SECTION 22 16 19.26 20

LARGE CENTRIFUGAL AIR COMPRESSORS (OVER 200 HP)
11/09

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 GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 2011	(2014B) Cylindrical Wormgearing Tolerance and Inspection Methods
ANSI/AGMA 2009	(2001B; R 2008) Bevel Gear Classification, Tolerances, and Inspection Methods

AMERICAN PETROLEUM INSTITUTE (API)

API Std 672	(2004; Errata 2007; Errata 2010) Packaged, Integrally Geared Centrifugal Air Compressors for Petroleum, Chemical, and Gas Industry Services

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME PTC 10	(1997; R 2014) Performance Test Code on Compressors and Exhausters

ASTM INTERNATIONAL (ASTM)

ASTM A312/A312M	(2015) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM B111/B111M	(2011) Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock
ASTM B171/B171M	(2012) Standard Specification for

	Copper-Alloy Plate and Sheet for Pressure Vessels, Condensers and Heat Exchangers
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM C553	(2013) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM E84	(2015a) Standard Test Method for Surface Burning Characteristics of Building Materials

COMPRESSED GAS ASSOCIATION (CGA)

CGA G-7.1	(2011) Commodity Specification for Air; 5th Edition

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

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

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 2151	(2004) Acoustics - Noise Test Code for Compressors and Vacuum Pumps - Engineering Method (Grade 2)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA MG 1	(2014) Motors and Generators

NSF INTERNATIONAL (NSF)

NSF/ANSI 61	(2014a; ERTA 1-2 2015) Drinking Water System Components - Health Effects

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-3316	(1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation
MIL-PRF-17331	(2013; Rev K) Lubricating Oil, Steam Turbine and Gear, Moderate Service
MIL-T-19646	(1990; Rev A) Thermometer, Gas Actuated, Remote Reading

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

29 CFR 1910.219	Mechanical Power Transmission Apparatus

UNDERWRITERS LABORATORIES (UL)

UL 347	(2016) Medium-Voltage AC Contactors, Controllers, and Control Centers

1.2 GENERAL REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, applies to this section except as specified herein.

1.3 PRODUCTS FURNISHED BUT NOT INSTALLED IN THIS SECTION

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM: Medium voltage motor control center must be installed under Section 26 20 00.

1.4 SUBMITTALS

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

SD-01 Preconstruction Submittals

Approval Of Testing Procedure

SD-02 Shop Drawings

Air compressor system; G

Include wiring diagrams of the air compressor with all accessories. The minimum acceptable scale is 1/4 inch to one foot.

Medium Voltage Motor Control Center; G

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Identify circuit terminals on wiring diagrams and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Indicate on the drawings adequate clearance for operation, maintenance, and replacement of operating equipment devices.

SD-03 Product Data

Air compressor; G

Air intake devices; G

Bypass line silencer; G

Air flow rate and pressure recorder; G

Carbon monoxide monitor; G

Medium Voltage Motor Control Center; G

Submit manufacturer's catalog data for compressor and auxiliary equipment in the format provided in API Std 672, Appendix A. Submit all applicable information. For air compressor, include intercoolers, oil cooler, lubrication system, and control valves. Submit air compressor and intercooler performance curves at specified summer and winter design conditions.

Drain Trap; G

SD-06 Test Reports

Air compressor performance tests; G

Balance tests; G

Sound level and run-in tests; G

Obtain approval prior to shipping compressor.

Air compressor performance tests; G

Instrumentation test; G

Sound level tests; G

Air compressor system tests; G

The test supervisor shall certify performance by test to be in compliance with specifications.

SD-07 Certificates

Air compressor system

Air compressor system installation

Work plan

Factory test procedures

Factory testing certification

Qualifications of field supervisors

Field test procedures

Training material

SD-10 Operation and Maintenance Data

Air compressor system, Data Package 3

Medium Voltage Motor Control Center, Data Package 3

Submit in accordance with Section 01 78 23 OPERATION AND

MAINTENANCE DATA, including a. Complete schematics and “as built” wiring diagrams, b. Enclosure elevations and layout drawings, c. System installation and startup manuals, and d. All drawings shall be done in AutoCAD..

SD-11 Closeout Submittals

Posted operating instructions for air compressor

Submit text.

1.5 QUALITY ASSURANCE

1.5.1 Work Plan

Submit a written schedule of dates of installation, start-up, checkout, and test of equipment.

1.5.2 Factory Testing Certification

Submit a statement that the air compressor factory is equipped to perform all required factory tests. Submit in accordance with paragraph entitled "Manufacturer's Certifications."

1.5.3 Qualifications of Field Supervisors

Submit the name and certified written resume of the engineer or technician, listing education, factory training and installation, start-up, and testing supervision experience for at least two projects involving compressors similar to those in this contract.

1.5.4 Training Material

Submit a detailed training program syllabus for training of government personnel, including instructional materials at least three weeks prior to start of tests.

1.5.5 System Installation

Submit certification of air compressor system performance conforming to ASME PTC 10 and ASME BPVC SEC VIII D1. Submit certification of proper system installation in accordance with paragraph entitled "Supervision."

1.5.6 Air Compressor System

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Data shall contain information required for maintenance and repair and shall contain no evidence that proprietary maintenance arrangements with the manufacturer will be necessary. Compressors which will require proprietary maintenance arrangement with the manufacturer require Government review and approval. The compressors may be disapproved if circumstances do not justify approval of compressors with limited availability of maintenance.

1.6 SAFETY

Construct all components of the unit in accordance with the requirements of OSHA 29 CFR 1910.219. Requirements include shaft coupling guards as specified in Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND

METHODS, thermal insulation and jacketing with manufacturer standard covering or aluminum sheet of all surfaces at 125 degrees F and higher within a height of 7 feet from floor level, and use of electrical safety devices. Thermal insulation, furnished by equipment manufacturer, shall conform to ASTM C553, Type I (flexible resilient), Class B-5 (up to 400 degrees F), 2 pcf nominal. Cement insulation to surface with MIL-A-3316, Class 2, adhesive and fasten with 16 gage wire bands at maximum 16 inches on center spacing. Cover insulation with ASTM B209 sheet aluminum jacket.

1.7 EQUIPMENT ARRANGEMENT

Arrangement selected shall maintain 3 foot clearance for access passage and 4 foot clearance for personnel to operate equipment. There are substantial physical and connection point differences among the several air compressors which comply with this specification. The Contractor shall be responsible for selecting equipment and submitting arrangement drawings covering required changes for approval by the Contracting Officer. Changes from the equipment arrangement shown on the contract drawings shall be performed by the Contractor at no additional cost to the Government.

1.8 ELECTRICAL REQUIREMENTS

Comply with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

1.9 SUPERVISION

The Contractor shall obtain the services of a qualified engineer or technician from the compressor manufacturer to supervise installation, start-up, and testing of the compressor. After satisfactory installation of the equipment, the engineer or technician shall provide a signed certification that the equipment is installed in accordance with the manufacturer's recommendations.

1.10 DEFINITIONS

Conform to ~~API Std 672 and~~ the following:

Compressor power is shaft power at shaft coupling, including all aerodynamic and mechanical losses.

1.11 INSULATION

Thermal and acoustical insulation shall have flame spread rating not higher than 75, and smoke developed rating not higher than 150 when tested in accordance with ASTM E84.

1.12 POSTED OPERATING INSTRUCTIONS

Provide for air compressor. Include start-up and shutdown sequence instructions.

1.13 SPARE PARTS

Provide manufacturer-recommended spare parts. A recommended spare parts list, and associated pricing, must be supplied with each different solid state reduced voltage starter.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Materials and equipment complete with accessories shall be selected by the Contractor for performance compatibility.

2.2 AIR COMPRESSOR (AC-12, AC-13)

The air compressors shall be the packaged, integrally geared, centrifugal type. Include the electric motor driver, medium voltage motor control center, integral gears and cases, staged compressors, intercoolers and moisture separators, instruments, controls, pressure lubrication system with prelubrication pump and shaft-driven lubrication pump, steel base and accessories. Delete the normally provided aftercooler since the intention is to use the heat of compression from the last stage in the air dryer.

2.2.1 Manufacturer's Certifications

The manufacturer shall certify that the air compressors proposed are of the same design, construction, and frame size, and of equal or not more than 10 percent smaller in capacity as compressors which have been in satisfactory continuous service for at least 2 years at not less than two locations. Furnish the name of the owner, the address of the installation, and the name of a person at the installation who can be contacted for verification. The manufacturer shall also certify that the factory is equipped to perform all required factory tests.

2.2.2 Guaranteed Performance

a. Net Compressed Air Output (All seal losses shall be considered internal and not included in the net output) (Minus zero plus minimum 4 percent): 6,000 SCFM

b. Output Pressure Immediately Downstream of Aftercooler (Minus zero plus 4 percent): 125 psig

c. Output Air Maximum Temperature: 400 degrees F

d. Inlet Air Pressure at First Stage: 14.7 psig

e. Inlet Air Temperature at First Stage: 83 degrees F (100% outdoor air)

f. Inlet Air Filtration Efficiency: 99.9 percent of 0.5 micrometer size

g. Barometric Pressure: 14.7 psia

h. Relative Humidity: 60 percent (100% outdoor air)

i. Cooling Water Inlet Temperature: 85 degrees F

j. Total Cooling Water Flow Rate: 245 gpm

k. Maximum Cooling Water Pressure Drop Through the Compressor and Any Intercooler or Oil Cooler: 8 psi

l. Maximum Compressor Power Required. (Plus or minus 4 percent): 1,500 hp

m. Unloaded Compressor Power and Compressor Interconnections: 300 hp

n. Maximum sound levels one meter horizontal from compressor and 5 feet above floor as measured per ISO 2151 Test Code for the Measurement of Sound from Pneumatic Equipment: 84 dBA, 90 dB for any octave band.

2.2.3 Additional Performance Requirements

2.2.3.1 Air Quality

Air at compressor intake will be considered breathing air quality conforming to CGA G-7.1, Type I, Grade D or better. Air compressors shall introduce no material, gases, or particles, or chemically alter any materials that will adversely affect or reduce the quality of the air passing through the unit.

2.2.3.2 Surge Output Pressure

API Std 672, paragraph 2.1.12.

2.2.3.3 Unloading

The compressor shall be designed to unload prior to surge limit. The surge limit shall not occur at a capacity greater than 70 percent of the guarantee point capacity. Unloaded compressor power shall not exceed 20 percent of full load power.

2.2.3.4 Ambient and Inlet Conditions Operating Ranges

Allowing for rational engineering performance adjustments due to variations in ambient and inlet conditions, the compressor shall be designed, equipped, and furnished to be fully operational without abnormal wear throughout the entire range between and including the limits of the winter and summer design conditions specified.

a. Summer Design Conditions:

Inlet Air: 92 degrees F dry bulb and 67 degrees F wet bulb temperatures

Inlet Cooling Water: 75 degrees F

Ambient Compressor Room Temperature: 104 degrees F maximum

Barometric Pressure: 14.7 psia

b. Winter (Low Ambient) Design Conditions:

Inlet Air: 21 degrees F dry bulb and 19 degrees F wet bulb temperatures

Inlet Cooling Water: 75 degrees F

Ambient Compressor Room Temperature: 104 degrees F maximum; 55 degrees F minimum

Barometric Pressure: 14.7 psia

2.2.3.5 Critical Speeds

Conform to API Std 672, paragraph entitled "Critical Speed."

2.2.3.6 Vibration and Balance

Conform to API Std 672, paragraphs entitled "Vibration and Balance." for design vibration limits and balancing tolerances.

2.2.4 Electrical Service Conditions

2.2.4.1 Air Compressor Drive Motor

4,160 volts, 3 phase, 3 wire, 60 hertz electrical service.

2.2.4.2 Accessory electrical Service

See Table I.

TABLE I - COMPRESSOR ACCESSORY ELECTRICAL SERVICE SCHEDULE			
Item	Voltage	Phase	Frequency
Control Power and Motors under 1/2 hp	120	1	60 Hz
Accessory Power	460	3	60 Hz

2.2.5 Compressor Controls

Provide complete programmable logic controller (PLC) based control system with human machine interface (HMI), including 10-inch color graphic touch screen display and user keypad. Display shall provide messages of compressor conditions, including initialization data, operating data, setpoints, first out annunciation, alarm and trip conditions, recall memory of events, date and time stamps, measuring point currents for troubleshooting, and control system self-diagnostics. Provide pneumatic load range control system with each compressor with a manually selectable capability for two modes of load range control as specified. Provide additional electrical, electro-pneumatic, or solid state electronic controls for other specified control and monitor functions. All controls shall conform to NEMA ICS 2 as selected by the compressor manufacturer. Control system enclosure shall conform to NEMA ICS 6, Type 4. Controls shall be suitable for individual operation of the compressor in local or remote mode, or remote operation with one or more other compressors through connection to the existing B818 master PLC and HMI, as indicated on the drawings.

2.2.5.1 Dual Control Mode

Provide auto-stop/start control, including auto load/unload. A pressure regulation control mode shall be furnished to control compressor output pressure to within plus or minus one percent of an adjustable output pressure set point. Provide an adjustment range of 105 to 125 psig. When the compressor operates at capacities above surge limit unload setting and below maximum flow stonewall conditions, the control system shall throttle flow at the compressor suction utilizing variable inlet guide vanes for inlet control in response to increasing discharge pressure due to decreased demand for compressed air. At lower demand, prior to reaching

surge limit at a flow capacity not more than 70 percent of guarantee point capacity, the compressor shall unload by closing the compressor inlet guide vanes and simultaneously opening the bypass vent valve. Use of the bypass vent valve alone to achieve pressure control by a modulation technique of spilling excess air is prohibited. At the low discharge pressure limit, the inlet guide vanes shall open and the bypass vent valve shall close to load the compressor.

2.2.5.2 Unloaded Compressor Start-Up

Each of the two pneumatic control mode systems shall have provision for start-up of the compressor in the unloaded control setting with the compressor inlet guide vane control closed and the bypass valve open.

2.2.5.3 Electrical Start-Up Interlocks

The manual starting circuit of each compressor shall have interlocks to prevent starting until pre-lubrication pump oil pressure and cooling water pump water flow have been established (proven) to the required values for safe operation as determined by the compressor manufacturer.

2.2.5.4 Monitor and Safety Controls

Provide supplementary electric, electro-pneumatic, or solid state electronic controls to provide alarm and shut down requirements, plus interlocks with accessories. Requirements are as follows:

a. Shutdown requirements shall cause the controlled compressor to shut down, energize alarms, and light labeled red lights.

b. Alarm only requirements shall not cause the controlled compressor to shut down, but shall sound the same alarms and light labeled amber lights.

c. Light only requirements shall not cause the controlled compressor to shut down, but shall light labeled amber lights.

d. The individual monitor and safety controls shall be as shown on Table 2 and as indicated on the drawings in the PLC Points Matrix for each compressor (AC-12 and AC-13).

TABLE 2 - MONITOR AND SAFETY CONTROL SCHEDULE

Item	Light and Shutdown	Indicating Alarm	Light Only
1. High Discharge Air Temperature 350 degrees F	Yes	Yes	-
2. High Intercooler Discharge Water Temperature, Each Intercooler	No	Yes	-
3. High Aftercooler Discharge Water Temperature	N/A	N/A	-

4. High Cooling Water Supply Temperature	No	Yes	-
5. High Lube Oil Temperature	Yes	Yes	-
6. Low Lube Oil Pressure	Yes	Yes	-
7. Low Cooling Water Flow	No	Yes	-
8. Low Oil Reservoir Level	No	Yes	-
9. High Condensate Level Intercooler (wired to one light)	Yes	Yes	-
10. Vibration Monitors Each Pinion	Yes	Yes	-
11. Surge Limit Approach	Yes	Yes	-
12. High Motor Stator Temperature	Yes	Yes	-
13. High Condensate Level Aftercooler	No	No	Yes
14. High Inlet Pressure Drop Across Inlet Air Filters (combined, 3 stage)	No	Yes	-
15. High CO Level	Yes	Yes	-

2.2.5.5 Monitoring Instruments

Provide the following monitoring instruments in addition to the monitor and safety controls. Pressure gages shall conform to ASME B40.100, 4 1/2 inch, red marking pointer, single bourdon tube, brass case, black enamel finish. Provide pressure gages with a pressure snubber and a stainless steel barstock needle isolation valve. Thermometers shall be extended stainless steel sheathed bimetallic stem, 3 1/2 inch dial, and separable 4 inch stainless steel wells. Temperature measurements at inaccessible locations shall be made with remote reading thermometers conforming to MIL-T-19646, Class C separable well of Type 304 stainless steel. Select pressure and temperature gage ranges to give a normal operating reading near the midpoint of the scale range.

a. Oil cooler outlet temperature gages for oil.

b. Oil cooler inlet and outlet temperature gages for water.

c. Lubrication oil pump discharge pressure gage.

d. Compressor seal air pressure gage, if applicable.

e. Inlet air filter differential pressure gage with 8, zero, 8 inch water gage. Provide selector valve, tubing, and tap to measure static gage pressure downstream of each filter stage.

f. Pinion shaft vibration monitor readout with stage selection switch.

g. Total running time readout.

h. Cooling water supply to compressor pressure gage.

i. Cooling water return from compressor pressure gage.

j. Interstage air pressure gages for each interstage.

k. Compressed air pressure downstream of last stage pressure gage.

l. Compressed air temperature downstream of last stage temperature gage.

m. Interstage air temperature after intercooler of each stage temperature gages.

n. Compressed air temperature at discharge of each stage of compression before cooling temperature gages.

o. Compressor inlet air temperature gage.

p. Cooling water to compressor temperature gage.

q. Cooling water outlet temperature at outlet of each intercooler and last stage temperature gages.

2.2.5.6 Gages on Schematics

Certain pressure and temperature gages are designed on schematic flow diagrams in the drawings. Where a monitor gage satisfies the required location on a schematic, no additional gage needs to be furnished.

2.2.5.7 Control Schematics

The drawings show a generalized overall control system for compressor, auxiliaries, remote panel transmitting and receiving, and remote panel. The system is shown using relay symbology. Contractor and equipment suppliers may use standard panel features to accomplish the total requirements using other methods of signal, solid state devices, or revised lamping. All wiring diagrams and required devices shall be approved by the Contracting Officer prior to installation.

2.2.6 Control Air Supply

Provide new control air piping of dry and purified air from the supply air piping header for the compressor controls. Sizing shall be based on not less than 15 SCFM. Filtration shall be to 5 micrometers minimum and the air from the dryer discharge piping shall have a maximum system pressure dew point minus 10 degrees F.

2.2.7 Compressor Design Features

Compressor shall be multistage centrifugal, with a minimum of 2 centrifugal compression stages, designed for optimum flow and speed requirements to produce highest space efficiencies at lowest compression ratio and temperature and lowest external noise level. Special attention shall be given to energy saving features in design and arrangement such as radial damper intake valve, long radius interstage piping, and low air velocities. Equipment shall be designed for economical and rapid maintenance. Casing components bearing housings and other major parts shall be shouldered, dowelled, or designed with other provisions to facilitate accurate alignment or reassembly. Shaft seals and bearings shall be accessible for inspection or replacement with a minimum of disassembly.

