator and audible signal are activated. This causes all notification appliances to be activated, including all associated auxiliary control functions. Verify that the control panel visually indicates the device or zone in alarm and transmits an alarm condition to the remote CRMS. Provide separate audible and visual notification appliance circuits, with sufficient capacity to operate all devices connected, plus 25 percent minimum spare capacity.

Verify that the FACP includes all components and modules required for installation of a non-addressable device network. Utilize network polling methods and provide two-way Class A, Style 6 supervised communications between the FACP and non-addressable smoke detectors and monitor, signal, or control non-addressable modules. Ensure that the FACP contains all components necessary to monitor and supervise all supervisory device circuits. Verify that when any valve tamper switch, low air pressure switch, water level indicator, or other supervisory device connected to the control panel is activated, the control panel supervisory visual indication and supervisory audible device is activated; and that control panel visually indicates the non-addressable device or zone in supervisory alarm and transmit a supervisory condition to the remote CRMS.

Provide FACP with all components necessary to operate and supervise the circuits for auxiliary power supplies indicated and auxiliary devices controlling equipment such as ventilating fans, air handling units, fan coil units, damper motors, solenoids, magnetic door holders, elevator recall, etc. Ensure circuits for auxiliary control relays are supervised to within 3 feet of the device to be controlled in accordance with NFPA 101. Include maintenance by-pass switches for all auxiliary control devices in the FACP. Ensure by-pass switches are supervised to report supervisory signal when in the maintenance (by-pass) position. Provide switches used for by-pass functions which are either toggle or soft key type, and listed for use with the control panel. In addition, provide each switch with a positive visual indication to show the function is ON.

Provide panel which monitors and reports any trouble open supervised circuits, ground faulted supervised circuits, removal of detector or device, removal or failure of control panel module, maintenance by-pass switch activated, loss of primary power, power supply trouble, low battery voltage, loss of battery voltage, FACP enclosure open, and activation of the alarm silence switch. Ensure all trouble signals are identified by initiating, notification appliance, auxiliary control, or signaling line circuit; and that trouble signals activate the control panel trouble visual indication and trouble audible devices, and send a trouble signal to the remote CRMS.

Provide alarm, supervisory, and trouble reset switches which reset a cleared device in alarm, supervisory, or trouble condition. Ensure alarm, supervisory, and trouble signals do not self-restore without activating the switch.

Ensure that alarm, supervisory, and trouble silence switches silence the alarm, supervisory, and trouble audibles, and that either switch placed in other than the normal position provides the following:

a. Report as an alarm, supervisory, or a trouble to the CRMS.

b. Transfer audible signal to a panel lamp visual indication.

c. Re-ring the trouble audible if the problem has been cleared, but the switch has been left in the silence position.

When the alarm silencing switches are in the silence position, ensure subsequent alarms reactivate the notification appliances, and the strobes remain operational until the FACP is reset.

Provide FACP suitable for use with UL listed or FM approved detectors and manual alarm stations and other fire alarm devices specified in this

section.

Provide FACP with an individual set of Form C dry contacts which activate for alarm, trouble and supervisory conditions for connection to the CRMS. Provide additional other fire monitoring or special function relay contacts as indicated.

Ensure all relays are continuous duty and have self-cleaning contacts of silver or an alloy of equivalent performance, and supervisory relays are suitably protected against dust by individual covers. Provide all relays with external functions, such as remote reporting, control device activation, and notification appliance activation, with at least one set of spare contacts. Permanently mark relays with the coil resistance, operating-current range, and internal pin connections using standard pin numbers.

Install a separate terminal cabinet adjacent to the FACP for interfacing device field wiring to the control panel. Provide outdoor cabinets of stainless steel construction rated NEMA 4X. Install terminal strips for all field wiring circuits plus 25 percent spare. Where a terminal cabinet is installed, install terminal strips to accommodate remote reporting circuits and associated surge suppressors. Provide copper ground bus within this terminal cabinet for termination of equipment ground conductors.

Provide steel FACP, terminal cabinets, surge suppression cabinets and battery cabinets (when used), with a hinged cover and an integral pin-tumbler cylinder lock (Lock Cylinder No. Best Universal Lock Co. No. 5E7FICR704C31612R90626 or equal) with removable core that accepts the key presently in use with other control units existing in the area. Lock core will be provided by the government. Paint cabinets with a prime coat and one or more finish coats of scratch-resistant baked enamel red finish coat unless otherwise indicated.

Provide system which operates from a power supply with 120 grounded V(AC) input and 24 V(DC) output, and functions satisfactorily with power input voltage varying from 85 to 110 percent of nominal value. Ensure power supply output is capable of powering all initiation, signaling, annunciation, and control devices during alarm condition with 25 percent minimum spare capacity.

Provide all FACPs and auxiliary power supplies with a DC power input and with a DC disconnect switch integral with the equipment provided (2P 30A switch), or provide a separate safety switch. If supplied within the cabinet, ensure the power on-off switch disconnects all power sources to the control panel. Provide the on-off switch with DC rated contacts for a provided battery disconnect switch.

Provide the means of automatically supplying the entire fire alarm system with backup power with batteries, charger, and power transfer equipment alarm system with battery backup power in event of a primary power system failure. Ensure system switches to battery power in event of AC power failure, and switches back to AC power upon return of primary power. Ensure control panel(s) and auxiliary power supplies are able to operate when the backup batteries are disconnected for any reason. Also ensure system controls charging currents and floating voltage levels to maintain batteries in optimum condition. Provide capability to recharge batteries in event of discharge. Fuse wiring to protect against battery over-current and polarity reversal. Confirm primary power, battery, or charging equipment failure results in a FACP trouble signal and visual indication.

Use sealed, spill-proof battery modules to prevent any corrosive fumes. Provide batteries listed for fire alarm service and suitable for high discharge currents required under alarm conditions. Size batteries to operate the fire alarm and detection system (including voice evacuation system where installed), in normal supervisory condition for 24 hours, minimum, then operate the system in the alarm mode for 10 minutes, minimum.

2.2 CRMS REPORTING EQUIPMENT

2.2.1 FACP Reporting

The FACP reports to the CRMS using radio frequency (RF) remote reporting to this central monitoring system.

2.2.2 Radio Based FACP Reporting

Provide AES/Intellinet Corporation Model 7788F transceiver with minimum eight (8) zone relays to provide general reporting as specified below:

FACP	Transceiver	Description
Relay 1	Zone 1	Summary Fire Alarm
Relay 2	Zone 2	Summary Supervisory
Relay 3	Zone 3	Summary Trouble
Relay 4	Zone 4	Summary Water flow
Relay 5	Zone 5	Smoke Detector
Relay 6	Zone 6	Spare
Relay 7	Zone 7	Spare
Relay 8	Zone 8	Spare

Provide optional reporting alarm connections to the spare transceiver zones where indicated. Provide separate enclosure(s) as required for 120 V(AC) power supply components (receptacle and plug-in step-down power transformer), AC power surge suppression, and 24 hour standby battery back-up power. Provide red finish coat on all enclosures unless otherwise indicated.

Provide relays in FACP grouped in a cabinet as indicated for all remote reporting signals required. Each relay is to include an end-of-line resistor for Class B wiring to the radio transceiver zone per the radio transceiver manufacturer's requirements.

Radio output power is to be 2 Watts with 2.5 db gain antenna mounted on the radio case unless otherwise indicated.

2.3 SMOKE DETECTORS

Provide alarm initiating smoke detectors designed for use with manual fire alarm systems in accordance with UL 268.

Provide 2.5 percent per foot nominal obscuration (photo-electric) type smoke detectors, listed for use with FACP installed, including all required accessories, rust and corrosion resistant. Ensure detector head is a plug-in unit, that detector contains no moving parts, nor requires read justment or removal to resume normal operation after an alarm. Provide all detector openings with screen to prevent the entry of insects and debris.

Provide detector head that plugs into a separate receptacle type base, with

base screw terminals suitable for No. 18 through No. 14 AWG diameter solid copper conductors for all wiring connections required. Ensure base is supervised to initiate a trouble signal at the fire alarm control panel if the detector is removed, and a light emitting diode indicator to provide a visual indication when the detector initiates an alarm.

Provide detectors in areas subject to moisture or exterior atmospheric conditions that are UL listed or FM approved for such locations.

Provide detectors with terminals suitable for Class A wiring powered from the panel alarm initiation or communication bus circuit; separate power sources are not acceptable.

2.4 MANUAL ALARM STATIONS

Provide non-coded, manual alarm stations designed for use with manual fire alarm systems in accordance with UL 38.

Ensure wiring terminals are suitable for Class A wiring and capable of accepting No. 18 through No. 14 AWG diameter solid copper conductors.

Ensure manual alarm station door has a protected, pull-down operating lever with recessed finger grip. When operated, ensure the station mechanically latches, breaks a glass or plastic rod, closes one or more sets of contacts, and locks the contacts in the operated position until reset. Stations with a pushbutton which depends upon a spring-loaded device to close the contacts when the handle is pulled are not acceptable, nor are stations which are resettable without the use of a key or tool.

Paint all exposed metal surfaces of enclosing cases with a prime coat and one or more finish coats of red enamel to produce a smooth, hard, durable finish. Provide identification and directions for operating fire-alarm stations on the cover in raised or depressed white-enameled letters. Manual alarm stations constructed of plastics or composite material are not acceptable.

Furnish surface-mounted stations with matching cast-iron or cast-aluminum back boxes with top and bottom threaded-conduit connections. For stations mounted outdoors, provide weatherproof type, with a neoprene gasket, and protect against corrosion. Provide a molded polycarbonate clear protective cover with the provision for a lead seal or plastic supervisory seal in all areas open to the general public. Ensure the protective cover does not have an integral warning horn.

2.5 ALARM BELLS

Provide red fire-alarm bells, 10 inch diameter, vibrating, under-dome, alarm notification appliances in accordance with UL 464, with bell which produces at least 87 dB at 10 feet, sound in a temporal pattern, conforming to NFPA 72.

Ensure alarm bells are solenoid-operated plunger sounding devices, with a rustproof operating mechanism, protected from dust and insects, and located behind the gong shell. Stop operation of bells on a signal silence.

Provide alarm bells which operate from polarized 24 V(DC) FACP, Class A parallel wired supervised notification appliance circuits. Make wiring connection on terminal blocks suitable for No. 16 through No. 12 AWG diameter solid copper conductors. Ensure audible notification appliance

circuits have sufficient capacity to operate all devices connected, plus 25 percent minimum spare capacity per circuit.

Provide strobe portion of combination audible/visual indicating appliances in accordance with the applicable provisions of the paragraph entitled, "Strobe Units," of this section.

Ensure surface-mounted alarm bells installed in unfinished areas with conduit exposed are secured to surface-mounted cast-iron, or aluminum back boxes, with threaded conduit connections. If installed outdoors, provide weatherproof alarm bells with a neoprene gasket that are protected against corrosion. Paint all exposed metal surfaces with a prime coat and one or more finish coats of red enamel to provide a smooth, hard, durable finish.

2.6 STROBE UNITS

Provide strobe units designed for use with manual fire alarm systems, in accordance with UL 1971.

Provide UL listed or FM approved strobe units including red cast metal housing, dome polycarbonate white lens with white "FIRE" lettering on two sides, and a zenon flash tube with solid state circuitry. Ensure unit brightness is 15, 30, 60, 75, or 110 candela in accordance with NFPA 72, producing a minimum flashing frequency of 1 Hz and a maximum of 3 Hz. Synchronize all strobes. Ensure strobes remain flashing until the FACP sends a silence signal. Ensure visual notification appliance circuits have sufficient capacity to operate all devices connected, plus 25 percent minimum spare capacity per circuit. Strobes will be synchronized.

