UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2024
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DIVISION 22 - PLUMBING

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LARGE NONLUBRICATED RECIPROCATING AIR COMPRESSORS (OVER 300 HP)

11/09

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

Preparing Activity: NAVFAC **Superseding**
UFGS-22 15 19.13 20 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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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).
****

****
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 must 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.

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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	(2020) 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	(2022) 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	(2022) 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	(2023) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A307	(2021) 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	(2023) 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 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2021) 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; Notice 1 2021) 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 and Air Force 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 and Air Force 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 must 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 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 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 must contain information required for maintenance and repair and must 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, must 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 must 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 must 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 must 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 must 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 must 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 must 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 must 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 must be positive displacement, reciprocating, double-acting compressors delivering oil-free air. No lubricant must 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 must 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 must 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 must 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 must 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 must 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 must 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 must conform to NEMA ICS 2 as selected by the compressor manufacturer. Control system enclosure must conform to NEMA ICS 6. Controls must 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 must start unloaded. The manual starting circuit for the compressor must 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 must 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 must be 689 kPa (gage) 100 psig, and maximum pressure must be 862 kPa (gage) 125 psig. Loading and unloading must 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 must 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 must 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 must be provided to provide alarm and shutdown requirements, plus interlocks with accessories. Requirements are as follows:

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

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

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

d. The individual monitor and safety controls must 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 must 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 must 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 must 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 must 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 must be provided between stages, and aftercooler must be provided after the final stage of compression. Silencers, lubricating system, cooling system, control system, and driver must 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 must be designed for economical and rapid maintenance. Frame, cylinders, cylinder heads, bearing housings, and other major parts must be shouldered, dowelled, or designed with other provisions, to facilitate accurate alignment or reassembly. Packing, seals, and bearings must be accessible for inspection or replacement with a minimum of disassembly.

2.2.6.1 Frame

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

2.2.6.2 Crankshaft and Main Bearings

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

2.2.6.3 Connecting Rod

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

2.2.6.4 Crossheads

Crossheads must 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 must be extra long, single compartment, and of sufficient length to prevent oil carryover. No part of the piston rod must alternately enter the crankcase (crosshead housing) and the air compression cylinder stuffing box. The rod must 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 must be provided to permit removal of the assembled packing case.

2.2.6.6 Pistons and Piston Rods

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

b. Piston rods: Piston rods must be of SAE 4140 alloy steel as a minimum with rolled or ground threads. Rods must 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 must be 0.25 to 0.51 micrometers 10 to 20 microinches, except that for carbon packing the finish must be 0.15 to 0.20 micrometers 6 to 8 microinches. Piston rods must be hard chrome plated.

2.2.6.7 Piston Rod Packing

The piston rod must be sealed against air leakage by floating, self-adjusting seal rings. The packing box must be water cooled. Packing box and packing gland clearances must 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 must be cast iron with integral cooling water passages. Air-cooled cylinders must not be permitted. Cylinders must 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 must 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 must be provided or the cylinder walls must 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 must 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 must be secured with studs. Cylinder lips supporting these devices must be fabricated so that overtorquing studs or nuts will not cause lip failure. Studs must be ASTM A307, Grade B, and must have each end chamfered to remove the first one-and-a-half threads. Studs must be secured into tapped holes by interference fit or other approved means.

d. Cylinder coolant system: Cylinder and cylinder head coolant systems must 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 must 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 must be made for complete drainage of coolant.

2.2.6.9 Valves

a. Valves must be alloy steel selected for long life, and must be ring, plate, or leaf form, direct or pilot pressure actuated. Suction valves must be provided with unloading devices for capacity control regulation. Each individual unloading device must 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) must be such that valve assemblies cannot be inadvertently reversed, nor a suction valve assembly be fitted into a discharge port.

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

d. The valve and cylinder designs must 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 must be squared and ground to protect the plate against damage by the spring ends.