2.2.7.1 Casings

Casing shall be cast iron, ductile iron, or cast steel. Casing stresses shall be within the limits allowed by ASME BPVC SEC VIII D1. Casings, supports, and baseplates shall be designed and fabricated to preclude excessive and injurious distortion from temperatures, pressures, and forces encountered in service conditions, including surge. Provide jackscrews, lifting lugs, eyebolts, guide dowels, and casing alignment dowels to facilitate disassembly and reassembly. When using jackscrews for parting contacting faces, relieve one of the faces by counterboring or recessing to prevent marring the face, which result in leaking or improper fit. Provide lifting lugs or eyebolts for removable portions of the casings. Flanged casing connections shall conform to ASME B16.1 or ASME B16.5. Threaded connections shall conform to ASME B1.20.1. Casing shall be split in a manner permitting direct access to impellers, shafts, and bearings. Compressors shall be axial flow inlet. Gear cases shall be enclosed, accessible, force lubricated and designed with seals and slingers to keep oil out of air system.

2.2.7.2 Shafts

Shafts shall be of forged or rolled alloy steel and shall have a machined finish throughout their entire length. All rotating components shall be positively secured to shafts by approved mechanical means or interference shrink fits.

2.2.7.3 Impellers

Impellers shall be of 400 series or 17-4 PH stainless steel, open or closed design, with backward leaning vanes, and of welded, milled, or cast construction.

2.2.7.4 Gears

Gears shall be of alloy steel, ANSI/AGMA 2009 and AGMA 2011 Quality Number 12 or better for both bull and pinion gears. Gears shall be hardened to 275 Brinell for bull gear and 320 Brinell for pinion, unless otherwise approved. Gears shall be ground to the required contours, checked for proper contact during assembly at the factory, and shall not require a break-in period in the field for proper operation. All gears shall be pressure lubricated.

2.2.7.5 Seals

Separate air and oil shaft seals shall be provided to confine air in the casing and prevent contamination of the air stream by lubricating oil. Shafts seals shall be labyrinth type, carbon ring type, or a combination of the two types. Provide an air space vented to the atmosphere between the air and oil seals. Seals shall be suitable for all operating conditions including suction throttling, start-up, shutdown, and momentary surge.

2.2.7.6 Thrust Bearings

Axial impeller thrusts shall be absorbed by thrust bearings on the pinion or transferred to the bull gear shaft by conical rider-ring thrust collars. Pinion thrust bearings shall be hydrodynamic (fluid film), multiple-segment type, entitled pad type, or other approved type, and shall be adequate to accommodate all operating conditions, including

surging or stonewall operation. Bull gear thrust bearings shall be sized for equal thrust in both directions and shall be adequate for any axial loads transmitted through the driver coupling.

2.2.7.7 Radial Bearings

Radial bearings shall be hydrodynamic (fluid film), precision bored sleeve or pad type, designed for easy replacement by a split design or axially removable arrangement. High speed pinion bearings shall be anti-oil whip, tilting pad, tilted pad, or other approved type. Bearing design shall provide low vibration and sufficient damping at rated speed and all operating modes, including rated capacity and unloading down to 15 to 20 percent of unloaded power.

2.2.7.8 Intercoolers and Oil Coolers

Intercoolers and oil cooler shall include admiralty brass or copper tubes conforming to ASTM B111/B111M in admiralty tube sheets conforming to ASTM B171/B171M with plate fins and baffles for optimum cooling and fouling resistance using fresh water. Provide an intercooler between stages of compression factory assembled on unit base with piping. Intercoolers and oil cooler shall be factory tested at 1.5 times operating pressure. External intercoolers shall be constructed in accordance with ASME BPVC SEC VIII D1, requirements and be ASME code stamped for 175 psig working pressure. Intercoolers shall be capable of one piece bundle removal. Each intercooler shall be equipped with an integral or direct connected moisture separator with condensate trap or automatic drainer valve assembly. Piping to drainer and drainer assemble shall be Class 300 stainless steel. Design intercoolers for 20 degrees F approach, and a fouling factor of 0.001 for both sides of exchanger; however, the approach temperature used to size the coolers shall be modified if required to meet the design air outlet temperature specified. Nonstandard coolers shall be provided if required to meet the design air outlet temperature requirement. All coolers shall be of counter-flow design.

2.2.7.9 Lubrication System

Include reservoir, shaft driven positive displacement pump, twin oil coolers, twin filter/strainer (readily replaceable cartridges while operating) and parallel piping and valving provisions to accommodate a separately driven prelube lubrication oil pump for start-up and standby. System shall be factory assembled and tested. The oil reservoir shall retain a minimum 3-minute oil supply. Lubricating oil shall conform to MIL-PRF-17331, Lubricant No. 2190-TEP or as recommended by compressor manufacturer. Oil cooler shall be designed for a fouling factor of 0.001 for both sides of exchanger. Pressure lubricate hydrodynamic bearings. Provide the oil sump with level indicator and drain and fill connections.

a. Prelubrication pump shall be sized by air compressor manufacturer for the requirements of the system, but shall meet the following requirements. Pump shall be positive displacement gear pump separately mounted with motor on a common base plate with drip lip and drain.

   (1) Performance: Pump shall have separate safety valve bypass set at 25 psi above peak expected pressure.

   (2) Materials shall be hardened steel gears and shaft, cast iron case, bronze bearings, mechanical seal.

(3) Flexible coupling with shaft guard shall be provided, except that these items are not required for a close-coupled pump.

(4) Motor shall be NEMA MG 1, Design A, Class B insulation, of open drip-proof type. Furnish combination type starter for motor.

b. Lube Oil Heater: Provide thermostatically controlled electric heater in lubrication oil sump of sufficient capacity to heat up and maintain manufacturer's recommended oil temperature when unit is cold at 40 degrees F ambient. Provide low oil level indicator with light for protection of heater.

2.2.8 Electric Motors

Efficiency and losses shall be determined in accordance with IEEE 112. Motor efficiency shall be calculated using Form B of IEEE 112 calculation procedure.

Polyphase motors larger that 125 horsepower shall be tested in accordance with IEEE 112 with stray load loss determined by direct measurement or indirect measurement (test loss minus conventional loss).

The efficiency shall be identified on the motor nameplate by the caption NEMA Nominal efficiency or NEMA Nom eff.

2.2.8.1 Main Electric Drive Motor

The main drive motor for each compressor shall be an induction motor, 1,500 horsepower, with a continuous service factor of 1.15. Size the motor so that the nameplate horsepower rating is not exceeded under the entire range of operating conditions specified. Motor shall be high efficiency type, rated not less than 95 percent based on IEEE 112 testing and labeling. Electrical service will be as specified. Motor shall be designed for reduced voltage starting initially at 50 percent of full voltage before ramping up, allowing for characteristics of the connected load, shall start without undervoltage tripping, and be compatible with the specified medium voltage motor control center. Provide resistance temperature detectors (RTD) attached to or imbedded in motor winding for control system. The motor shall meet the requirements of NEMA MG 1 with Class F insulation. Motor design shall include acoustical covering and reduced noise air intake housing and be rated for 84 dBA or less at 3 feet under full load. Provide space heaters for protection of windings during motor shutdowns.

2.2.8.2 Accessory and Related Equipment Motors

Motors less than 1/2 horsepower shall be single-phase induction motors and shall conform to NEMA MG 1. Motors 1/2 through 5 horsepower shall be three-phase induction motors and shall conform to NEMA MG 1. Single-phase and three-phase motors shall have bimetallic disk thermostats attached to or imbedded in the motor winding. Motors shall have NEMA MG 1 Class B insulation.

2.2.9 Control Panel

Control unit panel conforming to NEMA ICS 6, Type 4, package or frame mounted, factory designed, assembled, and mounted shall be provided complete with connections made to sensing points. The panel shall be

fabricated of formed stretcher leveled sheet steel, reinforced, and assembled into a rigid unit. Gasketed access doors shall be provided as required. Panel shall be factory finish painted. The panel shall meet NEMA 12 requirements.

a. Panel shall contain programmable logic controller (PLC) based controls with HMI mounted in panel face for electric and safety control work required, including either alarm annunciator or individual labeled pilot lights arranged in a group. Panel shall contain alarm device with light and silencing. Generalized arrangement in accordance with drawings.

b. Panel shall contain start and stop buttons (the latter with lockout feature), vibration monitor subpanel, discharge air pressure gage, control test switch and lights, reset button, green unit running light, and control selector switch.

c. Oil pressure gages shall be mounted separately from panel.

2.2.10 Accessories

Required accessories include:

2.2.10.1 Control Valves

Pneumatically controlled variable inlet guide vanes on suction inlet of compressor and control valve on blowoff bypass line.

2.2.10.2 Air Intake Devices

Compressor air inlet shall be piped to the outside of the building and consist of the following:

a. Intake weather hood with rain hood and bird screen. Material shall be galvanized steel or aluminum alloy, minimum 20 gage.

b. Filter housing by filter manufacturer to include filter frames, access door(s). Material for housing shall be 0.065 inch thickness, Class 5000 aluminum alloy. Unit shall be rigid and free from distress with all seams sealed.

c. Intake Pipe from Filter Enclosure to Compressor: Stainless steel ASTM A312/A312M, Grade 304, minimum 10 gage, flanged.

2.2.10.3 Compressor Air Outlet Connections

Compressor air outlet flexible connection of stainless steel bellows with braided steel cover jacket, with stainless steel liner sleeve, 18 inch nominal length bellows, flanged ends, Class 150. If air bypass connects separately to the compressor from the outlet line, provide a second flexible connection of stainless steel bellows with braided jacket for the bypass.

2.2.11 Compressor Intake Air Filters (CIAF-1, CIAF-2)

Provide a ~~three~~two-stage filter system, complete with mounting racks (horizontal flow), interstage seals, and replaceable filters. Filter unit shall be provided complete including enclosure or housing, and frames. Enclosure shall be Class 5000 aluminum alloy with inlet and outlet

flanges. Construction shall be welded or, where welding is not practical, close riveted and caulked, weathertight, with access doors for filter replacement and cleaning. Access doors shall be reinforced, fully gasketed with continuous flexible neoprene gaskets, corrosion-resistant continuous hinges and quarter-turn latches to ensure tightness. All internal ferrous surfaces, including galvanized, shall receive a factory-applied epoxy prime and finish coat for corrosion resistance. Filters shall consist of ~~three~~two separate stages and sized to fit the available space.

2.2.11.1 First-Stage

First-stage filter shall be flat, 2 inch thickness, replaceable media, and rated for the required air quantity at 500 FPM nominal face velocity, friction clean 0.25 inch water gage, efficiency 98 percent of ~~0.60 microinches~~10 microns~~ and 90 percent of 0.20 microinches~~.

~~2.2.11.2 Second-Stage~~

~~Second-stage filter shall be deep pleated type, 9 inchesnominal depth and rated for the required air quantity at 350 FPM nominal face velocity, friction clean 0.20 inch watergage, efficiency 98 percent to 0.20 microinches and 90 percent to 0.12 microinches.~~

2.2.11.2 ~~Third~~Second-Stage

~~Third~~Second-stage filter shall be deep pleated type 12 inches minimum depth and rated for the required air quantity at 350 FPM nominal face velocity, friction clean 0.30 inch watergage, efficiency 99.97 percent ~~to~~of 0.~~02~~3 ~~microinches~~microns.

2.2.11.3 Filter Media

Filter media shall be rated and listed UL Class 2. Filter efficiencies shall be based on National Bureau of Stands (NBS) type discoloration gravimetric test method using atmospheric dust.

2.2.12 Bypass Line Silencer

Provide a bypass line silencer with each compressor as selected by compressor manufacturer for sufficient noise attenuation to meet sound level criteria not greater than 84 dBA measured at an elevation of 5 feet, and 10 feet horizontally from silencer.

2.2.13 Isolating Pad

Each compressor steel frame shall be mounted on a neoprene waffle or rib type isolator pad which extends uniformly and continuously along the base mounting surface. The neoprene material shall be of bridge bearing pad quality neoprene and shall be formulated for 40 durometer hardness. The maximum bearing pressure on the isolating pad shall be 50 psi. The pads shall be composed of two layers or 5/16 inch neoprene bonded to and sandwiching 16 gage galvanized steel. Compressor bolt down through the pad shall be accomplished using 1/4 inch thick neoprene impregnated duck washers. Neoprene bushings are not acceptable.

2.3 AIR FLOW RATE AND PRESSURE RECORDER AND MEASUREMENT

Provide a complete flow and pressure measurement and recording package at

each compressor and at discharge piping serving Drydock 6, which is located near Grids C and 3 where piping is leaving new compressor building. Provide orifice flanges with pressure taps, square edged stainless steel paddle orifice plate. The orifice plate shall be concentric type, of 0.125 inch thickness and shall meet ASME Standards. Orifice shall be sized for 40 inch water column differential at a full scale flow rate of 7,000 SCFM at compressor based on 125 psig upstream pressure and a full scale flow rate of 20,000 scfm in discharge pipe serving Drydock 6 based on 125 psig upstream pressure. Static gage pressure measurement device of the recorder shall have a range of zero to 200 psig. Provide copper interconnecting tubing between the pressure taps and the recorder as part of this measurement and recording package. Provide solid state type recorder operation with milliamp signal to compressor PLC and remote electronic recorder for trend logging of air flow rate and discharge pressure.

2.4 CARBON MONOXIDE MONITOR

The carbon monoxide (CO) monitor unit shall be of the pressure type with attached sampling system. The unit shall be solid state type operation, 2 to 50 ppm range, CO indicating, with provisions for milliamp signal to remote recorder, adjustable set point, and normally open/normally closed contacts for remote signal. Power shall be 120 volt, single phase, 60 hertz with power cord and plug. Response time normally 2 minutes per sample/purge. Unit shall be mounted in a gasketed enclosure with face gage indication CO readings.

2.4.1 Sampling System

Sampling system shall include shutoff valve filter/regulator, pressure gage, manual drainer, and line humidifier set at 50 percent. Draw sample from compressor discharge.

2.4.2 Test System

Test system shall include calibration gas (20 ppm CO) cylinder test gas (200 ppm CO) cylinder, and calibration connectors with quick disconnect.

2.5 Drain Trap

The trap shall be fully automatic, zero-loss drain. The trap shall be fully pneumatic. The trap shall be complete with translucent reservoir, pneumatically actuated full port drain valve, and isolation valve. Outlet shall be 1/2-inch NPT, inlet 3/4-inch NPT. Power shall be dry compressed air 80-130 psig.

2.6 MEDIUM VOLTAGE MOTOR CONTROL CENTER

The medium voltage motor control center (MCC) with solid state soft starter shall meet the specified performance, functional requirements, and fabrication details for a digital reduced voltage, stepless, solid state medium voltage motor starter and shall provide a selectable voltage ramp, current limit or current ramp (all standard) method of soft starting 3-phase AC induction motors. Each motor starter shall be complete self-contained Class E-2 Combination Starters and house the fused disconnect switch, in-line isolation contactor, solid-state controller, motor overload protection and bypass contactor. Units must be approved and/or certified by, and carry the label(s) of Underwriters Laboratories (UL). Units shall be UL 347 listed as a complete assembly, including all

necessary sub assemblies and components in the same package.

Solid state reduced voltage motor starters shall be for the 4160 Volt compressor motors. The starter shall be fully compatible with the compressor motor and provided complete as part of the compressor system with the following standard features and adjustments:

2.6.1 Motor and Load Protection

Motor and Load Protection shall be integral to the starter assembly. Motor protection shall be based upon modeling of the thermal characteristics of the motor as programmed by the user and measured by the starter. All current referenced protection features shall be calculated from the motor nameplate FLA, and automatically adjusted for the Service Factor, NEMA Design, Insulation Class, Line Voltage and Line Frequency as entered by the user. All time-based protection features shall be based on a Real Time Clock, remaining active through any power loss. Starter shall provide the following functions:

a. Thermal Overload shall be provided by the on-board microprocessor control. Basic protection shall be inverse time-current trip curves as defined by NEMA trip curve classes. The trip curve classes shall be programmable from between Class 5 and Class 30 and the starter shall be UL listed to provide each individual class. As the most important protection feature of a starter, the overload protection shall be based on a Dynamic Thermal Register retained in memory and provide the following features:

(1) Retentive Thermal Memory shall be used to ensure that the Dynamic Thermal Register does not lose track of motor temperature after the power is lost or shut down. Upon reapplication of power, the microprocessor shall be automatically updated as to the motor temperature and adjusted for real time cooling while the power is off.

(2) Dynamic Reset Capacity shall retain a snapshot of the thermal capacity necessary to restart the motor. The starter shall determine these requirements by recording and averaging the previous three successful start-ups. After an overload trip has occurred, the protection shall prevent resetting until enough cooling time has passed and sufficient motor thermal capacity is available.

(3) True Thermal Modeling shall be a feature of the overload and reset calculations. Once established at setup, the Dynamic Thermal Register shall be biased according to the following input information when available: Cold Stall Time, Hot Stall Time, Stopped Cool Down Time, Running Cool Down Time, and all of the real time information from the RTD Option.

(4) Separate Trip Curves shall be provided for Start and Run, allowing a higher level curve to avoid nuisance tripping during acceleration, but dropping to another level for accurate motor protection while at full speed. To maximize flexibility, each trip curve shall be programmable as follows:

(a) Basic, using the NEMA Class ranges described above.

(b) Locked Rotor programmable between 400–800 percent of FLA, and

a trip time from 1–– 30 seconds.

(c) Measured Start Capacity (I*I*T curve area) taken from the previous successful start (only applicable to the Start Curve).

(5) Overload Alarm shall be provided to warn users of an impending overload trip. The Alarm level shall be programmable between 40-95 percent of the Dynamic Thermal Register value. It shall provide an adjustable delay of 1–20 seconds.

(6) Manual or Automatic Reset shall be selectable in programming to provide for automatic reset in unattended remote applications.

b. Phase Monitoring shall be standard and based on motor current. In order to protect against disconnected motor leads, this feature will function even if the line voltage remains normal. All features shall be as follows and capable of being disabled if not needed:

(1) Phase Loss shall shut down the starter if current through any leg drops to 20 percent of unit FLA or less. This protection shall be implemented via hardware and shall be non-adjustable. It shall provide an adjustable trip delay of 1–20 seconds.

(2) Phase Imbalance Protection shall be provided with programmable sensitivity to provide both Alarm and Trip points. The sensitivity shall be adjustable for phase-to-phase imbalances of between 5 and 30 percent. Each point shall provide an adjustable delay of 1–20 seconds.

(3) Phase Rotation protection shall be self-learning and field programmable. If phase rotation varies from the initial set pattern, the starter shall trip immediately. If phase rotation is correct, the starter can be re-taught to recognize the new rotation.

c. Short Circuit Detection with dual mode protection for starting and running operation shall be standard. This circuit MUST be provided to protect the starter from load failures. This protection shall be implemented via hardware and shall be non-adjustable.

(1) In the starting mode, the starter shall employ a second pre-check routine to determine if the load circuit has a fault condition and disable the ramping prior to reaching the Initial Voltage setting. This is to avoid additional equipment damage after a fault that may have occurred while the starter was off.

(2) In the running mode, this feature will shut down the starter if current through any leg exceeds 10 times unit FLA for 12.5 milliseconds.

d. Over Current Protection shall be provided separate from the above to be used as a Shear Pin trip. It shall be adjustable at lower levels for protecting mechanical components from undue shock when rapid unexpected load changes occur.

(1) Adjustment level shall be from 100 to 300 percent of the programmed motor FLA.

