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USACE / NAVFAC / AFCEC / NASA **UFGS-22 15 19.13 20 (November 2009)**

Preparing Activity: NAVFAC **Superseding**
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UNIFIED FACILITIES GUIDE SPECIFICATIONS

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DIVISION 22 - PLUMBING

SECTION 22 15 19.13 20

LARGE NONLUBRICATED RECIPROCATING AIR COMPRESSORS (OVER 300 HP)

11/09

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SECTION 22 15 19.13 20

LARGE NONLUBRICATED RECIPROCATING AIR COMPRESSORS (OVER 300 HP)

11/09

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NOTE: This guide specification covers the requirements for large nonlubricated reciprocating air compressors larger than 224 kW 300 hp.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

****

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NOTE: Cooling towers or closed-circuit coolers, cooling water piping, and other items are not included and must be included in other sections of the project specification.

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NOTE: The following information shall be shown on the project drawings:

1. Compressor, accessory equipment, and piping arrangement and details.

2. Equipment foundations.

3. Equipment schedules. If equipment schedules include operating conditions for the compressor, delete the information from this section.

****

PART 1 GENERAL

1.1 REFERENCES

****

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

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

AMERICAN PETROLEUM INSTITUTE (API)

API Std 618	(2007; R 2016) Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.5	(2017) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME PTC 9	(1970; R 1997) Displacement Compressors, Vacuum Pumps and Blowers (for historical

reference only)

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A307	(2014; E 2017) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM B111/B111M	(2018) 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 B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM C553	(2013; R 2019) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM E84	(2020) 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	(2017) 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) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2018) Motors and Generators

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-3316	(1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation
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

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 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G". Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required

as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force, and NASA projects, or choose the second bracketed item for Army projects.

****

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

SD-02 Shop Drawings

Air compressor system

Include wiring diagrams of the air compressor system with all accessories. The minimum acceptable scale is [1:50 1/4 inch to one foot] [_____].

SD-03 Product Data

****

NOTE: Include carbon monoxide monitor in systems which are used for breathing air per DM 3.5, Section 3.

****

Air compressor

Inlet air filters

Inlet line silencer

Air flow rate and pressure recorder

[Carbon monoxide monitor]

Filter housing

Submit manufacturer's catalog data for compressor and auxiliary equipment in the format provided in API Std 618, Appendix A. For air compressors, include aftercooler, intercoolers, oil cooler, lubrication system, and control valves. Submit air compressor intercooler, and aftercooler performance curves at specified summer design conditions.

SD-05 Design Data

Intake and discharge pipe calculations

SD-06 Test Reports

Air compressor performance tests

Sound level and run-in tests

Obtain approval prior to shipping compressor.

Air compressor performance tests

Instrumentation test

Sound level tests

Air compressor system test

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

SD-07 Certificates

Work plan

Factory test procedures

Factory testing certification

Qualifications of field supervisors

Field test procedures

Training material

Air compressor system

Air compressor system installation

SD-10 Operation and Maintenance Data

****
NOTE: Obtain approval of equipment with proprietary maintenance requirements from the appropriate contracts office.
****

Air compressor system, Data Package 3

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

SD-11 Closeout Submittals

Posted operating instructions for air compressor

Submit text.

1.4 QUALITY ASSURANCE

1.4.1 Intake and Discharge Pipe Calculations

Submit intake and discharge pipe calculations to show intake and discharge piping are not subject to damaging resonance pulsations. Include effects

of pulsation dampers and surge chambers, if required to limit pulsation.

1.4.2 Work Plan

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

1.4.3 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."

1.4.4 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.

1.4.5 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.

1.4.6 System Installation

Submit certification of air compressor system performance conforming to ASME PTC 9. Submit certification of proper system installation in accordance with paragraph entitled "Supervision."

1.4.7 Air Compressor System

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Air compressor system 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.

1.5 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, insulation and jacketing with manufacturer standard covering or aluminum sheet of all surfaces at 52 degrees C 125 degrees F and higher within a height of 2.10 meter 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 204 degrees C 400 degrees F), 32 kg/m3 2 pcf nominal. Cement insulation to surface with MIL-A-3316, Class 2, adhesive and fasten with 16 gage wire bands at maximum 405 mm 16 inches on center spacing. Cover insulation with ASTM B209M ASTM B209 sheet aluminum jacket.

