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USACE / NAVFAC / AFCEC / NASA **UFGS-43 11 00.10 (May 2020)**

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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
****

SECTION TABLE OF CONTENTS

DIVISION 43 - PROCESS GAS AND LIQUID HANDLING, PURIFICATION, AND STORAGE EQUIPMENT

SECTION 43 11 00.10

OFF-GAS FANS, BLOWERS AND PUMPS

05/20

PART 1 GENERAL

1.1 UNIT PRICES
1.1.1 Measurement
1.1.2 Payment
1.2 REFERENCES
1.3 SUBMITTALS
1.4 QUALITY ASSURANCE
1.4.1 Contractor
1.4.2 Single Source Supplier
1.4.3 Manufacturer's Representative
1.4.4 Detailed Drawings
1.4.5 Detailed Process Flow Diagrams
1.4.6 Piping and Instrumentation Diagram
1.5 PARTNERING/PRE-INSTALLATION MEETING
1.6 DELIVERY, STORAGE, AND HANDLING
1.7 SEQUENCING AND SCHEDULING
1.8 EXTRA MATERIALS
1.9 MAINTENANCE SERVICE

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION
2.1.1 Design Requirements
2.1.2 Selection Criteria
2.1.3 Performance Requirements
2.1.4 Service Conditions
2.2 MATERIALS AND EQUIPMENT
2.2.1 Standard Products
2.2.2 Nameplates
2.3 AIR MOVING EQUIPMENT
2.3.1 Capacities and pressure differentials
2.3.2 System Layout
2.3.3 Component Items List
2.3.4 Manufacturer Testing Certification

2.4 FANS
2.4.1 Single-Stage
2.4.2 Industrial Centrifugal
2.4.3 Pressure Blower
2.4.4 Multiple Stage
2.4.5 Backwards Inclined Impeller
2.5 DYNAMIC BLOWERS
2.5.1 Single Stage Centrifugal
2.5.2 Regenerative
2.5.3 Axial Flow
2.6 POSITIVE DISPLACEMENT BLOWERS
2.6.1 Rotary Lobe
2.6.2 Helical Screw
2.7 VACUUM PUMPS
2.7.1 Dry Rotary Blower
2.7.2 Water-Sealed Rotary Blower
2.7.3 Rotary Vane
2.7.4 Liquid Ring
2.8 CASING OR HOUSING
2.8.1 Construction Materials
2.8.2 Single Piece Casing
2.8.3 Horizontally Split Casing
2.8.4 Vertically Split Casing
2.8.5 Connections
2.8.5.1 Inlet and Discharge Connections
2.8.5.2 Casing Drains
2.8.5.3 Lifting Eyes
2.9 BLADES OR IMPELLERS
2.9.1 Dynamic Impellers
2.9.2 Rotary Lobe Impellers
2.10 SHAFT
2.11 SEALS, GASKETS AND PACKING
2.11.1 Shaft Seals
2.11.2 Internal Seals
2.11.3 Bearing Seals
2.12 BEARINGS
2.12.1 Shaft Bearings
2.12.2 Blower Bearings
2.13 DRIVE CONNECTION
2.13.1 Coupling
2.13.2 V-Belt Drive
2.14 GEARS
2.15 LUBRICATION SYSTEM
2.15.1 Pressure Oil
2.15.2 Splash Oil
2.15.3 Grease
2.16 INTAKE FILTER
2.16.1 Efficiency
2.16.2 Surface Area
2.16.3 Media
2.16.4 Weather Hood
2.17 NOISE MINIMIZATION
2.17.1 Silencer
2.17.2 Muffler
2.17.3 Acoustical Insulation
2.17.4 Sound Barriers
2.18 MONITORING
2.18.1 Flow
2.18.2 Temperature

2.18.2.1 Thermometers
2.18.2.2 Thermocouples
2.18.3 Pressure
2.18.3.1 Draft Gauge
2.18.3.2 Pressure Gauge
2.18.3.3 Differential Pressure Gauge
2.18.3.4 Piston Element
2.18.3.5 Bellows Element
2.18.4 Contaminant Monitoring and Sampling
2.18.4.1 Explosimeter
2.18.4.2 Hygrometer
2.18.4.3 Sampler
2.18.4.4 Transmitter
2.18.4.5 Remote Indicator and Recorder
2.19 CONTROL SYSTEM
2.19.1 Sequence of Control
2.19.2 Sequence of Equipment Operation
2.19.3 Intake Volume Control
2.19.4 Outlet Volume Control
2.19.5 Panel
2.19.6 Protective Devices
2.19.6.1 Bearing Temperature
2.19.6.2 Surge and Overload Protection
2.19.6.3 Oil Temperature and Pressure
2.20 ELECTRICAL EQUIPMENT
2.20.1 Electric Motors
2.20.2 Control Equipment
2.20.3 Variable Speed Controls
2.20.3.1 Description
2.20.3.2 Governing Requirements
2.20.3.3 Basic Features
2.20.3.4 Protective Circuits and Features
2.20.3.5 Adjustments
2.21 APPURTENANCES
2.21.1 Dielectric Fittings
2.21.2 Isolation Joints
2.21.2.1 Sleeve-type Couplings
2.21.2.2 Split-sleeve Type Couplings
2.21.3 Valves
2.21.3.1 Relief Valve
2.21.3.2 Unloading Valve
2.21.3.3 Combination Relief and Unloading Valve
2.21.3.4 Purge Valve
2.21.3.5 Vacuum Breaker
2.21.3.6 Check Valve
2.21.3.7 Control Valve
2.21.3.8 Back Pressure Valve
2.21.3.9 Manual Valve
2.21.4 Inlet and Discharge Elbows
2.21.5 Expansion Coupling
2.21.6 Heat Exchanger
2.21.7 Flame Arrestor
2.21.8 Drip Trap
2.21.9 Liquid Receiver
2.21.10 Air Receiver
2.22 BASE PLATE
2.23 WEATHERPROOF ENCLOSURE
2.24 ATTACHMENTS
2.25 COATINGS OR FINISHES

2.26 FACTORY TESTS
2.26.1 Integrity
2.26.2 Balance
2.26.3 Deflection
2.26.4 Vibration
2.26.5 Capacity
2.26.6 Noise
2.26.7 Variable Speed Drive
2.26.8 Continuity
2.26.9 Receivers
2.26.10 Valve Testing

PART 3 EXECUTION

3.1 EXAMINATION
3.2 INSTALLATION
3.2.1 Concrete Foundations
3.2.2 Seismic Requirements
3.3 FIELD PAINTING
3.3.1 Touch-Up Painting
3.3.2 Exposed Ferrous Surfaces
3.4 MANUFACTURER'S FIELD SERVICES
3.5 POSTING FRAMED INSTRUCTIONS
3.6 FIELD TESTING
3.6.1 Deficiencies
3.6.2 Correct Installation
3.6.3 Field Equipment Test
3.6.4 Noise Suppression
3.6.5 Reporting
3.7 CLOSEOUT ACTIVITIES
3.7.1 Field Training
3.7.2 Operating and Maintenance Instructions
3.7.2.1 Operating Instructions
3.7.2.2 Maintenance Instructions

-- End of Section Table of Contents --

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USACE / NAVFAC / AFCEC / NASA | **UFGS-43 11 00.10 (May 2020)**

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****

SECTION 43 11 00.10

OFF-GAS FANS, BLOWERS AND PUMPS
05/20

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NOTE: This guide specification covers the requirements for fans, blowers or vacuum pumps and drive units.

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).

****

PART 1 GENERAL

1.1 UNIT PRICES

****

NOTE: On many hazardous, toxic, radioactive waste (HTRW) projects, the Contractor is required to treat air or off-gas, as well as furnish the equipment. Measurement and payment and unit pricing may be necessary to cover treatment costs.

When it is determined that lump sum contract is advisable this paragraph will be deleted.

****

Measurement and payment will be based on completed work performed in accordance with the drawings, specifications, and the contract payment schedules. No additional payment will be made for installation,

calibration or commissioning of the equipment.

1.1.1 Measurement

Volume of [air supplied] [off-gas treated] will be determined by initial and final meter readings.

1.1.2 Payment

Payment will be made for volume of [air supplied] [off-gas treated] at the contract unit price per actual cubic meter foot. Payment will include the furnishing of testing, plant, labor, and material and incidentals necessary to complete the work, as specified and as shown.