(2) A time delay of up to 20 seconds shall avoid nuisance tripping

from short duration transients.

e. Under Current Protection shall alarm the starter on an adjustable condition. This Load Loss sensor shall be programmable from 10 to 90 percent of the programmed motor FLA, and with a time delay of up to 20 seconds shall avoid nuisance tripping from short duration transients.

f. Ground Fault protection shall be provided to protect the motor from damage using the Residual Current method. An Alarm and two trip levels, each adjustable from 5 to 90%, shall be available with separate trip times as follows:

(1) ALARM level preset at 5 percent with a 0.5–20 second delay.

(2) LOSET Trip level preset at 7 percent with a 1–20 second delay.

(3) HISET Trip level preset at 10 percent with an 8–250 millisecond delay.

g. Line Frequency Window shall be programmable from a 1 – 6Hz variance from the nominal line frequency as entered by the user. It shall provide an adjustable trip delay of 1–20 seconds.

h. Coast Down Lockout shall be provided to prevent restarting of the motor during backspin or other dangerous mechanical conditions after shutting off. The coast down lockout time shall be programmable between 0 and 60 minutes following a Stop command.

i. Starts-per-Hour Lockout shall be provided to prevent damage to the motor from rapid cycling of start commands for any reason. The maximum starts per hour shall be programmable between 1 and 10 starts.

(1) Time Between Starts Lockout shall also be programmable to work with the above. A minimum time of between 0 and 60 minutes between start attempts shall prevent restarting too rapidly for the motor and load conditions as determined by the user.

2.6.2 Acceleration Control

Acceleration Control shall be fully adjustable in programming to match any application. At a minimum, starter shall come complete with the following settings:

a. Ramp Type: To ensure maximum flexibility in matching the load conditions in the field, the starter shall provide all of the following methods of closed loop acceleration ramp control: Voltage Ramp, Voltage Ramp with Current Limit, Current Limit Only (Current Step), Current Ramp (Torque Ramp) or up to three Custom Ramp profiles that can be programmed by the user.

b. Starting Torque: Initial torque output shall be programmable as either Current or Voltage output, and adjustable between 0-100 percent of maximum Locked Rotor Torque (600 percent current) available from the motor.

c. Maximum Current Limit: To ensure reliability of starting under any circumstance that the motor can function in, Current Limit shall be adjustable between 200 and 600 percent of the unit rating. This will allow locked rotor current to be delivered to the motor if necessary.

Lighter duty starters with lower current limit settings will not be acceptable.

d. Ramp Time: The time between Initial Torque and Full Output shall be adjustable between 1 and 120 seconds.

e. Dual Ramps: To accommodate changing load conditions, the starter shall provide two separately adjustable ramp profiles, selectable via a dry contact closure. Each ramp will provide all of the above features.

f. Custom Ramp Curves shall be available that can be configured by the user to match any load or starting condition. Each of the three available custom curves can be profiled by entering eight torque and time points. The starter shall create a smooth acceleration curve from these plotted axis points.

g. Kick Start: To provide for starting difficult loads, the starter shall include a Kick Start feature that will apply a high output for a short time on initial start command. The Kick-Start voltage level shall be adjustable from 10–100 percent voltage, for 0.1-2 seconds maximum.

h. Jog: For checking rotation at start-up or other testing procedures, the starter shall provide a programmable Jog feature, adjustable from 5–75 percent of line voltage.

2.6.3 Deceleration Control

Deceleration Control (Ramp Down) shall be completely independent of any Accel Ramp settings and provide a fully adjustable Decel profile in order to avoid possible motor damage. Pre-programmed decel “algorithm” systems that do not allow contouring to match load conditions are not acceptable.

a. Step Down Voltage: Adjustable from 100 to 0 percent of line voltage, allowing the motor torque to drop off immediately to a level that affects output without waiting for a linear ramp.

b. Deceleration Ramp Time: Adjustable from 0–60 seconds to allow gentle controlled deceleration in excess of the natural coast-to-stop time of the load.

c. Stop Voltage Level: Adjustable from 100–0 percent of line voltage to automatically turn off the starter when the output torque has reached a desired level. Programming shall not allow the Stop level to be set higher than the Step Down Level. External timers shall not be needed to turn off the starter.

d. Selectable Operation During Overload shall be available to allow the user to decide if the motor shall turn off or continue to Decel when an overload condition is detected.

2.6.4 Starter Protection

Starter Protection shall be provided to maintain reliability of both the equipment and the circuit components, with the following features:

a. Shorted SCR Detection shall be standard. This function must automatically prevent a “start” sequence when at least one SCR is

shorted. A means of having qualified service personnel defeat the lockout of this circuit MUST be provided to allow for “Must Run” situations.

b. Shunt Trip Circuit shall be standard. This feature will instantly energize a dry relay contact that can be wired to a “Shunt Trip” coil of the circuit breaker in order to protect the motor from damage. This protection shall only operate if there is current flowing through any phase of the starter when in the “Off” condition, such as when there are multiple shorted SCRs or a bypass contactor stuck on. This feature shall be independent of the above Shorted SCR protection so that it cannot be defeated.

c. Starter Overtemp Trip shall be built in and protect the SCRs from excessive heat build-up in the enclosure or heat sinks. Thermal sensors on the heat sinks shall be pre-wired to one of the programmable inputs that has been factory preset as the Over Temp input.

2.6.5 Inputs

Inputs shall be provided for the control and option selection of the starter as follows:

a. Digital Inputs: All input and control devices shall be rated for 120VAC control or shall require dry contact closures without the need for external power supplies or interposing relays.

(1) On-Off Control shall be 120VAC to avoid potential problems with voltage drop in long control wire runs. The starter shall provide for 2-wire or 3-wire control schemes. Seal-In relay contact for the 3-wire control scheme shall be internal, dedicated to that use and not counted as an output contact. Terminals shall be provided for use in interlocking with programmable output relays or external devices.

(2) User Inputs: Four programmable digital inputs shall be provided. Each input shall accept dry contact closures from external user-supplied devices, and can be named for display on the DCU when energized. Two of these inputs shall be preset as Temperature and Dual Ramp Select, but can be changed by the user. Inputs can be programmed as N.O. or N.C., and programmed with a de-bounce timer of 0–60 seconds. Each input can be assigned to operate any of the Programmable Outputs.

(3) Analog Input shall be provided for optional Tach Feedback Starting. This input shall accept 4-20ma with adjustable offset and gain.

2.6.6 Outputs

Outputs shall be provided for the following functions in addition to the seal-in relay used in 3-wire control schemes as mentioned above:

a. Digital Outputs shall be eight Form “C” contact relay outputs, rated for 240VAC, 5AMPS, 1200VA maximum, with each relay being programmable for any one of the following functions:

(1) Indicator Relay programmable to change state on any of the

following conditions: Run/Stop, Start/End of Decel, Timed Output, At Speed/Stop, At Speed/End of Decel, Dual Ramp Selected, Self Test Fail.

(2) Fault Trip Relay programmable for each of the following fault conditions: Overload, Phase Imbalance/Loss/Reversal, Lock Out Inhibits, External Inputs, Short Circuit, Over Current/Shear Pin, Ground Fault HISET/LOSET, Over/Under Frequency, I2T Start Curve, Shorted SCR, Shunt Trip, Over Temp, Under Current/Load Loss.

(3) Alarm Relay including the following conditions: Overload Warning, Overcurrent Warning, Ground Fault Warning, Under Current Warning, Imbalance Warning, Thermal Register Warning.

(4) RTD Relay, including Stator or Non-Stator Trip and/or Warning, and RTD Failure.

b. Analog Output shall be included for providing information to external controls and be programmable as RMS Current or Percentage of Motor FLA. The Analog outputs can be programmed as Hottest RTD Temperature for Stator or Non-Stator RTDs.

2.6.7 Operator Interface Panel

Operator Interface Panel that provides simple-to-use adjustment and status indication on a dead-front shroud of the starter shall be provided.

a. Adjustments shall be made by keypad with tactile feedback keys for high noise environments. To prevent confusion, no binary coded dip switches shall be used for programming. Pass code protection shall be available to prevent unauthorized changes to the programming.

b. Alpha-Numeric Display shall be Backlit LCD with two lines by 20 characters.

c. Indicators using long life LED devices shall provide additional quick annunciation of Power, Run Alarm and Trip operation, as well as the status of the eight output relays.

d. Password Protection shall be provided, allowing three levels of access to program information, two of these levels requiring separate Passwords.

2.6.8 Metering

Metering functions shall be provided through the Alpha-Numeric Display for indicating the following:

a. Output Current for each individual phase or average of all three. Indicating range to be 0.0–9999.9 amps.

b. Ground Fault Current.

c. KVA, KW, MWH, KVAR, Power Factor, Peak On KW, KVAR, KVA Demand.

d. Motor Load percent of FLA.

e. Line Frequency.

f. Phase order.

g. Remaining Thermal Capacity to indicate heating effect and cooling rate of the motor. Range shall be 0–100 percent of the remaining capacity and count up towards 100 percent while cooling.

h. Thermal Capacity to Start indicating the required value that will be added to the thermal register as learned and averaged from the previous three successful starts.

i. Average Start Time learned from previous three successful starts.

j. Average Start Current learned from previous three successful starts.

k. I*I*T to Start measured from the previous start.

l. Last Start Time measured from Start Command to At-Speed.

m. RTD Metering for up to 12 Stator and Non Stator RTDs, displayed in degrees C and degrees F. Metering includes Hottest RTD, each RTD Temp, each RTD Max Temp Since Clear, Measured Run Cool Time in minutes, and Measured Stop Cool Time in minutes.

n. Starter Status including Ready, Starting, Running, Last Trip Cause.

o. Remaining time for O/L Trip, Thermal Inhibit, Coast Down Lock Out, Time Between Starts and Starts per Hour.

p. Event Recorder (last 60 events) with Phase and GF currents record at each event.

q. Last Trip including Cause, Phase and GF currents, Unbalance percent, Hz, Hottest Stator and Non Stator RTD recorded.

r. Statistics including Elapsed Run Time, Total Trips, Trips on Short Circuit, Start O/L, Run O/L, Frequency, Overcurrent, Stator RTD, Non-Stator RTD, G/F LOSET and HISET, Acceleration Time, Start Under Curve, Start Over Curve, I*I*T Start, Fail Shunt Trip, Phase Loss, Tach Accel, and four External Inputs.

s. Learned Start Curve. When enabled, the starter will record a start curve with 100 data points of current and time between Start and At-Speed. This data can be exported via the Comm. Port to be plotted on a graph or spreadsheet for baseline measurement and maintenance analysis.

2.6.9 Control or Protection

Control or protection shall include the following:

a. RTD Inputs. Allowing biasing and adjustment of the Dynamic Thermal Register based on real-world temperature readings from up to 12 RTDs, with the following features:

(1) Programmable RTD Type, shall accept 100 ohm platinum, 100 ohm nickel, 120 ohm nickel and/or 10 ohm copper RTDs

(2) Configurable RTDs allowing for up to 6 RTDs to be used for the Stator. All RTDs can have names assigned in programming for clear

indication on the display.

(3) RTD Voting providing for the requirement of at least two RTDs to be exceeding the setpoints for Trip or Alarm. This feature shall be programmable as Enabled or Disabled.

2.6.10 Serial Communications

Serial Communications shall be built in as a standard feature without the need for separate modules.

a. Communications protocol shall be RS-232 to a Windows-based program for data entry, and/or Modbus RTU protocol via RS485 signals.

b. Units shall be capable of being connected to an intelligent communication device in a network of up to 247 devices with unique addresses.

2.6.11 Power Ratings

a. Input: 4160VAC, plus 10 percent to minus 15 percent, 3 phase, 60Hz plus or minus 6Hz. Units will operate with any incoming phase sequence.

b. Output: Reduced voltage 3 phase AC derived from phase-angle fired inverse-parallel thyristors, ramped to full voltage.

c. Current Rating(s): 200, 400, 600 Amps (choose size for application)

d. Output Capacity: Heavy Duty, rated as follows: Overload Capacity = 500 percent of unit rating for 60 seconds; 600 percent for 30 seconds; minimum 115 percent of nominal motor FLA continuous. Light duty rated starters are not acceptable.

e. Control Power: 120VAC, 60Hz, derived from an integral transformer sized to be adequate to operate all associated devices in each starter.

2.6.12 Power Structure

a. Disconnect Switch: A “Fault-Make/Load-Break” rated disconnect switch shall be provided in the incoming power section of the starter assembly.

(1) Disconnect switch design voltage shall be 7200V.

(2) The Load-Break rating is to protect against any possible vacuum contactor failure, therefore isolation switches relying on the vacuum contactor to interrupt the load shall not be used.

(3) The disconnect shall be padlockable in the “Open” position. Lockout coordination with adjacent compartments will be as follows:

(a) The incoming line section door cannot be opened if the disconnect switch is in the closed position. The disconnect switch cannot be closed if the incoming line section door is open.

(b) All other associated doors in sections containing medium voltage potential shall be interlocked with the incoming line section door by either direct mechanical means or by use of

Kirk-key interlock mechanisms.

(4) A viewing window in the Main Incoming Power Compartment shall allow visual inspection of the disconnect blade status prior to opening the door.

(5) A separate knife arm shall bond the disconnect mechanism to ground when fully open.

b. Power Fuses: As a NEMA Class E2 controller, current limiting primary power fuses shall be provided for each incoming phase.

(1) Fuses shall be ANSI Class “R” for motor starting duty, sized according to motor locked rotor current and coordinated with the overload relay. Fuse and overload coordination shall be designed to allow the controller and contactor to clear low and medium level faults without blowing and without exceeding the contactor interrupt ratings. Fuses shall be used to interrupt high level faults exceeding those ratings.

(2) Fuse holders shall include blown fuse indicators, wired to the isolation contactor circuit to disconnect all three phases if any one of the fuses clears.

c. Isolation and Bypass Contactors: Vacuum contactors shall be provided for both In-Line Isolation and SCR Bypass.

(1) The contactor voltage ratings shall be 7200V minimum.

(2) A sequencing feature shall control the contactors. Under normal operating conditions it will ensure that both contactors always make and break under no-load conditions to maximize contactor life.

(3) Vacuum contactors shall be rated for maximum starting current of the unit design.

(4) Interrupt rating shall be in coordination with the primary fuses as per UL 347.

d. Bus Bars: Provide main horizontal phase bus bars (must specify) extending the entire length of the starter lineup. Bus bar material shall be tin-plated or silver-plated copper. All bus ratings shall be as per UL 347.

(1) Bus bars shall be braced with non-tracking fire resistant non-hygroscopic insulation supports and shall have a minimum fault current rating of 78,000 Amps.

(2) All bus connections shall use two bolts minimum, with Belleville spring washers to ensure tightness. Splice kits for each shipping split shall be included.

(3) A continuous ground bus bar with a minimum rating of 600 Amps shall extend the entire length of the starter lineup near the bottom of each enclosure. A grounding strap shall connect each vertically adjacent compartment and also tie the grounding arm of the disconnect switch to the main ground bus bar.

(4) Splice kits for each shipping split shall be provided when

horizontal bussing is specified.

e. Rated Short Circuit Amps: Starter and contactors shall be rated for 50kA RMS symmetrical. The entire assembly as a NEMA Class E2 controller shall have fault withstand ratings as per UL 347 of 350MVA symmetrical at up to 4160V.

f. Overall BIL Rating: Entire starter assembly shall have a BIL (Basic Impulse Level) rating of 60kV.

g. Insulation Rating: Standard insulation design shall be for 15kV. Insulation shall be tested for dielectric voltage withstand of 30kV for 60 seconds.

2.6.13 SCR Modules

a. PIV Ratings: SCRs will be connected as inverse parallel pairs in series circuits to attain the following Peak Inverse Voltage ratings as a minimum for each phase: System Voltage: 3300/4160V Series Pairs: Two; PIV Rating;13000V.

b. Protection: RC snubber network circuits on each phase assembly. To avoid possible component damage, MOV protective devices shall be used only on the gate firing circuitry.

c. Efficiency: 99.7 percent through SCRs, 99.97 percent in bypass mode.

d. Control Method: To ensure reliable gate firing even when powered with on-site generators, firing circuits shall use individual phase transformer coupling method for maximum isolation and rapid rise of firing pulse.

e. Noise Immunity: The gate firing circuitry shall be protected from electrical noise and transients to ensure reliable starting and firing of the SCRs under all power conditions, regardless of the available fault current or motor lead length.

(1) They shall be amplified and isolated from the control voltages by means of rugged encapsulated ring transformers that provide separate power sources for each set of SCR gate drives. The design shall allow for a “back-porch” DC carry-over of the firing pulse to prevent the SCRs from falsely turning off due to ringing of the output current or line notching caused by other connected equipment. The gate drive shall be maintained for 240 electrical degrees from the zero cross point to avoid motor switching transients.

(2) For additional reliability and to protect against EMI/RFI interface generated by the internal components, connections to the Digital Control Unit shall be fiber optic.

(3) When at all possible, the starter shall not require line reactors in the Medium Voltage power section. Those that do shall include them within the same enclosure as the starter and shall be UL listed in this configuration.

2.6.14 Ambient Conditions

a. Temperature: As a standard of unit design quality, starter shall be

documented to show the design has been tested for minus 32 to 122 degrees F operation, and Overload Capacity shall be rated at this temperature.

b. Altitude: 3,300 feet maximum without derating.

c. Humidity: 0–95 percent RH, non-condensing.

d. Thermal: Heat sink temperature switches designed to trip at 185 degrees F.

2.6.15 Electronics

a. Non-Volatile Memory will be used throughout the control and protection systems. To prevent the possibility of losing protection values, stored programs or statistical data, battery back-up memory systems will not be allowed.

(1) The starter shall store all factory defaults in a preset replaceable EPROM memory chip.

(2) User Programming and statistical data shall be stored in EEPROM memory for ready alteration. Loss of power shall not affect memory status.

(3) For fast updates and operation, running programs shall use DRAM memory. The starter shall store the DRAM memory contents to the EEPROM upon power failure, and restore it upon return to normal.

b. Data Sampling

(1) Critical operating data such as instantaneous current for Short Circuit, Ground Fault and Immediate Overload calculations shall be sampled every 2 milliseconds to prevent lagging operation.

(2) Non-Critical data shall be obtained from a true RMS calculation circuit, and sampled in a 350 millisecond moving window of individual phase currents.

c. Real Time Clock with automatic leap-year updating shall be provided. This clock alone shall use a battery back-up with a Lithium-Ion battery rated for at least 10 years of continuous operation without power applied. The clock shall be capable of being reset in the field after changing the battery, without affecting any other stored information.

2.6.16 Mechanical Construction

Enclosure shall contain the digital solid state controller and disconnect means and other components as required. Structure design shall be as follows:

a. Welded steel enclosures with a minimum thickness of 11 gauge will be provided to form rigid freestanding dead front structures. Enclosure design shall be in accordance with NEMA ICS 3-2 and UL 347.

b. NEMA type 12 with full gasketing to protect internal components from contamination. Enclosure can be field upgraded to type 3R with the

addition of a drip shield and drainage provisions.

c. Three isolated compartments shall be provided, dividing each starter assembly into:

(1) A Main Incoming Power Compartment housing the main disconnect switch and horizontal power bus bars.

(2) One or more Starter Power Compartments containing the fuses, vacuum contactors, SCR power modules, instrument transformers and all other medium voltage devices.

(3) A Low Voltage Control Compartment housing the digital microprocessor controller, LCD operator interface and all other low voltage devices and operator controls.