1.6 EQUIPMENT ARRANGEMENT

Arrangement selected shall maintain 0.90 meters 3 foot clearance for access passage and 1.20 meters 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.

1.7 ELECTRICAL REQUIREMENTS

Comply with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, [and [_____]].

1.8 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.

1.9 DEFINITIONS

API Std 618 and the following:

Compressor power is shaft power at shaft coupling, including all losses and connected appurtenances.

1.10 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.

1.11 POSTED OPERATING INSTRUCTIONS

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

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

****

NOTE: Provide sound attenuating enclosure or make other provisions to comply with OPNAV 5100.23, Chapter 18, paragraph 18202, "Preventive Measures," which contains noise abatement requirements for new

machinery and equipment. If manufacturers do not furnish sound attenuating enclosure as a factory-built option, delete the sound enclosure from this section and consider other means for meeting noise abatement requirements, such as: (1) other types of compressors which are furnished with sound attenuating enclosures, (2) field erected equipment enclosures from sources other than the compressor manufacturer, and (3) soundproofed office or personnel enclosure.

****

The air compressors shall be positive displacement, reciprocating, double-acting compressors delivering oil-free air. No lubricant shall be used within the compression cylinders. Include air compressor, electric motor driver, coolers, lubrication system, and regulation and control systems mounted on a common base frame, and, if required, completely enclosed for noise control.

2.2.1 Manufacturer's Certifications

The manufacturer shall certify that the air compressors proposed are of the same design, construction, 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

****

NOTE: Designer should furnish required information to complete the specification.

****

a. Net compressed air output (All packing and seal losses shall be considered internal and not included in the net output) (plus or minus 2 percent): [_____] standard liter per second (L/s) SCFM

b. Output pressure immediately downstream of aftercooler (minus zero plus 4 percent): 862 kPa (gage) 125 psig

c. Output air maximum temperature downstream of aftercooler: 38 degrees C 100 degrees F

d. Inlet air pressure at first stage: [_____] kPa (absolute) psig

e. Inlet air temperature at first stage: [_____] degrees C F

f. Inlet air filtration efficiency: 99.9 percent of 0.5 micron size

g. Barometric pressure: [_____] kPa (absolute) psig

h. Relative humidity: [_____] percent

i. Cooling water inlet temperature: [_____] degrees C F

j. Total cooling water flow rate: [_____] L/s gpm

k. Maximum cooling water pressure drop through the compressor and any intercooler, aftercooler, or oil cooler: [_____] [55 kPa] [8 psi]

l. Maximum compressor power required. (Plus or minus 4 percent): [_____] kW hp

m. Unloaded compressor horsepower (max.): [_____] kW hp

****

NOTE: Provide sound attenuating enclosure or make other provisions to comply with OPNAV 5100.23, Chapter 18, paragraph 18202, "Preventive Measures," which contains noise abatement requirements for new machinery and equipment. If manufacturers do not furnish sound attenuating enclosure as a factory-built option, delete the sound enclosure from this section and consider other means for meeting noise abatement requirements, such as: (1) other types of compressors which are furnished with sound attenuating enclosures, (2) field erected equipment enclosures from sources other than the compressor manufacturer, and (3) soundproofed office or personnel enclosure.

****

n. Maximum sound levels one meter horizontal from compressor and 1.5 meters 5 feet above floor as measured per ISO 2151: 84 dBA, 90 dB for any octave band.

o. Maximum compressor speed: 550 rpm

p. Maximum piston speed: 3 m/s 590 fpm

q. Maximum power per 47 L/s 100 ACFM: 16.40 kW 22 hp.

2.2.3 Additional Performance Requirements

2.2.3.1 Air Quality

****

NOTE: Compressors used to provide breathing air shall be situated to avoid entry of contaminated air into the system and suitable in-line filters installed to further assure breathing air quality. A receiver of sufficient capacity to enable the respirator wearer to escape from a contaminated atmosphere in the event of compressor failure is also required.

