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

Preparing Activity: USACE **Superseding without Revision UFGS-43 11 00 (April 2008)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2025
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SECTION 43 11 00.10

OFF-GAS FANS, BLOWERS AND PUMPS
05/20

****

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.

****

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	(2017) 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	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.40	(2024) Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems
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 19.3 TW	(2016) Thermowells Performance Test Codes
ASME PTC 25	(2023) Pressure Relief Devices

ASTM INTERNATIONAL (ASTM)

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

ASTM F1139	(1988; R 2024) Steam Traps and Drains
ASTM F1508	(1996; R 2021) 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	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2021) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 1 2024; TIA 24-1) 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	(2023; with Change 2, 2024) 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 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.

****

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. Submittals not having a "G" or "S" classification are 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 must 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 must 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 must 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. 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. For equipment stored longer than 60 days, suspend silica bags in the outlet and inlet of unit, fill bearings full of grease, fill unit with oil, coat machine surfaces with grease, and enclose entire unit with plastic or tarps. Turn shaft of rotating equipment, including motors, 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. Provide pipe and valves not specified in this Section 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 deliver them 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. Provide 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]. 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 must 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 includes [_____].

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.

****

Ensure capacity and design of the air moving equipment and accessories is suitable for 24-hour full load service in an [outdoor] [indoor] [_____] location, and meets 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 [_____] must be [appropriate for the capacity requirements of this paragraph] [a fan] [a blower] [a vacuum pump] [_____]. [Standard] [Actual] output volume must 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 must 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. Provide equipment supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site. Ensure pieces of equipment of the same types are products of the same manufacturer. Provide new and unused equipment, except for test equipment. Materials may be reprocessed/recycled with equivalent durability and product warranty/guarantee.

2.2.2 Nameplates

Provide each piece of equipment with 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 must 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 must show, at least, the minimum information required by paragraph 10.38 of NEMA MG 1. Show any other information that the manufacturer may consider necessary to complete identification 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. Provide equipment capable of operating at partial-load conditions without increased vibration over the normal vibration at full load operation and 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. Schedule certifications to be submitted with the pertinent drawings. 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

Date statements after contract award. State the Contractor's name and address, 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.
****

Provide centrifugal or propeller type fans 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.

****

Provide oil-free dynamic blowers 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. Include oil injection and outlet demisting systems 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. Include water injection systems and outlet water separation systems for each liquid ring vacuum pump.

2.8 CASING OR HOUSING

Provide casing or housing of modular design to permit inspection or removal and replacement of wearing parts. Provide ample clearance between the impeller or blades and casing. 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 must 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 must 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

Provide single piece casings with separate head plates.

2.8.3 Horizontally Split Casing

Machine horizontally split casings at the split to maintain the pressure without a gasket.

2.8.4 Vertically Split Casing

Provide vertically split casings consisting 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 must be ASME B16.1 or ASME B16.5 [Class 125] [125 pound] [_____] drilled and tapped flanges and are an integral part of the head. Connections 75 mm 3 inches in diameter and smaller must be [threaded] [sweat] [_____].

2.8.5.2 Casing Drains

Provide tapped and plugged drains at the low points in the casing.

2.8.5.3 Lifting Eyes

Provide casing with 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.
****

Cast or fabricate blades, vanes or impellers [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

Provide guide or diffuser vanes configured to receive and direct flow to the downstream impeller at the inlet to each centrifugal blower stage. Ensure centrifugal impellers are [open radial bladed] [closed backward bladed]. Butt multiple stage impeller hubs against each other either directly or through one piece metal spacers.

2.9.2 Rotary Lobe Impellers

Provide straight, two-lobe involute type rotary lobe impellers which operate without rubbing, liquid seals, or lubrication.

2.10 SHAFT

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

2.11 SEALS, GASKETS AND PACKING

Select gasket and packing material in accordance with WEF MOP 11. Ensure gaskets and seal ratings 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

Provide solid carbon mechanical ring shaft seals where the shaft passes through the inlet and discharge heads. Ensure seals are [purged] [or] [non purged], [balanced] [or] [unbalanced] to conform to specified service requirements. Ventilate to the atmosphere on the impeller side of shaft seals to eliminate carry-over of lubricant into the air stream.