(4) Compartment doors shall be rolled and formed to be capable of containing maximum fault forces. Doors shall open a minimum of 120 degrees and include means for holding them open during servicing or testing.

d. Removable conduit entry plates shall be provided in the top and bottom of the enclosures to facilitate drilling and punching of conduit holes without exposing the equipment to contamination from metal debris.

e. Enclosure finish shall be suitable for indoor or outdoor use in non-corrosive environments. Paint shall be NSF/ANSI 61 gray polyurethane powder over a zinc phosphate pre-treatment. Paint thickness shall be minimum 2 mil.

f. Lifting eyes or angles capable of supporting the maximum weight of each shipping split shall be provided on the top of the enclosure.

g. Seismic Qualifications: The entire starter assembly and installation procedures shall be suitable to withstand vertical and horizontal accelerations typical of seismic Zones 1 through 4 as defined in the UBC. The assembly will not overturn or show significant lateral movement, but shall not be expected to continue operating during or after a seismic event

2.6.17 Quality Requirements

a. All incoming material shall be inspected and/or tested for conformance to quality assurance.

b. Power semiconductors shall be fully tested for proper electrical characteristics (dv/dt, di/dt, etc.).

c. All subassemblies shall be inspected and/or tested for conformance to vendors engineering and quality assurance specifications.

d. Printed circuit boards shall be burned in for a minimum of 48 hours at 60 degrees C.

e. The complete unit shall be functionally tested under load before shipment to assure proper operation per specification. Complete test reports shall be available upon request.

2.7 SOURCE QUALITY CONTROL

2.7.1 Factory Test Procedures

The completely assembled air compressor package, including the actual contract drive motor, intercoolers, lubrication system, control panel, soft starter, and PLC-based controls with HMI shall be subjected to performance tests, balance tests, and sound level and run-in tests. Unit shall comply with guarantee requirements applying engineering adjustments to guarantee conditions. Test shall be certified by the manufacturer. Test shall be run on the manufacturer's test stand using driver for this contract. Tests shall be in accordance with ASME PTC 10 format. Full-range performance tests shall indicate performance at maximum rated flow, rating point, and blowoff conditions. All accessory performance conditions shall be reported, including intercoolers and lubrication and control systems. The complete unit shall be factory tested with sound meters in accordance with ISO 2151. Location shall be one horizontal meter from unit at 1.5 meters above the floor. Test shall include readings at each octave band midpoint and the "A" scale, and shall be 84 dBA or less and 90 decibels at any octave band. Results of test shall be included in the factory test report on the ISO 2151 format. Factory test data may be corrected to the levels of an equivalent background noise level of 60 dBA showing calculations for reference use.

2.7.2 Supervision of Testing

System and components testing shall be conducted or supervised by either a designated authorized and factory trained representative of the compressor manufacturer supplying the unit or a registered Mechanical Engineer experienced in such work.

2.7.3 System Test

Testing of system shall conform to requirements outlined and shall be witnessed by the Contracting Officer.

2.7.4 Approval of Testing Procedure

Proposed testing procedure shall be approved by the Contracting Officer and the individual in charge of testing prior to conducting tests.

2.7.5 Certification of Performance Tests

The test supervisor shall certify performance by test to be in compliance with specifications.

PART 3 EXECUTION

3.1 INSTALLATION

The Contractor shall install the air compressors and accessories in accordance with manufacturer's recommendations and as indicated on the drawings. All equipment shall be installed plumb and level and anchored to structure, matching holes provided.

3.1.1 Manufacturer's Supervision

Install the compressors under the direct supervision of an authorized representative of the manufacturer.

3.2 GENERAL REQUIREMENTS FOR INSTALLING AIR COMPRESSORS

Air compressors with contract motor and accessories shall be factory assembled, run in, and tested complete before shipment to job site. The Contractor is advised that there are limitations to door opening size. Contractor must make provisions for setting equipment in place, as no cranes are available from the Government. Should the unit require disassembly for installation, reassembly shall be under the direct supervision of the compressor manufacturer's authorized representative. Complete unit shall be mounted on a rigid single or equivalent mechanically joined steel or iron base. Submit installation sequence plans to the Contracting Officer for approval prior to installation. Any building materials removed to accomplish installation shall be reinstalled if undamaged by removal procedures; or if damaged, shall be replaced with new materials to match original configuration.

3.2.1 Prompt Installation

The Contractor is advised that any compressor received shall be installed and placed in operation promptly to prevent time deterioration when not installed. Should the Contractor sustain a delay exceeding 90 days prior to actual installation, the Contracting Officer shall have the option of requiring breakdown and reassembly to inspect and clean prior to placing in operation. This work shall be at no additional cost to the Government.

3.2.2 Start-Up Services for Compressors

The Contractor shall furnish the services of a compressor manufacturer's authorized representative to supervise prestart checkout, initial start-up, performance testing, and operator instruction. Time available shall be as required to properly start up but not less than 3 consecutive days for the compressor.

3.2.3 Start-Up Services for Soft Starter/MCC

The Contractor shall furnish the services of the factory's authorized representative to perform on-site inspection and start-up assistance, prior to first energization, and to perform initial startup, performance testing, and operator instruction. Time shall be concurrent with compressor start-up services.

3.3 FIELD QUALITY CONTROL

3.3.1 Field Test Procedures

Complete field performance testing of the total system shall be performed by the Contractor and witnessed by the Contracting Officer. Air compressor system tests shall be conducted by either a compressor manufacturer's factory trained and authorized representative approved by the Contracting Officer or a qualified registered Mechanical Engineer. Tests may be run on individual components or on the system as a whole at Contractor option. Field tests require use of the actual compressor drive motor. Test shall include operation at rated capacity for not less than 4 hours.

3.3.1.1 Air Compressor Performance Tests

Complete performance test shall be run at maximum load, rated load, at

point of unload but prior to unload, and unloaded condition. Data shall be recorded listing:

a. Air flow, inlet pressure and temperature, humidity; discharge pressure and temperature.

b. Intercooler water flows, temperatures, and pressures.

c. Last stage discharge, temperatures, and pressures.

d. Lube oil cooling water flow, temperatures, and pressures.

e. Lube oil flow, pressures, and temperature.

f. Cooling water pump flow, pressures, and motor amperage.

g. Closed circuit cooler air flow, water and air temperatures, water pressure, and motor amperage.

h. Electrical load in volts and amperes for compressor motor, prelube oil pump motor, and compressor auxiliaries.

i. Intake filter pressure differential (clean).

j. Start-up sequence, alarm signals and automatic system shutdown.

k. Control sequence, either modulating or in sequence with the other air compressors and existing plant air.

l. Test compressor intake and discharge for conformance to CGA G-7.1. Compressor discharge shall show no increase in contaminants.

3.3.1.2 Instrumentation Test

The Contractor may use instrumentation provided in the contract and instrumentation provided by the Contractor to conduct the test. The testing procedure and instrumentation shall be submitted to the Contracting Officer for approval prior to conducting tests. The format of ASME PTC 10 is required. It is intended that a full field test be performed.However, in lieu of precise instrumentation, the Contractor may use certified cooling water pump curves and closed circuit cooler fan curves. Shutdown signals shall be caused by throttling selected fluids. Test data, such as air intake temperature and humidity, shall be mathematically corrected to performance test requirement levels.

3.3.1.3 Sound Level Tests

Sound level tests shall be conducted concurrently. Broad Band "A" scale readings and Octave Band readings shall be taken and recorded at the same positions as on the factory testing. Maximum permissible level shall be 84 decibels one horizontal meter from the compressor and 1.5 meters above the floor, with unit in operation and all other significant equipment not required for test within the same building bay shutdown at the same location previously described. A background noise correction to 60 decibels is permissible.

3.3.1.4 Deficiencies Discovered in Testing

Any operational deficiencies noted in the tests shall be promptly

corrected and affected portions of the test rerun.

3.3.1.5 Testing Tolerances

A tolerance of plus 2 percent minus zero on flow, plus or minus 4 percent on power, or plus or minus 5 percent on any other variable for each item of equipment or fluid with all others conforming is permissible on field test results when compared to factory test data and to guarantee performance data except that compressor air flow, discharge pressure, and motor power shall be met.

3.3.2 Approval of Testing Procedure

Proposed testing procedure shall be approved by the Contracting Officer and the individual in charge of testing prior to conducting tests.

3.4 TRAINING OF GOVERNMENT PERSONNEL

During start-up and field testing, Contractor shall provide training of Government station personnel in the operation and maintenance of the compressed air system and compressor cooling water system, including compressors, MCC/soft starters, closed circuit fluid coolers, pumps, associated equipment, and all control and safety devices. Training shall not commence until equipment is operational and station personnel are in attendance. At least one day of classroom training and two days of field training shall be furnished for up to 8 designated Government personnel. When factory training is required by the compressor manufacturer for proper maintenance and overhaul of the compressors, such training shall be furnished by the compressor manufacturer at no additional cost to the Government. The Government will bear the cost of travel and living expenses for Government personnel as necessary for the factory training.

Provide demonstration of the compressed air system and the compressor cooling water system, including complete operating sequence, simulating field controls to the satisfaction of the Contracting Officer while the Field Technician(s) is/are on site. Adjustments must be made as necessary and a field start up report must be provided upon conclusion.

-- End of Section --

SECTION 33 05 23.13

UTILITY HORIZONTAL DIRECTIONAL DRILLING

PART 1 GENERAL

1.1 REFERENCES

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

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

29 CFR 1926.652	Safety and Health Regulations for Construction; Subpart P, Excavations; Requirements for Protective Systems

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-07 Certificates

Drill Rod

PART 2 PRODUCTS

2.1 DRILL ROD

Select the appropriate drill rod to be used. Submit certified statement that the drill rod has been inspected and is in satisfactory condition for its intended use.

2.2 DRILLING FLUIDS

Use a high quality drilling fluid to ensure hole stability, cuttings transport, bit and electronics cooling, and hole lubrication to reduce drag on the drill pipe and the product pipe. Use only fluid with a composition which complies with all federal, state, and local environmental regulations.

Mix the drilling fluid with potable water to ensure no contamination is introduced into the soil during the drilling, reaming, or pipe installation process. The Contractor is responsible for any required pH adjustments.

Disposal of the drilling fluids is the responsibility of the Contractor. Conduct disposal in compliance with all relative environmental regulations, right-of-way and work space agreements, and permit requirements.

Collect drilling fluid returns in the entrance pit, exit pit, or spoils recovery pit. Immediately clean up any drilling fluid spills or overflows

from these pits.

PART 3 EXECUTION

3.1 DRILL SET-UP AREA

The Contractor is responsible for design and construction of the drill entrance and exit pits.

3.2 DRILL ENTRANCE AND EXIT PITS

Drill entrance and exit pits are required. Maintain at minimum size to allow only the minimum amount of drilling fluid storage prior to transfer to mud recycling or processing system or removal from the site.

Do not allow drilling mud to flow freely on the site or around the entrance or exit pits. Remove spilled mud and restore ground to original condition.
Provide shore pits in compliance with OSHA Standards, 29 CFR 1926.652.

3.3 DRILL ENTRANCE AND EXIT ANGLE

Ensure entrance and exit angles and elevation profile maintains adequate cover to reduce risk of drilling fluid breakouts and ground exit occurs.

3.4 PILOT HOLE

The type and size of the pilot string cutting head and the diameter of the drill pipe is at the Contractor's discretion.

3.5 REAMING

Conduct reaming operations at the Contractor's discretion. Determine the type of back reamer to be utilized by the type of subsurface soil conditions that are encountered during the pilot hole drilling operation. The reamer type is at the Contractor's discretion.

3.6 PULL BACK

~~Fully assemble the entire pipeline to be~~Casing pipes shall be assembled in sections where required and installed via direction drill prior to commencement of pull back operations.

Support the pipeline during pullback operations in a manner to enable it to move freely and prevent damage. Install the pipeline in one continuous pull.

Minimize torsion stress by using a swivel to connect the pull section to the reaming assembly.

Minimize external pressure during installation of the pullback section in the reamed hole. Replace damaged pipe resulting from external pressure at no cost to the Government. Buoyancy modification is at the discretion of the Contractor.

3.7 GUIDANCE SYSTEMS

Walkover guidance systems are acceptable for this project or use a magnetic survey tool locator installed behind the pilot string cutting

head and an electric grid (tru-tracker) system for this project.

3.8 UTILITY LOCATING AND MARKING

Locate and clearly mark all utilities prior to start of excavation or drilling. The Contractor is responsible for damage to utilities, and repairs for such damages, at no cost to the Government.

-- End of Section --

SECTION 33 71 02

UNDERGROUND ELECTRICAL DISTRIBUTION
02/15

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO HB-17	(2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 318M	(2011; Errata 2013) Building Code Requirements for Structural Concrete & Commentary
ACI SP-66	(2004) ACI Detailing Manual

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2013) Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B496	(2014) Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C478	(2015) Standard Specification for Precast Reinforced Concrete Manhole Sections

ASTM C857	(2014) Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
ASTM C990	(2009; R 2014) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 400.2	(2013) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)
IEEE 404	(2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V
IEEE 48	(2009) Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2011) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
ANSI/NEMA WC 71/ICEA S-96-659	(1999) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit

NEMA TC 9	(2004) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

SOCIETY OF CABLE TELECOMMUNICATIONS ENGINEERS (SCTE)

ANSI/SCTE 77	(2013) Specification for Underground Enclosure Integrity

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1751F-644	(2002) Underground Plant Construction

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-60005	(Basic; Notice 2) Frames, Covers, Gratings, Steps, Sump And Catch Basin, Manhole

UNDERWRITERS LABORATORIES (UL)

UL 1072	(2006; Reprint Jun 2013) Medium-Voltage Power Cables
UL 1569	(2014; Reprint Dec 2015) Standard for Metal-Clad Cables
UL 1581	(2001; Reprint Jun 2015) Electrical Wires, Cables, and Flexible Cords
UL 2225	(2013) Standard for Cables and Cable-Fittings For Use In Hazardous (Classified) Locations
UL 44	(2014; Reprint Feb 2015) Thermoset-Insulated Wires and Cables
UL 467	(2007) Grounding and Bonding Equipment
UL 486A-486B	(2013; Reprint Feb 2014) Wire Connectors
UL 510	(2005; Reprint Jul 2013) Polyvinyl

	Chloride, Polyethylene and Rubber Insulating Tape
UL 514B	(2012; Reprint Nov 2014) Conduit, Tubing and Cable Fittings
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 651	(2011; Reprint May 2014) Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
UL 854	(2004; Reprint Nov 2014) Standard for Service-Entrance Cables
UL 94	(2013; Reprint Jul 2015) Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.

c. In the text of this section, "medium voltage cable splices," and "medium voltage cable joints" are used interchangeably and have the same meaning.

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.

SD-02 Shop Drawings

Precast underground structures; G

SD-03 Product Data

Medium voltage cable; G

Medium voltage cable joints; G

Medium voltage cable terminations; G

Precast concrete structures; G

Sealing Material

Pulling-In Irons

Manhole frames and covers; G

Handhole frames and covers; G

Composite/fiberglass handholes; G

Cable supports (racks, arms and insulators); G

MC-HL Armored Cable; G

SD-06 Test Reports

Medium voltage cable qualification and production tests; G

Field Acceptance Checks and Tests; G

Arc-proofing test for cable fireproofing tape; G

Cable Installation Plan and Procedure; G

Three copies of the information described below in 8-1/2 by 11 inch binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each cable pull. Separate sections by heavy plastic dividers with tabs, with all data sheets signed and dated by the person supervising the pull.

a. Site layout drawing with cable pulls numerically identified.

b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.

c. The cable manufacturer and type of cable.

d. The dates of cable pulls, time of day, and ambient temperature.

e. The length of cable pull and calculated cable pulling tensions.

f. The actual cable pulling tensions encountered during pull.

SD-07 Certificates

Cable splicer/terminator; G

Cable Installer Qualifications; G

1.5 QUALITY ASSURANCE

1.5.1 Precast Underground Structures

Submittal required for each type used. Provide calculations and drawings for precast manholes and handholes bearing the seal of a registered professional engineer including:

a. Material description (i.e., f'c and Fy)

b. Manufacturer's printed assembly and installation instructions

c. Design calculations

d. Reinforcing shop drawings in accordance with ACI SP-66

e. Plans and elevations showing opening and pulling-in iron locations and details

1.5.2 Certificate of Competency for Cable Splicer/Terminator

The cable splicer/terminator must have a certification from the National Cable Splicing Certification Board (NCSCB) in the field of splicing and terminating shielded medium voltage (5 kV to 35 kV) power cable using pre-manufactured kits (pre-molded, heat-shrink, cold shrink). Submit "Proof of Certification" for approval, for the individuals that will be performing cable splicer and termination work, 30 days before splices or terminations are to be made.

1.5.3 Cable Installer Qualifications

Provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. Provide a resume showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers. Cable installer must demonstrate experience with a minimum of three medium voltage cable installations. The Contracting Officer reserves the right to require additional proof of competency or to reject the individual and call for an alternate qualified cable installer.

1.5.4 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of IEEE C2 and NFPA 70 unless more stringent requirements are specified or indicated.

1.5.5 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.5.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable, unless specified otherwise.

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Rigid Metal Conduit

UL 6.

2.1.1.1 Rigid Metallic Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness must be nominal 85 Shore A durometer, dielectric strength must be minimum 400 volts per mil at 60 Hz, and tensile strength must be minimum 3500 psi.

2.1.2 Plastic Conduit for Direct Burial and Riser Applications

UL 651 and NEMA TC 2, EPC-80.

2.1.3 Plastic Duct for Concrete Encasement

Provide Type EPC-40 per UL 651 and NEMA TC 2.

2.1.4 Innerduct

Provide corrugated or solid wall polyethylene (PE) or PVC innerducts, or fabric-mesh innerducts, as indicated. Provide with pullwire. Provide size as indicated.

2.1.5 Duct Sealant

UL 94, Class HBF. Provide high-expansion urethane foam duct sealant that expands and hardens to form a closed, chemically and water resistant, rigid structure. Sealant must be compatible with common cable and wire jackets and capable of adhering to metals, plastics and concrete. Sealant must be capable of curing in temperature ranges of 35 degrees F to 95 degrees F. Cured sealant must withstand temperature ranges of -20 degrees F to 200 degrees F without loss of function.

2.1.6 Fittings

2.1.6.1 Metal Fittings

UL 514B.

2.1.6.2 PVC Conduit Fittings

UL 514B, UL 651.

2.1.6.3 PVC Duct Fittings

NEMA TC 9.

2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

Insulated conductors must be rated 600 volts and conform to the requirements of NFPA 70, including listing requirements. Wires and cables manufactured more than 12 months prior to date of delivery to the site are not acceptable. Service entrance conductors must conform to UL 854, type USE.

2.2.1 Conductor Types

Cable and duct sizes indicated are for copper conductors and THHN/THWN unless otherwise noted. Conductors No. 10 AWG and smaller must be solid. Conductors No. 8 AWG and larger must be stranded. All conductors must be copper.

2.2.2 Conductor Material

Unless specified or indicated otherwise or required by NFPA 70, wires in conduit, other than service entrance, must be 600-volt, Type XHHW conforming to UL 44. Copper conductors must be annealed copper complying with ASTM B3 and ASTM B8.

2.2.3 Jackets

Multiconductor cables must have an overall PVC outer jacket.

2.2.4 In Duct

2.2.5 Cable Marking

Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout the cable length.

