UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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DIVISION 44 - POLLUTION AND WASTE CONTROL EQUIPMENT

SECTION 44 10 00

AIR POLLUTION CONTROL

10/07

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SECTION 44 10 00

AIR POLLUTION CONTROL
10/07

****
NOTE: This guide specification covers the requirements for air pollution control equipment and accessories for use with various pollutant emitters.

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 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 204	(2005; R 2012) Balance Quality and Vibration Levels for Fans
AMCA 210	(2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 300	(2014) Reverberant Room Method for Sound Testing of Fans
AMCA 801	(2001; R 2008) Industrial Process/Power Generation Fans: Specification Guidelines

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA)

AIHA Z9.3	(2007) Spray Finishing Operations - Safety Code for Design, Construction and Ventilation

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

ASHRAE 15 & 34	(2013) ASHRAE Standard 34-2016 Safety Standard for Refrigeration Systems/ASHRAE Standard 34-2016 Designation and Safety Classification of Refrigerants-ASHRAE Standard 34-2016
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 B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M	(2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2016) Malleable Iron Threaded Fittings, Classes 150 and 300

ASME B16.5	(2017) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.15	(2018) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.24	(2016) Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2020) Power Piping
ASME B31.3	(2016) Process Piping
ASME B31.5	(2020) Refrigeration Piping and Heat Transfer Components
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME PTC 19.3 TW	(2016) Thermowells Performance Test Codes
ASME PTC 38	(1980; R 1985) Determining the Concentration of Particulate Matter in a Gas Stream

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C700	(2015) Cold-Water Meters - Displacement Type, Metal Alloy Main Case

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2016) Standard Specification for Gray Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

ASTM A240/A240M	(2020) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A302/A302M	(2017) Standard Specification for Pressure Vessel Plates, Alloy Steel, Manganese-Molybdenum and Manganese-Molybdenum-Nickel
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A733	(2016) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM A924/A924M	(2020) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B42	(2020) Standard Specification for Seamless Copper Pipe, Standard Sizes
ASTM B68/B68M	(2011) Standard Specification for Seamless Copper Tube, Bright Annealed (Metric)
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2020) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM B280	(2020) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM D1248	(2016) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D2854	(2009; R 2019) Standard Test Method for Apparent Density of Activated Carbon
ASTM D2862	(2016) Standard Test Method for Particle Size Distribution of Granular Activated Carbon
ASTM F1139	(1988; R 2019) Steam Traps and Drains

HYDRAULIC INSTITUTE (HI)

HI 3.1-3.5	(2015) Rotary Pumps

INSTITUTE OF CLEAN AIR COMPANIES (ICAC)

ICAC EP-1	(2000) Terminology for Electrostatic Precipitators
ICAC EP-7	(2004) Electrostatic Precipitator Gas Flow Model Studies
ICAC EP-8	(1993) Structural Design Criteria for Electrostatic Precipitator Casings
ICAC F-2	(1972) Fundamentals of Fabric Collectors and Glossary of Terms
ICAC F-3	(2002) Operation and Maintenance of Fabric Filters
ICAC FGD-1	(1982) Flue Gas Desulfurization Terminology
ICAC G-1	(1968; R 1972) Gaseous Emissions Equipment: Product Definitions and Illustrations
ICAC WS-1	(1975) Wet Scrubber Terminology
ICAC WS-3	(1976; R 1980) Basic Types of Wet Scrubbers
ICAC WS-4	(1975) Wet Scrubber System-Major Auxiliaries

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-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

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
NEMA SM 23	(1991; R 2002) Steam Turbines for Mechanical Drive Service

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
NFPA 91	(2020) Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists and Noncombustible Particulate Solids
NFPA 496	(2021) Standard for Purged and Pressurized Enclosures for Electrical Equipment

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019) Structural Engineering

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

29 CFR 1910	Occupational Safety and Health Standards
40 CFR 50	National Primary and Secondary Ambient Air Quality Standards
40 CFR 60	Standards of Performance for New Stationary Sources

UNDERWRITERS LABORATORIES (UL)