1.2 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.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 99	(2016) Standards Handbook
AMCA 210	(2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 300	(2014) Reverberant Room Method for Sound Testing of Fans
AMCA 301	(2014) Methods for Calculating Fan Sound Ratings from Laboratory Test Data

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings

ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

ACGIH 2098	(2016) Industrial Ventilation: A Manual of Recommended Practice for Design

AMERICAN GAS ASSOCIATION (AGA)

AGA ANSI B109.2	(2000) Diaphragm Type Gas Displacement Meters (500 cubic ft./hour Capacity and Over)

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 6011	(2014J) Specifications for High Speed Helical Gear Units

AMERICAN PETROLEUM INSTITUTE (API)

API Spec 6D	(June 2018, 4th Ed; Errata 1 July 2018; Errata 2 August 2018) Specification for Pipeline and Piping Valves

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

ASHRAE 52.2	(2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

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 B16.40	(2019) Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems
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 19.3 TW	(2016) Thermowells Performance Test Codes
ASME PTC 25	(2014) Pressure Relief Devices

ASTM INTERNATIONAL (ASTM)

ASTM D4167	(2015) Fiber-Reinforced Plastic Fans and Blowers

ASTM F1139	(1988; R 2019) Steam Traps and Drains
ASTM F1508	(1996; R 2016; E 2016) Standard Specification for Angle Style, Pressure Relief Valves for Steam, Gas, and Liquid Services

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1	(2003; R 2008) Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerances

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA MC96.1	(1982) Temperature Measurement Thermocouples

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

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2018) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST SP 250	(1991) Calibration Services Users Guide

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019) Structural Engineering

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

47 CFR 15	Radio Frequency Devices

WATER ENVIRONMENT FEDERATION (WEF)

WEF MOP 11 (2017) Operation of Water Resource Recovery Facilities

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

Detailed Drawings; G[, [_____]]

Detailed Process Flow Diagrams; G[, [_____]]

Piping and Instrumentation Diagram; G[, [_____]]

Control System; G[, [_____]]

SD-03 Product Data

Flame Arrestor; G[, [_____]]

Instrumentation; G[, [_____]]

Air Moving Equipment; G[, [_____]]

Variable Speed Controls; G[, [_____]]

Field Training

SD-06 Test Reports

Field Testing

SD-07 Certificates

Air Moving Equipment

Manufacturer's Representative

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions

1.4 QUALITY ASSURANCE

1.4.1 Contractor

Contractor shall have a minimum of [2] [3] [5] [_____] years of experience in the construction of systems for handling sour gas, condensable gas, off-gas or vapor.

1.4.2 Single Source Supplier

Assign to a single supplier full responsibility for the furnishing of the off-gas moving system. The designated single supplier, however, need not manufacture the system but shall coordinate the selection, assembly, installation, and testing of the entire system as specified herein.

1.4.3 Manufacturer's Representative

Provide the services of a manufacturer's field service representative who is experienced in the installation of the equipment furnished and who has complete knowledge of the proper operation and maintenance of the system. Submit the names and qualifications of the manufacturer's representative and training engineers, and certification from the manufacturer that the representative and trainers are qualified in the appropriate technical areas.

1.4.4 Detailed Drawings

Submit detailed drawings including location of components, layout and anchorage of equipment and appurtenances, equipment relationship to other parts of the work, clearances for maintenance and operation of the off-gas system and subsystems. Drawings shall be to the approved scale.

1.4.5 Detailed Process Flow Diagrams

Submit detailed process flow diagrams and data including, but not limited to: air and off-gas stream flows, direction of flow, range of flow rate and range of composition, identified by lines and arrows denoting the direction and destination of the flow; material, mass and energy balances for the entire air and off-gas system; subsystem equipment, operating capacity and operating conditions; blowers and pumps, valves and other in-line devices; sizes of conveying devices (pipe, ducts, etc.); number of parallel components or lines.

1.4.6 Piping and Instrumentation Diagram

Submit a piping and instrumentation diagram indicating: process equipment; instrumentation; piping and valves; stacks, vents and dampers; control equipment (including sensors, process controllers, control operators, valves, interlocks, and alarms); labels and other necessary information to correlate to the process flow diagram. The P&ID shall include blowers and pumps, valves and other in-line devices.

1.5 PARTNERING/PRE-INSTALLATION MEETING

****

NOTE: Remove this paragraph when meeting is not required.

****

[Partnering] [Pre-installation] meeting will be required. Ensure that involved subcontractors, suppliers, and manufacturers are [notified] [represented]. Furnish the date and time of the meeting to the Contracting Officer for approval.

1.6 DELIVERY, STORAGE, AND HANDLING

Store in a clean, dry location equipment delivered to the site and designated for storage; cover the equipment for protection against dust and moisture. Equipment stored longer than 60 days shall have silica bags suspended in the outlet and inlet of unit, bearings shall be filled full of grease, unit shall be filled with oil, machine surfaces shall be coated with grease, and entire unit shall be enclosed with plastic or tarps. Shaft of rotating equipment including motors shall be turned every two weeks to prevent flat spots on bearings.

1.7 SEQUENCING AND SCHEDULING

****

NOTE: Coordinate with the appropriate air pollution control equipment. The temperature increase induced by the air moving equipment may affect the materials selected in other Sections of the contract. Review the table of contents to assure that appropriate specifications have been included.

****

Details of and requirements for [stack] [vapor injection] [vapor extraction well construction] [_____] and treatment equipment are included in other sections of this specification. Notify the Contracting Officer of any deviations from head conditions specified for the source and

discharge to ensure coordination with this Section. Pipe and valves not specified in this Section shall be in accordance with Section 31 21 00 OFF-GASSING MITIGATION.

1.8 EXTRA MATERIALS

****

NOTE: This paragraph covers items to be furnished to the Government by the Contractor for future maintenance and repair. Items that might be difficult to obtain because of color or pattern match, or spare parts needed to ensure continued operation of critical equipment should be included. Specifications should identify the items, state the quantities required, and indicate to whom, when, and where items are to be delivered. Insert text as required or remove this paragraph.

****

Deliver auxiliary equipment, tools and spare parts at the same time as the equipment to which they pertain. Protect and safeguard the equipment, tools and parts until completion of the work, at which time they shall be delivered to the Contracting Officer. Furnish auxiliary equipment and spare as follows:

a. Spare parts for each different item of material and equipment specified including the parts recommended by the manufacturer to be replaced after [1] [and] [3] [year] [years] service.

b. For each air mover: one extra of each part used that is made from glass, hard rubber, or clear plastic; one complete set of gaskets; [4] [_____] air intake filter replacement cartridges.

c. One complete set of special tools, calibration devices, and instruments [as recommended by the manufacturer for field maintenance of the system] [as required for operation, calibration, and maintenance of the equipment] shall be provided. Special tools are considered to be those tools which, because of their limited use, are not normally available but which are necessary for the particular equipment. Special tools shall be high-grade, smooth, forged, alloy, tool steel.

d. One or more [tool boxes] [tool boards] [steel tool cases] complete with flat key locks, two keys, and clips or hooks to hold each special tool mounted [in the equipment room] [on the wall in a convenient location] [as directed by the Contracting Officer].

e. One [pressure] [lever type] grease gun or other lubricating device for each type of grease required.

f. [_____] sheaves of differing diameter covering the range of operation of belt driven equipment.

g. [_____].

1.9 MAINTENANCE SERVICE

****

NOTE: This paragraph covers provisions for

maintenance service as applicable to critical systems, equipment, and landscaping. Insert text as required or remove this paragraph.
****

Maintenance service shall include [_____].

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Design Requirements

****
NOTE: Determine design wind speed from ASCE 7-16 or UFC 3-301-01. Use 161 km/h 100 mph minimum. Use 1.2 kPa 25 psf snow load for most heavy snow climates; delete snow load where maximum snow is not a factor. In some cases, local climates and topography will dictate that a value greater than 197 Pa 25 psf be used for snow loading; this may be determined from ANSI A58.1, local codes, or by research and analysis of the effect of local climate and topography. Coordinate with paragraph Seismic Requirements in PART 3.
****

Capacity and design of the air moving equipment and accessories shall be suitable for 24-hour full load service in an [outdoor] [indoor] [_____] location, and shall meet the following criteria.

Design Life	
Minimum	[_____] years
Altitude (above MSL)	
Minimum	[_____] m ft
Barometric pressure	
Maximum	[_____] kPa in Hg
Minimum	[_____] kPa in Hg
Ambient air temperature	
Maximum	[_____] degrees C F
Minimum	[_____] degrees C F
Seismic parameters	[_____]
Soil bearing capacity	

Maximum	[_____] MPa psf
Wind speed	
Maximum	[_____] km/h mph
Ground snow load	
Minimum	[_____] kPa psf
i. Air relative humidity	
Maximum	[100+] [_____] percent
Minimum	[_____] percent

2.1.2 Selection Criteria

****
NOTE: Requirements included here may limit the selection of specified equipment.
****

Design air moving equipment using criteria based upon actual model developmental test data, and select it at a point within the maximum efficiency for a given impeller/casing combination. Deviations within [10] [5] [3] percent of maximum efficiency are permissible. Air moving equipment having impeller diameters larger than [90] [95] percent of the published maximum impeller diameter for the casing, or less than [15] [10] [5] percent larger than the published minimum impeller diameter for the casing, will be rejected. Do not base acceptable maximum impeller diameter calculations on percentage of impeller diameter range for a given casing.

2.1.3 Performance Requirements

****
NOTE: Provide required information for each air mover identified on the drawings. Co-ordinate with PART 2 and delete inapplicable requirements. Verify that more than one manufacturer's product can meet the efficiency requirement, ideally more than three.
****

Equipment identification number [_____] shall be [appropriate for the capacity requirements of this paragraph] [a fan] [a blower] [a vacuum pump] [_____]. [Standard] [Actual] output volume shall be a minimum of [_____] cubic meters/second cfs at a [minimum inlet] [minimum positive discharge] pressure of [_____] kPa feet of water [gage] [actual] [positive] [vacuum]. The minimum efficiency shall be [_____] percent under the stated conditions.