Identify each cable by means of a fiber, laminated plastic, or non-ferrous metal tags, or approved equal, in each manhole, handhole, junction box, and each terminal. Each tag must contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification.

Conductors must be color coded. Provide conductor identification within each enclosure where a tap, splice, or termination is made. Conductor identification must be by color-coded insulated conductors, plastic-coated self-sticking printed markers, colored nylon cable ties and plates, heat shrink type sleeves,or colored electrical tape. Control circuit terminations must be properly identified. Color must be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutrals must be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems must be as follows:

a. 208/120 volt, three-phase

(1) Phase A - black

(2) Phase B - red

(3) Phase C - blue

b. 480/277 volt, three-phase

(1) Phase A - brown

(2) Phase B - orange

(3) Phase C - yellow

c. 120/240 volt, single phase: Black and red

2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

Must provide a uniform compression over the entire conductor contact surface. Use solderless terminal lugs on stranded conductors.

a. For use with copper conductors: UL 486A-486B.

2.4 MC-HL ARMORED CABLE

UL 1569 Type MC-HL armored cable listed for use in cable tray and conduit.

a. Conductors: ASTM B3 uncoated soft copper. Sizes smaller than 8 AWG shall be ASTM B8 compressed stranded. Sizes 8 AWG and larger shall be ASTM B496 compact stranded.

b. Insulation: UL 44 type XHHW-2; 600 V. Thermoplastic insulation is not acceptable.

c. Conductor Identification: Comply with general requirements specified in this Section.

d. Ground Conductors: UL 1581, ASTM B3 stranded conductors. Furnish 3 distributed ground conductors, symmetrically spaced 120 degrees apart. Combined area shall meet the NEC requirements for the application.

e. Sheath: UL 1569 close fitting, impervious, continuous, welded, corrugated aluminum.

f. Shielding: Provided by sheath. Furnish UL 2225, UL 514B fittings; watertight grounding type.

g. Temperature Rating: 90 degrees C in wet and dry applications.

2.5 LOW VOLTAGE SPLICES

Provide splices in conductors with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with ANSI C119.1.

2.5.1 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material applied in accordance with the manufacturer's

written instructions.

2.5.2 Cold Shrink Rubber Splice

Provide a cold-shrink rubber splice which consists of EPDM rubber tube which has been factory stretched onto a spiraled core which is removed during splice installation. The installation must not require heat or flame, or any additional materials such as covering or adhesive. It must be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

2.6 MEDIUM VOLTAGE CABLE

Cable (conductor) sizes are designated by American Wire Gauge (AWG) and Thousand Circular Mils (Kcmil). Conductor and conduit sizes indicated are for copper conductors unless otherwise noted. Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout cable length. Wires and cables manufactured more than 12 months prior to date of delivery to the site are not acceptable. Provide single conductor type cables unless otherwise indicated.

2.6.1 Cable Configuration

Provide Type MV cable, conforming to NEMA WC 74/ICEA S-93-639 and UL 1072. Provide cables manufactured for use in duct applications. Cable must be rated as indicated with 133 percent insulation level.

2.6.2 Conductor Material

Provide concentric-lay-stranded, Class B compact round conductors. Provide soft drawn copper cables complying with ASTM B3 and ASTM B8 for regular concentric and compressed stranding or ASTM B496 for compact stranding.

2.6.3 Insulation

Provide ethylene-propylene-rubber (EPR) insulation conforming to the requirements of ANSI/NEMA WC 71/ICEA S-96-659 and AEIC CS8.

2.6.4 Shielding

Cables rated for 2 kV and above must have a semiconducting conductor shield, a semiconducting insulation shield, and an overall copper tape shield for each phase.

2.6.5 Jackets

Provide cables with a PVC jacket. Provide PVC jackets with a separator that prevents contact with underlying semiconducting insulating shield.

2.7 MEDIUM VOLTAGE CABLE TERMINATIONS

IEEE 48 Class 1; of the molded elastomer, prestretched elastomer, or heat-shrinkable elastomer. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations, where

required, must be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, or armor. Terminations must be provided in a kit, including: skirts, stress control terminator, ground clamp, connectors, lugs, and complete instructions for assembly and installation. Terminations must be the product of one manufacturer, suitable for the type, diameter, insulation class and level, and materials of the cable terminated. Do not use separate parts of copper or copper alloy in contact with aluminum alloy parts in the construction or installation of the terminator.

2.7.1 Cold-Shrink Type

Terminator must be a one-piece design, utilizing the manufacturer's latest technology, where high-dielectric constant (capacitive) stress control is integrated within a skirted insulator made of silicone rubber. Termination must not require heat or flame for installation. Termination kit must contain all necessary materials (except for the lugs). Termination must be designed for installation in low or highly contaminated indoor and outdoor locations and must resist ultraviolet rays and oxidative decomposition.

2.7.2 Heat Shrinkable Type

Terminator must consist of a uniform cross section heat shrinkable polymeric construction stress relief tubing and environmentally sealed outer covering that is nontracking, resists heavy atmospheric contaminants, ultra violet rays and oxidative decomposition. Provide heat shrinkable sheds or skirts of the same material. Termination must be designed for installation in low or highly contaminated indoor or outdoor locations.

2.8 MEDIUM VOLTAGE CABLE JOINTS

Provide joints (splices) in accordance with IEEE 404 suitable for the rated voltage, insulation level, insulation type, and construction of the cable. Joints must be certified by the manufacturer for waterproof, submersible applications. Upon request, supply manufacturer's design qualification test report in accordance with IEEE 404. Connectors for joint must be tin-plated electrolytic copper, having ends tapered and having center stops to equalize cable insertion.

2.8.1 Heat-Shrinkable Joint

Consists of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system, a high dielectric strength insulating material, and an integrally bonded outer conductor layer for shielding. Replace original cable jacket with a heavy-wall heat-shrinkable sleeve with hot-melt adhesive coating.

2.9 TELECOMMUNICATIONS CABLING

Provide telecommunications cabling in accordance with Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

2.10 TAPE

2.10.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.10.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section 31 00 00 EARTHWORK.

2.10.3 Fireproofing Tape

Provide tape composed of a flexible, conformable, unsupported intumescent elastomer. Tape must be not less than .030 inch thick, noncorrosive to cable sheath, self-extinguishing, noncombustible, adhesive-free, and must not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

2.11 PULL ROPE

Plastic or flat pull line (bull line) having a minimum tensile strength of 200 pounds.

2.12 GROUNDING AND BONDING

2.12.1 Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467 not less than 3/4 inch in diameter by 10 feet in length. Sectional type rods may be used for rods 20 feet or longer.

2.12.2 Grounding Conductors

Stranded-bare copper conductors must conform to ASTM B8, Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors must conform to ASTM B1 for sizes No. 8 and smaller. Insulated conductors must be of the same material as phase conductors and green color-coded, except that conductors must be rated no more than 600 volts. Aluminum is not acceptable.

2.13 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. In addition, provide concrete for encasement of underground ducts with 3000 psi minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts must be 4000 psi minimum 28-day compressive strength unless specified otherwise.

2.14 UNDERGROUND STRUCTURES

Provide precast concrete underground structures or standard type cast-in-place manhole types as indicated, conforming to ASTM C857 and ASTM C478. Top, walls, and bottom must consist of reinforced concrete. Walls and bottom must be of monolithic concrete construction. Locate duct entrances and windows near the corners of structures to facilitate cable racking. Covers must fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings must be free

from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Install a pulling-in iron in the wall opposite each duct line entrance. Cable racks, including rack arms and insulators, must be adequate to accommodate the cable.

2.14.1 Cast-In-Place Concrete Structures

Concrete must conform to Section 03 30 00 CAST-IN-PLACE CONCRETE. Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers.

2.14.2 Precast Concrete Structures, Risers and Tops

Precast concrete underground structures may be provided in lieu of cast-in-place subject to the requirements specified below. Precast units must be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes.

2.14.2.1 General

Precast concrete structures must have the same accessories and facilities as required for cast-in-place structures. Likewise, precast structures must have plan area and clear heights not less than those of cast-in-place structures. Concrete materials and methods of construction must be the same as for cast-in-place concrete construction, as modified herein. Slope in floor may be omitted provided precast sections are poured in reinforced steel forms. Concrete for precast work must have a 28-day compressive strength of not less than 4000 psi. Structures may be precast to the design and details indicated for cast-in-place construction, precast monolithically and placed as a unit, or structures may be assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. Structures must be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face.

2.14.2.2 Design for Precast Structures

ACI 318M. In the absence of detailed on-site soil information, design for the following soil parameters/site conditions:

a. Angle of Internal Friction (phi) = 30 degrees

b. Unit Weight of Soil (Dry) = 110 pcf, (Saturated) = 130 pcf

c. Coefficient of Lateral Earth Pressure (Ka) = 0.33

d. Ground Water Level = 3 feet below ground elevation

e. Vertical design loads must include full dead, superimposed dead, and live loads including a 30 percent magnification factor for impact. Live loads must consider all types and magnitudes of vehicular (automotive, industrial, or aircraft) traffic to be encountered. The minimum design vertical load must be for H20 highway loading per AASHTO HB-17.

f. Horizontal design loads must include full geostatic and hydrostatic

pressures for the soil parameters, water table, and depth of installation to be encountered. Also, horizontal loads imposed by adjacent structure foundations, and horizontal load components of vertical design loads, including impact, must be considered, along with a pulling-in iron design load of 6000 pounds.

g. Each structural component must be designed for the load combination and positioning resulting in the maximum shear and moment for thatparticular component.

h. Design must also consider the live loads induced in the handling, installation, and backfilling of the manholes. Provide lifting devices to ensure structural integrity during handling and installation.

2.14.2.3 Construction

Structure top, bottom, and wall must be of a uniform thickness of not less than 6 inches. Thin-walled knock-out panels for designed or future duct bank entrances are not permitted. Provide quantity, size, and location of duct bank entrance windows as directed, and cast completely open by the precaster. Size of windows must exceed the nominal duct bank envelope dimensions by at least 12 inches vertically and horizontally to preclude in-field window modifications made necessary by duct bank misalignment. However, the sides of precast windows must be a minimum of 6 inches from the inside surface of adjacent walls, floors, or ceilings. Form the perimeter of precast window openings to have a keyed or inward flared surface to provide a positive interlock with the mating duct bank envelope. Provide welded wire fabric reinforcing through window openings for in-field cutting and flaring into duct bank envelopes. Provide additional reinforcing steel comprised of at least two No. 4 bars around window openings. Provide drain sumps a minimum of 12 inches in diameter and 4 inches deep for precast structures.

2.14.2.4 Joints

Provide tongue-and-groove joints on mating edges of precast components. Shiplap joints are not allowed. Design joints to firmly interlock adjoining components and to provide waterproof junctions and adequate shear transfer. Seal joints watertight using preformed plastic strip conforming to ASTM C990. Install sealing material in strict accordance with the sealant manufacturer's printed instructions. Provide waterproofing at conduit/duct entrances into structures, and where access frame meets the top slab, provide continuous grout seal.

2.14.3 Manhole Frames and Covers

Provide cast iron frames and covers for manholes conforming to CID A-A-60005. Cast the words "ELECTRIC" or "TELECOMMUNICATIONS" in the top face of power and telecommunications manhole covers, respectively.

2.14.4 Handhole Frames and Covers

Frames and covers of steel must be welded by qualified welders in accordance with standard commercial practice. Steel covers must be rolled-steel floor plate having an approved antislip surface. Hinges must be of stainless steel with bronze hinge pin, 5 by 5 inches by approximately 3/16 inch thick, without screw holes, and must be for full surface application by fillet welding. Hinges must have nonremovable pins and

five knuckles. The surfaces of plates under hinges must be true after the removal of raised antislip surface, by grinding or other approved method.

2.14.5 Composite/Fiberglass Handholes and Covers

ANSI/SCTE 77. Provide handholes and covers of polymer concrete, reinforced with heavy weave fiberglass with a design load (Tier rating) appropriate for or greater than the intended use. All covers are required to have the Tier level rating embossed on the surface and this rating must not exceed the design load of the box.

2.15 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)

The metal portion of racks and arms must be zinc-coated after fabrication.

2.15.1 Cable Rack Stanchions

The wall bracket or stanchion must be 4 inches by approximately 1-1/2 inch by 3/16 inch channel steel, or 4 inches by approximately 1 inch glass-reinforced nylon with recessed bolt mounting holes, 48 inches long (minimum) in manholes. Slots for mounting cable rack arms must be spaced at 8 inch intervals.

2.15.2 Rack Arms

Cable rack arms must be steel or malleable iron or glass reinforced nylon and must be of the removable type. Rack arm length must be a minimum of 8 inches and a maximum of 12 inches.

2.15.3 Insulators

Insulators for metal rack arms must be dry-process glazed porcelain. Insulators are not required for nylon arms.

2.16 OIL CONTAINMENT ALARMS

Provide two-level float switches for oil containment structures. Connect to SCADA in accordance with Section 26 70 00 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA). Coordinate level setting with the Contracting Officer.

2.17 CABLE TAGS IN MANHOLES

Provide tags for each power cable located in manholes. The tags must be polyethylene. Do not provide handwritten letters. The first position on the power cable tag must denote the voltage. The second through sixth positions on the tag must identify the circuit. The next to last position must denote the phase of the circuit and include the Greek "phi" symbol. The last position must denote the cable size. As an example, a tag could have the following designation: "11.5 NAS 1-8(Phase A)500," denoting that the tagged cable is on the 11.5kV system circuit number NAS 1-8, underground, Phase A, sized at 500 kcmil.

2.17.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide

a one-piece nylon, self-locking tie at each end of the cable tag. Ties must have a minimum loop tensile strength of 175 pounds. The cable tags must have black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols must not fall off or change positions regardless of the cable tags' orientation.

2.18 SOURCE QUALITY CONTROL

2.18.1 Arc-Proofing Test for Cable Fireproofing Tape

Manufacturer must test one sample assembly consisting of a straight lead tube 12 inches long with a 2 1/2 inch outside diameter, and a 1/8 inch thick wall, and covered with one-half lap layer of arc and fireproofing tape per manufacturer's instructions. The arc and fireproofing tape must withstand extreme temperature of a high-current fault arc 13,000 degrees K for 70 cycles as determined by using an argon directed plasma jet capable of constantly producing and maintaining an arc temperature of 13,000 degrees K. Temperature (13,000 degrees K) of the ignited arc between the cathode and anode must be obtained from a dc power source of 305 (plus or minus 5) amperes and 20 (plus or minus 1) volts. The arc must be directed toward the sample assembly accurately positioned 5 (plus or minus 1) millimeters downstream in the plasma from the anode orifice by fixed flow rate of argon gas (0.18 g per second). Each sample assembly must be tested at three unrelated points. Start time for tests must be taken from recorded peak current when the specimen is exposed to the full test temperature. Surface heat on the specimen prior to that time must be minimal. The end point is established when the plasma or conductive arc penetrates the protective tape and strikes the lead tube. Submittals for arc-proofing tape must indicate that the test has been performed and passed by the manufacturer.

2.18.2 Medium Voltage Cable Qualification and Production Tests

Results of AEIC CS8 qualification and production tests as applicable for each type of medium voltage cable.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of NFPA 70 and IEEE C2 as applicable. In addition to these requirements, install telecommunications in accordance with TIA-758 and RUS Bull 1751F-644.

3.2 CABLE INSPECTION

Inspect each cable reel for correct storage positions, signs of physical damage, and broken end seals prior to installation. If end seal is broken, remove moisture from cable prior to installation in accordance with the cable manufacturer's recommendations.

3.3 CABLE INSTALLATION PLAN AND PROCEDURE

Obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature limits for installation, lubricants, coefficient of friction, conduit cleaning, storage procedures,

moisture seals, testing for and purging moisture, maximum allowable pulling tension, and maximum allowable sidewall bearing pressure. Perform pulling calculations and prepare a pulling plan and submit along with the manufacturer's instructions in accordance with SUBMITTALS. Install cable strictly in accordance with the cable manufacturer's recommendations and the approved installation plan.

Calculations and pulling plan must include:

a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.

b. List of cable installation equipment.

c. Lubricant manufacturer's application instructions.

d. Procedure for resealing cable ends to prevent moisture from entering cable.

e. Cable pulling tension calculations of all cable pulls.

f. Cable percentage conduit fill.

g. Cable sidewall bearing pressure.

h. Cable minimum bend radius and minimum diameter of pulling wheels used.

i. Cable jam ratio.

j. Maximum allowable pulling tension on each different type and size of conductor.

k. Maximum allowable pulling tension on pulling device.

3.4 UNDERGROUND FEEDERS SUPPLYING BUILDINGS

Terminate underground feeders supplying building at a point 5 feet outside the building and projections thereof, except that conductors must be continuous to the terminating point indicated. Coordinate connections of the feeders to the service entrance equipment with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide PVC, Type EPC-40 conduit from the supply equipment to a point 5 feet outside the building and projections thereof. Protect ends of underground conduit with plastic plugs until connections are made.

Encase the underground portion of the conduit in a concrete envelope and bury as specified for underground duct with concrete encasement.

3.5 UNDERGROUND STRUCTURE CONSTRUCTION

Provide standard type cast-in-place construction as specified herein and as indicated, or precast construction as specified herein. Horizontal concrete surfaces of floors must have a smooth trowel finish. Cure concrete by applying two coats of white pigmented membrane forming-curing compound in strict accordance with the manufacturer's printed instructions, except that precast concrete may be steam cured. Curing compound must conform to ASTM C309. Locate duct entrances and windows in the center of end walls (shorter) and near the corners of sidewalls (longer) to facilitate cable racking and splicing. Covers for underground

structures must fit the frames without undue play. Steel and iron must be formed to shape and size with sharp lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Manhole locations, as indicated, are approximate. Coordinate exact manhole locations with other utilities and finished grading and paving.

3.5.1 Cast-In-Place Concrete Structures

Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers.

3.5.2 Precast Concrete Construction

Set commercial precast structures on 6 inches of level, 90 percent compacted granular fill, 3/4 inch to 1 inch size, extending 12 inches beyond the structure on each side. Compact granular fill by a minimum of four passes with a plate type vibrator. Installation must additionally conform to the manufacturer's instructions.

3.5.3 Pulling-In Irons

Provide steel bars bent as indicated, and cast in the walls and floors. Alternatively, pipe sleeves may be precast into the walls and floors where required to accept U-bolts or other types of pulling-in devices possessing the strengths and clearances stated herein. The final installation of pulling-in devices must be made permanent. Cover and seal exterior projections of thru-wall type pulling-in devices with an appropriate protective coating. In the floor the irons must be a minimum of 6 inches from the edge of the sump, and in the walls the irons must be located within 6 inches of the projected center of the duct bank pattern or precast window in the opposite wall. However, the pulling-in iron must not be located within 6 inches of an adjacent interior surface, or duct or precast window located within the same wall as the iron. If a pulling-in iron cannot be located directly opposite the corresponding duct bank or precast window due to this clearance limitation, locate the iron directly above or below the projected center of the duct bank pattern or precast window the minimum distance required to preserve the 6 inch clearance previously stated. In the case of directly opposing precast windows, pulling-in irons consisting of a 3 foot length of No. 5 reinforcing bar, formed into a hairpin, may be cast-in-place within the precast windows simultaneously with the end of the corresponding duct bank envelope. Irons installed in this manner must be positioned directly in line with, or when not possible, directly above or below the projected center of the duct bank pattern entering the opposite wall, while maintaining a minimum clear distance of 3 inches from any edge of the cast-in-place duct bank envelope or any individual duct. Pulling-in irons must have a clear projection into the structure of approximately 4 inches and must be designed to withstand a minimum pulling-in load of 6000 pounds. Irons must be hot-dipped galvanized after fabrication.