2.11.2 Internal Seals

Provide labyrinth seals between blower stages.

2.11.3 Bearing Seals

Provide a [lip type oil] [grease] seal at each bearing to prevent lubricant from leaking into the output. Ventilate to the atmosphere on the impeller side of oil seals to 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

Support shaft 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.
****

Provide each blower with two [pressure, oil lubricated, sleeve type journal] [splash, oil lubricated, anti-friction type] [oil bath

lubricated] [grease lubricated] bearings. Bearings must be self-aligning, designed for both radial and thrust loads and 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. 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 must be [close coupled] [directly connected through a flexible coupling] [driven by a V-belt].

2.13.1 Coupling

Provide heavy-duty, flexible forged steel spacer coupling, keyed or locked to the shaft. Disconnect without removing the driver half of the driven unit half of the coupling from the shaft. Machine outside surface of coupling parallel to the axis of the shaft. Machine coupling faces perpendicular to the axis of the shaft.

2.13.2 V-Belt Drive

Design v-belt drive for no less than 150 percent of the driving motor capacity. When belt drive is provided, provide an adjustable sheave to furnish no less than 20 percent speed adjustment. Select sheaves to provide the required capacity at the approximate midpoint of the adjustment. The drive belt must be [covered with an acoustically treated sheet metal guard] [or] [completely enclosed within the unit casing].

2.14 GEARS

Make gears 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. [Furnish single speed centrifugal blower with high speed increasing gears.] [Time positive displacement impellers by a pair of machined, heat-treated, spur tooth timing gears.] Mount timing gears on the impeller shafts on a tapered fit and secure by a lock nut.

2.15 LUBRICATION SYSTEM

****

NOTE: Delete inapplicable lubrication systems.
****

Provide [pressure oil lubricated] [splash oil lubricated] [grease lubricated] drive. Provide [pressure oil lubricated] [splash oil lubricated] timing gears and gear end bearings. Lubricate bearings and seals as previously indicated. Design system to prevent leakage and contamination. Design oil-lubrication systems and vents so that oil vapors do not enter the air stream or motor and the shaft bearings will be isolated. Provide each oil reservoir 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

Provide console mounted pressure oil lubrication system and 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 must be totally enclosed fan cooled (TEFC), Design Type B in accordance with NEMA MG 1, with Class F insulation and equipped with 120 volts space heaters. Provide control in accordance with NEMA ICS 1. Provide factory piped and wired lubrication system with minimal interconnecting piping between the console and the oil pump required in the field.

2.15.2 Splash Oil

Provide splash lubrication 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. Provide a sight level gauge in the bearing housing. Provide a labyrinth seal combined with an atmospheric vent to prevent oil contamination of the air stream.

2.15.3 Grease

Equip grease type bearings with grease fittings. Extend grease tubing to a convenient location if fittings are inaccessible. Provide grease fittings which prevent over-lubrication and over-pressurization.

2.16 INTAKE FILTER

Install intake [screen and filter] [filter] on inlet to each unit.

2.16.1 Efficiency

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

2.16.2 Surface Area

Provide a minimum filter surface area of 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 must 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

Coat steel intake hood and filter housings with a chemically resistant coating and ensure entire unit element is 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.
****

Install flexible connections and silencers, muffler or sound barriers 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.
****

Provide each blower with [inlet] [and] [discharge] silencers. Use silencers for [standard] [critical] grade silencing. Provide [absorption] [canister] [chamber] type intake silencers. Provide [absorption] [canister] [chamber] [combination chamber-absorption] type discharge silencers. Construct canister type silencer 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. Use silencer size as recommended by the silencer manufacturer and compatible with the blower requirements. Ensure silencer connections match the adjacent piping. Provide mounting brackets as required for silencer support. Construct silencer 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.
****

Install hot-gas muffler [on the intake] [on the exhaust] [in-line] to

minimize the transmission of hot-gas pulsations.

2.17.3 Acoustical Insulation

Wrap silencers, [interior air piping,] [expansion joints,] [valves,] [and] [drive guards] 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 lag with a 0.41 mm 0.016 inch thick aluminum jacket. Provide insulation conforming 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.
****

Make sound barriers of insulated ductwork fastened to sheet steel walls. Limit flow velocity parallel to barriers 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.
****

Equip each unit for monitoring the flow downstream of any bypass connections. Calibrate sensors with standards traceable to NIST and in conformance with NIST SP 250.