Provide units which operate from polarized 24 V(DC), Class A, parallel wired supervised notification appliance circuits, with an operating current not exceeding 0.1 amperes and capability of operating over a 20 percent variation in nominal input voltage. Ensure wiring connection terminal blocks are suitable for No. 16 through No. 12 AWG diameter solid copper conductors. Stop operations of strobes on a signal silence.

Provide flush mounted interior units using standard electrical back boxes, and surface mounted units in cast iron or cast aluminum boxes with threaded conduit hubs. Provide weatherproof units with a neoprene gasket, protected from corrosion, in exterior or wet locations. Paint all metal exposed surfaces with a prime coat and one or more finish coats of red enamel paint to provide a smooth, hard durable finish.

If mounted in hazardous locations, provide strobes UL listed or FM approved for the hazardous location classification indicated. When the unit is not factory sealed, provide conduit seal-off fittings suitable for the hazardous location classification indicated at each conduit connection to the explosion-proof enclosure in accordance with NFPA 70.

2.7 WATER FLOW ALARM DEVICES

Provide alarm-initiating water flow devices designed for use with manual fire alarm systems, in accordance with UL 346, conforming to UL or FM requirements for the particular type of sprinkler system being specified.

Ensure contact have a minimum of 2 single pole, double throw contacts rated 5 amps at 28 V(DC) or 250 V(AC). Provide weatherproof and corrosion protected flow devices for outdoor installations.

If installed in hazardous locations, provide water flow devices UL listed or FM approved for the hazardous location classification indicated. When the switch is not factory sealed, provide conduit seal-off fittings suitable for the hazardous location classification indicated at each conduit connection to the explosion-proof enclosure in accordance with NFPA 70.

2.8 VALVE TAMPER SWITCHES

Provide supervisory initiating valve tamper switches designed for use with manual fire alarm systems, in accordance with UL 346, conforming to UL or FM requirements of use on the specified valve.

Provide contacts with a minimum of 2 single pole, double throw contacts rated 5 amps at 28 V(DC) or 250 V(AC). Provide weatherproof, corrosion-protected switches for outdoor installations. In hazardous locations, provide valve tamper switches UL listed or FM approved for the hazardous location classification indicated. If the tamper switch is not factory sealed, provide conduit seal-off fittings suitable for the hazardous location classification indicated, at each conduit connection to the explosion-proof enclosure in accordance with NFPA 70.

2.9 REMOTE AUXILIARY CONTROL RELAYS

Provide remote control relays with continuous duty coils rated 24 V(DC). Where relays are used on Class A parallel wired supervised circuits, ensure coils incorporate supervisory current blocking diode. Provide relays with a minimum of 2 single pole, double throw contacts rated 5 amps at 28 V(DC) or 250 V(AC). Where auxiliary control circuits connected to the relay are protected at a higher ampacity than the relay contacts are rated, provide fusing rated to protect the relay contacts in the relay enclosure.

Mount remote auxiliary control relays in enclosures indicated, or if not indicated, in manufacturer's required enclosure. Install outdoor relays in a weatherproof enclosure with a neoprene gasket and protection against corrosion.

In hazardous locations, install relays with enclosures UL listed or FM approved for the hazardous location classification indicated. Provide seal-off conduit fittings at each conduit connection to the explosion-proof enclosure in accordance with NFPA 70.

Paint enclosures with a prime coat and one or more finish coats of red enamel to provide a smooth, hard, and durable finish. Label enclosure with an engraved phenolic nameplate stating, "F/A RELAY."

Mount remote auxiliary control relays and supervise within 3 feet of the controlled device in accordance with NFPA 101.

2.10 POWER SOURCE

Ensure normal power to the local systems for all purposes, including separately powered notification appliances and initiating devices, is 120 volts 60 hertz. Ensure system operates satisfactorily between 85 and 110 percent of normal voltage. Provide fire-alarm-system disconnect/protective device as a fused switch with a red factory finish as specified herein for manual alarm stations. Mount this disconnect switch adjacent to the FACP. Mark as FIRE-ALARM DISCONNECT FED FROM (indicate supply circuit) with 1/2-inch high letters in white paint or engraved phenolic identification

plates fastened with sheetmetal screws. Ensure switch is capable of being locked in the "on" or "off" position, a feature which can not interfere with the circuit protection capability of the device. Equip switch with surge suppression for all phase and neutral conductors. Install current limiting Class RK1 fuses properly sized to protect the fire alarm equipment.

When power is supplied from a single 20 amp circuit breaker, provide an adjustable set screw type clamping device over the circuit breaker handle to prevent handle operation. Paint only the locking device red.

2.11 WIRING

Provide copper conductor wiring in accordance with NFPA 70 and NFPA 72. Connect all devices to Class A, parallel-wired circuits, per NFPA 72, with the wire types specified in this section, unless specifically noted otherwise in the paragraph entitled, "Wiring (Wire and MultiConductor Cable). For 120 V(AC) circuits, use No. 12 AWG minimum.

Ensure all conductors installed on fire alarm systems are solid copper with an insulation rating of not less than 300 volts, permanently marked with the size, voltage rating and manufacturer's name on the conductor jacket at no less than 2 feet intervals. Conductor sizes are listed below.

Where modifications are made to existing systems, match the new or added conductors to the size and color-coding of the existing system. Conductor AWG diameter and Insulation Type are listed below. Required wire colors are listed in the paragraph entitled, "Wiring (Wire and Multi-Conductor Cable)," of this section.

Provide solid copper, shielded, twisted pairs, meeting UL 2196 requirements, for conductors in multiplexed communication circuits, signaling line circuits, speaker audio circuits, remote phone circuits, and remote reporting circuits. Ensure cable is listed as Type FPL, Power-Limited Fire Protective Signaling Cable, with conductor size less than No. 16 AWG diameter for data circuits and No. 14 AWG diameter for audio circuits.

Air sampling detection units are permitted to use No. 18 AWG for connection to modules with maximum conductor length not to exceed 25 ft.

Provide direct current initiating device (manual pull station) circuit conductor size of not less than No. 16 AWG diameter, with insulation Type TFN for No. 16 AWG diameter, and Type THHN/THWN for No. 14 AWG diameter and larger.

Size power leads from the control panel for product-of-combustion detectors accordingly, but not less than No. 14 AWG diameter, with insulation Type THHN/THWN for No. 14 AWG diameter and larger.

Provide direct current notification appliance circuit (strobes, bells) conductor size of not less than No. 14 AWG diameter, with insulation Type THHN/THWN for No. 14 AWG diameter and larger.

Provide direct current auxiliary control device (AHU shut down relay) circuit conductor size of not less than No. 14 AWG diameter, with insulation Type THHN/THWN for No. 14 AWG diameter and larger.

Provide solenoid valve control circuit conductor size of not less than No. 14 AWG diameter, with insulation type THHN/THWN for No. 14 AWG diameter

and larger.

2.12 SURGE SUPPRESSORS

Provide line voltage and low voltage surge suppression devices to suppress all voltage transients which might damage the control panel components.

Install surge suppression in accordance with UL 497B on each conductor of fire alarm circuits which extend beyond a building. Locate protection as close as practical to the point where the circuits leave the building. Install protectors in surge suppression cabinets of adequate size with terminal strips for all wiring connections plus 25 percent spare. Paint enclosures with a prime coat and one or more coats of red baked enamel finish to provide a smooth, hard, and durable finish. Where installed outdoors, provide stainless steel NEMA 4X rated cabinets. Provide a copper ground bus inside the cabinet and connect protectors to an earth ground electrode system in accordance with the manufacturer's requirements and NFPA 70. Ensure an etched metal or engraved laminated plastic identification plate labeled, "Fire Alarm Cabinet," is affixed to the cabinet door of the alarm control unit to identify the cabinet as a fire alarm cabinet. For cabinets painted black, ensure the identification plate has white letters on a black background, and for cabinets not painted red, the identification plate has white letters on a red background.

2.12.1 Line Voltage Surge Suppressors

Provide suppressor UL 1449 listed with a maximum 330 volt clamping level and a maximum response time of 5 nanoseconds, and also meets IEEE C62.41, category B tests for surge capacity. Ensure suppressor is a multi-stage construction type which includes inductors and silicon avalanche zener diodes. Provide suppressor which has a long-life indicating lamp (light emitting diode or neon lamp) which extinguishes upon failure of protection components, with externally accessible fuses. Wire in series with the incoming power source to the protected equipment using screw terminations.

2.12.2 Low Voltage Surge Suppressors

Provide for all circuits which leave the building shell and as shown on the contract drawings. When circuits interconnect two (2) or more buildings, provide an arrestor at the circuit entrance to each building. Ensure suppressor is UL 497B listed, with a maximum 30 volt clamping level and a maximum response time of 5 nanoseconds, with multi-stage construction and both differential/common mode protection.

PART 3 EXECUTION

3.1 SYSTEM SEQUENCE OF OPERATION

3.1.1 Normal Operation

Ensure all switches are in the normal position; available power lamp is on, the trouble and detector identification lamps are off, and all circuits are electrically supervised.

3.1.2 Supervisory Condition

Per system conditions identified in the paragraph entitled, "Fire Alarm Control Panel," of this section, ensure that a supervisory signal is transmitted to the CRMS, device indication is provided, a supervisory

signal is activated in the FACP, and input is provided to remote annunciators (when used). Ensure supervisory signal in the alarm control unit is comprised of visual and audible indications and is self-restoring.

3.1.3 Trouble Condition

Per system conditions identified in the paragraph entitled, "Fire Alarm Control Panel," of this section, ensure that a trouble signal is transmitted to the remote reporting device of the CRMS, providing zone indication, activating a trouble signal in the FACP, and providing input to remote annunciators (when used). Ensure trouble signal in the alarm-control unit provides visual and audible indications.

3.1.4 Alarm Condition

Ensure activation of any detectors, manual alarm stations, water flow switches, or other initiating devices closes a contact that activates the appropriate FACP. FACP transmits a signal to the remote reporting device of the CRMS, activates the facility indicating appliances, provides zone identification, controls air handling and ventilating units, provides an input to remote annunciators (when used), and provides indication or control to devices or other systems.

3.2 INSTALLATION

Prior to performing any installation or modification work to existing Fire Alarm system(s), secure a Transfer of Responsibility Form completed by the COTR and signed by the Contractor and Institutional Services Contractor (ISC) Fire Protective Systems designee. The completed form will be turned over to the Contracting Officer by the COTR. Permanently affix a copy of the completed "Transfer of Responsibility" Form to the affected FACP throughout the construction period.

Install all equipment in accordance with manufacturer's recommendations and requirements of this Section.

3.2.1 Fire Alarm Control Panel(s) and Reporting Equipment

Install equipment in each protected building, located where indicated, and complete with all indicated accessories and devices. Install equipment in accessible locations in such a manner as to prevent damage from vibration or jarring. Equipment requires a minimum of 3 feet clearance directly in front of the panel for maintenance per NFPA 70. With multiple equipment, the 3 feet clearance is required directly in front of the complete configuration. In addition, provide a 28 inch clear aisle way for access to the equipment.

Ensure wiring within FACP(s) and reporting equipment is in accordance with the paragraph entitled, "Installation in Cabinets and Boxes," of this section.

Install conductors in accordance with the paragraph entitled, "Wiring," from the FACP to a new 25 point terminal strip labeled "FATB" in the indicated telephone terminal cabinet.

When FACP(s) and reporting equipment are installed flush or semi-flush, provide three spare 1-inch conduits in accordance with the paragraph entitled, "Conduit and Raceways," of this section, from the FACP wiring termination cabinet to an accessible location.