3.5.4 Cable Racks, Arms and Insulators

Cable racks, arms and insulators must be sufficient to accommodate the cables. Space racks in power manholes not more than 3 feet apart, and provide each manhole wall with a minimum of two racks. Space racks in signal manholes not more than 16 1/2 inches apart with the end rack being

no further than 12 inches from the adjacent wall. Methods of anchoring cable racks must be as follows:

a. Provide a 5/8 inch diameter by 5 inch long anchor bolt with 3 inch foot cast in structure wall with 2 inch protrusion of threaded portion of bolt into structure. Provide 5/8 inch steel square head nut on each anchor bolt. Coat threads of anchor bolts with suitable coating immediately prior to installing nuts.

b. Provide concrete channel insert with a minimum load rating of 800 pounds per foot. Insert channel must be steel of the same length as "vertical rack channel;" channel insert must be cast flush in structure wall. Provide 5/8 inch steel nuts in channel insert to receive 5/8 inch diameter by 3 inch long steel, square head anchor bolts.

c. Provide concrete "spot insert" at each anchor bolt location, cast flush in structure wall. Each insert must have minimum 800 pound load rating. Provide 5/8 inch diameter by 3 inch long steel, square head anchor bolt at each anchor point. Coat threads of anchor bolts with suitable coating immediately prior to installing bolts.

3.5.5 Field Painting

Cast-iron frames and covers not buried in concrete or masonry must be cleaned of mortar, rust, grease, dirt and other deleterious materials, and given a coat of bituminous paint.

3.6 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.6.1 Requirements

Run conduit in straight lines except where a change of direction is necessary. Provide numbers and sizes of ducts as indicated. Provide a 4/0 AWG bare copper grounding conductor below medium-voltage distribution duct banks. Bond bare copper grounding conductor to ground rings (loops) in all manholes and to ground rings (loops) at all equipment slabs (pads). Route grouding conductor into manholes with the duct bank (sleeving is not required). Ducts must have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of 3 inches per 100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Provide ducts with end bells whenever duct lines terminate in structures.

Perform changes in ductbank direction as follows:

a. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable.

b. The minimum manufactured bend radius must be 18 inches for ducts of less than 3 inch diameter, and 36 inches for ducts 3 inches or greater in diameter.

c. As an exception to the bend radius required above, provide field manufactured longsweep bends having a minimum radius of 25 feet for a change of direction of more than 5 degrees, either horizontally or vertically, using a combination of curved and straight sections. Maximum manufactured curved sections: 30 degrees.

3.6.2 Treatment

Ducts must be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers must be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer must be used whenever an existing duct is connected to a duct of different material or shape. Ducts must be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts must be thoroughly cleaned before being laid. Plastic ducts must be stored on a flat surface and protected from the direct rays of the sun.

3.6.3 Conduit Cleaning

As each conduit run is completed, for conduit sizes 3 inches and larger, draw a flexible testing mandrel approximately 12 inches long with a diameter less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. For conduit sizes less than 3 inches, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs.

3.6.4 Jacking and Drilling Under Roads and Structures

Conduits to be installed under existing paved areas which are not to be disturbed, and under roads and railroad tracks, must be zinc-coated, rigid steel, jacked into place. Where ducts are jacked under existing pavement, rigid steel conduit must be installed because of its strength. To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 50 feet in length, the predrilling method or the jack-and-sleeve method will be used. Separators or spacing blocks must be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 4 feet on centers. Hydraulic jet method must not be used.

3.6.5 Galvanized Conduit Concrete Penetrations

Galvanized conduits which penetrate concrete (slabs, pavement, and walls) in wet locations must be PVC coated and must extend from at least 2 inches within the concrete to the first coupling or fitting outside the concrete (minimum of 6 inches from penetration).

3.6.6 Multiple Conduits

Separate multiple conduits by a minimum distance of 3 inches, except that light and power conduits must be separated from control, signal, and telephone conduits by a minimum distance of 12 inches. Stagger the joints of the conduits by rows (horizontally) and layers (vertically) to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly must consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 10 feet of conduit assembly.

3.6.7 Conduit Plugs and Pull Rope

New conduit indicated as being unused or empty must be provided with plugs on each end. Plugs must contain a weephole or screen to allow water drainage. Provide a plastic pull rope having 3 feet of slack at each end of unused or empty conduits.

3.6.8 Conduit and Duct Without Concrete Encasement

Depths to top of the conduit must be not less than 24 inches below finished grade. Provide not less than 3 inches clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 3 inches, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 1/4 inch sieve. The first 6 inch layer of backfill cover must be sand compacted as previously specified. The rest of the excavation must be backfilled and compacted in 3 to 6 inch layers. Provide color, type and depth of warning tape as specified in Section 31 00 00 EARTHWORK.

3.6.8.1 Encasement Under Roads and Structures

Under roads, paved areas, and railroad tracks, install conduits in concrete encasement of rectangular cross-section providing a minimum of 3 inch concrete cover around ducts. Concrete encasement must extend at least 5 feet beyond the edges of paved areas and roads, and 12 feet beyond the rails on each side of railroad tracks. Depths to top of the concrete envelope must be not less than 24 inches below finished grade, and under railroad tracks not less than 50 inches below the top of the rails.

3.6.8.2 Directional Boring

HDPE conduits must be installed below the frostline and as specified herein.

For distribution voltages greater than 1000 volts and less than 34,500 volts, depths to the top of the conduit must not be less than 48 inches in pavement-covered areas and not less than 120 inches in non-pavement-covered areas. For distribution voltages less than 1000 volts, depths to the top of the conduit must not be less than 48 inches in pavement- or non-pavement-covered areas. For branch circuit wiring less than 600 volts, depths to the top of the conduit must not be less than 24 inches in pavement- or non-pavement-covered areas.

3.6.9 Duct Encased in Concrete

Construct underground duct lines of individual conduits encased in concrete. Depths to top of the concrete envelope must be not less than 18 inches below finished grade, except under roads and pavement, concrete envelope must be not less than 24 inches below finished grade, and under railroad tracks not less than 50 inches below the top of the rails. Do not mix different kinds of conduit in any one duct bank. Concrete encasement surrounding the bank must be rectangular in cross-section and must provide at least 3 inches of concrete cover for ducts. Separate conduits by a minimum concrete thickness of 3 inches. Before pouring concrete, anchor duct bank assemblies to prevent the assemblies from floating during concrete pouring. Anchoring must be done by driving reinforcing rods adjacent to duct spacer assemblies and attaching the rods to the spacer assembly. Provide steel reinforcing in the concrete

envelope as indicated. Provide color, type and depth of warning tape as specified in Section 31 00 00 EARTHWORK.

3.6.9.1 Connections to Manholes

Duct bank envelopes connecting to underground structures must be flared to have enlarged cross-section at the manhole entrance to provide additional shear strength. Dimensions of the flared cross-section must be larger than the corresponding manhole opening dimensions by no less than 12 inches in each direction. Perimeter of the duct bank opening in the underground structure must be flared toward the inside or keyed to provide a positive interlock between the duct bank and the wall of the structure. Use vibrators when this portion of the encasement is poured to assure a seal between the envelope and the wall of the structure.

3.6.9.2 Connections to Existing Underground Structures

For duct bank connections to existing structures, break the structure wall out to the dimensions required and preserve steel in the structure wall. Cut steel and extend into the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.

3.6.9.3 Connections to Existing Concrete Pads

For duct bank connections to concrete pads, break an opening in the pad out to the dimensions required and preserve steel in pad. Cut the steel and extend into the duct bank envelope. Chip out the opening in the pad to form a key for the duct bank envelope.

3.6.10 Duct Sealing

Seal all electrical penetrations for radon mitigation, maintaining integrity of the vapor barrier, and to prevent infiltration of air, insects, and vermin.

3.7 CABLE PULLING

Test existing duct lines with a mandrel and thoroughly swab out to remove foreign material before pulling cables. Pull cables down grade with the feed-in point at the manhole or buildings of the highest elevation. Use flexible cable feeds to convey cables through manhole opening and into duct runs. Do not exceed the specified cable bending radii when installing cable under any conditions, including turnups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with tape shield must have a bending radius not less than 12 times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.7.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.8 CABLES IN UNDERGROUND STRUCTURES

Do not install cables utilizing the shortest path between penetrations, but route along those walls providing the longest route and the maximum

spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space open for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each underground structure.

3.8.1 Cable Tag Installation

Install cable tags in each manhole as specified, including each splice. Tag wire and cable provided by this contract. Install cable tags over the fireproofing, if any, and locate the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes.

3.9 CONDUCTORS INSTALLED IN PARALLEL

Conductors must be grouped such that each conduit of a parallel run contains 1 Phase A conductor, 1 Phase B conductor, 1 Phase C conductor, and 1 neutral conductor.

3.10 LOW VOLTAGE CABLE SPLICING AND TERMINATING

Make terminations and splices with materials and methods as indicated or specified herein and as designated by the written instructions of the manufacturer. Do not allow the cables to be moved until after the splicing material has completely set. Make splices in underground distribution systems only in accessible locations such as manholes, handholes, or aboveground termination pedestals.

3.11 MEDIUM VOLTAGE CABLE TERMINATIONS

Make terminations in accordance with the written instruction of the termination kit manufacturer.

3.12 MEDIUM VOLTAGE CABLE JOINTS

Provide power cable joints (splices) suitable for continuous immersion in water. Make joints only in accessible locations in manholes or handholes by using materials and methods in accordance with the written instructions of the joint kit manufacturer.

3.12.1 Joints in Shielded Cables

Cover the joined area with metallic tape, or material like the original cable shield and connect it to the cable shield on each side of the splice. Provide a bare copper ground connection brought out in a watertight manner and grounded to the manhole grounding loop as part of the splice installation. Ground conductors, connections, and rods must be as specified elsewhere in this section. Wire must be trained to the sides of the enclosure to prevent interference with the working area.

3.13 CABLE END CAPS

Cable ends must be sealed at all times with coated heat shrinkable end caps. Cables ends must be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps must remain in place until the cable is spliced or terminated.

Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.14 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES

Fireproof (arc proof) wire and cables which will carry current at 2200 volts or more in underground structures.

3.14.1 Fireproofing Tape

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Install tape in accordance with manufacturer's instructions.

3.14.2 Tape-Wrap

Tape-wrap metallic-sheathed or metallic armored cables without a nonmetallic protective covering over the sheath or armor prior to application of fireproofing. Wrap must be in the form of two tightly applied half-lapped layers of a pressure-sensitive 10 mil thick plastic tape, and must extend not less than one inch into the duct. Even out irregularities of the cable, such as at splices, with insulation putty before applying tape.

3.15 GROUNDING SYSTEMS

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 25 ohms.

3.15.1 Grounding Electrodes

Provide cone pointed driven ground rods driven full depth plus 6 inches, installed to provide an earth ground of the appropriate value for the particular equipment being grounded.
If the specified ground resistance is not met, an additional ground rod must be provided in accordance with the requirements of NFPA 70 (placed not less than 6 feet from the first rod). Should the resultant (combined) resistance exceed the specified resistance, measured not less than 48 hours after rainfall, notify the Contracting Officer immediately.

3.15.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, by exothermic weld or compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies must be as recommended by the manufacturer. An embossing die code or other standard method must provide visible indication that a connector has been adequately compressed on the ground wire.

3.15.3 Grounding Conductors

Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with No. 6 AWG. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of handholes and pull boxes with a braided, copper ground strap with equivalent ampacity of No. 6 AWG. Provide direct connections to the grounding conductor with 600 v insulated, full-size conductor for each grounded neutral of each feeder circuit, which is spliced within the manhole.

3.15.4 Ground Cable Crossing Expansion Joints

Protect ground cables crossing expansion joints or similar separations in structures and pavements by use of approved devices or methods of installation which provide the necessary slack in the cable across the joint to permit movement. Use stranded or other approved flexible copper cable across such separations.

3.15.5 Manhole Grounding

Loop a 4/0 AWG grounding conductor around the interior perimeter, approximately 12 inches above finished floor. Secure the conductor to the manhole walls at intervals not exceeding 36 inches. Connect the conductor to the manhole grounding electrode with 4/0 AWG conductor. Connect all incoming 4/0 grounding conductors to the ground loop adjacent to the point of entry into the manhole. Bond the ground loop to all cable shields, metal cable racks, and other metal equipment with a minimum 6 AWG conductor.

3.15.6 Fence Grounding

Provide grounding for fences with a ground rod at each fixed gate post and at each corner post. Drive ground rods until the top is 12 inches below grade. Attach a No. 4 AWG copper conductor, by exothermic weld to the ground rods and extend underground to the immediate vicinity of fence post. Lace the conductor vertically into 12 inches of fence mesh and fasten by two approved bronze compression fittings, one to bond wire to post and the other to bond wire to fence. Each gate section must be bonded to its gatepost by a 1/8 by one inch flexible braided copper strap and ground post clamps. Clamps must be of the anti-electrolysis type.

3.16 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section 31 00 00 EARTHWORK.

3.16.1 Reconditioning of Surfaces

3.16.1.1 Paving Repairs

Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists make repairs as specified in Section 32 12 16 HOT-MIX ASPHALT FOR ROADS.

3.17 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.17.1 Concrete Slabs (Pads) for Equipment

Unless otherwise indicated, the slab must be at least 8 inches thick, reinforced with a 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 4 inches from the top of the slab. Slab must be placed on a 6 inch thick, well-compacted gravel base. Top of concrete slab must be approximately 4 inches above finished grade with gradual slope for drainage. Edges above grade must have 1/2 inch chamfer. Slab must be of adequate size to project at least 8 inches beyond the equipment.

Stub up conduits, with bushings, 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.

3.18 CONCRETE CURB AND SIDEWALK REPAIR

Where trenches, pits, or other excavations are made in existing curbs, sidewalks, or similar existing concrete structures in substations, make repairs as specified in Division 32.

3.19 FIELD QUALITY CONTROL

3.19.1 Performance of Field Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.19.1.1 Medium Voltage Cables

Perform tests after installation of cable, splices, and terminators and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Inspect for proper shield grounding, cable support, and cable termination.

(4) Verify that cable bends are not less than ICEA or manufacturer's minimum allowable bending radius.

(5) Inspect for proper fireproofing.

(6) Visually inspect jacket and insulation condition.

(7) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform a shield continuity test on each power cable by ohmmeter method. Record ohmic value, resistance values in excess of 10 ohms per 1000 feet of cable must be investigated and justified.

(2) Perform acceptance test on new cables before the new cables are connected to existing cables and placed into service, including terminations and joints. Perform maintenance test on complete cable system after the new cables are connected to existing cables and placed into service, including existing cable, terminations, and joints. Tests must be very low frequency (VLF) alternating voltage withstand tests in accordance with IEEE 400.2. VLF test frequency must be 0.05 Hz minimum for a duration of 60 minutes using a sinusoidal waveform. Test voltages must be as follows:

CABLE RATING	AC TEST VOLTAGE for ACCEPTANCE TESTING
5 kV	10kV rms(peak)
8 kV	13kV rms(peak)
15 kV	20kV rms(peak)
25 kV	31kV rms(peak)
35 kV	44kV rms(peak)

CABLE RATING	AC TEST VOLTAGE for MAINTENANCE TESTING
5 kV	7kV rms(peak)
8 kV	10kV rms(peak)
15 kV	16kV rms(peak)
25 kV	23kV rms(peak)
35 kV	33kV rms(peak)

3.19.1.2 Low Voltage Cables, 600-Volt

Perform tests after installation of cable, splices and terminations and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Verify tightness of accessible bolted electrical connections.

(4) Inspect compression-applied connectors for correct cable match and indentation.

(5) Visually inspect jacket and insulation condition.

(6) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 1000 volts dc for one minute.

(2) Perform continuity tests to insure correct cable connection.

3.19.1.3 Grounding System

a. Visual and mechanical inspection

Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

Perform ground-impedance measurements utilizing the fall-of-potential method in accordance with IEEE 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument must be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test. Provide site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance.

3.19.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer must be given 5 working days advance notice of the dates and times of checking and testing.

.... -- End of Section --

SECTION 43 15 00.00 20

LOW PRESSURE COMPRESSED AIR PIPING
04/06

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 WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2015) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2015) Structural Welding Code - Steel
AWS Z49.1	(2012) Safety in Welding and Cutting and Allied Processes

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B16.22	(2013) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.24	(2011) Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500
ASME B16.26	(2013) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.34	(2013) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2014) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.9	(2012) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.1	(2014; INT 1-47) Power Piping
ASME B31.3	(2014) Process Piping

ASME B31.9	(2014) Building Services Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME B46.1	(2009) Surface Texture, Surface Roughness, Waviness and Lay
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A106/A106M	(2014) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A183	(2014) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2014a) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2014a) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM B88	(2014) Standard Specification for Seamless Copper Water Tube
ASTM D1330	(2004; R 2010) Rubber Sheet Gaskets
ASTM D2000	(2012) Standard Classification System for Rubber Products in Automotive Applications

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

MSS SP-58	(1993; Reaffirmed 2010) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-80	(2013) Bronze Gate, Globe, Angle and Check Valves

NATIONAL FLUID POWER ASSOCIATION (NFLPA)

ANSI/NFLPA T3.12.3	(1992; Rev 2) Pneumatic Fluid Power - Pressure Regulator - Industrial Type

PIPE FABRICATION INSTITUTE (PFI)

PFI ES 22	(2013) Color Coding of Piping Materials

PLUMBING AND MECHANICAL CONTRACTORS ASSOCIATION (PMCA)

PPIC Seismic Restraint	(1982) Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Systems

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J513	(1999) Refrigeration Tube Fittings - General Specifications

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-1689	(Rev B) Tape, Pressure-Sensitive Adhesive, (Plastic Film)
CID A-A-58092	(Basic; Notice 1) Tape, Antiseize, Polytetrafluoroethylene
CID A-A-59617	(Basic) Unions, Brass or Bronze, Threaded Pipe Connections and Solder-Joint Tube Connections
CID A-A-60001	(Rev A) Traps, Steam
FS QQ-B-654	(Rev A; Notice 1; AM 1) Brazing Alloys, Silver
FS WW-S-2739	(Basic; Notice 1) Strainers, Sediment: Pipeline, Water, Air, Gas, Oil, or Steam

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

29 CFR 1910.219	Mechanical Power Transmission Apparatus

1.2 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, applies to this section, with the additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control

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

SD-03 Product Data

Desiccant air dryers (AD-12, AD-13)

Desiccant

Pipe

Fittings

Valves

Pressure gages

Hangers and supports

Quick disconnect couplings

Filters

Strainers

Traps

Flexible connections

Dielectric unions

Identification labels for piping

Tubing

Fusion Bonded Epoxy (FBE) Corrosion Protection Coating System

SD-06 Test Reports

Non-Destructive Examination (NDE) report for welding of piping

Leak tightness tests

SD-07 Certificates

Employer's record documents

Welding procedures and qualifications

Cleaning and flushing procedures

SD-10 Operation and Maintenance Data

Desiccant Air Dryers (AD-12, AD-13), Data Package 4

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

SD-11 Closeout Submittals

Posted operating instructions desiccant air dryers (AD-12, AD-13)

1.4 QUALITY ASSURANCE

Provide work specified in this section, including design, materials, fabrication, assembly, erection, installation, and examination, inspection and testing of compressed air systems in conformance with ASME B31.9, as modified and supplemented by this specification section and accompanying drawings. In ASME B31.1, ASME BPVC SEC VIII D1, and ASME BPVC SEC IX, the advisory provisions shall be considered mandatory, as though the word "shall" had been substituted for "should" wherever it appears; reference to the "authority having jurisdiction" and "owner" shall be interpreted to mean the Contracting Officer.