UL 5	(2016; Reprint Aug 2020) UL Standard for Safety Surface Metal Raceways and Fittings
UL 674	(2011; Reprint Nov 2018) UL Standard for Safety Electric Motors and Generators for Use in Hazardous (Classified) Locations
UL 823	(2006; Reprint Apr 2016) UL Standard for Safety Electric Heaters for Use in Hazardous (Classified) Locations
UL 900	(2015) Standard for Air Filter Units
UL 1203	(2013; Reprint Jan 2020) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations

1.2 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

Approved Detail Drawings; G[, [_____]]

SD-03 Product Data

Emission Monitoring System

Air Pollution Control Equipment

Instrumentation and Controls

Training

System Performance Test; G[, [_____]]

SD-06 Test Reports

Factory Tests

System Performance Test;

SD-07 Certificates

Manufacturer's Field Representative

SD-10 Operation and Maintenance Data

Air Pollution Control Equipment; G[, [_____]]

Accessories; G[, [_____]]

1.3 QUALIFICATIONS

1.3.1 Welding

****
NOTE: If the need exists for more stringent requirements for weldments, delete the first bracketed statement and the last bracketed statement applies. Dust collection equipment covered by the guide specification is not normally manufactured to the requirements of the ASME Boiler and Pressure Vessel code. Welding of these vessels will be governed by Section 05 50 14 STRUCTURAL METAL FABRICATIONS.
****

[Piping shall be welded in accordance with qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests and the tests shall be furnished at the work site if practicable. The Contracting Officer shall be furnished a copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators. The welder or welding operator shall apply his assigned symbol near his welds using a rubber stamp or felt-tipped marker with permanent weatherproof ink or other methods approved by the Contracting Officer that do not deform the metal. Structural members shall be welded in accordance with Section 05 05 23.16 STRUCTURAL WELDING.] [Welding and nondestructive testing procedures are specified in Section 40 05 13.96 WELDING PROCESS PIPING.] Nonpressure dust collection vessels shall be welded in accordance with provisions of Section 05 50 14 STRUCTURAL METAL FABRICATIONS.

1.3.2 Contractor

Contractor shall have had a minimum of [2][3][5][_____] years of experience in the construction and maintenance of industrial air pollution control systems.

1.3.3 Manufacturer's Field Representative

Services of a manufacturer's field representative and training engineer, who is experienced in the installation, adjustment, and operation of the equipment furnished, and who has complete knowledge of the proper operation and maintenance of the system, shall be provided. Field representative shall be onsite to supervise the installation, adjustment and compliance testing of the equipment. Field representative shall provide supervision of the system for [_____] days after startup of the system.

1.4 CONSTRUCTION REQUIREMENTS

System shall be suitable for [indoor] [outdoor] installation and shall be provided [with] [without] a weather enclosure. [Unit shall be provided

with [_____] mm inch of insulation with a k value of [_____] W/m K Btu/h ft] [Unit shall not be insulated]. System shall be designed for [a wind load of [_____] kph mph] [and] [an internal [negative] [positive] static pressure of [_____] Pa inch of water gauge]. [System shall be designed for a snow load of [_____] kPa psf]. Seismic protection of equipment shall be in accordance with UFC 3-301-01, Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT, Section 23 05 48.19 [SEISMIC] BRACING FOR HVAC, and Section 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

1.5 DELIVERY, STORAGE, AND HANDLING

Store all equipment delivered and placed in storage as recommended by the manufacturer, with protection from the weather, humidity and temperature variation, dirt and dust, or other contaminants.

1.6 EXTRA MATERIALS

****

NOTE: Include items needed for future maintenance and repair, items that might be difficult to obtain and spare parts needed to ensure continued operation of critical equipment.

****

Auxiliaries for maintenance shall be provided with the equipment and shall include all special tools, rigs, jigs, fixtures, equipment, or other devices required for normal operation and service. Any equipment required for routine maintenance such as filter wash facilities, oil or refrigerant removal, and replacement devices shall be provided. Tests or measurement instruments or gauges shall be included. The following shall also be furnished:

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

b. [One set of special tools for each type of equipment, including calibration devices, and instruments required for adjustment, calibration, disassembly, operation, and maintenance of the equipment.] [One set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment].

[c. One or more steel tool cases mounted on the wall in a convenient location complete with flat key locks, two keys, and clips or hooks to hold each special tool.]

[d. [_____].]