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

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

2.2.6.10 Compressor Connections

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

2.2.6.11 Intercoolers, Aftercooler, and Oil Coolers

Intercoolers, aftercooler, and oil cooler must 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 must be mounted separately from the unit base. Intercoolers, aftercooler, and oil cooler must be factory tested at 1.5 times operating pressure. External intercoolers and aftercooler must 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 must be capable of one piece bundle removal. Intercoolers and aftercooler must 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 must be reduced if required to meet aftercooler maximum air outlet temperature specified. Nonstandard coolers must be provided if required to meet the aftercooler maximum air outlet temperature requirement. All coolers must 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 must be factory assembled and tested. Lubricating oil must conform to recommendations of the compressor manufacturer. Bearings and crosshead shoes must 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 must 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 must be determined in accordance with IEEE 112. Unless otherwise specified horizontal polyphase squirrel cage motors rated one to 125 horsepower must be tested by dynamometer Method B as described in Section 6.4 of IEEE 112. Motor efficiency must be calculated using Form B of IEEE 112 calculation procedure.

Polyphase motors larger than 125 horsepower must 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 must 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 must 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 must be high efficiency type, rated not less than 95 percent, based on IEEE 112 testing and labeling.] Electrical service will be as specified. Motor must be designed for reduced voltage starting [at [50] [65] [80] percent of full voltage], allowing for characteristics of the connected load, and must start without undervoltage tripping. Provide resistance temperature detectors (RTD) attached to or imbedded in motor winding for control system. The motor must 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 must be single phase induction motors and must conform to NEMA MG 1. Motors 3/8 through 3.75 kW 1/2 through 5 horsepower must be three-phase induction motors and must conform to NEMA MG 1. Single-phase and three-phase motors must have bimetallic disk thermostats attached to or imbedded in the motor winding. Motors must have NEMA MG 1, Class B insulation.

2.2.8 Control Panel

Control unit panel must conform to NEMA ICS 6, floor or frame mounted, factory designed, and assembled, and must be provided complete. The panel must be fabricated of formed stretcher leveled sheet steel, reinforced, and assembled into a rigid unit. Gasketed access doors must be provided as required. Panel must be factory finish painted. The panel must meet NEMA 12 requirements.

a. Panel must contain electric and safety control work required, including either alarm annunciator or individual labeled pilot lights arranged in a group. Panel must contain alarm device with light and silencing. Generalized arrangement in accordance with drawings.

b. Panel must 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 must 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 must be piped to the outside of the building and consist of the following:

a. Intake weather hood with rain hood and bird screen. Material must 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 must be 1.65 mm 0.065 inch thick Class 5000 aluminum alloy. Unit must 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 must be provided complete including enclosure or housing, and frames. Enclosure must be Class 5000 aluminum alloy with inlet and outlet flanges. Construction must be welded or, where welding is not practical, close riveted and caulked, weathertight, with access doors for filter replacement and cleaning. Access doors must 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, must receive a factory-applied epoxy prime and finish coat for corrosion resistance. Filters must consist of three separate stages and sized to fit the available space.

2.2.10.1 First-Stage Filter

First-stage filter must 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 must 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 must 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 must be rated and listed UL Class 2. Filter efficiencies must 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 must 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, must be contained within a noise reducing enclosure. Design of the enclosure must 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 must be designed to support the weight of the sound suppression panels and to be easily demountable. Connections to the base frame must 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 must be of rigid construction to allow repeated access without damage or distortion. Sound absorbing material must be mineral fiber, treated to preclude shedding of fibers. Other approved insulation may be used except that polyurethane foam must not be permitted. Top panels must be secured to the enclosure frame with quick disconnect fittings and fabricated to allow easy hand removal for maintenance. End and side panels must be hinged or lift out with positive closure latches. Panels must be designed to allow the maximum access area when opened. Provide acoustic seals as required. Controls and instrumentation mounted on the panels must have flexible connections for panel opening and disconnects for enclosure removal. Disconnects must be of the male-female plug type.