****

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 Ambient and Inlet Conditions Operating Ranges

****
NOTE: Designer should furnish required information to complete the specification.
****

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: [_____] degrees C F dry bulb and [_____] degrees C F wet bulb temperatures, [_____] percent relative humidity Inlet cooling water: [_____] degrees C F, Ambient compressor room temperature: [_____] degrees C F, Barometric pressure: [_____] kPa (absolute) psig

b. Winter design conditions:

Inlet air: [_____] degrees C F dry bulb and [_____] degrees C F wet bulb temperatures, [_____] percent relative humidity Inlet cooling water: [_____] degrees C F, Ambient compressor room temperature: [_____] degrees C F, Barometric pressure: [_____] kPa (absolute) psig.

2.2.3.3 Critical Speeds

API Std 618, paragraph 2.5.1.

2.2.4 Electrical Service Conditions

2.2.4.1 Air Compressor Drive Motor

[_____] Volts, 3 phase, 3 wire, 60 hertz electrical service.

2.2.4.2 Accessory electrical Service

****
NOTE: Change accessory voltages if required for site conditions.
****

See Table I.

TABLE I - COMPRESSOR ACCESSORY ELECTRICAL SERVICE SCHEDULE

Item	Voltage	Phase	Frequency
Control Power and Motors under 3/8 kW	120	1	60 Hz
Accessory Power	460	3	60 Hz

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 a complete load regulation and control system with the compressor. Provide additional electrical, electro-pneumatic, or solid state electronic controls for other specified control and monitor functions. All electrical controls shall conform to NEMA ICS 2 as selected by the compressor manufacturer. Control system enclosure shall conform to NEMA ICS 6. Controls shall be suitable for individual operation of the compressor or parallel operation with one or more other compressors.

2.2.5.1 Compressor Start-Up

The compressor shall start unloaded. The manual starting circuit for the compressor shall have interlocks to prevent the compressor drive motor from starting until pre-lubrication pump (if provided), oil pressure, and cooling water pump water flow have been established to the required values for safe operation as determined by the compressor manufacturer.

2.2.5.2 Load Regulation

The compressor shall operate continuously at constant speed after being started. Provide means to load and unload the compressor automatically at preset minimum and maximum pressure settings. Minimum pressure shall be 689 kPa (gage) 100 psig, and maximum pressure shall be 862 kPa (gage) 125 psig. Loading and unloading shall be accomplished by a minimum of [three steps (full load, one-half load, and no load).] [five steps (full load, three-quarter load, one-half load, one-quarter load, and no load).] Unloading shall be accomplished by suction valve unloading, clearance pockets, or a combination of both suction valve unloading and clearance pockets. Input power at fully unloaded operation shall not exceed 15 percent of full load input.

2.2.5.3 Monitor and Safety Controls

Supplementary electric, electro-pneumatic, or solid state electronic controls shall be provided to provide alarm and shutdown 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.

TABLE 2 - MONITOR AND SAFETY CONTROL SCHEDULE			
Item	Light and Shutdown	Indicating Alarm	Light Only
1. High Discharge Air Temperature 135 degrees C 275 degrees F	Yes	Yes	-
2. High Intercooler Discharge Water Temperature, Each Intercooler	No	Yes	-
3. High Aftercooler Discharge Water Temperature	No	Yes	-
4. High Cooling Water Supply Temperature	No	Yes	-
5. High Lube Oil Temperature	Yes	Yes	-
6. Low Lube Oil Pressure	Yes	Yes	-
7. Low Oil Reservoir Level	No	Yes	-
8. High Condensate Level Intercooler (wired to one light)	Yes	Yes	-
9. High Motor Stator Temperature	Yes	Yes	-
10. High Condensate Level Aftercooler	No	No	Yes
11. High Inlet Pressure Drop Across Inlet Air Filters (combined, 3 stage)	No	Yes	-
12. High CO Level	Yes	Yes	-

2.2.5.4 Monitoring Instruments

Provide the following monitoring instruments in addition to the monitor and safety controls. Pressure gages shall conform to ASME B40.100, 115 mm 4 1/2 inch diameter, 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, 90 mm 3 1/2 inch dial, and separable 100 mm 4 inchstainless 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. Inlet air filter differential pressure gage with 1992, zero, 1992 Pa 8, zero, 8 inch water gage. Provide selector valve, tubing, and tap to measure static gage pressure downstream of each filter stage.

e. Total running time readout.

f. Interstage air pressure gages for each interstage.

g. Cooling water supply to compressor pressure gage.

h. Cooling water return from compressor pressure gage.

i. Compressed air pressure downstream of aftercooler pressure gage.

j. Compressed air temperature downstream of aftercooler temperature gage.