1.4.1 Welding procedures and qualifications

Provide welding work specified in this section for compressed air piping systems in conformance with ASME B31.9, as modified and supplemented by this specification section and the accompanying drawings. The welding work includes: qualification of welding procedures, welders, welding operators, and nondestructive examination personnel; maintenance of welding records, and examination methods for welds.

1.4.1.1 Butt Welded Joints

Butt welded joints shall be full penetration joints.

1.4.2 Employer's Record Documents

Submit to the ROICC for his review and approval the following documentation. This documentation and the subject qualifications shall be in compliance with ASME B31.9.

a. List of qualified welding procedures that is proposed to be used to provide the work specified in this specification section.

b. List of qualified welders, and welding operators that are proposed to be used to provide the work specified in this specification section.

c. List of qualified weld examination personnel that are proposed to be used to provide the work specified in this specification section.

1.4.3 Welding Procedures and Qualifications

Specifications and Test Results: Submit copies of the welding procedure specifications and procedure qualification test results for each type of welding required. Approval of any procedure does not relieve the Contractor of the responsibility for producing acceptable welds. Submit this information on the forms printed in ASME BPVC SEC IX or their equivalent.

1.4.3.1 Certification

Certification: Before assigning welders or welding operators to the work, submit a list of qualified welders, together with data and certification that each individual is performance qualified as specified. Do not start welding work prior to submitting welder, and welding operator qualifications. The certification shall state the type of welding and

positions for which each is qualified, the code and procedure under which each is qualified, date qualified, and the firm and individual certifying the qualification tests.

1.4.3.2 Renewal of Qualification

Requalification of a brazer or brazing operator shall be required under any of the following conditions:

a. When a brazer or brazing operator has not used the specific brazing process for a period of 6 months.

b. There is specific reason to question his ability to make brazes that will meet the requirements of the specifications.

1.4.4 Equipment Data

Submit the following data for equipment listed for "Operation and Maintenance Instructions, Parts and Testing."

a. Name and address of authorized branch or service department.

b. Characteristic curves.

c. Following applicable data completely filled in:

Manufacturer and model number _____

Operating speed _____

Capacity _____ (SCFM)

Type of bearings in unit _____

Type of lubrication _____

Type and adjustment of drive _____

Electric motor: Manufacturer, frame and type _____

Motor speed _____ RPM

Current characteristics and hp of motor _____

_____ Thermal cut-out switch: Manufacturer, type and model _____

Starter: Manufacturer: Type and model _____

1.5 SAFETY PRECAUTIONS

1.5.1 Temperature Restriction

Compressors in combination with their associated air dryers or other equipment shall not discharge compressed air to the air distribution main piping systems above 100 degrees F unless approved by the Contracting Officer. Aftercoolers or other devices shall be provided to comply with the temperature restriction.

1.5.2 Rotating Equipment

Fully guard couplings, motor shafts, gears and other exposed rotating or rapidly moving parts in accordance with OSHA 29 CFR 1910.219. Provide rigid and suitably secured guard parts readily removable without disassembling guarded unit.

1.5.3 Welding and Brazing

Safety in welding, cutting, and brazing of pipe shall conform to AWS Z49.1.

PART 2 PRODUCTS

2.1 DESICCANT AIR DRYERS (AD-12, AD-13)

The air dryers shall be the packaged, heat-of-compression, two-tower desiccant dryers that utilize the heat of compression from the compressors for regeneration type. Include the interconnecting piping, valves, aftercooler, desiccant charge, drain trap, controls, instrumentation, afterfilter, steel base, and accessories. All dryer components shall be mounted on a structural skid, so as to comprise a single unit. The only customer connection points will be air inlet/outlet, cooling water inlet/outlet 460/3/60 power with integral transformer to provide 115/1/60 volt power for controls and the drain lines.

Chamber of welded steel, 125 psig working pressure, ASME labeled conforming to ASME BPVC SEC VIII D1, with flanged or threaded fittings, and automatic drain valve. Manufacturer's recommended desiccant in tablet form which will not nest or cake. Contractor shall provide a supply of desiccant for initial operations in unbroken shipping containers equal to not less than four charges of desiccant for the dryer.

2.1.1 Guaranteed Performance

a. Maximum Inlet Pressure: 125 psig

b. Design Flow Rate: 6,000 scfm

c. Maximum Inlet Temperature: 300 degrees F.

d. Maximum/Minimum Design Cooling Water Temperature: 85/50 degrees F.

e. Maximum Outlet Pressure Dew Point Temperature under all Conditions: Minus 20 degrees F.

2.1.2 Desiccant Towers

All pressure vessels shall be designed and fabricated in accordance with the ASME BPVC SEC VIII D1. Vessels larger than 6-inch diameter shall be provided with a "U" stamp or "UM" stamp and be registered with the National Board of Boiler and Pressure Vessel Inspector as required by the ASME code. The vessels and entire dryer design shall be designed for 10 percent greater than the maximum operating pressure of the compressor.

The desiccant towers shall be insulated with a 1-1/2-inch thickness of fiberglass and covered by an aluminum jacket. Insulation shall be weatherproof, suitable for outdoor service.

Separate, adequately sized desiccant fill and drain ports shall be

provided on each tower. Fill and drain connections shall be independent of piping assembly.

Each tower shall be provided with an ASME-rated pressure relief valve.

The velocity of air through the tower shall be less than that which would disrupt, upset, or fluidize the desiccant.

2.1.3 Desiccant Charge

Desiccant shall be specifically formulated and tested for use in heat-of-compression dryers. Desiccant selection shall be based on nominal inlet air temperature to the dryer. Desiccant shall be Activated Alumina, 3/16-inch in size.

2.1.4 Piping and Valves

Switching valves shall be manufacturer's standard design. Switching valves shall be non-lubricated, 2-way valves. **3-way and 4-way switching valves are not acceptable**.

Valves 2 inches and smaller shall be non-lubricated, 2-way air actuated ball valves.. Valves 3 inches and larger shall be non-lubricated, 2-way high performance butterfly valves with double-acting actuators. Butterfly valve internals shall be stainless steel with reinforced PTFE seats. The valve shall be rated to 600 degrees F.

All piping shall be in accordance with ASME B31.3.

2.1.5 Regeneration System/Heating Cycle

The dryer's NEMA cycle shall be 8 hours; 4 hours regenerating on one tower with the opposing tower drying the process stream for 4 hours. The 4-hour regenerating cycle will consist of 1.5 hours heating, 1.5 hours of stripping, and 1.0 hours of closed loop cooling. The dryer will be designed so that the owner can operate the dryer with stripping or without stripping.

The idle desiccant bed shall be regenerated by passing all of the hot air from the compressor outlet through the bed. A proportional flow valve allowing less than full flow heating is not acceptable.

Regeneration shall be carried out at full line pressure. No process air shall be lost during heating.

Regeneration airflow shall be downwards through the bed during heating.

2.1.6 Stripping Cycle

The standard four-hour regeneration cycle will consist of 1.5 hours of heating, 1.5 hours of stripping, and 1 hour of closed loop cooling.

During the 90-minute stripping mode, the dryer shall use no more than 2 percent of the inlet flow rate. Therefore, on a time based average, the purge rate will equal 3/4 of 1 percent (2 percent x 90/240). And purge will be further reduced with the dew point demand control mode.

Provide a trim heater to assure that the dryer is capable of delivering a year round minus 20 degree F pressure dew point or better. The heater

will be installed in the stripping piping loop and will be engaged only when necessary. If the heater is engaged, it will turn on for only 45 minutes every 4-hour regeneration cycle. The heater shall be rated at a maximum watt density of 14 watts per square inch. The heater shall have an Inconel sheath and it shall be insulated. The heater shall be controlled by a dual setpoint indicating temperature controller. The controller shall have a primary and secondary setpoint with a high temperature alarm. Additionally, another thermostat shall be located in the cold zone (inlet) of the heater.

The dryer shall be designed such that it can operate in two modes: 1) heat of compression and 2) heatless. The operator will be able to switch between these modes via the touch pad on the PLC panel. As an example, the heatless mode of operation would be used if a portable compressor was installed with an aftercooler. Hence, the aftercooler would make heat of compression operation useless. The operator would simply make the adjustment on the PLC control panel and adjust the purge line to 15 percent and the dryer automatically becomes a heatless dryer.

2.1.7 Cooling Cycle

The cooling cycle will divert a portion of the dry outlet air into the regenerating tower where this airstream will gradually pick up and carry excess heat from the regenerating tower. This airstream will then re-entrain with the outlet process flow stream. There will be no loss of air during the 1-hour cooling mode. Cooling of the desiccant bed is necessary to eliminate/diminish the possibility of pressure dew point spikes due to residual heat in the bed at tower reversal.

2.1.8 Aftercooler

The dryer shall be provided with a shell-and-tube heat exchanger that shall be used to reduce the temperature of the regenerating air prior to the drying tower.

The cooler shall be designed and fabricated to the ASME code.

The cooler shall be designed based on an ambient temperature of 80 degrees F and an ambient relative humidity of 80 percent.

The cooler shall have a maximum approach of 10 degrees F and a maximum pressure drop of 1 psig.

The aftercooler tubes shall be constructed of copper or stainless steel.

2.1.9 Separator

The dryer shall be provided with a cleanable coalescing type moisture separator consisting of a stainless steel mesh pad inserted into an ASME code stamped pressure vessel. Centrifugal or cyclone type separators are not acceptable. Coalescing filters are not acceptable.

2.1.10 Drain Trap

The dryer shall be furnished with a fully automatic zero-loss drain. A primary and secondary trap shall be provided.

The primary trap shall be a fully pneumatic mechanical trap complete with translucent reservoir, equalizing line, pneumatically actuated drain

valve, and isolation valve. The drain shall be capable of 24 oz. discharge capacity.

The secondary drain shall consist of a liquid level sensor, solenoid valve, and pilot valve. If the primary trap fails, water will enter the secondary liquid level sensor, which will energize the solenoid, thus opening the pilot valve. As water exits the liquid level sensor, the pilot valve shall close.

Any time the secondary drain operates, a primary drain failure alarm light and horn shall be activated. The control panel for the light and horn shall include an acknowledge button and a horn silence switch.

2.1.11 Electrical/Controls and Instrumentation

The dryer shall operate on 460/3/60 electric power. The dryer must consume less than 50 watts of power at all times, except when the trim heater is in operation.

The dryer shall be controlled by a PLC with a panel display screen is flush mounted onto the front of the electrical enclosure. The PLC must have Modbus communications. The panel shall display dryer status and alarm conditions. It shall also display the dryer's outlet pressure dew point and the dryer inlet temperature and the aftercooler inlet and outlet temperature. The PLC shall allow the dryer to operate in heat of compression or heatless mode as mentioned in 2.1.6. (The heatless mode could be used when rental compressors with aftercoolers are installed on the system.) The PLC panel display screen view shall also allow the operator to program the dryer to run in either the stripping or non-stripping mode.

The dryer shall be equipped with a dewpoint demand controller that switches towers based on the dewpoint of the outlet air. The dewpoint controller shall include a direct reading dewpoint indicator. The NEMA 4 electrical enclosure shall include a high dewpoint alarm and contacts for remote indication of high dewpoint. The controller shall be equipped with an adjustable setpoint and shall have a 4-20 mA output. The controller shall also have a selector switch to allow manual selection of dewpoint or fixed time control. The dew point range of the controller shall be minus 146 degrees F to plus 68 degrees F.

The dryer shall include tower pressure gauges, cooler inlet and outlet temperature transmitters and dryer inlet temperature transmitter

The dryer shall include a low regeneration temperature alarm light and high aftercooler temperature alarm light.

The electrical enclosure shall be NEMA 4 suitable for weatherproof service, unless otherwise specified.

Tubing shall be copper supported throughout the dryer by a series of rigid tubing supports.

2.1.12 Painting

The dryer shall be either machine cleaned or sandblasted prior to painting. Painting shall consist of a prime coat and finish coat of industrial enamel paint. Insulated surfaces shall not be painted.

2.1.13 Afterfilter

An afterfilter shall be provided for removal of suspended desiccant particles. The filter shall be capable of removing 99.99 percent of all particles 1.0 micron and larger. A PREFILTER IS NOT REQUIRED.

Afterfilter shall be suitable for the temperature of the application.

Afterfilter shall have replaceable cartridges.

Afterfilter shall be mounted on the dryer skid and shall be provided with a differential pressure indicator.

2.2 LOW PRESSURE COMPRESSED AIR PIPING AND ACCESSORIES

Compressed air piping is for distribution of high quality air used for breathing. Low pressure compressed air piping and accessories 125 psig at 150 degrees F, shall conform to the following:

2.2.1 Steel Piping

a. Pipe: ASTM A53/A53M, seamless or electric resistance welded carbon steel, Schedule 40, black.

b. Fittings, size 2 inches and larger: ASME B16.9, carbon steel, butt welding, schedule 40, or ASME B46.1, carbon steel welding neck flanges, Class 150, ASME B46.1, flanged fittings, carbon steel, Class 150, gaskets 1/16 inch oil resistant synthetic rubber ASTM D1330, bolts ASTM A193/A193M, Grade B7, and nuts, ASTM A194/A194M, Grade 7. Butt welded joints shall be full penetration consumable insert or backing ring type.

c. Fittings, size 1 1/2 inches and smaller: ASME B16.3, threaded malleable iron, Class 150, or ASME B16.11, forged carbon steel Class 3000 socket welding or Class 2000 threaded. Joints may also be butt welded or flanged, as specified for sizes 2 inches and larger.

d. Flat-faced steel flanges: Where connections are made to Class 125 cast iron flanges with steel flanges, use only flat-faced Class 150 steel flanges.

e. Unions: ASME B16.39, Class 1 (300 psig WOG).

f. Grooved Mechanical Connections For Steel: At contractor's option, grooved joints may be provided in new compressor building, DD6 tunnels, DD6 galleries, and aboveground piping supported on Building 1124.

   Rigid grooved mechanical connections may only be used in serviceable aboveground locations. Flexible grooved connections shall be used only as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria specified for the similar welded, flanged, or threaded component specified herein.

   Each grooved mechanical joint shall be a system, including coupling housing, gasket, fasteners, all furnished by the same manufacturer. Joint installation shall be in compliance with joint manufacturer's written instructions.

Use fitting and coupling houses of malleable iron conforming to ASTM A47/A47M, Grade 32510; ductile iron conforming to ASTM A536, Grade 65-45-12; or steel conforming ASTM A106/A106M, Grade B or ASTM A53/A53M. Use gaskets of molded synthetic rubber with central cavity, pressure responsive configuration and conforming to ASTM D2000 Grade No. 2CA615A15B44F17Z. Grooved mechanical connections shall conform to AWWA C606. Coupling nuts and bolts shall be Type 316 stainless steel and shall conform to ASTM A183. Pipe connections and fittings shall be the product of the same manufacturer. Provide joint installation be in compliance with joint manufacturer's written instructions.

2.2.2 Copper Tubing

a. Tubing: ASTM B88, Type K or L, hard drawn, Class 1.

b. Fittings: ASME B16.22 wrought copper or bronze, with silver brazed joints.

c. Brazing filler metal: FS QQ-B-654, Class III.

d. Unions: bronze, CID A-A-59617, brazed joint type.

e. Flanges and flanged fittings: ASME B16.24, bronze, Class 150, gaskets, oil resistant synthetic rubber, ASTM D1330, bolts ASTM A193/A193M, Grade B7, and nuts ASTM A194/A194M, Grade 7.

f. Flared fittings: ASTM B88, Type K or L, annealed, with ASME B16.26 or SAE J513 flared fittings.

2.2.3 Valves

2.2.3.1 Gate Valves

a. Bronze Gate Valves: MSS SP-80, Class 150, 2 inches and smaller, wedge disc, rising stem, inside screw type, with brazed joints ends when used with copper tubing.

b. Steel Gate Valves: ASME B16.34, 2 inches and smaller, ASME B16.34, over 2 inches, flanged ends, outside screw and yoke type with solid wedge or flexible wedge disc, Class 150. Provide motor operator where indicated.

2.2.3.2 Globe and Angle Valves

a. Bronze globe and angle valves: MSS SP-80, Class 150, 2 inches and smaller, Class 200, except that Class 150 valves with brazed ends may be used for copper tubing. Valves shall have renewable seats and discs except brazed-end valves which shall have integral seats.

b. Steel globe and angle valves: ASME B16.34, 2 inches and smaller, ASME B16.34, over 2 inches, flanged ends, Class 150. Provide motor operator where indicated.

2.2.3.3 Pressure Reducing Valves

ANSI/NFLPA T3.12.3, with nominal pressure rating of not less than inlet system pressure indicated. Provide pressure reducing valves capable of

being adjusted to specified flow and pressure, and suitable for intended service. Provide pilot valve for dome loaded type if required for proper operation.

2.2.3.4 Safety Valves

ASME BPVC SEC VIII D1 and ASME BPVC SEC IX Code stamped safety valve), 125 psig, for unfired pressure vessels, bronze, with threaded or flanged connections; factory set and sealed.

2.2.3.5 Check Valves

MSS SP-80, Bronze body with brazed joint or threaded ends or steel body with flanged end, ASME B16.34, or threaded ends, ASME B16.34. The check valve shall have a perforated piston with closed downstream end, in line with the pipe and held closed by a steel poppet return spring.

2.2.3.6 Pressure Regulators

Diaphragm type, air loaded, tight closing single seat, brass body with integral filter and bowl.

2.2.3.7 Needle Valves

One-piece bodies with integral or screwed bonnet, stems of hardened stainless steel with fine thread for metering and ease of adjusting, Teflon packing; and shall be of the pressure balanced type. Needle valves shall be of the slow opening type.

2.2.3.8 Ball Valves

Full port design, copper alloy body, except sizes 2.5 inches and larger shall be ANSI Class 150 steel-bodied. Valves shall have two-position lever handles.

2.2.4 Pressure Gages

ASME B40.100, Accuracy Grade A, for air, with steel or brass case, and nonshatterable safety glass, and a pressure blowout back to prevent glass from flying out in case of an explosion. Gages shall have a 3 1/2 inch minimum diameter dial and a dial range of approximately twice working pressure.

2.2.5 Hangers and Supports

Provide pipe hangers and supports conforming to MSS SP-58, MSS SP-69, and ASME B31.1, except as specified or indicated otherwise. Furnish zinc plated pipe hangers and supports except for copper plated inserts for copper piping. Provide tubing supports of U-shaped steel bolts and nuts firmly secured to adequately support structures such as walls, columns, floors, or brackets. Clips shall fit closely around piping but shall have sufficient clearance to permit longitudinal movement of piping during normal expansion and contraction. Provide supports at valves, fittings, branch lines, outlets, changes in direction, equipment, and accessories.

2.2.6 Quick Disconnect Couplings

All brass and suitable for a working pressure of not less than 125 psig. Female side of coupling (fixed end) shall have male thread connection with

automatic shutoff. Provide male side of coupling with hose stem and ball check to bleed pressure from hose and prevent hose whipping.