Panels must split around all piping connections to allow enclosure removal without detaching piping. Controls must be visible and operable from outside the enclosure.

2.2.12.3 Ventilation

Fan(s) and sound baffled ventilation grilles must be provided as part of the enclosure. Ventilation must 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 must be concentric type, of 3 mm 0.125 inch thickness and must meet ASME Standards. Orifice must 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 must 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 must record pressure (0 to 1379 kPa (gage) 200 psig range) and air flow (0 to [_____] L/s SCFM). Recorder must be electric drive and housed in dust-tight steel cabinet. Charts must be 305 mm 12 inchdiameter with evenly divided graduations. Drive must be 7 day circle. Provide continuous flow integration of a 7 digit counter type. Pens must be supplied with long-life cartridges and capillary supply. Chart case must be internally illuminated. Access to charts must be through front access window door. Calibrated overall accuracy of the recorded measurements must 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 must be of the pressure type with attached sampling system. The unit must 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 must be 120 volt, single phase, 60 hertz with power cord and plug. Response time normally 2 minutes per sample/purge. Unit must be mounted in a gasketed enclosure with face gage indicating CO readings.

2.4.1 Sampling System

Sampling system must 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 must 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 must be subjected to air compressor performance tests and sound level and run-in tests. Unit must comply with guarantee requirements applying engineering adjustments to guarantee conditions. Test must be certified by the manufacturer. Test may be run on the manufacturer's test stand using driver for this contract. Tests must be in accordance with ASME PTC 9 format. Full-range performance tests must indicate performance at maximum rated flow, rating point, and unloaded conditions. All accessory performance conditions must be reported, including intercoolers, aftercoolers, and lubrication and control systems. Completed unit must be factory tested with sound meters in accordance with ISO 2151. Location must be one horizontal meter from unit at 1.5 meters above the floor. Test must include readings at each octave band midpoint and the "A" scale, and must not exceed 84 dBA and 90 decibels at any octave band. Results of test must 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 must 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 must conform to requirements outlined and must be witnessed by the Contracting Officer.

2.5.4 Approval of Testing Procedure

Proposed testing procedure must 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 must certify performance by test to be in compliance with specifications.

PART 3 EXECUTION

3.1 INSTALLATION

The Contractor must install the air compressors and accessories in accordance with manufacturer's recommendations and as indicated on the drawings. All equipment must 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.
****

Air compressors with contract motor and accessories must 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 must be under the direct supervision of the compressor manufacturer's authorized representative. Complete unit must 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 must be reinstalled if undamaged, by removal procedures; or if damaged, must be replaced with new materials to match original configuration.]

3.2.1 Prompt Installation

The Contractor is advised that any compressor received must 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 must have the option of requiring breakdown and reassembly to inspect and clean prior to placing in operation. This work must be at no additional cost to the Government.

3.2.2 Start-Up Services

The Contractor must furnish the services of a compressor manufacturer's authorized representative to supervise prestart checkout, initial start-up, performance testing, and operator instruction. Time available must 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 must be performed by the Contractor and witnessed by the Contracting Officer. Air compressor system test must 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 must include operation at rated capacity for not less than 4 hours.

3.3.1.1 Performance Tests

Complete performance test must be run at maximum load, rated load, at point of unload but prior to unload, and unloaded condition. Data must 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 must 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 must 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 must be caused by throttling selected fluids. Test data, such as air intake temperature and humidity, must be mathematically corrected to performance test requirement levels.

3.3.1.3 Sound Level Tests

Sound level tests must be conducted concurrently. Broad Band "A" scale readings and Octave Band readings must be taken and recorded at the same positions as on the factory testing. Maximum permissible level must 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 must 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 must be met.

3.3.2 Approval of Testing Procedure

Proposed testing procedure must 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 must 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 must 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 --