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

l. Compressor inlet air temperature gage.

m. Cooling water to compressor temperature gage.

n. Cooling water outlet temperature at outlet of each intercooler and aftercooler temperature gages.

2.2.6 Compressor Design Features

****

NOTE: Provide sound attenuating enclosure or make other provisions to comply with OPNAV 5100.23, Chapter 18, paragraph 18202, "Preventive Measures," which contains noise abatement requirements for new machinery and equipment. If manufacturers do not furnish sound attenuating enclosure as a factory-built option, delete the sound enclosure from this section and consider other means for meeting noise abatement requirements, such as: (1) other types of compressors which are furnished with sound attenuating enclosures, (2) field erected equipment enclosures from sources other than the compressor manufacturer, and (3) soundproofed office or personnel enclosure.

****

The compressor shall be a multistage, nonlubricated, oil-free reciprocating, double-acting compressor, with a minimum of two compressor stages and water-cooled cylinders and heads. The cylinder arrangement may be horizontal, vertical, V-type, radial, or semi-radial, which will fit in space indicated. An intercooler shall be provided between stages, and aftercooler shall be provided after the final stage of compression. Silencers, lubricating system, cooling system, control system, and driver shall be mounted as part of the package. Provide a common base frame for the compressor system and driver. [Provide a sound enclosure over the compressor and driver.] Equipment shall be designed for economical and rapid maintenance. Frame, cylinders, cylinder heads, bearing housings,

and other major parts shall be shouldered, dowelled, or designed with other provisions, to facilitate accurate alignment or reassembly. Packing, seals, and bearings shall be accessible for inspection or replacement with a minimum of disassembly.

2.2.6.1 Frame

Frame shall be one-piece cast iron, ribbed for strength, and shall provide support for crankshaft main bearings and crossheads, and a sump or reservoir for lubricating oil. The frame shall be completely enclosed and provided with gasketed access covers for inspection and maintenance.

2.2.6.2 Crankshaft and Main Bearings

Crankshaft shall be one-piece solid forged steel, heat treated, machined, and ground, with hardened bearing surfaces. Counterweights may be removable. Passages for pressure lubrication shall be rifle drilled into the crankshaft. The crankshaft shall be free of sharp corners with drilled holes or changes in section finished with generous radii and highly polished. Main bearings shall be steel backed babbit type or anti-friction, roller type. Crankshaft shall be counterweighted and balanced.

2.2.6.3 Connecting Rod

Connecting rod shall be of heat treated forged steel, drilled for pressure lubrication, and removable without removing crankshaft. The crankpin bearings shall be the steel backed babbit type. The crosshead pin bearings shall be bronze. Crosshead pin shall be full floating.

2.2.6.4 Crossheads

Crossheads shall be box type, cast iron or steel with babbitted wearing surfaces or shoes which are adjustable and replaceable unless means of adjustment are provided in the crosshead guides.

2.2.6.5 Distance Pieces

Distance pieces shall be extra long, single compartment, and of sufficient length to prevent oil carryover. No part of the piston rod shall alternately enter the crankcase (crosshead housing) and the air compression cylinder stuffing box. The rod shall be fitted with an oil slinger or wiper to prevent oil loss from the crankcase, preferably of a split design for easy access to the piston rod packing. Access openings of adequate size shall be provided to permit removal of the assembled packing case.