3.2.2 Smoke Detectors

Provide smoke detector location, number, and general arrangement as indicated. Ensure field installation in accordance with NFPA 72. Do not install detectors until the work of other trades is complete.

Utilize 'T' bar corner plate bracket for devices mounted in acoustical, lay-in type ceilings. Cut ceiling tile as required to accommodate mounting plate and device wiring.

Locate detectors no closer than 6 feet from a fluorescent light fixture. Locate detectors no closer than 3 feet from any return air diffuser and no closer than 6 feet from any supply diffuser. Ensure detectors installed in areas subject to moisture or exterior atmospheric conditions are UL listed or FM approved for such locations.

3.2.3 Manual Pull Stations (Fire Alarm Boxes)

Mount manual pull stations at locations indicated within 18-inch of the latch side of the door. Ensure mounting height is 48-inch above the finished floor measured from the top of the device.

Where manual pull stations are installed outdoors, arrange conduit systems to drain away from the manual pull stations.

3.2.4 Alarm Bells

Mount bells at the approximate locations indicated. Ensure mounting height is 90-inch above the finished floor measured from the top of the bell, but no less than 6-inch below the ceiling.

Where bells are installed outdoors, arrange conduit systems to tap into the bottom of the junction box and to drain away from the bells or strobes.

3.2.5 Strobe Units/Combination Audio Visual

Mount strobe notification appliances at the approximate locations indicated. Ensure locations are unobstructed and allow viewing by area occupants in accordance with NFPA 70. Ensure mounting height is 80-inch above the finished floor measured from the bottom of the strobe, but no less than 6-inch below the ceiling.

Where strobes are installed outdoors, arrange conduit systems to tap into the bottom of the junction box and to drain away from strobe enclosure. Ensure visual and audible appliances are capable of operating independently via separate and independent circuits for both the audible and strobe portions.

3.2.6 Auxiliary Control Relays

Install and supervise remote control relays in accessible locations within 3 feet of the device to be controlled.

3.2.7 Wiring (Wire and Multi-Conductor Cable)

Provide wiring conforming to the requirements of NFPA 70 and the following special requirements:

Install fire alarm system circuits in a separate raceway system. Route each circuit type (Initiating, Notification, Signaling, and Control) through a dedicated separate conduit or raceway system configured to comply with NFPA 72 Class "A" conduit system requirements. Do not allow 60-Hertz power circuits to enter enclosures containing fire alarm circuits except where required to connect to the fire alarm system.

Provide continuous conductors from a terminal point at one device to a terminal point at the next device and from a device to the FACP. Break wires at each terminal; do not loop wires over a terminal. Terminate approved explosion proof devices, provided with pigtail wiring connection leads, on a field installed terminal strip installed in the box on which the device is mounted. Install solderless ring tongue terminal lugs with manufacturer's required tooling on the device wiring connection leads. Use this ring type lug on stranded wire only. Terminate solid wire on compression or screw type terminals. When screw type terminals are used, capture the conductor under 80 percent of the screw head surface. Identify all circuit conductors within each enclosure where a tap, splice, or termination is made. Provide conductor identification by heat-shrink-type sleeves or other approved method. Use point destination type conductor labels to indicate cabinet, circuit board, terminal block and screw terminal location for each individual conductor.

Provide conductor colors as listed below and in accordance with FED-STD-595. Where modifications are made to existing systems, match the new or added conductors to the size and color-coding of the existing system.

Mark conductors for multiplexed communication circuits, speaker audio circuits, remote phone circuits, and remote station signaling circuits with circuit designation, and maintain consistent color-coding for the positive and negative loops throughout the cable system.

Install direct current initiating device circuits (heat detectors, manual pull station) as Class A, parallel-wired circuits per NFPA 72. Ensure the positive loop conductor is colored blue, Color No. 15102, and the negative loop conductor is colored black, Color No. 17038.

Install power leads from the control panel for product-of-combustion detectors as Class A, parallel-wired circuits per NFPA 72. Ensure the positive conductor is be colored white, Color No. 17877, and the negative conductor is colored black, Color No. 17038.

Install direct current notification appliance (bells, strobes) circuits as Class A, parallel-wired circuits per NFPA 72. Ensure the positive conductor is colored red, Color No. 11105, and the negative conductor is colored orange, Color No. 12473.

Install direct current auxiliary device control device circuits (AHU shutdown relay) as Class A, parallel-wired circuits per NFPA 72. Ensure the positive conductor is colored yellow, Color No. 13591, and the negative conductor is colored brown, Color No. 10055.

Install solenoid valve control circuits as Class B circuits per NFPA 72. Ensure the positive conductor is colored yellow, Color No. 13591, and the negative conductor is colored violet, Color No. 37100.

3.2.7.1 60-Hertz Power

Provide 60-hertz power to FACP(s) or separately powered devices of 120 volts. Provide one black phase conductor, one white or gray solidly grounded neutral conductor, and one green equipment grounding conductor. Size conductor as shown on the drawing with the minimum size No. 12 AWG copper. Install surge arrestors in accordance with NFPA 72 and NFPA 70.

Clearly identify Circuit Breakers used to supply AC power to the FACP. Provide a permanent label with white background and red lettering adjacent to the circuit breaker.

3.2.7.2 Installation in Cabinets and Boxes

Install wiring in control cabinets and boxes in a neat and orderly manner with wire properly grouped, tie-wrapped, or laced parallel and perpendicular to the major axis, supported and identified. Provide continuous control wiring from device to device with no splices unless otherwise indicated. Permanently mark all wires entering or leaving control cabinets, boxes, and devices and terminate on screw terminals. Ensure marking is consistent throughout the fire alarm system and is the same as the identification shown on the connection drawings.

Ensure wire labels correspond to the approved connection drawings and use a method indicating the destination of the other end of the wire. Provide labels in control panel equipment or between fire alarm terminal cabinets which indicate the destination of the other end by cabinet designation-terminal strip designation-terminal number. Provide labels in fire alarm terminal cabinets indicating connection in control panel equipment by fire alarm cabinet designation-module identifier-module terminal strip identifier-terminal number. Provide conductor labels with legible machine-printed black lettering on white background using indelible ink. Ensure labels are heat shrink or wrap around type.

3.2.8 Conduit and Raceways

Minimum size for fire alarm system initiating, notification, signaling line and control circuit conduits and raceways is 3/4-inch. Install in accordance with NFPA 70. Ensure all Class A initiating device, signaling line, notification appliance and control circuits use diverse routing in accordance with NFPA 72. Do not run outgoing and return redundant circuit conductors in the same cable assembly, enclosure or raceway. The outgoing and return circuit conductors are only permitted to be run in a single conduit or raceway for drops that enter or exit an initiating device, notification appliance, or control unit enclosure.

Install rigid galvanized steel conduit in all hazardous (classified) locations, exterior locations where the conduit is exposed above grade, interior exposed locations from finished floor to 1 foot above finished floor unless otherwise shown on the drawings. EMT with hexnut expansion gland-type fittings can be installed in all other locations. Use flexible metal conduit, maximum length 6 feet, as the final connecting raceway to a fire alarm device mounted on vibrating equipment or on a suspended ceiling.

Where devices, junction boxes, and cabinets are installed outdoors, arrange conduit systems to drain away from the box; ensure conduit enters the box side or bottom only and drain type fittings are installed.

Use schedule 80 PVC for conduit direct buried in earth. Ensure that portions of underground raceway systems that penetrate above finished grade

are rigid, galvanized, heavy-wall steel conduit with a 40-mil PVC coating or painted with a bitumastic compound.

Conceal all conduit in interior finished areas. Fire-stop all conduit passing through fire-resistant rated walls, floors, ceilings, in a manner that maintains the fire-resistant rating of the wall, floor or ceiling.

Ensure conduit installed in a vertical position is parallel with walls and perpendicular with the floor and ceiling, and that conduit installed in a horizontal position is parallel with the floor and ceiling and perpendicular to the walls. Make changes in direction of runs with symmetrical bends. For bends of over 1-inch in diameter, provide factory made elbows.

3.3 FIELD TESTING

After complete installation of the equipment and at such time as directed by the Contracting Officer, conduct tests to demonstrate that the installation requirements of this specification have been met and that the sequential functions of the system comply with the requirements specified herein. Perform the Tests covered in the following paragraphs in two parts:

a. Contractor Checkout - Perform this test to remove all troubles, ground faults, ensure all devices are fully functional and operational, and test the programming to ensure the installation meets the contract drawings and specifications.

b. Preliminary - Perform this test using the approved test procedure and witnessed by the Government construction inspectors. Verify Record (as-built) fire alarm system drawings against the system installed, annotate all red-lines, and summarize on a single set of record (as-built) drawings. Follow the test procedures as written and annotate all red-lines on a single Test Procedure. Secure the initials and date on the summarized set of drawings and test procedures from the construction inspector and the fire alarm vendor. The Preliminary test is not considered complete until all steps in the test procedure have been satisfactorily completed. This includes any additional steps required to complete 100 percent testing of the fire alarm system and its associated functionality.

c. Final Acceptance - After the successful completion of the preliminary test, schedule a Final Acceptance test. Incorporate the final acceptance test procedure and record (as-built) drawings including all red lines from the preliminary test. Provide a copy of the consolidated redlines for the record (as-built) drawings and preliminary test procedures from the preliminary test. Ensure the Contracting Officer and the Authority Having Jurisdiction or their designee(s) witness the final acceptance test for the fire alarm system. During the Final Acceptance Test, provide two corrected as-built drawings and Final Acceptance Test Procedures for use in conducting the final acceptance test. Upon completion of the Final Acceptance Test, provide the following documentation to the Contracting Officer; a copy of the Final Acceptance Test procedure (with all steps annotated as complete), a corrected set of as-built drawings and a signed and completed NFPA 72 Fire Alarm System Record of Completion form.

On both preliminary and final tests, follow the approved testing procedures.

3.3.1 External System Wiring

Perform the following tests on the external system wiring before connection to the control panel:

Check continuity of circuits with an ohmmeter. Insert temporary jumpers in appropriate sockets of missing detectors and install the end-of line resistor when this test is performed. Verify resistance reading for each circuit is the value of the end-of-line resistor, plus or minus 10 percent.

Check each wire for grounds with 300-volt and 500-volt insulation resistance test set. Ensure resistance to ground is not less than 20 megohms. Isolate each wire tested from ground, with all other wires within the same conduit grounded. Verify that the conduit system is grounded prior to insulation resistance testing by verifying a short circuit between the conduit and earth ground.

3.3.2 Fire Alarm System Acceptance Test Procedures (For Both Preliminary and Final Tests)

After completion of the above tests, connect the external system wires to the appropriate terminals in the control panel and perform the following tests:

With the control panel energized, demonstrate the proper operation of all indicating lights and alarms.

Activate each manual pull station to demonstrate proper operation.

Each time an initiating or supervisory circuit is activated, verify that the notification appliances circuits, auxiliary control circuits, and alarm reporting to the CRMS is activated and the correct information is displayed by the color graphics units.

Remove and ground one lead at each alarm initiating device, (manual pull station, flow switch, tamper switch, etc.), to demonstrate circuit trouble, ground fault, and then alarm over ground fault with an open circuit. Alternate between positive (plus) and negative (minus) leads during the device testing process.

Turn off power to each separately powered panel or device to simulate loss of power and to demonstrate operation of the trouble alarm.

Open and close water suppression system valves requiring tamper switches, to demonstrate proper operation.

Activate water flow/pressure switches by water flow at the inspector's test valve to demonstrate proper operation. Set water flow time delay between 45 and 90 seconds.

Verify discharge of electrically activated suppression systems. Verify each initiation device that activates the suppression system to activate the solenoid valve. Fully discharge the overall system at least once.