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The system shall consist of 9.5 mm 3/8 inch [carbon steel] [alloy] [stainless steel] scrubber vessel(s), insulated electrostatic grid(s), transformer-rectifier(s), high voltage control section, pea-sized gravel media, media circulation system including lift, air blower(s), piping, valves, and seal legs, dust collection and separation system, and controls. Dirty gas shall enter the dry scrubber vessel which shall

contain several louvered concentric tubes. The annular space between the inner wall of the vessel and the outer louver wall shall be filled with circulating pea-size gravel media. Prior to entering the scrubber, the dirty gas shall pass an ionization electrode or grid in the two-grid`unit where the dust particles are electrostatically charged. In both grid configurations, dirty flue gas shall pass through the circulating gravel media which has been converted to the equivalent of a collecting electrode by the high voltage bed electrical grid. Particulate shall be separated from the gas by both impaction and electrostatic collection, and deposited on the circulating gravel. The cleaned gas shall exit the downstream duct of the scrubber. The dust-laden gravel shall drop into a hopper(s) from which it shall be air lifted to the separation or deentrainment chamber. The dust shall be separated from the gravel by the airlift action and shall exit the top of the deentrainment chamber to the collection and disposal system. The cleaned media shall be returned to the scrubber vessel.

2.2 MATERIALS

2.2.1 Standard Products

Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products. Items of equipment shall essentially duplicate equipment that has been in satisfactory use at least 2 years prior to bid opening. Equipment shall be supported by in-service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site. In-service organization shall respond to a service call within [_____] hours [_____] days.

2.2.2 General Requirements

Equipment and appurtenances shall be as specified and as shown on the approved detail drawings, and shall be suitable for the service intended. Materials and equipment shall be new and unused, to include testing equipment furnished under the contract. Components that serve the same function and are the same size shall be identical products of the same manufacturer.

Detail drawings contain complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

2.2.3 Nameplates

Each major component of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the equipment. Each piece of equipment shall bear the approval designation and the markings required for that designation. Valves shall be marked in accordance with MSS SP-25 and shall bear a securely attached tag with the manufacturer's name, catalog number and valve identification permanently displayed.

2.2.4 Equipment Guards[and Access]

****

NOTE: Catwalk, ladder, stair, and guardrail may be required. If so, select the applicable item, delete

the others, and indicate on drawings the selected item.
****

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts so located that any person may come in close proximity thereto, shall be enclosed or guarded to prevent accidental personal injury, in accordance with 29 CFR 1910, Subpart O, Machinery and Machine Guarding. Guards shall be removable and arranged to allow access to the equipment for maintenance. High-temperature equipment and piping so located as to endanger personnel or to create a fire hazard shall be guarded or covered with insulation of type specified for service. [Items such as[catwalk,][stair,][ladder,][and][guardrail] shall be provided where shown and shall be in accordance with Section [08 31 00 ACCESS DOORS AND PANELS][05 51 33 METAL LADDERS]]

2.3 GAUGE

****
NOTE: Pipe, fitting, and valve materials listed in this section are suitable for water service, but not for corrosive, erosive, and some petrol services. The designer should select the proper alloy (e.g., stainless steel 304, 316, etc.), rubber or other elastomer lining or plastic for these and other applications where the chemistry of the process shall dictate material selection.
****

Gauge shall conform to the following:

2.3.1 Draft Gauge

ASME B40.100. Tubing for gauges for service above 66 degrees C 150 degrees F shall conform to ASTM B68/B68M; for service below 66 degrees C 150 degrees F, plastic tubing conforming to ASTM D1248 may be used.

2.3.2 Gauges, Pressure and Vacuum

ASME B40.100, range suitable for the related conditions.

2.4 LOW-WATER CUTOFF

****
NOTE: Low-water cutoff applies to all wet scrubber tanks, reservoirs, and sumps if low level or loss of water can affect scrubber or boiler operation and safety. Coordinate requirement for deenergizing boiler panel to stop firing the boiler if scrubber components are subject to damage from excess heat in a loss of water supply.
****

Low-water cutoff shall be provided for all scrubber liquid sumps, holding tanks, reservoirs, and mixing tanks. Cut-off shall cause a safety shutdown of the scrubber and shall be provided with auxiliary contacts to be used to sound an alarm. [Low-water shutdown shall require a manual reset before any equipment can recycle or operate.]