2.1.4 Service Conditions

****
NOTE: Delete chemical data if the equipment is designed to deliver a fresh air supply. Standard

materials will be adequate.
****

Service [air supply to] [vapor collected from] [municipal landfill] [hazardous waste landfill] [petroleum spill] [subsurface remediation unit] [air stripper]. Anticipated contaminant concentration in the [air] [vapor] [off-gas] is:

[_____]	[_____] ug/L Maximum
	[_____] ug/L Average
pH	[_____] Minimum
	[_____] Average
	[_____] Maximum
Sulfide	[_____] mg/L Maximum
	[_____] mg/L Average
Ammonia	[_____] mg/L Maximum
	[_____] mg/L Average

2.2 MATERIALS AND EQUIPMENT

2.2.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate equipment that has been in satisfactory operation at least [2] [_____] years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site. Pieces of equipment of the same types shall be products of the same manufacturer. Equipment shall be new and unused, except for test equipment. Materials may be reprocessed/recycled with equivalent durability and product warranty/guarantee.

2.2.2 Nameplates

Each piece of equipment shall have a standard nameplate securely affixed in a conspicuous place showing the manufacturer's name, address, type or style, model, serial number, and catalog number. In addition, the nameplate for each air moving unit shall show the capacity in standard cubic meters/second feet per minute (SCFM) at rated speed in rpm and head in kPa inches of water. Nameplate for each electrical motor shall show, at least, the minimum information required by paragraph 10.38 of NEMA MG 1. Any other information that the manufacturer may consider necessary to complete identification shall be shown on the nameplate.

2.3 AIR MOVING EQUIPMENT

****
NOTE: Coordinate these paragraphs with a schedule

on the drawings showing the air moving equipment identification number and type and with paragraph Performance Requirements. Delete inappropriate types of equipment or service.
****

Furnish and install air moving equipment complete with drive units, filters, controls and appurtenances indicated or specified. Equipment shall be capable of operating at partial-load conditions without increased vibration over the normal vibration at full load operation and shall be capable of continuous operation down to the lowest step of unloading. Provide each unit with unloading, vibration isolators, thermal overloads, high-and-low pressure safety cutoffs, low oil pressure cutout, internal motor-winding temperature sensing protection device, internal pressure relief valve, a complete oil charge, and protection against short cycling. Submit the following:

2.3.1 Capacities and pressure differentials

Make and model with associated performance charts and curves (including the complete selection of impeller sizes for a given casing for centrifugal blowers).

2.3.2 System Layout

Diagrams showing the complete layout of the entire system, including equipment, piping, valves, wiring and control sequence. Condensed operating instructions in typed form explaining preventative maintenance procedures, safe methods of checking the equipment for normal operation, and safe procedures for starting and stopping the equipment. Post diagrams and instructions, framed under glass or in approved laminated plastic, where directed before acceptance testing of the systems.

2.3.3 Component Items List

Complete list of equipment and materials. A listing covering component items forming a system or items that are interrelated and scheduled to be coordinated and submitted concurrently. Certifications to be submitted with the pertinent drawings shall be so scheduled. Include in the data tabular lists showing location, features, or other pertinent information regarding products, materials, equipment, or components to be used in the work.

2.3.4 Manufacturer Testing Certification

Statements shall be dated after contract award, shall state the Contractor's name and address, the project and location, and the specific requirements which are being certified. Indicate in the certificate the methods of testing used. In lieu of a certificate, a seal or label from a nationally recognized testing agency will be acceptable as evidence that the equipment conforms to agency requirements.

2.4 FANS

****
NOTE: See Section 1 (Fans and Systems) of AMCA 201 (Fan Application Manual) for additional guidance on selection of fans.
****

Fans shall be centrifugal or propeller type as best suited for the application.

2.4.1 Single-Stage

****

NOTE: Fan pressure will vary with fan revolutions per minute (RPM) ratio squared. Single stage equipment allows flow variation at low end pressure.

Fans are generally divided into two classifications based on the airflow through the impeller. The classes are centrifugal and axial. In axial fans, airflow is parallel to the shaft. Axial fans are most commonly used in low static pressure applications, while centrifugal fans are used at higher static pressures.

****

A single-stage fan is allowable for the capacity range 0.025 to 50 cubic meters/second 53 to 106,000 cfm at pressure ranges from 0.25 to 15 kPa 0.08 to 5 feet of water column.

2.4.2 Industrial Centrifugal

An industrial centrifugal fan is allowable for the capacity range over 45 cubic meters/second 95,000 cfm at pressure ranges from 7.5 to 12 kPa 2.5 to 4 feet of water column.

2.4.3 Pressure Blower

A pressure blower fan is allowable for the capacity range of less than 2.4 cubic meters/second 5,100 cfm at pressure ranges from 10 to 30 kPa 3.3 to 10 feet of water column.

2.4.4 Multiple Stage

****

NOTE: Multiple stages limit volume and develop pressures toward the upper end.

****

A multi-stage pressure blower fan is allowable for the capacity of less than 3.3 cubic meters/second 7,000 cfm at pressure ranges up to 70 kPa 23 feet of water column or vacuum to -40 kPa -13 feet of water column.

2.4.5 Backwards Inclined Impeller

****

NOTE: If the flow is relatively clean, backwards inclined impeller fans should be specified for higher efficiency and quieter operation.

****

A backwards inclined impeller fan is allowable for the capacity range over 190 cubic meters/second 403,000 cfm and pressure ranges from 2.5 to 4.5 kPa 0.84 to 1.5 feet of water column.

2.5 DYNAMIC BLOWERS

****

NOTE: Dynamic blowers should be designed for highest inlet pressure loss and highest inlet air temperature conditions within the design operating range.

****

Dynamic blowers shall be oil-free and of modular design with the required number of compression stages to comply with the specified operating requirements.

2.5.1 Single Stage Centrifugal

A single stage centrifugal blower is allowable for pressure ranges from 0.25 to 7.5 kPa 0.084 to 2.5 feet of water column.

2.5.2 Regenerative

****

NOTE: Regenerative blowers are compact single or multi-stage centrifugal blowers.

****

A regenerative blower is allowable for capacity up to 5 cubic meters/second 10,000 cfm and pressure ranges of 20 to 60 kPa 6.7 to 20 feet of water column or vacuum up to -35 kPa -12 feet of water column.

2.5.3 Axial Flow

An axial flow blower is allowable for pressure ranges higher than 70 kPa 23 feet of water column or vacuum requirements greater than -40 kPa -13 feet of water column.

2.6 POSITIVE DISPLACEMENT BLOWERS

2.6.1 Rotary Lobe

A rotary lobe blower is allowable for capacity up to 14 cubic meters/second 30,000 cfm at pressures higher than 125 kPa 42 feet of water column or up to 10 cubic meters/second 21,200 cfm at vacuum up to -125 kPa -41.8 feet of water column.

2.6.2 Helical Screw

A helical screw blower is allowable for capacity up to 1 cubic meter/second 2,100 cfm and pressure ranges of 30 to 60 kPa 10 to 20 feet of water column or vacuum up to -35 kPa -11.7 feet of water column.

2.7 VACUUM PUMPS

2.7.1 Dry Rotary Blower

A dry rotary blower vacuum pump is allowed for vacuum flows of 1 cubic meter/second 2,100 cfm at -90 kPa -30.1 feet of water column to 6 cubic meters/second 12,700 cfm at -60 kPa -20.1 feet of water column.

2.7.2 Water-Sealed Rotary Blower

A water-sealed rotary blower vacuum pump is allowed for vacuum flows of 1 cubic meter/second 2,100 cfm at -80 kPa -26.8 feet of water column to 6 cubic meters/second 12,700 cfm at -70 kPa -23.4 feet of water column.

2.7.3 Rotary Vane

A rotary vane vacuum pump is allowed for vacuum flows of 2.5 cubic m/second 5,300 cfm at -100 kPa -33.5 feet of water column to 4.25 cubic m/second 9,000 cfm at -60 kPa -20.1 feet of water column. Oil injection and outlet demisting systems shall be included for each rotary vane vacuum pump.

2.7.4 Liquid Ring

A liquid ring vacuum pump is allowed for vacuum flows of 2.5 cubic m/second 5,300 cfm at -80 kPa -26.8 feet of water column to 8 cubic m/second 16,950 cfm at -60 kPa -20.1 feet of water column. Water injection systems and outlet water separation systems shall be included for each liquid ring vacuum pump.

2.8 CASING OR HOUSING

Casing or housing shall be of modular design to permit inspection or removal and replacement of wearing parts. Ample clearance shall be provided between the impeller or blades and casing. Casing shall incorporate ribbed construction to resist heat accumulation, deflection and distortion under the specified operating conditions.

2.8.1 Construction Materials

****

NOTE: Three types of spark resistant construction are available for fans as detailed by AMCA 99 (Classification for Spark Resistant Construction). Temperature is limited to 177 degrees C 350 degrees F when using aluminum parts.

Type A - all aluminum fan housing, inlet cone and wheel with a ground and polished steel shaft cover with an aluminum sleeve.

Type B - aluminum wheel and wear plate where shaft passes through the housing.

Type C - aluminum inlet cone and wear plate where shaft passes through the housing.

****

Fabrication shall be from [alloy steel] [monel] [316 stainless steel] [304 stainless steel] [heavy gauge hot rolled low carbon steel with continuous welds] [fiberglass in accordance with ASTM D4167]. Construction shall be close grain cast [iron] [aluminum Type [A] [B] [C] in accordance with AMCA 99] of uniform quality and free from blowholes, porosity, hard spots, shrinkage defects, cracks, and other injurious defects.