2.2.7 Single Cartridge Type Filters

125 psig operating pressure and filter housing of brass or bronze. Provide cellulose cartridge filters of graded density construction capable of removing liquids and solids of 5 microns and larger. Filter capacity shall be compatible with rated flow of equipment or pressure reducing valves provided.

2.2.8 Strainers

FS WW-S-2739. Bronze or malleable iron body, Class 125, Style Y, Type II, simplex type, with 20-mesh Monel or stainless steel screen.

2.2.9 Traps

CID A-A-60001 to drain water and other liquids from system. Type of traps, as indicated, and rated working pressure not less than system operating pressure.

2.2.10 Flexible Connections

Vibration isolation, wire braid reinforced corrugated metal hose type, line-sized, with bronze end connections, suitable for pressure indicated. Length as recommended by manufacturer but not less than 18 inches.

2.2.11 Dielectric Unions

Steel female pipe thread end and copper solder-joint ends, conforming to dimensional, strength and pressure requirements of ASME B16.39, Class 1. 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, it shall also be able to withstand a 600-volt breakdown test.

2.2.12 Tetrafluoroethylene Tape

CID A-A-58092 for screw-jointed pipe.

2.3 SLEEVES

2.3.1 Roof Slabs and Outside Walls Above Grade

Galvanized-steel pipe having an inside diameter at least 1/2 inch larger than the outside diameter of the pipe passing through it. Provide sufficient sleeve length to extend completely through roofs, and walls, so that sleeve ends are flush with finished surfaces. Sleeves located in waterproofed construction shall include flange and clamping ring.

2.3.2 Partitions

Galvanized sheet steel, 26 gage or heavier, of sufficient length to completely extend through partition thickness with sleeve ends flush with partition finished surface.

2.4 IDENTIFICATION LABELS FOR PIPING

Labels for pipes 3/4 inch o.d. and larger shall bear printed legends to identify contents of pipes and arrows to show direction of flow. Except that of pipes smaller than 3/4 inch o.d., labels shall have color coded backgrounds to signify levels of hazard in accordance with PFI ES 22. Legends and type and size or characters shall also conform to PFI ES 22. Labels shall be made of plastic sheet in conformance with CID A-A-1689 with pressure-sensitive adhesive suitable for the intended applications or they may be premolded of plastic to fit over specific pipe outside diameters 3/4 inch and larger. For pipes smaller than 3/4 inch o.d., furnish brass identification tags 1 1/2 inches in diameter with legends in depressed black-filled characters.

2.5 BURIED UTILITY WARNING AND IDENTIFICATION TAPE

Polyethylene plastic tape manufactured specifically for warning and identification of buried utility lines. Tape shall be of the type provided in rolls, 6 inches minimum width, color codes for compressed air (gray) with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall be "CAUTION BURIED COMPRESSED AIR LINE BELOW" or similar wording. Code and letter coloring shall be permanent, unaffected by moisture and other substances contained in trench backfill material.

2.6 FRESH WATER

Fresh water for cleaning, flushing, and testing shall be clean and potable.

2.7 SOURCE QUALITY CONTROL

Test compressed air dryers at the factory to assure proper operation. Certify satisfactory accomplishment of tests.

PART 3 EXECUTION

3.1 INSTALLATION

Install materials and equipment as indicated and in accordance with the manufacturer's recommendations.

3.1.1 Piping

Provide Non-Destructive Examination (NDE) report for welding of piping. Unless specifically stated to the contrary, fabrication, assembly, welding, and brazing shall conform to ASME B31.1 for all piping of the air system. Piping shall follow the general arrangement shown. Cut piping accurately to measurements established for the work. Work piping into place without springing or forcing, except where cold-springing is specified. Piping and equipment within buildings shall be entirely out of the way of lighting fixtures and doors, windows, and other openings. Locate overhead piping in buildings in the most inconspicuous positions. Do not bury or conceal piping until it has been inspected, tested, and approved. Where pipe passes through building structure, pipe joints shall not be concealed, but shall be located where they may be readily inspected and building structure shall not be weakened. Avoid interference with other piping, conduit, or equipment. Except where specifically shown otherwise, vertical piping shall run plumb and straight and parallel to walls. Piping connected to equipment shall be installed to provide

flexibility for vibration. Adequately support and anchor piping so that strain from weight of piping is not imposed on the equipment.

3.1.1.1 Fittings

Use long radius ells where appropriate to reduce pressure drops. Pipe bends in lieu of fittings may be used for low pressure piping where space permits. Pipe bends shall have a uniform radius of at least five times the pipe diameter and must be free from any appreciable flattening, wrinkling, or thinning of the pipe. Mitering of pipe to form elbows, notching straight runs to form full sized tees, or any similar construction shall not be used. Make branch connections with welding tees, except factory made forged welding branch outlets or nozzles having integral reinforcements conforming to ASME B31.1 may be used.

3.1.1.2 Clearances for Welding

Provide clearances from walls, ceilings, and floors to permit the installation of joints. The clearances shall be at least 6 inches for pipe sizes 4 inches and less, 10 inches for pipe sizes over 4 inches, and sufficient in corners. However, the specified clearances shall not waive requirements for welders to be qualified for the positions to be welded.

3.1.1.3 Cleaning and Flushing Procedures

Before jointing and erection of piping or tubing, thoroughly clean interiors of pipe sections, tube, and components. In steel pipe, loosen scale and other foreign matter by rapping sharply and expel by wire brush and swab. Blow out both steel pipe and copper tube and components with compressed air at 100 psig or more. Maintain cleanliness by closure of pipe/tube openings with caps or plugs. Before making final terminal connections, blow out complete system with compressed air at 100 psig or more.

3.1.1.4 Changes in Pipe Size

Use reducing fittings for changes in pipe size. The use of bushings will not be permitted. In horizontal lines, 2 1/2 inches and larger, reducing fittings shall be of the eccentric type to maintain the bottom of the lines in the same plane.

3.1.1.5 Drainage and Flexibility

Compressed air piping shall be free of unnecessary pockets and pitched approximately 3 inches per 100 feet in the direction of flow to low points. Where pipes must be sloped so that condensate flows in opposite direction to air flow, slope 6 inches per 100 feet or greater. Provide flexibility by use of fittings, loops, and offsets in piping. Install branches at top of a main to prevent carryover of condensate and foreign matter.

3.1.2 Threaded Joints

Where possible use pipe with factory cut threads, otherwise cut pipe ends square, remove fins and burrs, and cut taper pipe threads in accordance with ASME B1.20.1. Threads shall be smooth, clean, and full cut. Apply thread tape to male threads only. Work piping into place without springing or forcing. Backing off to permit alignment of threaded joints will not be permitted. Engage threads so that not more than three threads

remain exposed.

3.1.3 Welding and Brazing Procedures

Perform welding and brazing in accordance with qualified procedures using qualified welders and welding operators and brazers. Do not perform welding and brazing when the quality of the completed weld or braze could be impaired by the prevailing working or weather conditions. The Contracting Officer will determine when weather or working conditions are unsuitable for welding. Welding of hangers, supports, and plates to structural members shall be in accordance with AWS D1.1/D1.1M.

3.1.3.1 Cleaning for Welding and Brazing

Surfaces to be welded or brazed shall be free from loose scale, slag, rust, paint, oil, and other foreign material. Joint surfaces shall be smooth and free from defects which might affect proper welding. Clean each layer of weld metal thoroughly by wire brushing, grinding, or chipping prior to inspection or deposition of additional weld metal.

3.1.3.2 Stress Cracking During Brazing

For material susceptible to stress corrosion cracking from molten brazing filler metal, avoid applying stress during brazing.

3.1.3.3 Welding or Brazing of Valves

Welding or Brazing of Valves: Disassemble valves subject to damage from heat during welding or brazing and reassemble after installation. Open valves two or three turns off the seat when not subject to heat damage during welding or brazing; do not backseat valve.

3.1.4 Grooved Mechanical Connections

Prepare grooves in accordance with the coupling manufacturer's instructions. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, or narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.

3.1.5 Flare Fittings

Provide flare fittings only where necessary to connect copper tubing to equipment. Use short sections of annealed tubing soldered or brazed to hard drawn tubing using couplings on expanded ends on the annealed tubing made with special tools designed for that purpose. Make flares with the appropriate flaring tools. Cut annealed tubing only with cutting wheel tool. Do not ream out inside burr or lip left by the cutting wheel but fold back lip with flare tool to form seal/gasket inside flare. When new, the flare should cover not more than 75 percent of the flare seating surface of either the male or female flare fittings. Put the flare nut on the tube before making the flare.

3.1.6 Valves

ASME B31.1. Install valves at the locations indicated and elsewhere as required for the proper functioning of the system.

3.1.6.1 Gate Valves

Provide gate valves unless otherwise directed. Install valves in positions accessible for operation and repair. Install valve with stem horizontal or above.

3.1.6.2 Globe Valves

Install globe valves so that the pressure will be below the disk. Install globe valves with the stems vertical.

3.1.6.3 Pressure-Reducing Valves

Provide compressed air entering each pressure-reducing valve with a strainer. Provide each pressure-reducing valve unit with two block valves and with a globe or angle bypass valve and bypass pipe. Provide a bypass around a reducing valve of reduced size to restrict its capacity to approximately that of the reducing valve. Provide each pressure reducing valve unit with an indicating gage to show the reduced pressure, and a safety valve on the low pressure side. These requirements do not apply to small pressure regulating valves used to adjust pressure for pneumatic equipment.

3.1.7 Hangers and Supports

Selection, fabrication and installation of piping hangers and supports shall conform to MSS SP-58, MSS SP-69 except that spacing of the hangers and supports shall be as per Table I, unless indicated otherwise. Provide seismic restraints for piping in accordance with PPIC Seismic Restraint.

TABLE I. MAXIMUM SPAN FOR PIPE (FEET-INCHES)

DIAMETER INCHES	STD. WT. STEEL PIPE SCHEDULE 40	EX. STRONG STEEL PIPE SCHEDULE 80	COPPER TUBE TYPE K	COPPER TUBE TYPE L
1/2	5'-0"	5'-0"	3'-9"	3'-9"
3/4	5'-9"	5'-9"	4'-3"	4'-3"
1	6'-6"	6'-6"	5'-0"	4'-9"
1-1/2	7'-6"	7'-9"	5'-9"	5'-6"
2	8'-6"	8'-6"	6'-6"	6'-6"
2-1/2	9'-3"	9'-6"	7'-3"	7'-0"
3	10'-3"	10'-6"	7'-9"	7'-6"
3-1/2	11'-0"	11'-0"	8'-3"	8'-3"

TABLE I. MAXIMUM SPAN FOR PIPE (FEET-INCHES)				
DIAMETER INCHES	STD. WT. STEEL PIPE SCHEDULE 40	EX. STRONG STEEL PIPE SCHEDULE 80	COPPER TUBE TYPE K	COPPER TUBE TYPE L
4	11'-6"	11'-9"	9'-0"	8'-9"
5	12'-9"	13'-0"	10'-0"	9'-6"
6	13'-9"	14'-0"	10'-9"	10'-6"
8	15'-6"	16'-0"		
10	17'-0"	17'-6"		
12	18'-3"	19'-0"		

3.1.8 Pressure Gages

Provide pressure gages with a shut-off valve or petcock installed between the gage and the line.

3.1.9 Strainers

Provide strainers with meshes suitable for the services where indicated, or where dirt might interfere with the proper operation of valve parts, orifices, or moving parts of equipment.

3.1.10 Equipment Foundations

Provide equipment foundations of sufficient size and weight and of proper design to preclude shifting of equipment under operating conditions or under any abnormal conditions which could be imposed upon the equipment. Provide foundations which meet the requirements of the equipment manufacturer, and when required by the Contracting Officer, obtain from the equipment manufacturer approval of the foundation design and construction for the equipment involved. Equipment vibration shall be maintained within acceptable limits, and shall be suitably dampened and isolated.

3.1.11 Equipment Installation

Install equipment strictly in accordance with these specifications, and the manufacturers' installation instructions. Grout equipment mounted on concrete foundations before piping is installed. Install piping in a manner that does not place a strain on any of the equipment. Do not bolt flanged joints tight unless they match properly. Extend expansion bends adequately before installation. Grade, anchor, guide and support piping without low pockets.

3.1.12 Cleaning of System

Clean the various system components before final closing as the installations are completed. Remove foreign matter from equipment and surrounding areas. Preliminary or final tests will not be permitted until

the cleaning is approved by the Contracting Officer.

3.1.13 Pipe Sleeves

Provide pipe sleeves where pipes and tubing pass through masonry or concrete walls and roofs. Hold sleeves securely in proper position and location before and during construction. Sleeves shall be of sufficient length to pass through entire thickness of walls or slabs. Pack space between the pipe or tubing and the sleeve firmly with oakum and caulk both ends of the sleeve with elastic cement.

3.1.14 Wall and Ceiling Plates

Provide chromium-plated steel or nickel-plated cast iron plates on pipes passing through floors and partitions of finished rooms. Provide painted cast-iron, malleable iron, or steel for other areas.

3.1.15 Flashing for Buildings

Provide flashing in accordance with Section 07 60 00 FLASHING AND SHEET METAL where pipes pass through building roofs and outside walls.

3.1.16 Unions and Flanges

Provide unions and flanges where necessary to permit easy disconnection of piping and apparatus, and as indicated. Provide a union for each connection having a screwed-end valve. Provide unions or flanges not farther apart than 100 feet. Provide unions or flanges as indicated. Provide unions on piping under 2 inches in diameter, and provide flanges on piping 2 inches and over in diameter. Install dielectric unions or flanges between ferrous and non-ferrous piping, equipment, and fittings; except that bronze valves and fittings may be used without dielectric couplings for ferrous-to-ferrous or non-ferrous to non-ferrous connections.

3.1.17 Painting of Piping and Equipment

Paint piping and equipment in accordance with Section 09 90 00 PAINTS AND COATINGS. Piping installed outdoors, in tunnels, in manholes, and in service galleries, shall be painted in accordance with Section 09 96 00 HIGH-PERFORMANCE COATINGS.

Direct buried compressed air pipe and fittings shall be provided with a factory-applied two- or three-layer-high performance fusion bonded epoxy (FBE) corrosion protection coating system with outer layer of polyethylene or polypropylene for a total minimum thickness of 30 to 40 mils.

3.1.18 Identification of Piping

Identify piping in accordance with PFI ES 22. Use commercially manufactured piping identification labels. Space identification marking on runs not farther apart than 50 feet. Provide two copies of the piping identification code framed under glass and install where directed.

3.1.19 Warning and Identification Tape

Coordinate installation of utility warning and identification tape with backfill operation. Provide tape above buried lines at a depth of 8 to 12 inches below finish grade.

3.2 CLEANING PIPING

Clean piping to remove particulate, scale, or residual flux remaining in the system after fabrication. Use one of the procedures below. The hot flush and hot recirculating flush are preferred. Minimum flow rate through any part of the system in gallons per minute shall be 1.5 times the inside diameter of the pipe in inches. For any flushing method used, the system shall be full of water so that joints are completely submerged at all times.

3.2.1 Hot Flushing Method

Hot flush the system for one hour using heated fresh water. No part of the system shall go below 110 degrees F.

3.2.2 Hot Recirculating Flush Method

Perform hot recirculating flush for one hour. Heat water during flushing so that no part of the system falls below 110 degrees F. After completing the hot recirculating flush, flush the system with cold fresh water for 15 minutes.

3.2.3 Cold Soak Method

Cold soak the system using fresh water at not less than 60 degrees F for 12 hours. Following the 12 hour soak, flush the system with fresh water at not less than 60 degrees F for 4 hours.

3.3 FIELD QUALITY CONTROL

3.3.1 Examinations

3.3.1.1 Welding Examinations

The Contractor shall perform visual examinations to detect surface and internal discontinuities in completed welds. NDE on piping welds covered by ASME B31.9 is visual inspection only. Verify piping welds meet the acceptance criteria. Submit a NDE report meeting the requirements specified in ASME B31.9. Visually examine all welds. When examination indicates defects in a weld joint, the weld shall be repaired by a qualified welder. Remove and replace defects as specified in ASME B31.1, unless otherwise specified. Repair defects discovered between weld passes before additional weld material is deposited. Whenever a defect is removed, and repair by welding is not required, blend the affected area into the surrounding surface, eliminating sharp notches, crevices, or corners. After defect removal is complete and before rewelding, examine the area by the same methods which first revealed the defect to ensure that the defect has been eliminated. After rewelding, reexamine the repaired area by the same test methods originally used for that area. Any indication of a defect shall be regarded as a defect unless reevaluation by surface conditioning and reexamination shows that no unacceptable defects are present. The use of any foreign material to mask, fill in, seal, or disguise welding defects will not be permitted.

3.3.1.2 Brazing Examinations

The Contractor shall perform brazing examinations. Visually examine all compressed air systems as follows:

a. Check brazed joint fit-up. Diametrical clearances shall conform to brazing procedure requirements.

b. Check base material of pipe and fitting for conformance to the applicable drawing or specification.

c. Check grade of brazing alloy for conformance to the brazing procedure before fit-up or brazing.

d. Check completed brazed joint for a complete ring of brazing alloy between the outside surface of the pipe and the face of the fitting, and for a visible fillet.

e. Check stainless steel and other susceptible material for evidence of stress cracks. Check inside of joint if possible with bore scope or other aids.

Defective joints may be repaired. However, no more than two attempts to repair by reheating and additional face feeding of brazing filler metal will be permitted, after which the defective joint shall be unsweated, reprepared as a new joint, examined for defects on pipe and fittings, and rebrazed.

3.3.2 Testing

3.3.2.1 General Requirements, Testing

Perform testing after cleaning. Contractor shall provide everything required for tests. Tests shall be subject to the approval of the Contracting Officer. Calibrate the test pressure gages with a dead weight tester within 15 days before use and certify by initial and date on a sticker applied to dial face. Pressurize each piping system individually and check to assure that there are no cross-connections between different systems prior to hydrostatic and operational tests.

3.3.2.2 Hydrostatic Tests and Leak Tightness Tests

a. Preliminary Preparation

Remove or isolate from the system the compressor, air dryer, filters, instruments, and equipment which would be damaged by water during hydrostatic tests and reinstall after successful completion of tests.

b. Performance of Hydrostatic Tests

Hydrostatically test piping systems in accordance with ASME B31.1. Vent or flush air from the piping system. Pressurize system for 10 minutes with water at one and one-half times design working pressure, then reduce to design working pressure and check for leaks and weeps.

Notify Contracting Officer 14 days prior to test in order for test to be witnessed by Government personnel at Contracting Officer's option.

c. Compressed Air Leak Test

After satisfactory completion of hydrostatic pressure test, blow systems dry with clean, oil-free compressed air, and test with clean, dry air at design working pressure. Brush joints with soapy water solution to check for leaks. Install a calibrated test pressure gage in piping system to

observe any loss in pressure. Maintain required test pressure for a sufficient length of time to enable an inspection of joints and connections.

3.3.2.3 Operational Tests

Test equipment as in service to determine compliance with contract requirements and warranty. During the tests, test equipment under every condition of operation. Test safety controls to demonstrate performance of their required function. Completely test system for compliance with specifications.

3.4 INSTRUCTION TO GOVERNMENT PERSONNEL

Provide 2 man-days of instruction to 2 Government personnel in accordance with Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS for each type of compressed air dryer in the project.

-- End of Section --