2.5 PIPE, FITTINGS, AND TUBING

Pipe, fittings, and tubing shall conform to the following:

2.5.1 Pipe

ASTM A53/A53M, Type S, Grade A, standard weight; or copper pipe, ASTM B42.

2.5.2 Nipples

ASTM A733, standard weight to match adjacent piping.

2.5.3 Pipe Fittings

2.5.3.1 Steel Pipe Fittings

ASME B16.9 for butt-welding fittings; ASME B16.11 for socket-welding fittings; and ASME B16.5 for flanged fittings.

2.5.3.2 Brass or Bronze Pipe Fittings

ASME B16.15, Class A, 862 kPa 125 pound.

2.5.3.3 Malleable-Iron Pipe Fittings

ASME B16.3, type to match adjacent piping.

2.5.3.4 Unions

ASME B16.39, type to match adjacent piping.

2.5.3.5 Flanges, Cast-Iron and Bronze

ASME B16.1 and ASME B16.24.

2.5.3.6 Pipe Threads

ASME B1.20.2MASME B1.20.1.

2.5.4 Tube, Copper

2.5.4.1 Tube for Air, Water, Gas, and Drains

ASTM B68/B68M or ASTM B88M ASTM B88.

2.5.4.2 Tube for Refrigeration Systems

ASTM B280.

2.6 STEEL SHEET

Steel sheets shall conform to the following:

2.6.1 Zinc Coated (Galvanized)

ASTM A653/A653M;ASTM A924/A924M for dust collector casings, housing, and components. Gauges specified are manufacturers' standard gauge.

2.6.2 Low-Carbon

Gauges specified, for dust collector casings, housings, and components, refer to manufacturers' standard gauge.

2.6.3 Corrosion Resistant

ASTM A167, Class 304 or 316. Gauges specified refer to U.S. Standard Gauge.

2.7 AIR TRAPS

Air traps for removal of moisture from plant compressed air supplied to air pollution control equipment shall conform to ASTM F1139.

2.8 THERMOMETERS

Thermometers shall conform to ASME PTC 19.3 TW with wells and temperature range suitable for the use encountered.

2.9 VALVES

Valves shall conform to the following:

2.9.1 Angle Valves

MSS SP-80, Types 1, 2, or 3, Class 125, except that valves over 80 mm 3 inch shall have iron bodies and brass or bronze standard trim with glands or followers in the stuffing boxes. Valves shall have nonmetallic renewable composition discs and raised flat seats designed for 862 kPa 125 psi steam. Wheels shall be secured with hexagonal nuts.

2.9.2 Check Valves

MSS SP-80, Types 1, 2, 3, or 4, Class 125, as required. Valves over 80 mm 3 inch shall have iron bodies and shall be the swing type designed for 862 kPa 125 psi steam. Check valves shall have renewable composition discs or shall have metallic discs of the regrinding type to permit regrinding without removing valve from the line.

2.9.3 Gate Valves

Sizes of 40 mm 1-1/2 inch or less, MSS SP-80, Class 125, Type 1 and 2; 50 mm 2 inch size and over, MSS SP-70, Class 125 or 250, as specified; outside screw and yoke with threaded end (design OT), or flanged end (design OF), as required.

2.9.4 Globe Valves

MSS SP-80, Type 1. Valves over 80 mm 3 inch shall have iron bodies and brass or bronze standard trim and shall have glands or followers in the stuffing boxes. Valves shall have nonmetallic renewable composition discs and raised flat seats designed for 1035 kPa 150 psi steam. Wheels shall be secured to the stems with hexagonal nuts.

2.10 WATER METERS

Water meters shall be the disc type with reinforced disc for hot water above 66 degrees C 150 degrees F, and rubber or carbon disc for cold

water, and shall be constructed of bronze composition or cast iron protected by noncorrosive coating. Moving parts subject to wear shall be easily replaceable. Meters shall conform to the requirements of AWWA C700.

2.11 ELECTRICAL WORK

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NOTE: Indicate on drawing the type and class of motor enclosure depending on environment in which the motor is to be used.