2.2.6.6 Pistons and Piston Rods

a. Pistons shall be lightweight castings of anodized aluminum alloy or cast iron. Cast iron pistons shall be chromium plated or otherwise treated for corrosion resistance. Pistons shall be fitted with not less than two fluorocarbon compression rings in individual ring grooves. Wear bands of fluorocarbon material, if required, shall be of one-piece construction. Pistons which are removable from the rod shall be attached to the rod by a shoulder and lock nut design. The nuts on the end of the rod must be positively locked in place. The rod shall be positively locked to the crosshead to prevent rotation.

b. Piston rods: Piston rods shall be of SAE 4140 alloy steel as a minimum with rolled or ground threads. Rods shall be surface hardened to 50 Rockwell C hardness in the packing or other wear areas and nondestructively tested for cracks by the magnetic particle or liquid penetrant methods. Rod finish in the packing area shall be 0.25 to 0.51 micrometers 10 to 20 microinches, except that for carbon packing the finish shall be 0.15 to 0.20 micrometers 6 to 8 microinches. Piston rods shall be hard chrome plated.

2.2.6.7 Piston Rod Packing

The piston rod shall be sealed against air leakage by floating, self-adjusting seal rings. The packing box shall be water cooled. Packing box and packing gland clearances shall be adequate to prevent scoring of the piston rod, when maximum wear of the piston wear band occurs.

2.2.6.8 Cylinder and cylinder Heads

a. Cylinders and cylinder heads shall be cast iron with integral cooling water passages. Air-cooled cylinders shall not be permitted. Cylinders shall be spaced and arranged to permit access to all openings and components, including water jacket opening covers, distance piece covers, packing, valves, unloaders, or other controls mounted on the cylinder, without removing the cylinders, the cylinder head, or major piping. Water jackets shall be arranged so that there are no gasketed joints which might allow water to enter the cylinder.

b. Cylinder liners or provisions for reboring: Replaceable hardened stainless steel cylinder liners shall be provided or the cylinder walls shall be of thickness to permit reboring to a radial depth of at least 1.60 mm 1/16 inch without encroaching on the maximum allowable working pressure or the maximum allowable rod load. Cylinder walls or liners using fluorocarbon rings and wear bands shall be honed to a finish of 0.25 to 0.51 micrometers 10 to 20 microinches and fluorocarbon burnished.

c. Fasteners: Cylinder heads, stuffing boxes for packing, clearance pockets, and valve covers shall be secured with studs. Cylinder lips supporting these devices shall be fabricated so that overtorquing studs or nuts will not cause lip failure. Studs shall be ASTM A307, Grade B, and shall have each end chamfered to remove the first one-and-a-half threads. Studs shall be secured into tapped holes by interference fit or other approved means.

d. Cylinder coolant system: Cylinder and cylinder head coolant systems shall be designed for not less than [_____] [517 kPa (gage)] [175 psig] working pressure and for a [_____] [69 kPa (gage)] [10 psig] maximum pressure drop. Recommended flow rates shall be based on no more than a 6 degrees C 10 degree F temperature rise and a 0.002 fouling factor on the coolant side. Provisions shall be made for complete drainage of coolant.

2.2.6.9 Valves

a. Valves shall be alloy steel selected for long life, and shall be ring, plate, or leaf form, direct or pilot pressure actuated. Suction valves shall be provided with unloading devices for capacity control regulation. Each individual unloading device shall be provided with a

visual indication of its position and its load (loaded or unloaded) condition.

b. The valve design (including that for double-decked valves) shall be such that valve assemblies cannot be inadvertently reversed, nor a suction valve assembly be fitted into a discharge port.

c. Valve seats shall be removable. Valve seat-to-cylinder gaskets and valve cover-to-cylinder gaskets shall be solid metal. Nonmetallic gaskets shall not be used.

d. The valve and cylinder designs shall be such that the valve cage or the assembly bolting (or both) cannot fall into the cylinder even if the valve assembly bolting breaks or unfastens.

e. The ends of coil valve springs shall be squared and ground to protect the plate against damage by the spring ends.

f. Valve hold-downs shall bear at not less than three points on the valve cage. The bearing points shall be arranged as symmetrically as possible.

g. Metal valve discs or plates, when furnished, shall be suitable for installation with either-side sealing and shall be lapped on both sides. Edges shall be suitably finished to remove stress risers. Valve seats shall also be lapped.