Demonstrate each alarm initiating circuit to operate its associated alarm-control and auxiliary control units and remote reporting.

Remove and ground one lead at each notification appliance and auxiliary control device to demonstrate open circuit trouble, ground fault trouble, and then operation over ground fault with an open circuit. Alternate between positive (plus) and negative (minus) leads during the device testing process.

Measure and record sound pressure level with a sound level meter meeting ANSI S1.4a, Specifications for Sound Level Meters, Type 2 requirements. Measure and record sound pressure Levels and ambient background levels throughout the protected area. Set the sound level meter in accordance with ANSI S3.41, American National Standard Audible Evacuation Signal, using the time-weighted characteristic F (FAST). Record the maximum output when the audible emergency evacuation signal is on. Verify audible information to be distinguishable and understandable. In locations where voice intelligibility is required, verify by one of the NFPA 72 approved methods. Ensure Acceptable Sound pressure level differentials comply with NFPA 72.

Demonstrate each alarm control unit to operate in all modes.

Demonstrate capacity and the operation of the battery backup system to operate as required by these specifications by disconnecting the 120 volt, 60 Hz power from the fire alarm (control) panel and operating the system as specified for backup operation.

Demonstrate all circuits interconnecting with other systems such as fire protection, HVAC, security and safety, etc., to operate as specified on alarm from the associated zone or zones.

Verify all maintenance bypass functions operate as specified. Independently verify each device or circuit controlled by the bypass function.

Test multiplex equipment, devices, and wiring in accordance with NFPA 70 and manufacturer's requirements. Remove and ground one lead at each device to demonstrate open circuit trouble, ground fault trouble, and then operation over ground fault with an open circuit. Alternate between positive (plus) and negative (minus) leads during the device testing process.

Test Style 7 network wiring configuration and fault tolerance to verify proper operation.

3.4 OPERATION AND MAINTENANCE MANUALS

Submit Operation and Maintenance Manuals. Bind information in manual format and group by technical sections consisting of manufacturer's standard brochures, schematics, procedures, recommended spare parts, recommended test equipment, and safety precautions. Submit this information prior to acceptance tests being performed.

3.5 PAINTING

Bring all manufacturer's standard finish equipment surfaces, damaged during construction, to as-new condition by touchup or repainting to the satisfaction of the Contracting Officer, or replace with new undamaged equipment at no additional cost to the Government.

Paint all fire alarm conduit, junction boxes, and cover plates red, Color

No. 11120 in accordance with FED-STD-595. In lieu of painting all conduit junction boxes and cover plates, unions and fittings, provide red-colored conduit that has a factory applied red coating.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 31 - EARTHWORK

SECTION 31 00 00

EARTHWORK

PART 1 GENERAL

1.1 REFERENCES
1.2 DEFINITIONS
1.2.1 Satisfactory Materials
1.2.2 Unsatisfactory Materials
1.2.3 Degree of Compaction
1.2.4 Unstable Material
1.3 DEWATERING WORK PLAN
1.4 QUALITY CONTROL TESTING DURING CONSTRUCTION
1.5 TEST REPORTS
1.6 DRAWINGS
1.7 SUBMITTALS

PART 2 PRODUCTS

2.1 REQUIREMENTS FOR OFFSITE SOILS
2.2 BACKFILL AND FILL MATERIALS
2.3 COHESIONLESS MATERIALS
2.4 COHESIVE MATERIALS
2.5 SUBBASE MATERIAL
2.6 COMPOST
2.7 COMPACTION EQUIPMENT
2.8 STRUCTURAL MATERIALS
2.9 BURIED WARNING AND IDENTIFICATION TAPE
2.9.1 Warning Tape for Metallic Piping
2.9.2 Tracer Wire for All Piping Including Horizontal Directional Drilling
2.10 GROUT
2.11 PIPE CASING
2.11.1 Casing Pipe
2.11.2 Wood Supports

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS
3.2 UNAUTHORIZED EXCAVATION
3.3 SURFACE PREPARATION
3.3.1 Stripping Of Topsoil
3.3.2 Clearing
3.3.3 Tree Removal
3.3.4 Pruning
3.3.5 Grubbing Operations
3.3.6 Filling Depressions
3.3.7 Stability of Sides
3.3.8 Shoring and Bracing

3.4 GENERAL EXCAVATION
3.4.1 Ditches, Gutters, and Channels
3.4.2 Utility Structures
3.4.3 Drainage
3.4.4 Dewatering
3.4.4.1 Dewatering System
3.4.4.2 Observation Wells
3.4.4.3 Discharge
3.4.5 Trench Excavation Requirements
3.4.5.1 Removal of Unstable Material
3.4.5.2 Removal of Unsatisfactory Materials
3.4.5.3 Removal of Unsatisfactory Soil Materials
3.4.5.4 Excavation for Appurtenances
3.4.5.5 Excavation For Water Distribution System
3.4.5.6 Excavation For Electrical Utilities
3.4.5.7 Jacking, Boring, and Tunneling
3.4.6 Underground Utilities
3.5 OPENING AND DRAINAGE OF EXCAVATION AND BORROW PITS
3.6 SHORING
3.6.1 General Requirements
3.7 GRADING AREAS
3.7.1 Grading Outside Building Lines
3.8 FINAL GRADE OF SURFACES TO SUPPORT CONCRETE
3.9 GROUND SURFACE PREPARATION
3.9.1 General Requirements
3.9.2 Frozen Material
3.10 UTILIZATION OF EXCAVATED MATERIALS
3.11 BURIED TAPE AND TRACER WIRE
3.11.1 Buried Warning and Identification Tape
3.11.2 Buried Tracer Wire
3.12 FILLING AND BACKFILLING
3.12.1 Preparations Prior to Backfill Placement
3.12.2 Preparation of Ground Surface to Receive Fill
3.12.3 Placement and Compaction
3.12.4 Trench Backfill
3.12.4.1 Replacement of Unstable Material
3.13 COMPACTION
3.13.1 Percentage of Maximum Density Requirements
3.13.2 Moisture Control
3.14 SPECIAL REQUIREMENTS
3.14.1 Water Lines
3.14.2 Electrical Distribution System
3.14.3 Pipeline Casing
3.14.3.1 Bore Holes
3.14.3.2 Cleaning
3.14.3.3 End Seals
3.14.4 Grouting
3.15 EMBANKMENTS
3.15.1 Earth Embankments
3.16 SUBGRADE PREPARATION
3.16.1 Proof Rolling
3.16.2 Construction
3.16.3 Compaction
3.16.3.1 Subgrade for Pavements
3.17 FINISHING
3.17.1 Subgrade and Embankments
3.17.2 Capillary Water Barrier
3.17.3 Grading Around Structures
3.18 TESTING

3.18.1 Fill and Backfill Material Gradation
3.18.2 In-Place Densities
3.18.3 Check Tests on In-Place Densities
3.18.4 Moisture Contents
3.18.5 Optimum Moisture and Laboratory Maximum Density
3.18.6 Tolerance Tests for Subgrades
3.19 MAINTENANCE
3.19.1 Protection of Graded Areas
3.19.2 Reconditioning Compacted Areas

-- End of Section Table of Contents --

SECTION 31 00 00

EARTHWORK

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 145	(1991; R 2000) Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
AASHTO T 180	(2009) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and an 457-mm (18-in) Drop
AASHTO T 2	(1991; R 2006) Standard Method of Test for Sampling of Aggregates (same as ASTM D 75)
AASHTO T 87	(1986; R 2004) Standard Method of Test for Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010) Structural Welding Code - Steel

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA C2	(2003) Lumber, Timber, Bridge Ties and Mine Ties - Preservative Treatment by Pressure Processes
AWPA P5	(2005) Standard for Waterborne Preservatives

ASTM INTERNATIONAL (ASTM)

ASTM A 139/A 139M	(2004) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over)
ASTM A 252	(1998; R 2007) Standard Specification for Welded and Seamless Steel Pipe Piles
ASTM C 117	(2004) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in

	Mineral Aggregates by Washing
ASTM C 136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D 1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(2009) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D 2216	(2005) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 2487	(2006e1) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 3740	(2004) Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
ASTM D 422	(1963; R 2007) Particle-Size Analysis of Soils
ASTM D 4318	(2005) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 6938	(2008a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

FLORIDA DEPARTMENT OF TRANSPORTATION (FDOT)

Index 600 Series	Traffic Control Thru Work Zones

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 600/4-79/020	(1983) Methods for Chemical Analysis of Water and Wastes
EPA SW-846.3-3	(1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

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

29 CFR 1926	Safety and Health Regulations for Construction

1.2 DEFINITIONS

1.2.1 Satisfactory Materials

Satisfactory materials shall mean ASTM D 2487, SP, SP-SM, SM, A-2-3, A-2-4, and A-3.

1.2.2 Unsatisfactory Materials

Unsatisfactory soil materials shall mean ASTM D 2487, GW, GP, GM, GP-GM, CW-GM, GC, GP-GC, GM-GC, SW, SW-SM, SC, SW-SC, SP-SC, CL, ML, CL-ML, CH, MH, and AASHTO M 145, Soil Classification Groups A-2-5, A-2-6, A-2-7, A-4, A-5, A-6, and A-7, peat, muck and other highly organic soil, and other highly organic material, buried vegetation, roots, and post consumer materials such as trash, refuse, or other debris and soil materials of any classification that have a moisture content at the time of compaction beyond the range of 1 percentage point below and 3 percentage points above the optimum moisture content of the soil material as determined by moisture-density relations test.

1.2.3 Degree of Compaction

Degree of compaction required is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557, Method B or D.

1.2.4 Unstable Material

Unstable materials are too wet to properly support the utility pipe, conduit, or appurtenant structure.

1.3 DEWATERING WORK PLAN

Submit procedures for accomplishing dewatering work in accordance with drawings.

1.4 QUALITY CONTROL TESTING DURING CONSTRUCTION

Soil survey for satisfactory soil materials and samples of soil materials shall be furnished by the Contractor. A certified soil-testing service approved by the Contracting Officer shall be provided by the Contractor. Testing shall include soil survey for satisfactory soil materials; sampling and testing soil materials proposed for use in the work, and field-testing facilities for quality control during construction period.

Testing agencies shall conform to the requirements of ASTM D 3740.

Soil materials shall be tested by the Contractor during construction as follows:

MATERIAL	REQUIREMENT	TEST METHOD	NUMBER OF TESTS
Satisfactory soil materials	Sieve analysis of fine and coarse aggregates	ASTM C 136	One daily for each soil material from each source; additional test whenever there is any apparent change
	Preparation of samples	AASHTO T 87	
	Sieve analysis is of fine and coarse aggregates	ASTM C 136	

MATERIAL	REQUIREMENT	TEST METHOD	NUMBER OF TESTS
	Amount of material passing No. 200 sieve	ASTM C 117	
	Moisture content of subbase material	ASTM D 2216	
Soil materials prior to compaction	Moisture-density relations of soil	ASTM D 1557	One of each type of subgrade soil material except under backfill for structures; one for each backfill and fill material from each source
Soil material-in-place after compaction	Density of soil-in-place	ASTM D 1556 Sand Cone Method	At least three daily for each subgrade soil material except under backfill for structures, and for each layer and backfill and fill material; for each 400 linear feet of trench or fraction thereof, whichever is greater; and additional test whenever there is any change in moisture conditions

1.5 TEST REPORTS

No soil material shall be used until a written report of Soil Test results has been reviewed and approved by the Contracting Officer.

1.6 DRAWINGS

As-Built Drawings shall be submitted in accordance with Section 01 78 00 CLOSE-OUT SUBMITTALS.

1.7 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; G

Dewatering Work Plan; G

Submit 15 days prior to starting work.