2.18.1 Flow

[Provide a turbine type flow meter equipped with transmitter and recorder for continuous metering of the process flow. Ensure accuracy is within 0.5 percent of full scale.] [Provide gas meters conforming to AGA ANSI B109.2.]

2.18.2 Temperature

2.18.2.1 Thermometers

Provide thermometers conforming to ASME PTC 19.3 TW with wells and temperature range suitable for the use encountered. Provide thermometers to indicate [inlet air temperature,] [discharge air temperature,] [and] [lubrication oil temperature.] Ensure thermometers are either red-reading mercury-in-glass type or dial type. Scale range must include full range of expected operation and up to 125 percent, but no more than 150 percent of maximum. Ensure accuracy is within 0.5 percent of full scale.

2.18.2.2 Thermocouples

Provide sensors conforming to ISA MC96.1, Type K, and provide downstream of each blower or as otherwise directed. Ensure thermocouple is suitable for continuous operation and control at temperatures up to [_____] degrees C F, accurate to [0.75] [_____] percent of full scale, and long enough to

be inserted 150 mm 6 inches into the air flow. Provide thermocouple with an adjustable flange and with a protecting tube suitable for insertion into the air flow without support of the projecting end. Supply compensating lead wire 1.52 mm 16 gauge in diameter and 30 m 100 feet long with a weatherproof braid for connecting the thermocouple to the instrument. The installed unit must indicate gas passage temperatures and activate the high temperature alarm when the set point temperature is exceeded.

2.18.3 Pressure

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

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

2.18.3.1 Draft Gauge

Provide gauge conforming to ASME B40.100 with a diaphragm or bellows actuating system, a circular scale and a zero adjustment screw. Provide inlet gauges with a range of 0 to 7.5 kPa 0 to 30 inches water gauge vacuum. Include the accessories for [control panel] [wall] [pipe] mounting.

2.18.3.2 Pressure Gauge

Provide gauges conforming to ASME B40.100 with a single Bourdon tube style actuating system, a circular scale and a zero adjustment screw. Provide discharge gauges with a range of 0 to 75 kPa 0 to 11 psi. Include the accessories for [control panel] [wall] [pipe] mounting.

2.18.3.3 Differential Pressure Gauge

Equip housing of each unit 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 must be within the mid-range of the gauge. Ensure accuracy is within 0.5 percent of full scale.

2.18.3.4 Piston Element

Provide piston type element consisting of a spring-supported, corrosion resistant piston moving inside a glass cylinder with an operating pressure of 1.03 MPa 150 psi. Provide cylinder with stainless steel end flanges with Viton O-ring seals and a cylinder burst pressure of no less than 4.15 MPa 600 psi. Construct the gauge such that a 3-valve manifold is not necessary. If only one bar stock valve is closed, do not damage the gauge by up to 2.1 MPa 300 psi differential pressure in either direction.

2.18.3.5 Bellows Element

Install bellows pressure sensing element to measure pressure differential

across the air moving equipment and dual opposed, liquid filled, rupture-proof type with bellows movement converted to rotation and transmitted by a torque tube. Provide stainless steel bellows housing with a rated working pressure of no less than 3.5 MPa 500 psi. Use liquid to fill the bellows that is 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

Perform continuous monitoring and recording of percentages of upper and lower explosive limits.

2.18.4.2 Hygrometer

Locate humidity sensor downstream of the heat exchanger or blower.

2.18.4.3 Sampler

Provide sampling port and equipment for collecting discrete and composite samples with adequate access for personnel and equipment.

2.18.4.4 Transmitter

Use transmitter to 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. Provide transmitter with built-in pulsation damper and suitable over-range protection. Do not require recalibration due to power outages. Transmitter must be UL listed for [Class 1, Division 1, Group D hazardous locations] [the electrical classification for the area as indicated on the drawings]. Supply each transmitter with a factory assembled five-valve stainless steel manifold. Furnish vent valves on upper ports of each transmitter. Mount and install transmitter according to manufacturer's recommendations.