2.2.6.10 Compressor Connections

Flanged compressor connections shall conform to ASME B16.1 or ASME B16.5. Threaded connections shall conform to ASME B1.20.1.

2.2.6.11 Intercoolers, Aftercooler, and Oil Coolers

Intercoolers, aftercooler, and oil cooler shall include ASTM B111/B111M admiralty brass or other corrosion resistant tubes in ASTM B171/B171M admiralty or steel tube sheets and baffles for optimum cooling and fouling resistance using [fresh] [_____] water. Provide intercoolers between stages of compression either integral with unit or factory assembled on unit base with piping. The aftercooler shall be mounted separately from the unit base. Intercoolers, aftercooler, and oil cooler shall be factory tested at 1.5 times operating pressure. External intercoolers and aftercooler shall be constructed in accordance with ASME BPVC SEC VIII D1 requirements and be ASME code stamped for [_____] [1207 kPa (gage)] [175 psig] working pressure. Intercoolers and aftercooler shall be capable of one piece bundle removal. Intercoolers and aftercooler shall be equipped with an integral or direct connected moisture separator with condensate trap assembly. Design intercoolers and aftercooler for 11 and 8 degrees C 20 and 15 degrees F approach, respectively; however, the approach temperature used to size the coolers shall be reduced if required to meet aftercooler maximum air outlet temperature specified. Nonstandard coolers shall be provided if required to meet the aftercooler maximum air outlet temperature requirement. All coolers shall be of counter-flow design, with a fouling factor of 0.002 for both sides of the coolers.

2.2.6.12 Lubrication System

Include an integral sump, shaft driven positive displacement pump, oil cooler, and duplex filter/strainer (readily replaceable cartridges while

operating). System shall be factory assembled and tested. Lubricating oil shall conform to recommendations of the compressor manufacturer. Bearings and crosshead shoes shall be pressure lubricated. Provide the oil sump with a level indicator and drain and fill connections.

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 [_____] [0 degrees C] [32 degrees F] ambient. Provide low level indicator with light for protection of the heater.

2.2.6.13 Pulsation Control

If pulsation problems exist, provide pulsation dampers or surge chambers.

2.2.7 Electric Motors

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NOTE: Polyphase motors shall be selected based on requirements of the driven equipment, service conditions, motor power factor, life cycle cost, and high efficiency in accordance with NEMA MG 10.

Use Motor Master software program to identify the most efficient and cost effective polyphase motor for a specific application. Motor Master is located in the "TOOLS" section of Construction Criteria Base (CCB). For additional guidance contact Charlie Mandeville of the NAVFAC Criteria Office at (757) 322-4208. Another source of information on energy efficiency is E-source, accessible to Navy, users on the Naval Facilities Engineering Service (NFESC) energy home page http://energy.navy.mil/.

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Efficiency and losses shall be determined in accordance with IEEE 112. Unless otherwise specified horizontal polyphase squirrel cage motors rated one to 125 horsepower shall be tested by dynamometer Method B as described in Section 6.4 of IEEE 112. Motor efficiency shall be calculated using Form B of IEEE 112 calculation procedure.

Polyphase motors larger than 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.

2.2.7.1 Main Electric Drive Motor

The main drive motor for each compressor shall be a polyphase [induction] [or] [synchronous] motor, [_____] kW horsepower, with a continuous service factor of 1.0. Size the motor so that the nameplate kW horsepower rating is not exceeded under the entire range of operating conditions specified. [Design of induction 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 [at [50] [65] [80] percent of full voltage], allowing for characteristics of the connected load, and shall start without

undervoltage tripping. 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. Provide space heaters for protection of windings during motor shutdowns.

2.2.7.2 Accessory and Related Equipment Motors

Motors less than 3/8 kW 1/2 horsepower shall be single phase induction motors and shall conform to NEMA MG 1. Motors 3/8 through 3.75 kW 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.

2.2.8 Control Panel

Control unit panel shall conform to NEMA ICS 6, floor or frame mounted, factory designed, and assembled, and shall be provided complete. 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 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), 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.