SD-06 Test Reports

Borrow Site Testing

Within 24 hours of conclusion of physical tests, 6 copies of test results, including calibration curves and results of calibration tests. Results of testing at the borrow site.

Contractor shall submit written Test Reports of Soil Test results within 5 calendar days. Submit test reports in accordance with paragraph entitled, "Quality Control Testing During Construction," of this section.

SD-07 Certificates

Certificates for Proposed Soil Materials shall be submitted to the Contracting Officer in accordance with paragraph entitled, " Backfill and Fill Materials," of this section.

PART 2 PRODUCTS

2.1 REQUIREMENTS FOR OFFSITE SOILS

Test offsite soils brought in for use as backfill for Total Petroleum Hydrocarbons (TPH), Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) and full Toxicity Characteristic Leaching Procedure (TCLP) including ignitability, corrosivity and reactivity. Backfill shall contain a maximum of 100 parts per million (ppm) of total petroleum hydrocarbons (TPH) and a maximum of 10 ppm of the sum of Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) and shall pass the TCLP test. Determine TPH concentrations by using EPA 600/4-79/020 Method 418.1. Determine BTEX concentrations by using EPA SW-846.3-3 Method 5030/8020. Perform TCLP in accordance with EPA SW-846.3-3 Method 1311. Provide Borrow Site Testing for TPH, BTEX and TCLP from a composite sample of material from the borrow site, with at least one test from each borrow site. Do not bring material onsite until tests have been approved by the Contracting Officer.

2.2 BACKFILL AND FILL MATERIALS

Backfill and fill material shall consist of sandy clay, sand, gravel, soft shale, or other satisfactory soil materials as defined in Subpart 1.2.1 Satisfactory Materials.

Materials for backfill and fill shall be satisfactory soil materials, free of clay clods, rock or gravel larger than 2 inches in any dimension, debris, waste, frozen materials and other deleterious matter, and shall be satisfactory soil material as follows:

MATERIAL	REQUIREMENT	TEST METHOD	NUMBER OF TESTS
Satisfactory soil materials	Sampling	AASHTO T 2	One for each source of material to determine conformance to definition of satisfactory soil materials; additional tests whenever there is any apparent change
	Preparation of samples	AASHTO T 87	
	Sieve analysis of fine and coarse aggregate	ASTM C 136	
	Mechanical analysis of soils	ASTM D 422	
	Liquid limit of soils	ASTM D 4318	
	Plastic limit and plasticity index of soils	ASTM D 4318	
	Moisture-density relations of soil	AASHTO T 180, Method B or D	

2.3 COHESIONLESS MATERIALS

Cohesionless soil materials include gravels, gravel-sand mixtures, sands, and gravelly-sands. Moisture-density relations of compacted cohesionless soils, when plotted on graphs, will show straight lines or reverse-shaped moisture density curves.

2.4 COHESIVE MATERIALS

Cohesive soil materials include clayey and silty gravels, sand-clay mixtures, gravel-silt mixtures, clayey and silty sands, sand-silt mixtures, clays, silts, and very fine sands. Moisture-density relations of compacted cohesive soils, when plotted on graphs, will show normal moisture-density curves.

2.5 SUBBASE MATERIAL

Subbase material shall be a naturally or artificially graded mixture of natural or crushed gravel, crushed stone, or sand.

2.6 COMPOST

Compost shall be yard trimmings or yard waste compost processed and graded according to state and local regulations.

2.7 COMPACTION EQUIPMENT

Compaction equipment shall consist of sheepsfoot rollers, pneumatic-tired rollers, tamper rollers, vibrating tampers, or other compaction equipment capable of obtaining the required density throughout the entire layer.

2.8 STRUCTURAL MATERIALS

Ensure that materials used for shoring and bracing, such as sheet piling, uprights, stringers, and crossbraces, are in good serviceable condition. Ensure that any timber used is sound and free from large or loose knots.

Use pressure-treated timber where wood sheeting or piling is specified or indicated to be cut and left in place.

Ensure that shoring and sheeting for excavations are designed by a Florida-registered Professional Engineer and are in accordance with 29 CFR 1926 OSHA Document 2226 "Safe Working Practices - Excavating and Trenching."

2.9 BURIED WARNING AND IDENTIFICATION TAPE

Provide 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. Provide permanent color and printing, unaffected by moisture or soil.

Warning Tape Color Codes

Red:	Electric
Yellow:	Gas, Oil; Dangerous Materials
Orange:	Telephone and Other Communications
Blue:	Water Systems
Green:	Sewer Systems
White:	Steam Systems
Gray:	Compressed Air

2.9.1 Warning Tape for Metallic Piping

Provide acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.003 inch and a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.9.2 Tracer Wire for All Piping Including Horizontal Directional Drilling

Provide a single conductor #6 gauge thick wire with Type TW insulation.

2.10 GROUT

Provide durable 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, as determined by the Contracting Officer. Mix grout in a concrete mixer.

2.11 PIPE CASING

2.11.1 Casing Pipe

ASTM A 139/A 139M, Grade B, or ASTM A 252, Grade 2, smooth wall pipe. Match casing size to the outside diameter and wall thickness as indicated on the drawings. Protective coating is to be fusion-bonded epoxy.

2.11.2 Wood Supports

Pressure-treated, locally available, rough, structural grade. Provide wood with nonleaching water-borne pressure preservative (ACA or CCA) and treatment conforming to AWPA P5 and AWPA C2, respectively. Secure wood supports to carrier pipe with stainless steel or zinc-coated steel bands.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

Before starting earthwork, the location of underground utilities shall be carefully verified by hand methods. Utilities to be left in place shall be protected from damage.

Excavation, filling, backfilling, and grading shall be to subgrade elevations specified.

Excavated materials suitable for backfill shall be piled in an orderly manner sufficiently distant from excavations to prevent overloading, slides, and cave-ins.

Excavations shall be done in ways that will prevent surface water and subsurface water from flowing into excavations and will also prevent flooding of the site and surrounding area.

Protect excavation and trenching by shoring, bracing, sheet piling, underpinning, or other methods as required to prevent cave-ins or loose dirt from falling into excavations and trenches.

The Contractor shall maintain traffic in accordance with FDOT Standard Index 600 Series and the technical specifications. One traffic lane must be maintained at all times with use of flagger. All traffic lanes must be open for traffic at the close of workdays. All signing, barricades, lighting, flaggers, and other necessary materials shall be included in the lump-sum cost. For roadways with more than two lanes, the Contractor shall maintain one traffic lane in each direction.

3.2 UNAUTHORIZED EXCAVATION

Unauthorized excavation shall consist of removal of materials beyond indicated subgrade elevations or side dimensions specified without specific direction and shall be replaced as specified at no additional cost to the Government.

Unauthorized excavation under foundations or retaining walls shall be filled by lowering the bottom elevation of the footing or base to the excavation bottom without altering the approved top elevation.

Elsewhere unauthorized excavations shall be backfilled and compacted as specified for authorized excavations of the same classification.

3.3 SURFACE PREPARATION

Heavy growths of grass and other vegetation, roots, debris, stones, objects

larger than 2 inches in any dimension, and other materials undesirable to the subsurface construction shall be removed by mowing, grubbing, raking, or other methods from the surface of areas to be stripped.

3.3.1 Stripping Of Topsoil

Where indicated or directed, strip topsoil to a depth of 4 inch. Spread topsoil on areas already graded and prepared for topsoil, or transported and deposited in stockpiles convenient to areas that are to receive application of the topsoil later, or at locations indicated or specified. Keep topsoil separate from other excavated materials, brush, litter, objectionable weeds, roots, stones larger than 2 inch in diameter, and other materials that would interfere with planting and maintenance operations. Excavated topsoil shall be transported to, and stockpiled in, designated topsoil storage areas.

3.3.2 Clearing

Clearing shall consist of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within the areas to be cleared. Trees, stumps, roots, brush, and other vegetation in areas to be cleared shall be cut off flush with or below the original ground surface, except such trees and vegetation as may be indicated or directed to be left standing. Trees designated to be left standing within the cleared areas shall be trimmed of dead branches 1-1/2 inches or more in diameter and shall be trimmed of all branches the heights indicated or directed. Limbs and branches to be trimmed shall be neatly cut close to the bole of the tree or main branches. Cuts more than 1-1/2 inches in diameter shall be painted with an approved tree-wound paint. Apply herbicide in accordance with the manufacturer's label to the top surface of stumps designated not to be removed.

3.3.3 Tree Removal

Where indicated or directed, trees and stumps that are designated as trees shall be removed from areas outside those areas designated for clearing and grubbing. This work shall include the felling of such trees and the removal of their stumps and roots as specified in paragraph GRUBBING. Trees shall be disposed of as specified in paragraph DISPOSAL OF MATERIALS.

3.3.4 Pruning

Trim trees designated to be left standing within the cleared areas of dead branches 1 1/2 inches or more in diameter; and trim branches to heights and in a manner as indicated. Neatly cut limbs and branches to be trimmed close to the bole of the tree or main branches. Paint cuts more than 1 1/4 inches in diameter with an approved tree wound paint.

3.3.5 Grubbing Operations

Grubbing shall consist of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, shall be removed to a depth of not less than 18 inches below the original surface level of the ground in areas indicated as areas to be paved and sodded. Material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, shall be removed to a depth of not less

than 10 feet below the original surface level of the ground in areas indicated as areas for buildings, dry retention ponds and in a 10 foot wide perimeter around Buildings.

3.3.6 Filling Depressions

Depressions resulting from grubbing operations shall be completely filled with acceptable backfilling material, unless further excavation or earthwork is required.

Prior to filling, subgrade surfaces of depressions shall be free of standing water, frost, or frozen material. Unsatisfactory soil materials shall be removed.

Any structural backfill or fill required for site development should be placed in loose lifts not exceeding 12 inches in thickness and compacted by the use of a vibratory drum roller. If hand-held or track-mounted compaction equipment is used, the lift thickness should be reduced to 6 and 8 inches, respectively. Each layer shall be compacted at the optimum moisture content to a density equal to the original adjacent ground. Surface of filled depressions shall be graded to meet adjacent contours and to provide surface water drainage.

3.3.7 Stability of Sides

Sides of excavations over 5 feet in depth shall be sloped not steeper than 34 degrees from the horizontal (slope 1/1.5) of the material excavated or shall be shored and braced where sloping is not possible because of space restrictions, stability of material excavated, or where excavations are subjected to vibrations from vehicular traffic, the operation of machinery, or any other source.

Sides and slopes of excavations shall be maintained in a safe condition by scaling, benching, shelving, or bracing until completion of backfill placement.

3.3.8 Shoring and Bracing

Where sheeting and bracing are required to support the side walls of the excavation, retain a Professional Engineer, registered in Florida, to design sheeting and bracing. Ensure that the design establishes requirements for sheeting and bracing and complies with all applicable codes, authorities having jurisdiction, and federal, state, and local regulations.

The sole responsibility for the design, methods of installation, and adequacy of sheeting and bracing shall be and shall remain that of the Contractor and the Contractor's Professional Engineer. Provide all necessary sheeting and bracing or other procedures as required to ensure safe working conditions and to protect the excavations.

Provide sheeting and bracing consisting of braced steel sheet piling, trench box, braced wood lagging, and soldier beams, or other approved methods.

Immediately fill and compact voids formed outside the sheeting. Where soil cannot be properly compacted to fill the void, use Class B concrete as backfill at no additional cost to the Government.

Install sheeting outside the required clearances and dimensions. Ensure that sheeting is plumb, securely braced, and tied in position. Ensure that sheeting is adequate to withstand all pressure to which is may be subjected. Correct any movement or bulging at no expense to the Government to provide the necessary clearances or dimensions.