2.8.2 Single Piece Casing

Single piece casings shall have separate head plates.

2.8.3 Horizontally Split Casing

Horizontally split casings shall be machined at the split to maintain the pressure without a gasket.

2.8.4 Vertically Split Casing

Vertically split casings shall consist of rigid sections secured between inlet and outlet heads by steel tie rods.

2.8.5 Connections

2.8.5.1 Inlet and Discharge Connections

****
NOTE: Threaded and sweat connections should be considered if flange-connected types are not available in small capacity units.
****

Inlet and discharge connections shall be ASME B16.1 or ASME B16.5 [Class 125] [125 pound] [_____] drilled and tapped flanges and shall be an integral part of the head. Connections 75 mm 3 inches in diameter and smaller shall be [threaded] [sweat] [_____].

2.8.5.2 Casing Drains

Tapped and plugged drains shall be provided at the low points in the casing.

2.8.5.3 Lifting Eyes

Casing shall have lifting eyes capable of supporting the equipment for installation and maintenance purposes.

2.9 BLADES OR IMPELLERS

****
NOTE: Require non-sparkling impeller material if it is likely that the mixture of air and other gases will be within the explosive limits during the project life.
****

Blades, vanes or impellers shall be cast or fabricated [iron] [aluminum] [aluminum alloy] [fiberglass] [monel] [steel] [carbon steel] [phenolic coated steel] [PTFE coated steel] [304 stainless steel] [316 stainless steel] [non-sparkling material].

2.9.1 Dynamic Impellers

Guide or diffuser vanes configured to receive and direct flow to the downstream impeller shall be provided at the inlet to each centrifugal blower stage. Centrifugal impellers shall be [open radial bladed] [closed backward bladed]. Multiple stage impeller hubs shall butt against each other either directly or through one piece metal spacers.

2.9.2 Rotary Lobe Impellers

Rotary lobe impellers shall be of the straight, two-lobe involute type and shall operate without rubbing, liquid seals, or lubrication.

2.10 SHAFT

Shaft shall be made of accurately machined, ground and polished high grade [ductile iron casting] [alloy steel] [stainless steel] [carbon steel]. Impellers or blade [and shaft shall be a common casting.] [assembly shall be mounted and keyed to the shaft and secured by a lock nut.] Design shall permit inspection or replacement of the [seals] [and] [bearings] without [disconnecting suction or discharge piping] [disassembling the casing]. The shaft shall be designed to operate at below [80] [90] percent of the first critical speed. Shaft shall be of sufficient diameter, mass and strength to perform the work required with minimum vibration.

2.11 SEALS, GASKETS AND PACKING

Gasket and packing material selection shall be in accordance with WEF MOP 11. Gasket and seal ratings shall encompass the maximum pressure or vacuum capacity of the equipment and the ranges of temperature and quality of the off-gas or air.

2.11.1 Shaft Seals

Solid carbon mechanical ring shaft seals shall be provided where the shaft passes through the inlet and discharge heads. Seals shall be [purged] [or] [non purged], [balanced] [or] [unbalanced] to conform to specified service requirements. Ventilation to the atmosphere on the impeller side of shaft seals shall be provided to eliminate carry-over of lubricant into the air stream.

2.11.2 Internal Seals

Labyrinth seals shall be provided between blower stages.

2.11.3 Bearing Seals

A [lip type oil] [grease] seal shall be provided at each bearing to prevent lubricant from leaking into the output. Ventilation of the impeller side of oil seals to atmosphere shall be provided to eliminate any carry-over of lubricant into the air stream.

2.12 BEARINGS

****
NOTE: Verify bearing L-10 life requirements.
****

2.12.1 Shaft Bearings

Shaft shall be supported by anti-friction [spherical ball] [roller] bearings designed for both radial and thrust loads and sized for a minimum L-10 life of [30,000 hours] [50,000 hours] [5 years] continuous operation as defined by ABMA 9 or ABMA 11.

2.12.2 Blower Bearings

****
NOTE: Delete inapplicable lubrication methods.
****

Each blower shall be provided with two [pressure, oil lubricated, sleeve type journal] [splash, oil lubricated, anti-friction type] [oil bath lubricated] [grease lubricated] bearings. Bearings shall be self-aligning, shall be designed for both radial and thrust loads and shall be sized for an L-10 life of [30,000 hours] [50,000 hours] [5 years] continuous operation as defined by ABMA 9 or ABMA 11. It shall be possible to replace the bearings without disassembling the casing or disconnecting piping.

2.13 DRIVE CONNECTION

****
NOTE: Direct-driven equipment is limited to common synchronous motor speeds (3600, 1800, and 1200 rpm). This equipment is usually noisier than belt-driven equipment because it tends to run at higher speeds. Motors that run slower than 1800 rpm are expensive and not as readily available.

On belt-driven equipment, the speed is increased or decreased by changing pulleys or changing the diameter of adjustable pitch pulleys. On a fixed air moving system, flow rate is directly proportional to speed. The power requirement varies with the cube of the speed. A 25 percent increase in speed raises the flow rate 25 percent, but it almost doubles the power requirement. V-belts are generally used on positive displacement blowers.
****

Each unit shall be [close coupled] [directly connected through a flexible coupling] [driven by a V-belt].

2.13.1 Coupling

Coupling shall be heavy-duty, flexible forged steel spacer coupling, keyed or locked to the shaft. Disconnection shall be accomplished without removing the driver half of the driven unit half of the coupling from the shaft. Coupling outside surface shall be machined parallel to the axis of the shaft. Coupling faces shall be machined perpendicular to the axis of the shaft.

2.13.2 V-Belt Drive

V-belt drive shall be designed for not less than 150 percent of the driving motor capacity. When belt drive is provided, an adjustable sheave to furnish not less than 20 percent speed adjustment shall be provided. Sheaves shall be selected to provide the required capacity at the approximate midpoint of the adjustment. The drive belt shall be [covered with an acoustically treated sheet metal guard] [or] [completely enclosed within the unit casing].

2.14 GEARS

Gears shall be made of hardened, helical, alloy steel, manufactured in accordance with AGMA 6011 with a minimum 1.5 service factor applied to full power rating of the motor. [Single speed centrifugal blower shall be furnished with high speed increasing gears.] [Positive displacement impellers shall be timed by a pair of machined, heat-treated, spur tooth timing gears.] Timing gears shall be mounted on the impeller shafts on a tapered fit and secured by a lock nut.

2.15 LUBRICATION SYSTEM

****
NOTE: Delete inapplicable lubrication systems.
****

Drive shall be [pressure oil lubricated] [splash oil lubricated] [grease lubricated]. Timing gears and gear end bearings shall be [pressure oil lubricated] [splash oil lubricated]. Bearings and seals shall be lubricated as previously indicated. System shall be designed to prevent leakage and contamination. Oil-lubrication systems and vents shall be designed so that oil vapors do not enter the air stream or motor and the shaft bearings will be isolated. Each oil reservoir shall be provided with an opening for filling, an overflow opening with overflow container at the proper location to prevent overfilling, and a drain at the lowest point.

2.15.1 Pressure Oil

Pressure oil lubrication system shall be console mounted and shall include a main oil pump driven by the shaft, an auxiliary electric motor driven oil pump, an oil cooler, an oil [strainer] [or] [filter], oil reservoir with 3-minute minimum retention time, and the switches, temperature and pressure gauges and controls necessary to protect unit. The electric motor driving the auxiliary oil pump shall be totally enclosed fan cooled (TEFC), Design Type B in accordance with NEMA MG 1, shall have Class F insulation and shall be equipped with 120 volts space heaters. Control shall be in accordance with NEMA ICS 1. The lubrication system shall be factory piped and wired with minimal interconnecting piping between the console and the oil pump required in the field.

2.15.2 Splash Oil

Splash lubrication shall be provided by a slinger on the shaft splashing oil into the bearing whenever the compressor is running. A constant level oiler located on the bearing housing or a metering orifice will be provided to maintain the oil level in the oil reservoir integral with the bearing housing. A sight level gauge shall be provided in the bearing housing. A labyrinth seal combined with an atmospheric vent shall be provided to prevent oil contamination of the air stream.

2.15.3 Grease

Grease type bearings shall be equipped with grease fittings. Grease tubing shall be extended to a convenient location if fittings are inaccessible. Grease fittings shall be the type which prevents over-lubrication and over-pressurization.

2.16 INTAKE FILTER

Intake [screen and filter] [filter] shall be installed on inlet to each unit.

2.16.1 Efficiency

Intake filter shall be at least [90] [96] percent efficient when tested in compliance with ASHRAE 52.2 dust spot method. [High volume bag intake filter shall be provided for filtration down to 5 microns 2 mils on vacuum pump intake.]

2.16.2 Surface Area

Minimum filter surface area shall be 1 square meter per 0.127 cubic m/second 1 square foot per 25 cubic feet/minute to produce a filter flow through velocity of less than 0.127 m/second 25 feet per minute.

2.16.3 Media

Filter media shall be [washable] [or] [disposable] dry type felt material made from [glass fiber,] [polyester,] fiber resistant to moisture and chemicals to which it will be exposed with 25 mm 1 inch pleat separation.

2.16.4 Weather Hood

Steel intake hood and filter housings shall be coated with a chemically resistant coating and entire unit element shall be resistant to moisture and chemicals to which it will be exposed.