2.2.9 Accessories

Required accessories include:

2.2.9.1 Compressor Air Inlet

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NOTE: Change air compressor inlet description to suit project if required.
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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. Intake pipe, ASTM A36/A36M steel, ASTM A123/A123M or ASTM A153/A153M galvanized, 12 gage or Schedule 5 minimum, from intake weather hood to filter housing flange, welded construction.

c. Filter housing by filter manufacturer to include filter frames, access door(s). Material for housing shall be 1.65 mm 0.065 inch thick Class 5000 aluminum alloy. Unit shall be rigid and free from distress with all seams sealed.

d. Intake pipe from filter enclosure to compressor: Steel pipe, ASTM A53/A53M, seamless or welded, 6.35 mm 0.250 inchminimum wall thickness. Fittings butt welding, ASME B16.9, 6.35 mm 0.250 inch minimum wall thickness. Flanges: ASME B16.5, Class 150, welding neck or slip-on, flat-faced.

2.2.9.2 Compressor Air Outlet

Compressor air outlet flexible connection of stainless steel bellows with braided steel cover jacket, with stainless steel liner sleeve, 460 mm 18 inch nominal length bellows, flanged ends, Class 150.

2.2.10 Inlet Air Filters

Provide a three-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 separate stages and sized to fit the available space.

2.2.10.1 First-Stage Filter

First-stage filter shall be flat, 50 mm 2 inch thickness, replaceable media, and rated for the required air quantity at 2.54 m/s 500 FPM nominal face velocity, friction clean 62 Pa 0.25 inch water gage, efficiency 98 percent of 15 microns and 90 percent of 5 microns.

2.2.10.2 Second-Stage Filter

Second-stage filter shall be deep pleated type, 230 mm 9 inchesnominal depth and rated for the required air quantity at 1.78 m/s 350 FPM nominal face velocity, friction clean 50 Pa 0.20 inch watergage, efficiency 98 percent of 5 microns and 90 percent of 3 microns.

2.2.10.3 Third-Stage Filter

Third stage filter shall be deep pleated type 305 mm 12 inchesminimum depth and rated for the required air quantity at 1.78 m/s 350 FPM nominal face velocity, friction clean 75 Pa 0.30 inch watergage, efficiency 99.9 percent of 0.5 micron.

2.2.10.4 Filter Media

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

2.2.11 Inlet Line Silencer

An inlet line silencer shall be furnished with each compressor as selected

by compressor manufacturer for sufficient noise attenuation to meet OSHA sound level criteria but not greater than 84 dBA measured at an elevation of 1.50 meter 5 feet, and 3 meter 10 feet horizontally from silencer.

2.2.12 Sound Attenuating Enclosure

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NOTE: Provide sound attenuating enclosure or make other provisions to comply with OPNAV 5100.23, Chapter 18, paragraph 18202, "Preventive Measures," which contains noise abatement requirements for new machinery and equipment. If manufacturers do not furnish sound attenuating enclosure as a factory-built option, delete the sound enclosure from this section and consider other means for meeting noise abatement requirements, such as: (1) other types of compressors which are furnished with sound attenuating enclosures, (2) field erected equipment enclosures from sources other than the compressor manufacturer, and (3) soundproofed office or personnel enclosure.

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The compressor package, including the driver motor, shall be contained within a noise reducing enclosure. Design of the enclosure shall be such as to limit noise transmission to 84 dBA or less at a distance of one meter from the compressor in any direction.

2.2.12.1 Enclosure Frame

The enclosure frame shall be designed to support the weight of the sound suppression panels and to be easily demountable. Connections to the base frame shall be designed to allow the enclosure frame to be detached and lifted away without damage to the connections, enclosure frame or base frame, and to allow accessibility and replacement of any component.