2.18.4.5 Remote Indicator and Recorder

Display monitored parameters and excursion alarms locally on the control panel. Record digital data at intervals not exceeding one minute. Maintain process data in the control room and record on magnetic media in the approved micro computer compatible digital format. Flow information must include rate monitoring, integration and totalizing. Maintain hard copies of recorded data and summaries of recorded data in the control room. Ensure copies are available upon request.

2.19 CONTROL SYSTEM

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

Provide [a manual][an automatic] control system. Automatic controls are responsible for the balancing of the capacity with system requirements. Use these controls to automatically balance the equipment capacity with the load. Provide the system with the necessary control devices required for normal operation. TAlso 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 are 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.
****

Include logic 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 are subject to automatic control logic permissives. 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]. Provide additional controls or protective devices 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.
****

Install [automatically] [manually] controlled [adjustable guide vanes]

[line sized butterfly valve] 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.
****

[Install variable speed control to control output volume] [Provide automatically controlled bypass to recirculate directly around the blower] [Install manual line sized [unloading] [check] [butterfly] valve 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 must be [floor mounted] [wall mounted] [mounted with vibration isolators on the unit] and provided with hinged cover and latch. Provide direct reading type instruments that are factory mounted and connected. Connect shutdown feature to the annunciator on the instrument panel and identify each shutdown feature. 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

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

2.19.6.1 Bearing Temperature

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

****

Provide a set-point controller to monitor current input to the motor. Allow the controller to open and close the inlet [guide vanes] [butterfly valve] in response to current. Initiate automatic shutdown sequence and give visual indication of reason for shutdown if surge conditions are indicated by the motor current. Provide manual control and override to enable equipment startup and shutdown.

2.19.6.3 Oil Temperature and Pressure

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

2.20 ELECTRICAL EQUIPMENT

****

NOTE: Show hazardous area classification on the drawings.

****

Provide electrical equipment conforming to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical motor driven equipment herein specified complete with motors, motor starters, and controls. Provide electrical equipment and wiring 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

Drive each electric motor-driven unit by a weather-protected, Type [I][II][totally-enclosed fan cooled] continuous-duty electric motor. Provide motor with a [_____] service factor. Provide [squirrel-cage induction][synchronous] motors with normal-starting-torque and low-starting-current characteristics, and sized to avoid exceeding the nameplate power rating throughout the entire published characteristic curve. Provide premium efficiency type integral size motors in accordance

with NEMA MG 1. Use motor bearings to provide smooth operations under the conditions encountered for the life of the motor. Provide adquate thrust bearing in the motor to carry the weight of the rotating parts plus the hydraulic thrust that are capable of withstanding upthrust imposed during starting [and under variable head] conditions specified. Ensure motors are rated [_____] volts, [_____] phase, 60 Hz and such rating is stamped on the nameplate. Motors must conform to NEMA MG 1.

2.20.2 Control Equipment

[Manually controlled units must have START-STOP pushbutton in cover.][Automatically controlled units must have three-position MANUAL-OFF-AUTOMATIC selector switch in cover.] Provide additional controls or protective devices 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 must 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

Use variable speed drive to produce an adjustable ac voltage/frequency output for complete motor speed control. The variable speed drive must 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 must be self contained, totally enclosed in a NEMA MG 1 ventilated cabinet and capable of operation between 0 and 40 degrees C 32 and 104 degrees F. The variable speed drive maximum output current rating must be equal to or exceed the motor nameplate full load. The manufacturer must advise the maximum recommended motor sine wave current for each controller rating. Variable speed drive multiple motor operation at same frequency/speed must 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 must be [85] [90] [95] percent efficient at 100 percent of rated output power.

2.20.3.2 Governing Requirements

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

2.20.3.3 Basic Features

Provide variable speed drive with 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

Provide variable speed drive controller including 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 must 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

Install dielectric fittings between threaded ferrous and nonferrous metallic pipe, fittings and valves. Use dielectric fittings, suitable for the required working pressure, to prevent metal-to-metal contact of dissimilar metallic piping elements.