2.17 NOISE MINIMIZATION

****
NOTE: Equipment selection should consider the pressure drop through silencer or muffler.
****

Flexible connections and silencers, muffler or sound barriers shall be installed on the equipment [discharge] [inlet and discharge] to attenuate sound level.

2.17.1 Silencer

****
NOTE: Canister type silencers should be considered for attenuation of low frequency sound levels, pressures higher than 5 kPa 20 inches of water and velocities greater than 20 meters per second 4,000 feet per minute. Use high temperature acoustical packing for temperature greater than 122 degrees C 250 degrees F.
****

Each blower shall be provided with [inlet] [and] [discharge] silencers. Silencers shall be for [standard] [critical] grade silencing. Intake silencers shall be of the [absorption] [canister] [chamber] type. Discharge silencers shall be of the [absorption] [canister] [chamber] [combination chamber-absorption] type. Canister type silencer shall be constructed of two concentric perforated cylinders lined with high

temperature acoustical packing forming an annular flow path, with an internal plug creating a blocked line of sight. Silencer size shall be as recommended by the silencer manufacturer and shall be compatible with the blower requirements. Silencer connections shall match the adjacent piping. Mounting brackets shall be provided as required for silencer support. Silencer shall be constructed of heavy-duty rolled and welded steel plate with the inner liner welded to the outer shell to acoustically deaden the outer shell.

2.17.2 Muffler

****
NOTE: Hot-gas mufflers should be considered to effectively minimize the transmission of hot-gas pulsations whenever the noise level is an important consideration.
****

Hot-gas muffler shall be installed [on the intake] [on the exhaust] [in-line] and shall minimize the transmission of hot-gas pulsations.

2.17.3 Acoustical Insulation

Silencers, [interior air piping,] [expansion joints,] [valves,] [and] [drive guards] shall be wrapped with 25 mm 1 inch thick high density woven glass fiber mat having a minimum density of 4.6 kg/square meter 15 ounces/square foot and shall be lagged with a 0.41 mm 0.016 inch thick aluminum jacket. Insulation shall conform to EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING.

2.17.4 Sound Barriers

****
NOTE: Barriers generally have limited high frequency attenuation.
****

Sound barriers shall be made of insulated ductwork fastened to sheet steel walls. Flow velocity parallel to barriers shall be limited to 1200 m 4000 feet per minute at pressures less than 5 kPa 20 inches of water.

2.18 MONITORING

****
NOTE: On projects with extensive process monitoring and control, replace text with a reference to Section 40 60 00 PROCESS CONTROL.
****

Each unit shall be equipped for monitoring the flow downstream of any bypass connections. Calibration of sensors shall be with standards traceable to NIST and in conformance with NIST SP 250.

2.18.1 Flow

[A turbine type flow meter equipped with transmitter and recorder shall be provided for continuous metering of the process flow. Accuracy shall be within 0.5 percent of full scale.] [Gas meters shall conform to AGA ANSI B109.2.]

2.18.2 Temperature

2.18.2.1 Thermometers

Thermometers shall conform to ASME PTC 19.3 TW with wells and temperature range suitable for the use encountered. Thermometers shall be provided to indicate [inlet air temperature,] [discharge air temperature,] [and] [lubrication oil temperature.] Thermometers shall be either red-reading mercury-in-glass type or dial type. Scale range shall include full range of expected operation and up to 125 percent, but not more than 150 percent of maximum. Accuracy shall be within 0.5 percent of full scale.

2.18.2.2 Thermocouples

Sensors shall conform to ISA MC96.1, Type K, and shall be provided downstream of each blower or as otherwise directed. The thermocouple shall be suitable for continuous operation and control at temperatures up to [_____] degrees C F, shall be accurate to [0.75] [_____] percent of full scale, and shall be long enough to be inserted 150 mm 6 inches into the air flow. The thermocouple shall be provided with an adjustable flange and with a protecting tube suitable for insertion into the air flow without support of the projecting end. Compensating lead wire 1.52 mm 16 gauge in diameter and 30 m 100 feet long with a weatherproof braid shall be supplied for connecting the thermocouple to the instrument. The installed unit shall indicate gas passage temperatures and shall activate the high temperature alarm when the set point temperature is exceeded.

2.18.3 Pressure

****
NOTE: Verify the pressure ranges for the system.
****

High and low pressure connections shall be 6 mm 1/4 inch NPT female with a [stainless steel bar stock valve] [suitable shutoff cock] at each connection. [The high pressure connection to the gauge shall have a 10 micrometer 10 micron pleated paper filter and the low pressure connection shall have a fine mesh stainless steel strainer.] [Each pressure connection to the gauge shall have a snubber.]

2.18.3.1 Draft Gauge

Gauge shall conform to ASME B40.100 with a diaphragm or bellows actuating system, a circular scale and a zero adjustment screw. Inlet gauges shall have a range of 0 to 7.5 kPa 0 to 30 inches water gauge vacuum. Gauges shall include the accessories for [control panel] [wall] [pipe] mounting.

2.18.3.2 Pressure Gauge

Gauges shall conform to ASME B40.100 with a single Bourdon tube style actuating system, a circular scale and a zero adjustment screw. Discharge gauges shall have a range of 0 to 75 kPa 0 to 11 psi. Gauges shall include the accessories for [control panel] [wall] [pipe] mounting.

2.18.3.3 Differential Pressure Gauge

The housing of each unit shall be equipped with a direct-reading gauge that measures the differential pressure range [of 0 to 100 kPa 0 to 14.5

psi with an accuracy of plus or minus 2 percent of full scale, calibrated linearly with 2 kPa 0.34 psi scale graduations] [necessary to operate in conjunction with the corresponding venturi tube]. During operating conditions the pointer shall be within the mid-range of the gauge. Accuracy shall be within 0.5 percent of full scale.

2.18.3.4 Piston Element

Piston type element shall consist of a spring-supported, corrosion resistant piston moving inside a glass cylinder with an operating pressure of 1.03 MPa 150 psi. The cylinder shall have stainless steel end flanges with Viton O-ring seals and a cylinder burst pressure of not less than 4.15 MPa 600 psi. Construction of the gauge shall be such that a 3-valve manifold is not necessary. If only one bar stock valve is closed, the gauge shall not be damaged by up to 2.1 MPa 300 psi differential pressure in either direction.

2.18.3.5 Bellows Element

Bellows pressure sensing element shall be installed to measure pressure differential across the air moving equipment and shall be dual opposed, liquid filled, rupture-proof type with bellows movement converted to rotation and transmitted by a torque tube. Bellows housing shall be stainless steel and shall have a rated working pressure of not less than 3.5 MPa 500 psi. Liquid used to fill the bellows shall be suitable for the expected maximum temperature of the off-gas and the minimum ambient temperature.

2.18.4 Contaminant Monitoring and Sampling

2.18.4.1 Explosimeter

Continuous monitoring and recording of percentages of upper and lower explosive limits shall be performed.

2.18.4.2 Hygrometer

Humidity sensor shall be located downstream of the heat exchanger or blower.

2.18.4.3 Sampler

Sampling port and equipment for collecting discrete and composite samples shall be provided with adequate access for personnel and equipment.

2.18.4.4 Transmitter

Transmitter shall provide an analog two-wire electrical 4-20 milliamp signal directly proportional to the differential pressure and accurate to within 0.25 percent of sensor indication. Transmitter shall be provided with built-in pulsation damper and suitable over-range protection. Transmitter shall not require recalibration due to power outages. Transmitter shall be UL listed for [Class 1, Division 1, Group D hazardous locations] [the electrical classification for the area as indicated on the drawings]. Each transmitter shall be supplied with a factory assembled five-valve stainless steel manifold. Vent valves shall be furnished on upper ports of each transmitter. Transmitter shall be mounted and installed according to manufacturer's recommendations.

2.18.4.5 Remote Indicator and Recorder

Monitored parameters and excursion alarms shall be displayed locally and displayed on the control panel. Digital data shall be recorded at intervals not exceeding one minute. Process data shall be maintained in the control room and recorded on magnetic media in the approved micro computer compatible digital format. Flow information shall include rate monitoring, integration and totalizing. Hard copies of recorded data and summaries of recorded data shall be maintained in the control room. The copies shall be available upon request.

2.19 CONTROL SYSTEM

****

NOTE: The designer will decide which automatic controls are needed and delete any inapplicable items.

****

Unit shall have [a manual][an automatic] control system. Automatic controls shall be responsible for the balancing of the capacity with system requirements. These controls shall automatically balance the equipment capacity with the load. Provide the system with the necessary control devices required for normal operation. The automatic controls shall also include each of the following: a safe system operating mode when controls fail, indications for system failure, protective mechanisms and controls that are required for the safe operation of system equipment in an enclosure conforming to NEMA ICS 6. Submit wiring and ladder diagrams, and control sequences showing the control of the entire system.

2.19.1 Sequence of Control

****

NOTE: Develop and insert the sequence of control for each system.

****

The sequence of control shall be as follows: [_____].

2.19.2 Sequence of Equipment Operation

****

NOTE: Develop the sequence of equipment operation and insert requirements in this paragraph.

Include instrumentation to modulate the output to meet pressure and/or volume demands as well as start or stop units if the system requires pressure and/or volume control.