2.2.12.2 Panels

The panels shall be of rigid construction to allow repeated access without damage or distortion. Sound absorbing material shall be mineral fiber, treated to preclude shedding of fibers. Other approved insulation may be used except that polyurethane foam shall not be permitted. Top panels shall be secured to the enclosure frame with quick disconnect fittings and fabricated to allow easy hand removal for maintenance. End and side panels shall be hinged or lift out with positive closure latches. Panels shall be designed to allow the maximum access area when opened. Provide acoustic seals as required. Controls and instrumentation mounted on the panels shall have flexible connections for panel opening and disconnects for enclosure removal. Disconnects shall be of the male-female plug type. Panels shall split around all piping connections to allow enclosure removal without detaching piping. Controls shall be visible and operable from outside the enclosure.

2.2.12.3 Ventilation

Fan(s) and sound baffled ventilation grilles shall be provided as part of the enclosure. Ventilation shall be sufficient to limit interior temperature to that required for cooling the motor.

2.3 AIR FLOW RATE AND PRESSURE RECORDER MEASUREMENT

Provide a complete flow and pressure measurement and recording package. Provide orifice flanges with pressure taps, square edged stainless steel paddle orifice plate. The orifice plate shall be concentric type, of 3 mm 0.125 inch thickness and shall meet ASME Standards. Orifice shall be sized for 10 kPa 40 inch water column differential at a full scale flow rate of [_____] L/s SCFM at compressor based on 827 kPa (gage) 120 psig upstream pressure. Static gage pressure measurement device of the recorder shall have a range of zero to 1379 kPa (gage) 200 psig. Provide copper interconnecting tubing between the pressure taps and the recorder as part of this measurement and recording package. Provide a two-pen recorder for the measurement station. Pens shall record pressure (0 to 1379 kPa (gage) 200 psig range) and air flow (0 to [_____] L/s SCFM). Recorder shall be electric drive and housed in dust-tight steel cabinet. Charts shall be 305 mm 12 inchdiameter with evenly divided graduations. Drive shall be 7 day circle. Provide continuous flow integration of a 7 digit counter type. Pens shall be supplied with long-life cartridges and capillary supply. Chart case shall be internally illuminated. Access to charts shall be through front access window door. Calibrated overall accuracy of the recorded measurements shall be within plus or minus 1.0 percent of full scale. Furnish a supply of 400 charts with the recorder.

2.4 CARBON MONOXIDE MONITOR

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NOTE: Include carbon monoxide monitor in systems which are used for breathing air per DM 3.5, Section 3.

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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 indicating 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 SOURCE QUALITY CONTROL

2.5.1 Factory Test Procedures

The completely assembled air compressor package including the actual contract drive motor, intercooler, lubrication system, and control panel shall be subjected to air compressor performance 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 may be run on the manufacturer's test stand using driver for this contract. Tests shall be in accordance with ASME PTC 9 format. Full-range performance tests shall indicate performance at maximum rated flow, rating point, and unloaded conditions. All accessory performance conditions shall be reported, including intercoolers, aftercoolers, and lubrication and control systems. Completed 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 not exceed 84 dBA 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.

2.5.2 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.

2.5.3 System Test

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

2.5.4 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.

2.5.5 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. Install the compressor under the direct supervision of an authorized representative of the manufacturer.

3.2 GENERAL REQUIREMENTS FOR INSTALLING AIR COMPRESSORS

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NOTE: Delete or modify requirements on existing building and weight handling equipment to suit the project.

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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 sizes and

available crane lifting capacity. Crane unit is specified to permit single lifts of complete compressor under special approval only.] 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

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 three consecutive days for the compressor.

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 test 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 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. Aftercooler water flow, 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. [Cooling tower] [Closed circuit cooler] air flow, water and air temperatures, water pressure, and motor amperage.

h. Electrical load in volts and amperes for compressor motor (loaded and unloaded) and compressor auxiliaries.

i. Intake filter pressure differential (clean).

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

k. 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 9 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 [cooling tower] [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 Operational Deficiencies

Any operational deficiencies noted in the tests shall be promptly corrected and affected portions of the test rerun.

3.3.1.5 Field Test Tolerances

A tolerance of plus or minus 2 percent 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, train Government station personnel in the operation and maintenance of compressor, [cooling tower,] [closed circuit cooler,] 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 one day of field training shall be furnished for each designated Government personnel. When factory training is required by the compressor manufacturer for proper maintenance and overhaul of the compressor, such training will 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.

-- End of Section --