****

Electrical motor-driven equipment specified shall be provided complete with motors, motor starters, and controls. Electrical equipment and wiring shall be in accordance with [Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM]. [Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION]. [Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION]. Electrical characteristics shall be as indicated or specified. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control specified. Each motor shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified but not shown, shall be provided. Motors shall conform to NEMA MG 1, with enclosures as indicated [except as specified for Petrol Vapor Recovery Unit]. Controls, interlocks, instruments, status indication lights, and other devices required for operation and observation of equipment status shall be assembled on an [open face panel] [enclosed panel with [latched door] [key locked door]]. Panel shall be [factory-assembled, connected to equipment, and mounted on unit] [or] [factory assembled and boxed for field installation]. [Instrumentation and control system shall include local control panels and a central control panel located in the facility control room. The control system shall integrate local controls provided with equipment, as specified, so that complete system operation can be monitored and controlled from the control room]. The air pollution control system shall be integrated with the emission generating equipment. The control system shall provide integrated control of all system processes and equipment, and shall contain all necessary instrumentation required for monitoring and operation of the air pollution control system. Control system panels shall graphically display the system. Local control panels shall be provided with selector switches so that equipment can be operated manually for test and maintenance purposes. Suitable safety interlocks shall be incorporated to assure that proper permissive conditions have been met prior to changing the operating status of major system components. Shutdown of the air pollution control equipment system, or portion thereof, shall be automatically initiated, with alarms should unsafe conditions arise during operation of the system. Visible and audible alarms shall be provided on critical functions locally. and at central control room. Controls shall conform to NEMA ICS 1. Enclosures for power and control panels shall conform to NEMA ICS 6.

2.12 DRAFT FANS

****

NOTE: In new installations, coordinate design with boiler or incinerator specification. For retrofit, fans will be sized for air pollution control

equipment. For fans operating in corrosive or erosive environment, provide liners for scroll sheets and rotor blades. References to draft fans will be deleted if inapplicable for the equipment specified.

****

Centrifugal fans conforming to AMCA 801 [Type I] [Type II] [forced draft] [and] [induced draft] shall be furnished as an integral part of air pollution control equipment design. Fans shall be [centrifugal] [_____] with [backward curved blades] [radial tip blades] [or] [axial flow type]. Each fan shall be sized for an output volume and static pressure rating sufficient for pressure losses, leakages, temperature, and elevation corrections for worst ambient conditions. In addition, fan sizing shall include margins of 10 percent volume and 21 percent static pressure, plus margins of [5] [_____] degrees C [10] [_____] degrees F for forced draft fans and [22] [_____] degrees C [40] [_____] degrees F for induced draft fans. [Induced draft fans shall be provided with outlet dampers]. Noise levels for fans shall not exceed 85 decibels in any octave band at a 914 mm 3 foot station. Fan bearings shall be [air cooled] [or] [water cooled], and backward curved fan blade type with bearings not requiring water cooling may be of the self-aligning antifriction type. [Scroll sheets and rotor blades shall have liners.]

2.12.1 Draft Fan Control

****

NOTE: Variable speed control, inlet vane control, and inlet damper control are, in descending order of efficiency, capable of control draft fan conditions. The choice is based on economics. However, in erosive services, inlet vane control is not desirable.

****

Forced draft centrifugal fans shall have [inlet vane control] [variable speed control] where indicated. Induced draft centrifugal fans shall have [inlet vane control] [inlet damper control] [variable speed control]. [Axial propeller fans shall have variable propeller pitch control and variable speed drive.] Inlet vanes or dampers shall be suitable for use with air pollution control equipment.

2.12.2 Draft Fan Drives

****

NOTE: Where motor starters for mechanical equipment are provided in motor control centers, delete the reference to motor starters.

Steam driven boiler auxiliaries will not be used unless the exhaust steam can be utilized completely. Reference to steam drives will be deleted if inapplicable for the equipment specified.