Maintain sheeting and bracing in excavations and trenches for the entire time excavations are open.

Do not brace sheeting against pipe being laid. Brace sheeting so that no concentrated load of horizontal thrust is transmitted to the pipe.

Do not withdrawn sheeting if driven below the spring line of any pipe. Cut off tops as indicated on the drawings and leave bottoms permanently in place.

3.4 GENERAL EXCAVATION

3.4.1 Ditches, Gutters, and Channels

Excavation shall be accomplished by cutting accurately to the cross sections, grades, and elevations indicated. Excessive open-ditch or gutter excavation shall be backfilled with suitable materials to grade at no additional cost.

3.4.2 Utility Structures

Excavation for valve vaults and similar structures shall be sufficient to leave at least 12 inches in the clear between the outer surfaces and the embankment or timber used to hold and protect the walls. Any overdepth excavation below such appurtenances that has not been directed will be considered unauthorized and shall be refilled with select bedding material or concrete, as directed by the Contracting Officer, at no additional cost to the Government.

Excavation shall be made accurately to the lines, grades, and elevations indicated. Dimensions and elevations of footings and foundation excavations are only approximate and may be changed if necessary to ensure adequate foundation support. Trenches and foundation pits shall be of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as indicated. Rock or other hard foundation materials shall be cleaned of loose debris and cut to a firm surface, either level, stepped, or serrated, as indicated. Loose disintegrated rock and thin strata shall be removed. When concrete or masonry is to be placed in an excavated area, special care shall be taken not to disturb the bottom of the excavation. Excavation to the final grade level shall not be made until just before concrete or masonry is to be placed.

3.4.3 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Completely drain construction site during periods of construction to keep soil materials sufficiently dry. 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 provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils. 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.

3.4.4 Dewatering

3.4.4.1 Dewatering System

The dewatering system shall be adequate to pre-drain the soils to be excavated to the extent that the piezometric water level in the construction area is a minimum of 2 feet below the bottom of the excavation, side slopes of excavations, or bottom of the footings at all times, or as otherwise required to obtain the specified compaction and installation conditions. Pipeline trenches must be dewatered at least 6 inches below the trench bottom.

In the event of layered soils, the hydrostatic head in the zone below the subgrade elevation shall be relieved to prevent uplift.

Unless otherwise noted and prior to any excavating below or within 2 feet above the groundwater level, a dewatering system shall be placed into operation to lower water levels to the extent specified previously, and then shall be operated continuously 24 hours per day, 7 days a week, until work has been completed to the satisfaction of the Contracting Officer.

Where used, well points shall be installed in an approved manner and in sufficient numbers to provide the necessary removal of water as stated previously. Well points and header piping shall be installed in such a manner that traffic on public thoroughfares and site access roads will not be impeded.

The Contractor shall be solely responsible for the arrangements, locations, and depths of the dewatering system necessary to accomplish the specified work.

To prevent excessive noise, exhaust from all pumps and engines shall be silenced and muffled.

Wellpoint pump discharge shall be controlled to prevent erosion, undermining, and all other damage, and be piped to approved locations.

The Contractor shall comply with any and all applicable regulations and permitting requirements concerning groundwater and discharge.

Excavations shall be kept free from water during the placing of concrete structures and utilities.

3.4.4.2 Observation Wells

The Contractor shall install observation wells as may be required to record accurate water levels.

The Contractor shall be responsible for maintaining wells and observing and recording the elevation of the piezometric water levels daily.

3.4.4.3 Discharge

Discharge of water from dewatering shall be in accordance with NASA KSC policy.

3.4.5 Trench Excavation Requirements

Trenches shall be of adequate width and depth for the specified purpose. Side slopes of the trenches shall be as nearly vertical as practicable. Care shall be taken not to overexcavate. Bottoms of the trenches shall be accurately graded to provide uniform bearing and support for each section of pipe on undisturbed soil at every point along its entire length except where it is necessary to excavate for bell holes and for proper sealing of pipe joints. Bell holes and depressions for joints shall be dug after the trench bottom has been graded to ensure that the pipe rests on the prepared bottom for as much of its full length as practicable. Bell holes and depressions shall be only of such length, depth, and width as required to make the joint. Stones shall be removed, as necessary, to avoid point bearing. Where rock excavation is required in trenches for pipe, the rock shall be excavated to a minimum overdepth of 6-inches below the trench depth specified. Except as specified for wet or otherwise unstable material, overdepths shall be backfilled with materials specified for backfilling the lower portion of trenches. Whenever wet or otherwise unstable material that is incapable of properly supporting the pipe, as determined by the Contracting Officer, is encountered in the bottom of the trench, it shall be removed and the trench shall be backfilled to the proper grade with coarse sand, fine gravel, or other suitable, approved material.

Trench excavations in surfaced areas shall be by open cut, unless otherwise shown. The pavement shall be cut by concrete saw or other approved method. Cuts shall be in straight lines parallel to the utility line location and shall be to a depth of at least one quarter of the pavement thickness. The remainder of the pavement shall be broken out. Pavement shall be removed a minimum of 12 inches on each side of the trench and 6 inches beyond where the base course is to be removed.

3.4.5.1 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with select granular material as provided in paragraph BACKFILLING AND COMPACTION. When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the Contractor is responsible for excavating the resulting material and replacing it without additional cost to the Government.

3.4.5.2 Removal of Unsatisfactory Materials

Remove unsatisfactory materials to a horizontal distance of 10 feet beyond the structural element plan and to a vertical depth of not less than 10 feet below the original surface level of the ground in areas designated as structural elements and dry retention ponds. A structural element is a building slab or a foundation.

3.4.5.3 Removal of Unsatisfactory Soil Materials

Unsatisfactory soil materials encountered that extend below the required elevations, as specified under Grubbing Operations shall be excavated to the depth directed by the Contracting Officer.

3.4.5.4 Excavation for Appurtenances

Provide excavation for valve vaults or similar structures sufficient to leave at least 12 inch clear between the outer structure surfaces and the face of the excavation or support members. Clean rock or loose debris and cut to a firm surface either level, stepped, or serrated, as shown or as directed. Remove loose disintegrated rock and thin strata. Specify removal of unstable material. When concrete or masonry is to be placed in an excavated area, take special care not to disturb the bottom of the excavation. Do not excavate to the final grade level until just before the concrete or masonry is to be placed.

3.4.5.5 Excavation For Water Distribution System

Trenches shall be graded to avoid high points that necessitate placing vacuum and relief valves in the waterlines. If a profile of the pipes is not provided, trenches shall be of a depth to provide a minimum cover over the top of the pipe of 3 feet from the existing ground surface or the indicated finished grade (whichever is lower) unless it is necessary to avoid interference of the waterlines with other utilities. Ensure that utility separation requirements are as shown on the drawings and in paragraph entitled "Location" in Section 33 11 00 WATER DISTRIBUTION.

3.4.5.6 Excavation For Electrical Utilities

Excavation of trenches for electrical cables and duct lines shall provide vertical walls, unless otherwise approved by the Contracting Officer, and the trench shall be only as wide as necessary for workers to install the cables or ducts. Abrupt changes in grade of the trench bottom shall be avoided. Trenches shall be of a depth to provide a minimum cover over the top of the cables or ducts of 3 feet below finished grade, unless it is necessary to avoid interference of the electrical cables or ducts with other utilities. Ensure that utility separation requirements are as shown on the drawings and in paragraph entitled "Location" in Section 33 11 00 WATER DISTRIBUTION.

3.4.5.7 Jacking, Boring, and Tunneling

Unless otherwise indicated, provide excavation by open cut except that sections of a trench may be jacked, bored, or tunneled if, in the opinion of the Contracting Officer, the pipe, cable, or duct can be safely and properly installed and backfill can be properly compacted in such sections.

3.4.6 Underground Utilities

The Contractor is responsible for movement of construction machinery and equipment over pipes and utilities during construction. Perform work adjacent to non-Government utilities as indicated in accordance with procedures outlined by the 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.

3.5 OPENING AND DRAINAGE OF EXCAVATION AND BORROW PITS

Notify the Contracting Officer sufficiently in advance of the opening of any excavation or borrow pit to permit elevations and measurements of the undisturbed ground surface to be taken. Except as otherwise permitted, excavate borrow pits and other excavation areas providing adequate drainage. Transport overburden and other spoil material to designated spoil areas or otherwise dispose of as directed. Provide neatly trimmed and drained borrow pits after the excavation is completed. Ensure that excavation of any area, operation of borrow pits, or dumping of spoil material results in minimum detrimental effects on natural environmental conditions.

3.6 SHORING

3.6.1 General Requirements

Where sheeting and bracing are required, ensure that the sheeting and bracing system meet the requirements in these specifications.

Submit a Shoring and Sheeting plan for approval 15 days prior to starting work. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations. Finish shoring, including sheet piling, and install as necessary to protect workmen, banks, adjacent paving, structures, and utilities. Remove shoring, bracing, and sheeting as excavations are backfilled, in a manner to prevent caving.

3.7 GRADING AREAS

Areas within the limits of grading under this section, including adjacent transition areas, shall be uniformly graded. Finished surface shall be smooth within the specified tolerances, compacted, and with uniform levels or slopes between points where elevations are indicated or between such points and existing grades.

3.7.1 Grading Outside Building Lines

Areas outside the building lines for each structure shall be graded to drain away from the structure and to prevent ponding of water after rains. Finished surface shall be within the tolerance specified below for each area classification, compacted as specified, and free from irregular surface changes.

Grassed or planted areas:

Finished surface of areas to receive topsoil blend shall be not more than 0.10 foot above or below the indicated finish elevations.

3.8 FINAL GRADE OF SURFACES TO SUPPORT CONCRETE

Do not excavate to final grade until just before concrete is to be placed. Protect all surfaces from erosion resulting from ponding or water flow.

3.9 GROUND SURFACE PREPARATION

3.9.1 General Requirements

Remove and replace unsatisfactory material with satisfactory materials, as directed by the Contracting Officer, in surfaces to receive fill or in excavated areas. Scarify the surface to a depth of 6 inches before the fill is started. Plow, step, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that the fill material will bond with the existing material. When subgrades are less than the specified density, break up the ground surface to a minimum depth of 6 inch, pulverizing, and compacting to the specified density. When the subgrade is part fill and part excavation or natural ground, scarify the excavated or natural ground portion to a depth of 12 inches and compact it as specified for the adjacent fill.

3.9.2 Frozen Material

Do not place material on surfaces that are muddy, frozen, or contain frost. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.

3.10 UTILIZATION OF EXCAVATED MATERIALS

Dispose of unsatisfactory materials removed from excavations into designated waste disposal or spoil areas. Use satisfactory material removed from excavations, insofar as practicable, in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes. Do not waste any satisfactory excavated material without specific written authorization. Dispose of satisfactory material, authorized to be wasted, in designated areas approved for surplus material storage or designated waste areas as directed by the Contracting Officer. Clear and grub newly designated waste areas on Government-controlled land before disposal of waste material thereon. Stockpile and use coarse rock from excavations for constructing slopes or embankments adjacent to streams, or sides and bottoms of channels and for protecting against erosion. Do not dispose excavated material to obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way.

3.11 BURIED TAPE AND TRACER WIRE

3.11.1 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.

3.11.2 Buried Tracer Wire

Install tracer wire on all piping in accordance with the Typical Trench Detail. Install tracer wire for horizontal directional drilling in accordance with the installer's recommendations.