2.21.2 Isolation Joints

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

2.21.2.1 Sleeve-type Couplings

Use sleeve-type couplings for joining plain end pipe sections. The two couplings must 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

Use split-sleeve type couplings, in aboveground installations when approved in special situations, that 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 must be equal to the diameter of the pipe in which the valve is located unless otherwise indicated. Ensure valves are [screw] [socket weld] [buttweld] [sweat] [flange] connected. Rated operating conditions are [_____] degrees C F and [_____] kPa psig, minimum. Materials of construction are [aluminum] [bronze] [stainless steel] [_____] body, [bronze] [316 stainless steel] trim, and [Buna-N] [EPR] [Viton] [PTFE] elastomers. Mark valves 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.

****

Provide relief valve capable of maintaining a constant upstream pressure regardless of the downstream demand for each air mover. Valve must be [ASTM F1508 angle spring loaded] [weighted] [pilot-operated diaphragm] differential pressure relief valve with a [_____] percent accumulation. Rate valve to relieve [the full capacity of the air moving equipment] [[_____] cubic meters/second feet/minute]. Ensure vlve is factory-set to open at the [actual] [gauge] [pressure] [vacuum] of [_____] kPa psi and field adjustable within a minimum range of plus or minus 20 percent. Locate valve 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 must be [pilot-operated diaphragm valve with auxiliary solenoid operator] [butterfly valve] actuated by the system controls and field adjustable within a minimum range of plus or minus 20 percent. Set unloading valve 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.

****

Set combination relief and unloading valve 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.

****

Equip each vacuum unit with a manually adjustable, normally closed automatic purge valve. Ensure valve is factory-set to open at at the gauge pressure of 0.5 kPa 0.15 inches Hg and field adjustable within a minimum range of plus or minus 20 percent. Locate valve 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.

****

Provide [pilot-operated diaphragm type with auxiliary solenoid operator] [butterfly valve actuated by blower system controls] vacuum breaker to protect blower or vacuum pump from surges. Rate valve 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 must be [aluminum] [bronze] [stainless steel] body, [bronze] [316 stainless steel] trim, and [Buna-N] [EPR] [Viton] [Teflon] elastomers. Provide rating of 100 degrees C 212 degrees F and 1000 kPa 147 psi, minimum.

2.21.3.6 Check Valve

Provide 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. Prevent reverse flow and open at a controlled rate to keep air mover starting surges from shocking downstream equipment. Opening rate must 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 must be a [pilot-operated diaphragm valve with auxiliary solenoid operator] [butterfly valve actuated by system controls].

2.21.3.8 Back Pressure Valve

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

2.21.3.9 Manual Valve

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

2.21.4 Inlet and Discharge Elbows

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

2.21.5 Expansion Coupling

Provide inlet and the outlet of each unit 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

Provide [an air-to-air] [a water cooled] heat exchanger on the blower [inlet] [outlet] with sufficient capacity to reduce the air temperature [_____] degrees C F.

2.21.7 Flame Arrestor

Locate flame arrestor 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

Provide drip trap in accordance with ASTM F1139.

2.21.9 Liquid Receiver

Design, fit, and rate liquid receivers for 0.345 MPa 50 psi working pressure. Provide each receiver with a storage capacity no less than [_____] L gal. Equip each receiver with inlet and outlet drop pipe, drain with valve, relief valve and two bull's-eye liquid-level sight glasses. Ensure sight glasses are 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, provide external gauge glass with metal glass guard and automatic closing stop valves. The outside of liquid receivers must be galvanized or supplied with commercial enamel finish.

2.21.10 Air Receiver

Design receiver for 0.345 MPa 50 psi working pressure. Equip receivers with safety relief valves and accessories, including pressure gauges and automatic and manual drains. Design and construct receivers in accordance with ASME BPVC SEC VIII D1 and with the design working pressures specified herein. Provide 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. The outside of air receivers must be galvanized or supplied with commercial enamel finish.

2.22 BASE PLATE

Mount each unit on all-welded structural steel or cast iron base complete with vibration isolators with published load rating. Provide base plate with vertical jacking screws to facilitate leveling. Isolate the entire unit from the building structure.

2.23 WEATHERPROOF ENCLOSURE

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

Provide a weatherproof enclosure for the air moving equipment and motor assembly. Provide enclosure with lockable access doors and louvered for ventilation. [Insulate and equip the enclosure with a thermostatically controlled electric heating and ventilation.]