****

Fan shall be driven by [an electric motor] [or] [a steam turbine]. [Electric motor shall be [drip-proof] [totally enclosed nonventilated] [totally enclosed fan-cooled] [totally enclosed fan-cooled], suitable for installation in a Class II, Division 1, Group F, hazardous location

conforming to NFPA 70]. [Motor starter shall be magnetic [across-the-line] [reduced voltage start] type with [general-purpose] [weather-resistant] [water tight] [dust-tight] [explosion-proof] enclosure and shall be furnished with four auxiliary interlock contacts]. [Steam turbines shall operate properly with a steam inlet pressure of [_____] Pa psig and with steam back pressure of [_____] Pa psig. Turbines shall have horizontally-split, centerline support casings, water-cooled bearing housings with ring-oiled, babbitt-lined, bronze packed sleeve bearings. Turbines shall also be equipped with a mechanical shaft speed governor and valve, and independent emergency overspeed governor and trip valve, reed tachometer, constant pressure type governor, insulation with removable metal jacket, oil-sight glasses with guards, removable stainless steel steam strainer [without disconnecting piping], any special wrenches and tools required for servicing turbine, and a sentinel warning on the exhaust casings. Turbines shall conform to NEMA SM 23].

2.13 DUCTWORK

****

NOTE: References to ductwork will be deleted if inapplicable for the equipment specified. Ductwork thickness or gauge will depend on both size and pressure.

****

Ductwork shall be [galvanized sheet metal conforming to ASTM A653/A653M] [_____] with a minimum thickness of [_____] mm [_____] gauge [_____] inch [_____] gauge. Ductwork shall be designed to convey air with a minimum of pressure loss due to friction. Ducts shall be straight and smooth on the inside with laps made in the direction of airflow. Ducts shall be externally braced and shall be so installed and anchored as to be free of vibration. Access and inspection doors shall be provided as indicated, with a minimum of one in each section between dampers or items of equipment. Ducts shall be constructed with long radius elbows having a centerline radius of 1.5 times the duct width, or where the space does not permit the use of long radius elbows, short radius or square elbows with factory-fabricated turning vanes may be used. Duct joints shall be substantially air-tight and shall have adequate strength for the service.

2.14 AIR POLLUTION CONTROL EQUIPMENT

****

NOTE: Delete all equipment requirements not required on the project. Title 40, Part 60 of the Code of Federal Regulations for Protection of Environment (40 CFR 60), state and local codes contain regulations pertaining to air pollution control. 40 CFR 60 contains Standards of Performance for New Stationary Sources. In addition, EPA Test Report No. AP-42 with latest supplements contains emission factors for the specific pollutant emitter (uncontrolled). Determine the degree of required pollutant removal from the gas stream to meet the more stringent of local, state and EPA regulations and indicate whether EPA, state or local regulations apply. With the information thus obtained, determine the most effective and economical air pollution control equipment required. This process will be repeated

for each pollutant emitter identifying the pertinent regulation. Indicate on drawings for each pollution control equipment electric power requirements including motor sizes, etc., where applicable. Coordinate performance, operation, and control of pollution control equipment with all other related system components to assure total system operation and that safety requirements are met. Indicate on drawings any such items as walkways, guardrails, stairs, and ladders furnished as part of the pollution control equipment, if required.

****

Performance of equipment shall be as indicated in Paragraph SCHEDULES. [Paint spray and wet process gas ductwork shall comply with AIHA Z9.3 and NFPA 91.][Air and water piping shall comply with ASME B31.1.][Particulate emission control equipment shall conform to ASME PTC 38].[Equipment shall be provided with steel walkways, safety rails and stairs, or ladders as indicated. Access shall be by means of [caged ladders][step stairs with handrails]].

a. Submit a complete list of equipment and material, including manufacturer's descriptive data and technical literature, performance charts and curves, catalog cuts, and installation instructions. Spare parts data for each different item of material and equipment specified, after approval of detail drawings and not later than [_____] months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply.

b. Submit proposed diagrams, instructions, and other sheets, prior to posting. Framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, including equipment, piping, valves, and control sequence, shall be posted where directed. Condensed operating instructions explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams, and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the system.

c. Submit detailed manufacturer's data on the instrumentation and controls. Include overall controls, sensors, process controllers, control operators, ladder diagrams, timers, sequence of controls, valves, alarms, signals, interlocks and cut off systems. Data describing in detail the equipment used to monitor emissions, including the sampling probe, filters, sampling pump, moisture separator/drier, tubing, analyzer, analyzer calibration system, data recorder, and alarms. Process and instrumentation diagrams (P&IDs).