3.12 FILLING AND BACKFILLING

3.12.1 Preparations Prior to Backfill Placement

Excavations shall be backfilled as promptly as the work permits but not

until completion of the following:

Approval of construction below finish grade

Inspection, testing, approval, and recording location of underground utilities

Removal of concrete formwork

Removal of shoring and bracing; backfilling of voids with satisfactory soil material; temporary sheet piling driven below bottom of structures; and cutting off and removing of utilities in a manner that prevents settlement of the structure or utilities

Removal of trash and debris

Completion of concrete waterproofing

3.12.2 Preparation of Ground Surface to Receive Fill

Vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious materials shall be removed from ground surface prior to the placement of fills. Sloped surfaces steeper than 1 vertical to 4 horizontal shall be plowed, stripped, or broken up in such manner that fill material will bond with the existing material.

When the ground surface has a density less than that specified for the particular area classification, the ground surface shall be broken up, pulverized, moisture-conditioned to near optimum moisture content of the soil material, and compacted to the required depth and percentage of maximum density.

3.12.3 Placement and Compaction

Any structural backfill or fill required for site development should be placed in loose lifts not exceeding 12 inches in thickness and compacted by the use of a vibratory drum roller. If hand-held or track-mounted compaction equipment is used, the lift thickness should be reduced to 6 and 8 inches, respectively. Before compaction, each layer of backfill or fill material shall be moistened or aerated as necessary to provide the optimum moisture content of the soil material and shall then be compacted to the percentage of maximum density for each area classification as specified. Backfill or fill material shall not be placed on surfaces that are muddy, frozen, icy, or contain frost.

Backfill and fill materials adjacent to structures shall be brought up evenly around structures and shall be carried up to the indicated elevations.

Compaction adjacent to structures, within a horizontal distance from the face of the structure equal to the depth of backfill or fill material (measured from the bottom of footing or bottom of foundation or retaining wall) to final grade, shall be done with power-driven hand tampers.

3.12.4 Trench Backfill

3.12.4.1 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or

excavation with select granular material placed in layers not exceeding 6 inch loose thickness.

3.13 COMPACTION

3.13.1 Percentage of Maximum Density Requirements

Actual density of each layer of soil material-in-place shall be not less than the following percentages of the maximum density of the same soil material determined by the moisture-density test.

AREA CLASSIFICATION	PERCENT MAXIMUM DENSITY
Grassed areas	95
Walks	95
Utility trenches	95
Structures	
Each layer of back-fill material	98
Building slabs and steps	
Top 12 inches of subgrade and each layer of backfill material	98

3.13.2 Moisture Control

Moisture content in soil material at time of compaction shall be within specified limits.

Where the moisture content of a layer of soil material is below optimum before compaction, the required amount of water shall be uniformly applied to the surface of the layer of soil material and the layer of soil disked or otherwise mixed until a uniform moisture content is reached.

Where the moisture of a layer of soil material is above optimum, it shall be dried.

3.14 SPECIAL REQUIREMENTS

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

3.14.1 Water Lines

Excavate trenches to a depth that provides a minimum cover of 3 feet from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe.

3.14.2 Electrical Distribution System

Provide a minimum cover of 36 inches from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.14.3 Pipeline Casing

Provide new smooth wall steel pipeline casing under existing railroad and 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. Install pipeline casing by dry boring and jacking method as follows:

3.14.3.1 Bore Holes

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.

3.14.3.2 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.

3.14.3.3 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. Provide watertight end seals as indicated.

3.14.4 Grouting

Distribute grout to place of final deposit and work into place at end of pipe with spades or trowels.

3.15 EMBANKMENTS

3.15.1 Earth Embankments

Construct earth embankments from satisfactory materials free of organic or frozen material and rocks with any dimension greater than 3 inches. Place the material in successive horizontal layers of loose material not more than 8 inches in depth. Spread each layer uniformly on a soil surface that has been moistened or aerated as necessary, and scarified or otherwise broken up so that the fill will bond with the surface on which it is placed. After spreading, plow, disk, or otherwise brake up each layer; moisten or aerate as necessary; thoroughly mix; and compact to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials. Compaction requirements for the upper portion of earth embankments forming subgrade for pavements are identical with those requirements specified in paragraph SUBGRADE PREPARATION. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.16 SUBGRADE PREPARATION

3.16.1 Proof Rolling

Finish proof rolling on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade.

3.16.2 Construction

Shape subgrade to line, grade, and cross section, and compact as specified. Include plowing, disking, and any moistening or aerating required to obtain specified compaction for this operation. Remove soft or otherwise unsatisfactory material and replace with satisfactory excavated material or other approved material as directed. Excavate rock encountered in the cut section to a depth of 6 inch below finished grade for the subgrade. Bring up low areas resulting from removal of unsatisfactory material or excavation of rock to required grade with satisfactory materials, and shape the entire subgrade to line, grade, and cross section and compact as specified. After rolling, do not show deviations for the surface of the subgrade for roadways greater than 1.0 inch when tested with a 10-foot straightedge applied both parallel and at right angles to the centerline of the area. Do not vary the elevation of the finish subgrade more than 0.05 foot from the established grade and cross section.

3.16.3 Compaction

Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Except for paved areas, compact each layer of the embankment to at least 98 percent of laboratory maximum density.

3.16.3.1 Subgrade for Pavements

As indicated on the drawings.

3.17 FINISHING

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Provide the degree of finish for graded areas within 0.1 foot of the grades and elevations indicated except that the degree of finish for subgrades specified in paragraph SUBGRADE PREPARATION. Finish gutters and ditches in a manner that will result in effective drainage. Finish the surface of areas to be turfed from settlement or washing to a smoothness suitable for the application of turfing materials. Repair graded, topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.17.1 Subgrade and Embankments

During construction, keep embankments and excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation. Protect and maintain the finished subgrade in a satisfactory condition until ballast, subbase, base, or pavement is placed. Do not permit the storage or stockpiling of materials on the finished subgrade. Do not lay subbase, base course, ballast, or pavement until the subgrade has been checked and approved, and in no case place subbase, base, surfacing, pavement, or ballast on a muddy, spongy, or frozen subgrade.

3.17.2 Capillary Water Barrier

Place a capillary water barrier under concrete floor and area-way slabs grade directly on the subgrade and compact with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.17.3 Grading Around Structures

Construct areas within 5 feet outside of each building and structure line true-to-grade, shape to drain, and maintain free of trash and debris until final inspection has been completed and the work has been accepted.

3.18 TESTING

Perform testing by a Corps validated commercial testing laboratory or the Contractor's validated testing facility. If the Contractor elects to establish testing facilities, do not permit work requiring testing until the Contractor's facilities have been inspected, Corps validated and approved by the Contracting Officer. Determine field in-place density in accordance with ASTM D 1557. When test results indicate, as determined by the Contracting Officer, that compaction is not as specified, remove the material, replace and recompact to meet specification requirements. Perform tests on recompacted areas to determine conformance with specification requirements. Appoint a registered professional civil engineer to certify inspections and test results. These certifications shall state that the tests and observations were performed by or under the direct supervision of the engineer and that the results are representative of the materials or conditions being certified by the tests. The following number of tests, if performed at the appropriate time, will be the minimum acceptable for each type operation.

3.18.1 Fill and Backfill Material Gradation

One test per 75 cubic yards stockpiled or in-place source material. Determine gradation of fill and backfill material in accordance with ASTM C 136.

3.18.2 In-Place Densities

a. One test per 2,000 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines.

b. One test per 2,000 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by hand-operated machines.

3.18.3 Check Tests on In-Place Densities

If ASTM D 6938 is used, check in-place densities by ASTM D 1556 as follows:

a. One check test per lift for each 2,000 square feet, or fraction thereof, of each lift of fill or backfill compacted by other than hand-operated machines.

b. One check test per lift for each 2,000 square feet, of fill or backfill areas compacted by hand-operated machines.

3.18.4 Moisture Contents

In the stockpile, excavation, or borrow areas, perform a minimum of two

tests per day per type of material or source of material being placed during stable weather conditions. During unstable weather, perform tests as dictated by local conditions and approved by the Contracting Officer.

3.18.5 Optimum Moisture and Laboratory Maximum Density

Perform tests for each type material or source of material including borrow material to determine the optimum moisture and laboratory maximum density values. One representative test per 75 cubic yards of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density.

3.18.6 Tolerance Tests for Subgrades

Perform continuous checks on the degree of finish specified in paragraph SUBGRADE PREPARATION during construction of the subgrades.

3.19 MAINTENANCE

3.19.1 Protection of Graded Areas

Newly graded areas shall be protected from traffic and erosion and shall be maintained free of trash and debris.

3.19.2 Reconditioning Compacted Areas

Where approved compacted areas are disturbed by subsequent construction operations or adverse weather, the surface shall be scarified, reshaped, and compacted as specified to the required density prior to further construction.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 32 - EXTERIOR IMPROVEMENTS

SECTION 32 01 16.17

COLD MILLING OF BITUMINOUS PAVEMENTS

PART 1 GENERAL

1.1 UNIT PRICES
1.1.1 Measurement
1.1.2 Payment
1.2 REFERENCES
1.3 SYSTEM DESCRIPTION
1.3.1 Cold-Milling Machine
1.3.2 Cleaning Equipment
1.3.3 Straightedge
1.4 QUALITY ASSURANCE
1.4.1 Grade
1.4.2 Surface Smoothness
1.4.3 Traffic Control
1.5 ENVIRONMENTAL REQUIREMENTS

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE
3.2 MILLING OPERATION
3.3 GRADE AND SURFACE-SMOOTHNESS TESTING
3.3.1 Grade-Conformance Tests
3.3.2 Surface-Smoothness Tests
3.4 REMOVAL OF MILLED MATERIAL

-- End of Section Table of Contents --

SECTION 32 01 16.17

COLD MILLING OF BITUMINOUS PAVEMENTS

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

The quantity of milled pavement will be the number of square yards completed and accepted as determined by the Contracting Officer. Determine the number of square yards of milled pavement by measuring the length and width of the milled surface within the specified work area. Measurement to determine the area shall be to the closest inch for width and the closest foot for length.

1.1.2 Payment

Payment will be to the nearest square yard. No payment will be made for milling outside the specified area of work.

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.

FLORIDA DEPARTMENT OF TRANSPORTATION (FDOT)

Section 327 (2010) Milling of Existing Asphalt Pavement

1.3 SYSTEM DESCRIPTION

Maintain in a satisfactory working condition equipment, tools, and machines used in the performance of the work.

1.3.1 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.

1.3.2 Cleaning Equipment

Provide cleaning equipment suitable for removing and cleaning loose material from the pavement surface.

1.3.3 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.

1.4 QUALITY ASSURANCE

1.4.1 Grade

Conform the finished milled surfaces to the lines, grades, and cross sections indicated. The finished milled-pavement surfaces shall vary not more than 0 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.

1.4.2 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.

1.4.3 Traffic Control

Provide all necessary traffic controls during milling operations.

1.5 ENVIRONMENTAL REQUIREMENTS

Milling shall not be performed when there is accumulation of snow or ice on the pavement surface.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Clean the pavement surface of excessive dirt, clay, or other foreign material immediately prior to milling the pavement.

3.2 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 and in accordance with FDOT Section 327. 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.

3.3 GRADE AND SURFACE-SMOOTHNESS TESTING

3.3.1 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.

3.3.2 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.