2.24 ATTACHMENTS

Provide shafts, chains or gear driven equipment with all-metal guards enclosing the drive mechanism. Construct guard of galvanized sheet steel, or galvanized woven wire, or expanded metal set in galvanized steel frame. Secure guards 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.
****

Clean and prime motors, casings and similar parts of equipment finished in the shop and give 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. Give ferrous surfaces not painted at the factory a shop coat of grease or other suitable rust resistant coating.

2.26 FACTORY TESTS

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

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

2.26.1 Integrity

Test each [impeller] [rotor] assembly by operating at a speed to [20] [_____] percent above operating speed and check for cracks using the dye penetrant method or similar method of equal accuracy.

2.26.2 Balance

Statically and dynamically balance rotating parts in accordance with

ISO 1940-1. First critical speed is at least 150 percent of maximum operating speed. Statically and dynamically balance the shaft and impeller or blade assembly 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 must 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 is not allowed to 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 is not allowed to exceed 2.5 microns 1.0 mil at the bearing housing with the equipment operating.] [Ensure peak vibration velocity is less than 7.62 mm/second 0.30 inch per second.]

2.26.5 Capacity

Determine volume and pressure characteristics of air moving equipment by the [manufacturer] [a nationally recognized testing agency] in accordance with AMCA 210. Submit certified test results and sample calculation from test readings 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

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

2.26.7 Variable Speed Drive

Subject each variable speed drive to an in-plant quality control inspection. Integrated circuits must undergo a 160-hour "burn-in" to test reliability. Cycle the temperature between 0 and 70 degrees C 32 and 158 degrees F during the "burn-in". Each completed unit must undergo a fully loaded 24-hour "burn-in".

2.26.8 Continuity

Check wiring and instrumentation assembled at the factory for continuity prior to shipping.

2.26.9 Receivers

Ensure receivers are factory air tested to 1.5 times the specified working pressure.

2.26.10 Valve Testing

Test relief valves 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.
****

Install vibration dampener in sufficient quantity to isolate each unit from the structural base on which the unit is installed. Install, align and level each air moving unit and motor in accordance with the written instruction of the manufacturer [and under the direct supervision of the manufacturer's representative]. [Deviation from horizontal must be below limits of measurement.] [Set impellers by the manufacturer's representative]. Do not use flexible couplings to compensate for misalignment between driver and driven unit. Blower venting is not allowed toviolate the provisions of either ACGIH 2098 or AMCA 99.

3.2.1 Concrete Foundations

Provide concrete for equipment foundations [as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE] [with a minimum compressive strength of at least 17 MPa 2,500 psi]. Provide concrete foundations that are [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]. Furnish foundation bolts, as required, 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 CONTROL FOR MISCELLANEOUS EQUIPMENT and 23 05 48.19 SEISMIC BRACING FOR MECHANICAL SYSTEMS, properly edited, must be included in the contract documents.
****

Support and bracequipment and attached valves to resist seismic loads as specified under UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR MISCELLANEOUS EQUIPMENT and 23 05 48.19 SEISMIC BRACING FOR MECHANICAL SYSTEMS[as shown on the drawings].

3.3 FIELD PAINTING

Do not paint stainless steel, galvanized steel, and nonferrous surfaces.

3.3.1 Touch-Up Painting

Clean factory painted items, requiring touching up in the field, of foreign material and prime top-coat 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

Paint equipment which did not receive a factory finish and other exposed ferrous surfaces as specified in Section 09 90 00 PAINTS AND COATINGS. Ensure coating is 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. Supervise the installing, adjusting, and testing of the equipment.

3.5 POSTING FRAMED INSTRUCTIONS

Post framed instructions containing wiring and control diagrams where directed. Post condensed operating instructions as specified. Post the framed instructions before acceptance testing of the systems.

3.6 FIELD TESTING

3.6.1 Deficiencies

If any deficiencies are revealed during any tests, correct such deficiencies and reconduct the tests.

3.6.2 Correct Installation

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, carry out operating tests to ensure that the installation operates properly. [Make arrangements to have the manufacturer's representative present when field equipment tests are made.] Give each unit 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 must 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. Identify test methods used and record test results. Indicate the final position of controls in each test report.

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. 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 --