****

Logic shall be included to allow for automatic or manual alternation of lead/lag/standby assignments of units installed in parallel. Include Instrumentation to modulate the pressure and volume output as well as start or stop units to meet pressure and/or volume demands. Off-gas systems with safety, emission, or process controls shall be subject to automatic control logic permissives. Controls shall include start and stop push button switches, [hand-off-automatic (H-O-A) switches where the system controls operation] [safety features such as blade and belt guards,

vibration or temperature switches] [surge warning and shutdown,] [low oil pressure,] [high oil temperature switches] [process oriented switches such as upstream or downstream process equipment failure shutdown or emission detection shutdown]. Additional controls or protective devices shall be as indicated.

Submit detailed manufacturer's data on the overall controls, sensors, process controllers, control operators, valves, interlocks and alarms.

2.19.3 Intake Volume Control

****

NOTE: Under colder air operating conditions, in centrifugal blowers with a relatively flat characteristic flow curve, volume may be controlled over a narrow working range by adjusting variable inlet guide vanes to vary the pressure-volume characteristics. Variable inlet vanes are acceptable, but inefficient. A butterfly valve may be used to create inlet head losses to throttle the blower inlet and reduce volumetric flow rate.

****

[Automatically] [Manually] controlled [adjustable guide vanes] [line sized butterfly valve] shall be installed on blower inlet to create inlet head losses and reduce the volumetric flow rate.

2.19.4 Outlet Volume Control

****

NOTE: The most efficient method to vary both volume and pressure is to vary the speed of the driver.

Other methods of controlling output are outlet damper and eddy current coupling (generally an outdated way to achieve speed control). Outlet dampers may serve if high pressure at low volume is desired and high energy costs are not of concern.

****

[Variable speed control shall be installed to control output volume] [Automatically controlled bypass shall be provided to recirculate directly around the blower] [Manual line sized [unloading] [check] [butterfly] valve shall be installed on blower outlet to create system head losses and reduce the volumetric flow rate].

2.19.5 Panel

****

NOTE: Delete inapplicable items. Consider site location and operational factors for alarm requirements. Indicate equipment on drawings and/or reference other specifications as appropriate.

****

A NEMA [4] [7] [12] [explosion proof] [weather proof] [instrument panel] [control panel] enclosing relays, Contractor, timers, and selector switches shall be [floor mounted] [wall mounted] [mounted with vibration isolators on the unit] and provided with hinged cover and latch.

Instruments shall be of the direct reading type and shall be factory mounted and connected. Shutdown feature shall be connected to the annunciator on the instrument panel and each shutdown feature shall be identified. Panel shall include the following features and instruments:

a. Running time meter.

b. Alarm annunciator [with single audible alarm] [and] [with contacts to operate a remote alarm] and individual lights for each alarm condition.

2.19.6 Protective Devices

Blower protective devices, upon alarm condition, shall cause immediate de-energization of the motor, shall initiate the automatic shutdown sequence, and shall provide audible and visual alarm indication.

2.19.6.1 Bearing Temperature

Temperature sensors with switches shall be installed on each bearing. The control relay, selector switch, test push buttons, and running indicator, or light, on the panel shall indicate bearing status. High temperature of any bearing shall initiate protective shutdown and the indicator, or light, shall indicate the affected bearing.

2.19.6.2 Surge and Overload Protection

****

NOTE: Centrifugal blowers are subject to a characteristic called "surge" or minimum flow point below which the blower performance is unstable. The instability manifests itself in pressure pulsations and flow reversals which can become severe enough to damage the blower or system. Surge occurs when the system resistance is greater than the pressure that the blower is capable of producing at a given inlet volume; this results in a backward rush through the blower and out the inlet, lowering the pressure in the discharge line at which time normal compression resumes and cycle is repeated, until discharge pressure is decreased or blower pressure increased. Surge may be prevented by using manual or automatic controls.

****

A set-point controller shall monitor current input to the motor. The controller shall open and close the inlet [guide vanes] [butterfly valve] in response to current. The controller shall initiate automatic shutdown sequence and give visual indication of reason for shutdown if surge conditions are indicated by the motor current. Manual control and override shall be provided to enable equipment startup and shutdown.

2.19.6.3 Oil Temperature and Pressure

Temperature and pressure sensors with switches shall be installed on each oil pump. The control relay, selector switch, test push buttons, and running indicator, or light, on the panel shall indicate status. High oil temperature, high oil pressure or low oil pressure shall initiate protective shutdown and the indicator, or light, shall indicate the affected setting.

2.20 ELECTRICAL EQUIPMENT

****
NOTE: Show hazardous area classification on the drawings.
****

Electrical equipment shall conform to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical motor driven equipment herein specified shall be provided complete with motors, motor starters, and controls. Electrical equipment and wiring shall be in accordance with NFPA 70, with proper consideration given to environmental conditions such as moisture, dirt, corrosive agents, and hazardous area classification.

2.20.1 Electric Motors

Each electric motor-driven unit shall be driven by a weather-protected, Type [I][II][totally-enclosed fan cooled] continuous-duty electric motor. Motor shall have a [_____] service factor. Motors shall be [squirrel-cage induction][synchronous] having normal-starting-torque and low-starting-current characteristics, and shall be sized to avoid exceeding the nameplate power rating throughout the entire published characteristic curve. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1. Motor bearings shall provide smooth operations under the conditions encountered for the life of the motor. Adequate thrust bearing shall be provided in the motor to carry the weight of the rotating parts plus the hydraulic thrust and shall be capable of withstanding upthrust imposed during starting [and under variable head] conditions specified. Motors shall be rated [_____] volts, [_____] phase, 60 Hz and such rating shall be stamped on the nameplate. Motors shall conform to NEMA MG 1.

2.20.2 Control Equipment

[Manually controlled units shall have START-STOP pushbutton in cover.][Automatically controlled units shall have three-position MANUAL-OFF-AUTOMATIC selector switch in cover.] Additional controls or protective devices shall be as indicated.

2.20.3 Variable Speed Controls

****
NOTE: Include this paragraph if any of the motors has a variable speed control.
****

The variable speed motor controller shall convert 460 volt plus 15 percent, minus 5 percent, three phase, 60 Hz (plus or minus 2 Hz) utility power to adjustable voltage/frequency, three phase, ac power for stepless motor control from 5 percent to 105 percent of base speed. With the product data submittal for the controls, provide capacities and capacity ranges; performance charts and curves.

2.20.3.1 Description

The variable speed drive shall produce an adjustable ac voltage/frequency output for complete motor speed control. The variable speed drive shall be automatically controlled by [a pneumatic 20.7 to 103.4 kPa 3 to 15 psig

control signal] [a grounded electronic control signal]. The variable speed drive shall be self contained, totally enclosed in a NEMA MG 1 ventilated cabinet and shall be capable of operation between 0 and 40 degrees C 32 and 104 degrees F. The variable speed drive maximum output current rating shall be equal to or exceed the motor nameplate full load. The manufacturer shall advise the maximum recommended motor sine wave current for each controller rating. Variable speed drive multiple motor operation at same frequency/speed shall be possible as long as the sum of connected motor full load sine wave currents are less than or equal to the variable speed drive maximum continuous current rating. Variable speed drive shall be [85] [90] [95] percent efficient at 100 percent of rated output power.

2.20.3.2 Governing Requirements

Variable speed drive shall comply with 47 CFR 15 regulation of RF1/EM1 emission limits for Class A computing devices. The FCC label of compliance shall be displayed on the variable speed drive. Variable speed drive and option design and construction thereof shall comply with the applicable provisions of NFPA 70, Article 43D, Sections A-L.

2.20.3.3 Basic Features

The variable speed drive shall have the following basic features:

a. Hand/off/auto operation.

b. Manual/auto speed reference switch.

c. Minimum/maximum adjustable speeds.

d. Speed potentiometer.

e. Auto restart.

f. Linear timed acceleration and deceleration for soft starting and stopping.

g. Controlled speed range 3-63 Hz. (Factory set at 15 Hz minimum).

h. Terminal connections for time clock control, fire, smoke, freeze detectors, and EP relay pre-set speed override.

i. Output frequency terminals for remote metering.

2.20.3.4 Protective Circuits and Features

The variable speed drive controller shall include the following protective circuits/features:

a. Current limits to 100 percent design by slowing the down motor.

b. Instantaneous electronic trip to automatically shut down the motor if current exceeds 120 percent of design or phase-to-phase output short circuit occurs.

c. The variable speed drive will restart automatically when input line returns to normal in the event of intermittent power outage or phase loss or overvoltage shutdown.

d. Input power protection shuts down the unit on low input line voltage or loss of an input phase.

e. Insensitive to incoming power phase.

f. Fast acting current limiting input fuses, (Class J) rated with 200,000 interrupting amperes capability.

g. Isolated 115 volt control circuit and dedicated control transformer.

h. Line-to-line fault protection.

i. Line-to-ground short circuiting and accidental motor grounding protection.

j. Output thermal overload relay trip.

2.20.3.5 Adjustments

The variable speed drive shall have 0 to 75 percent of minimum speed, and 100 percent of maximum speed, adjustments available via potentiometers located on the faceplate of a single, regulator printed circuit board.

2.21 APPURTENANCES

2.21.1 Dielectric Fittings

Dielectric fittings shall be installed between threaded ferrous and nonferrous metallic pipe, fittings and valves. Dielectric fittings shall prevent metal-to-metal contact of dissimilar metallic piping elements and shall be suitable for the required working pressure.