3.4 REMOVAL OF MILLED MATERIAL

Material that is removed shall become the property of the Contractor and removed from the site.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 32 - EXTERIOR IMPROVEMENTS

SECTION 32 10 00

BITUMINOUS CONCRETE PAVEMENT

PART 1 GENERAL

1.1 REFERENCES
1.2 SUBMITTALS
1.3 PROTECTION OF PERSONS AND PROPERTY
1.4 MAINTAINING TRAFFIC
1.5 SAMPLING AND TESTING
1.5.1 Testing and Inspection
1.5.2 Tests for Bituminous Concrete Materials
1.5.3 Test for Bituminous Concrete Mixture
1.5.4 Quality Control Testing During Construction
1.5.5 Field Testing Facilities at the Mixing Plant
1.6 CONSTRUCTION EQUIPMENT LIST
1.7 ENVIRONMENTAL REQUIREMENTS

PART 2 PRODUCTS

2.1 BITUMINOUS CONCRETE
2.1.1 Aggregate for Bituminous-Concrete
2.1.2 Mineral Filler
2.2 ASPHALT CEMENT
2.3 BITUMINOUS PRIME COAT
2.4 BITUMINOUS TACK COAT
2.5 JOB-MIX FORMULAS
2.6 PERFORMANCE REQUIREMENTS
2.7 PRECAST CAR STOPS

PART 3 EXECUTION

3.1 PREPARATION
3.1.1 Excavation and Filling
3.2 SUBBASE OR BASE COURSE
3.2.1 Preparation of Subgrade or Subbase
3.2.2 Placing and Compacting
3.2.3 Smoothness
3.2.4 Thickness Control
3.3 ASPHALT CONCRETE SURFACE COURSE
3.3.1 Weather Limitations
3.3.2 Transportation of Mixtures
3.4 PREPARATION OF AREA TO BE PAVED
3.4.1 Surface Preparation
3.4.2 Priming the Base Course Surface
3.4.3 Priming Other Contact Surfaces
3.5 PLACING BITUMINOUS-CONCRETE COURSES
3.5.1 General
3.5.2 Pavement Placing

3.5.3 Hand Placing
3.5.4 Joints
3.6 COMPACTION
3.6.1 General
3.6.2 Rolling Procedure
3.6.3 Initial Rolling
3.6.4 Second Rolling
3.6.5 Finish Rolling
3.6.6 Patching Deficient Areas
3.6.7 Protection of Pavement
3.7 ACCEPTANCE PROVISIONS
3.7.1 General
3.7.2 Density and Thickness Requirements
3.7.3 Surface Requirements
3.8 WASTE MANAGEMENT

-- End of Section Table of Contents --

SECTION 32 10 00

BITUMINOUS CONCRETE PAVEMENT

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 T 166	(2007) Standard Method of Test for Bulk Specific Gravity of Compacted Hot-Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
AASHTO T 176	(2008) Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
AASHTO T 180	(2009) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and an 457-mm (18-in) Drop
AASHTO T 2	(1991; R 2006) Standard Method of Test for Sampling of Aggregates (same as ASTM D 75)
AASHTO T 30	(2008) Mechanical Analysis of Extracted Aggregate
AASHTO T 37	(2007) Standard Method of Test for Sieve Analysis of Mineral Filler for Hot-Mix Asphalt (ASTM D 546)

ASPHALT INSTITUTE (AI)

AI MS-02	(6th Edition; 1997) Mix Design Methods for Asphalt

ASTM INTERNATIONAL (ASTM)

ASTM C 127	(2007) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C 128	(2007a) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C 131	(2006)Standard Test Method for Resistance to Degradation of Small-Size Coarse

	Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 88	(2005) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D 1073	(2007) Fine Aggregate for Bituminous Paving Mixtures
ASTM D 113	(2007) Standard Test Method for Ductility of Bituminous Materials
ASTM D 1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1754	(1997; R 2002) Standard Test Method for Effects of Heat and Air on Asphaltic Materials (Thin-Film Oven Test)
ASTM D 1856	(1995a; R 2003) Recovery of Asphalt from Solution by Abson Method
ASTM D 2041	(2003a) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D 2170	(2007) Kinematic Viscosity of Asphalts (Bitumens)
ASTM D 2172	(2005) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2216	(2005) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 242	(2004) Mineral Filler for Bituminous Paving Mixtures
ASTM D 2922	(2005) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 3176	(1989; R 2002) Standard Practice for Ultimate Analysis of Coal and Coke
ASTM D 3180	(2007) Standard Practice for Calculating Coal and Coke Analyses from As-Determined to Different Bases
ASTM D 3282	(1993; R 2004) Standard Practice for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
ASTM D 4	(1986; R 2004) Bitumen Content
ASTM D 5	(2006e1) Penetration of Bituminous

	Materials
ASTM D 5581	(2007a) Standard Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
ASTM D 692	(2000; R 2004) Coarse Aggregate for Bituminous Paving Mixtures
ASTM D 70	(2008) Specific Gravity and Density of Semi-Solid Bituminous Materials (Pycnometer Method)
ASTM D 854	(2006e1) Specific Gravity of Soil Solids by Water Pycnometer
ASTM D 92	(2005a; R 2010) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D 979	(2001; R 2006e1) Sampling Bituminous Paving Mixtures

FLORIDA DEPARTMENT OF TRANSPORTATION (FDOT)

Section 300	(2010) Prime and Tack Coats for Base Courses
Section 300-1	(2010) Prime and Tack Coats for Base Courses - Description
Section 300-2	(2010) Prime and Tack Coats for Base Courses - Materials
Section 330	(2010) Hot Bituminous Mixtures - General Construction Requirements
Section 330-13	(2010) Hot Bituminous Mixtures - General Construction Requirements - Protection of Finished Surface
Section 334	(2010) Superpave Asphalt Concrete
Section 916-1	(2010) Bituminous Materials - Superpave PG Asphalt Binder
Index 600	(2010) Maintenance of Traffic Through Work Zones

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-03 Product Data

Manufacturer's catalog data for bituminous concrete shall be

submitted showing description, mixing, and application instructions for the following items:

Bituminous Concrete; G
Asphalt Cement; G
Bituminous Prime Coat; G
Bituminous Tack Coat; G

SD-05 Design Data

A Job-Mix Formula (G) for bituminous concrete shall be submitted in accordance with paragraph entitled, "Job-Mix Formulas," of this section.

SD-06 Test Reports

Test Reports shall be submitted in accordance with the paragraph entitled, "Quality Control Testing During Construction" of this section.

1.3 PROTECTION OF PERSONS AND PROPERTY

Paving operations shall be conducted in a manner that will ensure the safety of persons and property.

1.4 MAINTAINING TRAFFIC

Vehicular and pedestrian traffic shall be maintained in accordance with FDOT Index 600, during the construction of the work by keeping open vehicular traffic lanes.

Traffic lanes posted with warning signs for safety and directing traffic. Warning lights shall be provided during hours of darkness, in accordance with FDOT.

1.5 SAMPLING AND TESTING

1.5.1 Testing and Inspection

A bituminous-concrete testing and inspection service shall be provided by the Contractor. Testing service shall be approved and shall include sampling and testing bituminous-concrete materials proposed for use in the work, tests and calculations for bituminous concrete mixture, and field-testing facilities for quality control during construction of bituminous-concrete courses.

1.5.2 Tests for Bituminous Concrete Materials

Bituminous-concrete materials proposed for use in the work shall be sampled and tested as follows:

MATERIAL	REQUIREMENT	TEST METHOD	NUMBER OF TESTS
Coarse and fine aggregates	Sampling	AASHTO T 2	One for each material
	Sieve analysis	ASTM C 136	
	Magnesium Sulfate Sound-	ASTM C 88	

MATERIAL	REQUIREMENT	TEST METHOD	NUMBER OF TESTS
	ness Test		
	Sand Equivalent Test of fine aggregate	AASHTO T 176	
	Resistance to abrasion of small size coarse aggregate	ASTM C 131	
Mineral Filler	Sieve analysis	AASHTO T 37	One for each source of material
Asphalt cement	Penetration	ASTM D 5	One for each specified penetration grade
	Flash point	ASTM D 2170 ASTM D 92	
	Ductility	ASTM D 113	
	Loss on heating	ASTM D 1754	
	Solubility	ASTM D 4, Procedure No. 1	
	Ash	ASTM D 3176 ASTM D 3180	

1.5.3 Test for Bituminous Concrete Mixture

MATERIAL	REQUIREMENT	TEST METHOD	NUMBER OF TESTS
Compacted bituminous-concrete mix	Bulk density	AASHTO T 166	Four for each bituminous-concrete mixture
	Marshall Stability Test	ASTM D 5581	
Aggregate and asphalt cement	Specific gravity of coarse aggregate	ASTM C 127	One for each material
	Specific gravity of fine aggregate	ASTM C 128	
	Apparent specific gravity of mineral filler	ASTM D 854	
	Apparent specific gravity of asphalt cement	ASTM D 70	
Uncompacted bituminous-	Maximum theoretical specific	ASTM D 2041	Two for each bituminous-con-

MATERIAL	REQUIREMENT	TEST METHOD	NUMBER OF TESTS
concrete mix	gravity		crete mixture

A density and voids analysis shall be calculated for each series of bituminous-concrete mixture test specimens in conformance with AI MS-02 and shall include the quantity of absorbed asphalt cement in pounds of dry aggregate, percent of air voids, and percent of voids in mineral aggregate.

Report of each job-mix formula shall be submitted on the form entitled, "Hot-Mix Design Data by the Marshall Method" as shown in AI MS-02.

1.5.4 Quality Control Testing During Construction

Soil and base materials shall be tested during construction as follows:

MATERIAL	REQUIREMENT	TEST METHOD	NUMBER OF TESTS
Subbase or base course	Soil classification	ASTM D 3282	One for each soil material
	Moisture content of subbase or base material (Just prior to compaction)	ASTM D 2216	
Soil materials prior to compaction	Moisture-density relations of soil	AASHTO T 180, Method Bor D	One for each type of soil material
Soil material-in-place after compaction	Unit Weight of soil-in-place	ASTM D 1556, Sand Cone Method, or ASTM D 2922, Nuclear Method	At least three daily for each soil material and for each layer; additional test whenever there is any change in moisture conditions

Bituminous-concrete mixtures shall be sampled and tested for quality control during construction of the bituminous-concrete courses as follows:

MATERIAL	REQUIREMENT	TEST METHOD	NUMBER OF TESTS
Uncompacted bituminous-concrete mix	Sampling	ASTM D 979	One for each mixture or day of operation
	Asphalt cement content	ASTM D 2172	
	Mechanical analysis extracted aggregates	AASHTO T 30	
	Recovery of	ASTM D 1856	

MATERIAL	REQUIREMENT	TEST METHOD	NUMBER OF TESTS
	asphalt cement by Abson Method		
	Penetration of recovered asphalt cement	ASTM D 5	
	Ductility of recovered asphalt cement	ASTM D 113	
Compacted bituminous-concrete Marshall samples	Bulk density	AASHTO T 166	Same as specified for uncompacted mix
	Marshall Stability and Flow Tests	ASTM D 5581	
In-place pavement	Density and thickness	As specified	One specimen for each 500 square yards of completed bituminous-concrete course

Test reports results shall be reported in writing on the same day that tests are made.

A bituminous-concrete mixture that does not meet the requirements specified shall not be used in the specified work.

1.5.5 Field Testing Facilities at the Mixing Plant

Field-testing facilities for testing bituminous-concrete materials and mixes at the bituminous mixing plant shall be provided by the testing service.

1.6 CONSTRUCTION EQUIPMENT LIST

Construction equipment list for all major equipment used for transporting, spreading and finishing shall be submitted to the Contracting Officer prior to construction.

1.7 ENVIRONMENTAL REQUIREMENTS

Do not produce or place bituminous concrete when the weather is rainy or foggy, when the base course is frozen or has excess moisture, or when the ambient temperature is less than 40 degrees F in the shade away from artificial heat.

PART 2 PRODUCTS

2.1 BITUMINOUS CONCRETE

2.1.1 Aggregate for Bituminous-Concrete

Coarse aggregate shall conform to ASTM D 692.