2.21.2 Isolation Joints

Isolation joints shall be installed between nonthreaded ferrous and nonferrous metallic pipe, fittings and valves. Isolation joints shall consist of a sandwich-type flange isolation gasket of the dielectric type, isolation washers, and isolation sleeves for flange bolts. Isolation gaskets shall be full faced with outside diameter equal to the flange outside diameter. Bolt isolation sleeves shall be full length. Units shall be of a shape to prevent metal-to-metal contact of dissimilar metallic piping elements.

2.21.2.1 Sleeve-type Couplings

Sleeve-type couplings shall be used for joining plain end pipe sections. The two couplings shall consist of one steel middle ring, two steel followers, two gaskets, and the necessary steel bolts and nuts to compress the gaskets.

2.21.2.2 Split-sleeve Type Couplings

Split-sleeve type couplings shall be used in aboveground installations when approved in special situations, and shall consist of gaskets and a housing in two or more sections with the necessary bolts and nuts.

2.21.3 Valves

****

NOTE: Evaluate the need for silencers and/or carbon adsorption units if handling toxic gases downstream of relief and/or unloading valves.

Threaded connections are common on valves 25 mm 1 inch and smaller, and are sometimes used on valves up to 50 mm 2 inch. If a welded end connection is desired for valves 50 mm 2 inch and smaller, a socketweld is usually chosen. Socketweld end dimensions are standardized by ASME B16.11. Buttweld ends are preferred when zero leakage is required. The valve body material must be compatible with the adjoining pipe material for welding.

****

Valve diameter shall be equal to the diameter of the pipe in which the valve is located unless otherwise indicated. Valves shall be [screw] [socket weld] [buttweld] [sweat] [flange] connected. Rated operating conditions shall be [_____] degrees C F and [_____] kPa psig, minimum. Materials of construction shall be [aluminum] [bronze] [stainless steel] [_____] body, [bronze] [316 stainless steel] trim, and [Buna-N] [EPR] [Viton] [PTFE] elastomers. Valves shall be marked in accordance with MSS SP-25 to identify the manufacturer, valve sizes, pressure rating, body and seat material.

2.21.3.1 Relief Valve

****

NOTE: Relief valves are provided in the following configurations: weighted type (install in horizontal position only), spring type and pilot operated diaphragm type which (with an optional solenoid valve) can be used for an unloading valve as well. Relief valves are also used to relieve possible thermal expansion in a pipe line if no other provisions exist. Indicate on the drawings a site flow indicator downstream of each relief valve. Indicate the operating pressure required for each valve.

ASTM F1508 covers only spring-loaded, angle style valves.

****

Relief valve capable of maintaining a constant upstream pressure regardless of the downstream demand shall be provided for each air mover. Valve shall be [ASTM F1508 angle spring loaded] [weighted] [pilot-operated diaphragm] differential pressure relief valve with a [_____] percent accumulation. Valve shall be rated to relieve [the full capacity of the air moving equipment] [[_____] cubic meters/second feet/minute]. Valve shall be factory-set to open at the [actual] [gauge] [pressure] [vacuum] of [_____] kPa psi and shall be field adjustable within a minimum range of plus or minus 20 percent. Valve shall be located within [_____] m feet upstream of vacuum equipment or downstream of pressure equipment.

2.21.3.2 Unloading Valve

****
NOTE: Unloading valves allow the blower to start under reduced pressure.
****

Unloading valve shall be [pilot-operated diaphragm valve with auxiliary solenoid operator] [butterfly valve] actuated by the system controls and shall be field adjustable within a minimum range of plus or minus 20 percent. Unloading valve shall be set to relieve [_____] cubic m/second feet/minute at a set gage pressure of [_____]kPa psi or a vacuum of [_____] kPa inches Hg.

2.21.3.3 Combination Relief and Unloading Valve

****
NOTE: Combination valves should be carefully located with respect to heavily contaminated off-gas streams or deleted in favor of separate valves.
****

Combination relief and unloading valve shall be set to relieve at a set [actual] [gauge] [pressure] [vacuum] of [_____] kPa psi.

2.21.3.4 Purge Valve

****
NOTE: For vacuum pump applications, an automatic purge valve is useful in clearing the system of vapors which may condense in shutdown or startup.
****

Each vacuum unit shall be equipped with a manually adjustable, normally closed automatic purge valve. Valve shall be factory-set to open at at the gauge pressure of 0.5 kPa 0.15 inches Hg and shall be field adjustable within a minimum range of plus or minus 20 percent. Valve shall be located within 1 m 3.3 feet downstream of vacuum equipment.

2.21.3.5 Vacuum Breaker

****
NOTE: Edit the settings appropriately for the equipment required.
****

[Pilot-operated diaphragm type with auxiliary solenoid operator] [Butterfly valve actuated by blower system controls] vacuum breaker shall be provided to protect blower or vacuum pump from surges. Valve shall be rated to relieve 0.05 cubic m/second 1.76 cfm at a set gage pressure of 100 kPa 14.7 psi or a vacuum of -50 kPa -15 inches Hg. Materials shall be [aluminum] [bronze] [stainless steel] body, [bronze] [316 stainless steel] trim, and [Buna-N] [EPR] [Viton] [Teflon] elastomers. Rating shall be 100 degrees C 212 degrees F and 1000 kPa 147 psi, minimum.

2.21.3.6 Check Valve

Valve shall be a [pilot-operated diaphragm valve with auxiliary solenoid operator] [butterfly valve actuated by system controls] with a closing

time of 1 to 5 seconds, located on the discharge side of each air mover. Valve shall prevent reverse flow and shall open at a controlled rate to keep air mover starting surges from shocking downstream equipment. Opening rate shall be adjustable from 5 to 60 seconds.

2.21.3.7 Control Valve

****

NOTE: Starting and stopping the air moving equipment is preferable to operation against a closed system.

****

Valve shall be a [pilot-operated diaphragm valve with auxiliary solenoid operator] [butterfly valve actuated by system controls].

2.21.3.8 Back Pressure Valve

Valve shall be capable of maintaining a constant upstream pressure regardless of the downstream demand.

2.21.3.9 Manual Valve

[Ball valves shall be in accordance with MSS SP-72. Gate, plug and ball valves shall be in accordance with API Spec 6D. Thermoplastic gas shutoffs and valves shall be in accordance with ASME B16.40. Manual valve shall be wrench operated, rising stem, with cap.] [Non-automatic valve shall be as required by Section 31 21 00 OFF-GASSING MITIGATION.]

2.21.4 Inlet and Discharge Elbows

Inlet and discharge elbows shall be of the long sweep type with ASME B16.1, Class 125 flanges.

2.21.5 Expansion Coupling

The inlet and the outlet of each unit shall be provided with flexible expansion couplings of extra heavy gauge rubber, wire reinforced type suitable for temperature range of minus 29 to plus 121 degrees C minus 20 to plus 250 degrees F and pressure range from 51 to 103 kPa 15 inches of mercury vacuum to 15 psig.

2.21.6 Heat Exchanger

[An air-to-air] [A water cooled] heat exchanger shall be provided on the blower [inlet] [outlet] with sufficient capacity to reduce the air temperature [_____] degrees C F.

2.21.7 Flame Arrestor

Flame arrestor shall be located immediately upstream of any source of flame. Submit rating, capacity and pressure differentials. Also include installation instructions with the submittal.

2.21.8 Drip Trap

Drip trap shall be in accordance with ASTM F1139.

2.21.9 Liquid Receiver

Liquid receivers shall be designed, fitted, and rated for 0.345 MPa 50 psi working pressure. Each receiver shall have a storage capacity not less than [_____] L gal. Each receiver shall be equipped with inlet and outlet drop pipe, drain with valve, relief valve and two bull's-eye liquid-level sight glasses. Sight glasses shall be in the same vertical plane, 90 degrees apart, perpendicular to the axis of the receiver, and not over 75 mm 3 inches horizontally from the drop pipe measured along the axis of the receiver. In lieu of bull's-eye sight glass, external gauge glass with metal glass guard and automatic closing stop valves shall be provided. The outside of liquid receivers shall be galvanized or supplied with commercial enamel finish.

2.21.10 Air Receiver

Receiver shall be designed for 0.345 MPa 50 psi working pressure. Receivers shall be equipped with safety relief valves and accessories, including pressure gauges and automatic and manual drains. Receivers shall be designed and constructed in accordance with ASME BPVC SEC VIII D1 and shall have the design working pressures specified herein. A display of the ASME seal on the receiver or a certified test report from an approved independent testing laboratory indicating conformance to the ASME Code shall be provided. The outside of air receivers shall be galvanized or supplied with commercial enamel finish.

2.22 BASE PLATE

Each unit shall be mounted on all-welded structural steel or cast iron base complete with vibration isolators with published load rating. The base plate shall have vertical jacking screws to facilitate leveling. The entire unit shall be isolated from the building structure.

2.23 WEATHERPROOF ENCLOSURE

****

NOTE: Include this paragraph for equipment mounted partially or completely outdoors.

****

A weatherproof enclosure shall be provided for the air moving equipment and motor assembly. The enclosure shall have lockable access doors and shall be louvered for ventilation. [The enclosure shall be insulated and equipped with a thermostatically controlled electric heating and ventilation.]

2.24 ATTACHMENTS

Shafts, chains or gear driven equipment shall be provided with all-metal guards enclosing the drive mechanism. Guard shall be constructed of galvanized sheet steel, or galvanized woven wire, or expanded metal set in galvanized steel frame. Guards shall be secured in position by steel braces or straps which will permit easy removal for servicing the equipment.

2.25 COATINGS OR FINISHES

****

NOTE: Consult with coatings supplier on specific

coating once liquid and gas composition are known. Be aware of the VOC content of the coating and the regulations that restrict application of high VOC coatings; use low VOC coatings unless quality of coating will not meet requirements.
****

Motors, casings and similar parts of equipment finished in the shop shall be cleaned, primed and given two finish coats with [alkyd primer followed by two alkyd modified silicone final coats] [severe chemical service phenolic type coatings] [paint suitable for the environment in which the unit is to be placed] at the factory. Ferrous surfaces not painted at the factory shall be given a shop coat of grease or other suitable rust resistant coating.

2.26 FACTORY TESTS

****
NOTE: Delete inapplicable tests.
****

Equipment shall be subject to in-plant shop and quality control inspections before approval for shipment from manufacturer's facilities. Rotating parts of the equipment shall operate throughout the required range without excessive end thrust, vibration or noise.

2.26.1 Integrity

Each [impeller] [rotor] assembly shall be tested by being operated at a speed to [20] [_____] percent above operating speed and checked for cracks using the dye penetrant method or similar method of equal accuracy.

2.26.2 Balance

Rotating parts shall be statically and dynamically balanced in accordance with ISO 1940-1. First critical speed shall be at least 150 percent of maximum operating speed. Rotating parts shall be statically and dynamically balanced. The shaft and impeller or blade assembly shall be statically and dynamically balanced as a unit. Removing of metal from the impeller or blades by boring is not an acceptable means of balancing the shaft and impeller unit. Impeller or blade assemblies shall be statically and dynamically balanced to within 0.5 percent of W times R squared, where W equals weight and R equals impeller radius.

2.26.3 Deflection

Total shaft peak-to-peak dynamic deflection measured by vibrometer at seal face shall not exceed 5.1 microns 2 mils under the complete range of operating conditions.

2.26.4 Vibration

****
NOTE: Deflection is normally specified for centrifugal blowers. Velocity is normally specified for positive displacement blowers.
****

[Vibration shall not exceed 2.5 microns 1.0 mil at the bearing housing

with the equipment operating.] [Peak vibration velocity shall be less than 7.62 mm/second 0.30 inch per second.]

2.26.5 Capacity

Volume and pressure characteristics of air moving equipment shall be determined by the [manufacturer] [a nationally recognized testing agency] in accordance with AMCA 210. Certified test results and sample calculation from test readings shall be submitted to the Contracting Officer. Where two or more identical units are specified, the capacity of only one representative unit needs to be tested.

2.26.6 Noise

Air moving equipment shall be tested with sound attenuation devices installed by the [manufacturer] [a nationally recognized testing agency]. Certified test results and sample calculation from test readings shall be submitted to the Contracting Officer. Where two or more identical units are specified, only one representative unit needs to be tested. Fans shall be tested in accordance with AMCA 300 with results interpreted in accordance with AMCA 301.

2.26.7 Variable Speed Drive

Each variable speed drive shall be subjected to an in-plant quality control inspection. Integrated circuits shall undergo a 160-hour "burn-in" to test reliability. During the "burn-in" the temperature shall be cycled between 0 and 70 degrees C 32 and 158 degrees F. Each completed unit shall undergo a fully loaded 24-hour "burn-in".

2.26.8 Continuity

Wiring and instrumentation assembled at the factory shall be checked for continuity prior to shipping.

2.26.9 Receivers

Receivers shall be factory air tested to 1.5 times the specified working pressure.

2.26.10 Valve Testing

Relief valves shall be tested in accordance with ASME PTC 25.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

****

NOTE: Rotary lobe blowers must be absolutely horizontal to operate properly.

****

Vibration dampener shall be installed in sufficient quantity to isolate each unit from the structural base on which the unit is installed. Each air moving unit and motor shall be installed, aligned and leveled in accordance with the written instruction of the manufacturer [and under the direct supervision of the manufacturer's representative]. [Deviation from horizontal shall be below limits of measurement.] [Impellers shall be set by the manufacturer's representative]. Flexible couplings shall not be used to compensate for misalignment between driver and driven unit. Blower venting shall not violate the provisions of either ACGIH 2098 or AMCA 99.

3.2.1 Concrete Foundations

Concrete for equipment foundations shall [be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE] [have a minimum compressive strength of at least 17 MPa 2,500 psi]. Concrete foundations shall be [integral with and of the same class as that of the building floor] [entirely separated from the surrounding floor with a premolded filler strip installed between the foundation and floor slab as shown]. Foundation bolts, as required, shall be furnished for proper positioning during the placement of the concrete.

3.2.2 Seismic Requirements

****

NOTE: Provide seismic requirements, if a Government designer (either Corps office of A/E) is the Engineer of Record and show on the drawings. Delete the bracketed phrase if seismic details are not provided. Pertinent portions of UFC 3-310 and Sections 13 48 73 [SEISMIC] BRACING FOR MISCELLANEOUS EQUIPMENT and 23 05 48.19 [SEISMIC] BRACING FOR HVAC, properly edited, must be included in the contract documents.

****

Equipment and attached valves shall be supported and braced to resist seismic loads as specified under UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and 23 05 48.19 [SEISMIC] BRACING FOR HVAC[as shown on the drawings].

3.3 FIELD PAINTING

Stainless steel, galvanized steel, and nonferrous surfaces shall not be painted.

3.3.1 Touch-Up Painting

Factory painted items, requiring touching up in the field, shall be cleaned of foreign material and shall be primed top-coated with the manufacturer's standard factory finish, provided it does not discolor in the presence of hydrogen sulfide fumes, high water vapor atmosphere, alkaline water vapor, and concentrated chlorine (oxidizing) conditions.

3.3.2 Exposed Ferrous Surfaces

Equipment which did not receive a factory finish and other exposed ferrous surfaces shall be painted as specified in Section 09 90 00 PAINTS AND COATINGS. Coating shall be not less than 0.05 mm 1.75 mils thick.

3.4 MANUFACTURER'S FIELD SERVICES

Provide the services of a manufacturer's representative experienced in the installation, adjustment, and operation of the equipment specified. The representative shall supervise the installing, adjusting, and testing of the equipment.

3.5 POSTING FRAMED INSTRUCTIONS

Post framed instructions containing wiring and control diagrams where directed. Condensed operating instructions shall be posted as specified. The framed instructions shall be posted before acceptance testing of the systems.

3.6 FIELD TESTING

3.6.1 Deficiencies

If any deficiencies are revealed during any tests, such deficiencies shall be corrected and the tests shall be reconducted.

3.6.2 Correct Installation

Tests shall assure that the units and appurtenances have been installed correctly, there is no objectionable heating or vibration, noise from any part is not excessive, and manual and automatic controls function properly.

3.6.3 Field Equipment Test

After installation of the air moving units and appurtenances is complete, operating tests shall be carried out to ensure that the installation operates properly. [Make arrangements to have the manufacturer's representative present when field equipment tests are made.] Each unit shall be given a running field test in the presence of the Contracting Officer for a minimum of [4] [_____] hours [at its rated capacity] [at the point of maximum power requirement indicated on the head-capacity curve or point on the curve selected by the Contracting Officer]. Provide an accurate and acceptable method of measuring the discharge flow and pressure.

3.6.4 Noise Suppression

Sound level shall be less than [60] [70] [80] dB measured at 1.5 m 5 feet from the source.

3.6.5 Reporting

Submit test reports in booklet form showing field tests performed to adjust each component and field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed equipment. Test methods used shall be identified and test results shall be recorded. Indicate in each test report the final position of controls.

3.7 CLOSEOUT ACTIVITIES

3.7.1 Field Training

****

NOTE: The number of hours required to instruct a Government representative in operation and maintenance of the system will depend on the complexity of the system specified. Designer is to establish the number of hours of training based on equipment manufacturer recommendations, system complexity and consultation with the installation.

****

Conduct a field training course for designated operating, maintenance and supervisory staff members. Submit training course curriculum and training instructions 14 days prior to the start of training. Provide training after the system is functionally complete but prior to final acceptance tests, for a total period of [16] [24] [_____] hours of normal working time. Field training shall cover the items contained in the operating and maintenance instructions.

3.7.2 Operating and Maintenance Instructions

3.7.2.1 Operating Instructions

Submit [six] [_____] complete copies of operating instructions outlining the step-by-step procedures required for system startup, operation and shutdown. Include in the operating instructions the following for system components: manufacturer's name, model number, service manual, parts list, and brief description of each piece of equipment and its basic operating features; flow diagrams; system layout showing piping, valves, and controls; [as-built] [approved] wiring and control diagrams; control sequence describing startup, operation, and shutdown; manufacturer's bulletins, cuts, and descriptive data.

3.7.2.2 Maintenance Instructions

Submit [six] [_____] complete copies of maintenance instructions for each piece of equipment including the following: manufacturer's complete list of parts, recommended spare parts and supplies, with current unit prices and source of supply; routine maintenance procedures, including the requirements of WEF MOP 11, as a minimum; possible breakdowns and repairs; a troubleshooting guide to help the operator determine what steps must be taken to correct any equipment problems.

-- End of Section --