2.14.1 Dry Dynamic Precipitator

****

NOTE: Select construction features required including drive component and delete all others. Dry dynamic precipitators may be used for collecting coarse dry particulates from coal crusher, conveyor, and bunker ventilation where the objective is to

control material losses and to remove coarse fly-ash particulates from boiler flue gases of chain-grate or stoker-fired boilers. It is not effective in removing gaseous pollutants or particles of 7 micrometers and under.

****

Unit must be a mechanical collector consisting of a motor-driven fan, a fan casing, a hopper or dust bin, fan motor, fan motor starter with overload protection, [fan drive coupling] [belt drive with fan and motor pulleys and adjustable motor base], fan and motor mounting base on hopper, and a [ceiling mounting] [floor mounting] stand for the entire assembly. The fan shall comply with AMCA 99, Section 99-0401, Classification for Spark Resistant Construction, AMCA 210, and AMCA 300.

2.14.1.1 Fan Impeller

Fan Impellers must be steel and designed to provide the static head required for pumping the dirty and cleaned gas streams through the duct systems and related components. Impeller shall be keyed and locked on a cold drawn, turned and polished steel shaft mounted on heavy duty grease or oil lubrication ball or roller bearings. Shaft shall have a diameter and stiffness that will limit deflection at the maximum shaft loading, within the operating range of the fan, to not more than 0.167 mm/meter 0.002 inch/foot of shaft. Shaft shall be provided with a locked key slot for mounting a pulley, a direct drive, or coupling. The entire rotating assembly shall be dynamically balanced at operating speeds. Fans shall be dynamically balanced and factory-tested in accordance with AMCA 204 at the design operating RPM to Fan Application Category BV-3, Balance Quality Grade G6.3 or approved equivalent. Installed vibration levels shall not exceed the levels specified in AMCA 801.

2.14.1.2 Fan Casing

Fan casing shall be abrasion resistant cast iron conforming to ASTM A48/A48M or abrasion resistant steel consisting of a fan support base with back-housing, involute fan discharge scroll with inlet and discharge duct connections, and a dirt discharge port. Scroll shall be provided with readily replaceable wear plates and shall be constructed to permit field positioning the direction of discharge in at least eight different directions. Scroll shall provide means for accumulating and diverting the bulk of the particulate enriched gas stream into the hopper before the gas stream is returned to the inlet to the scroll.

2.14.1.3 Hopper Storage

****

NOTE: Determine the rate and quantity of pollutant material collected, the final disposition of the material, and the manner and frequency of transport to disposal location. From this, determine the hopper size to be indicated and select the bracketed hopper outlet. Delete those not selected.

****

Hopper storage capacity shall be as indicated. Unit shall be constructed of not less than 3.4 mm 10 gauge [welded low carbon] [corrosion resistant] steel plate for the vertical sides and bottom which shall be sloped steeper than the slump angle of the material being collected to minimize

bridging over at the outlet. Top shall be constructed to support the fan, motor, and drive without buckling or being resonated by the fan and shall be not less than 6.4 mm 1/4 inch thick. Hopper shall be provided with an access door and shall have [a manually-operated rotary lock] [a motor-driven rotary lock] [a guillotine-type slide gate].

2.14.1.4 Test Connections

Pressure test connections shall be provided at the suction and discharge ducts connecting to the precipitator.

2.14.2 Wet Dynamic Precipitator

****

NOTE: Select construction features required including drive component and delete all others. Wet dynamic precipitators are frequently used for ventilation air cleaning of coal crushing, conveying, and storage facilities where the dust loading is 1 to 4.6 grams per cubic meter 1/2 to 2 grains (weight) per cubic foot of air and the particles are 50 percent or more of 2 to 7 micrometers size. It will remove some gaseous pollutants.

****

Unit shall be a mechanical collector consisting of a motor-driven fan, a fan casing with water sprayhead, [a hopper or slurry bin,] fan motor, fan motor starter with overload protection, [fan drive coupling,] [belt drive with fan and motor pulleys and adjustable motor base,] [fan and motor support on [the hopper] [a rigid structural steel base] arranged for [floor mounting]]. Fan shall comply with AMCA 99,Section 99-0401, Classification for Spark Resistant Construction, AMCA 210, and AMCA 300.

2.14.2.1 Collector

****

NOTE: Delete inapplicable materials and equipment. Pipe, fitting, and valve materials listed in this section are suitable for water service, but not for corrosive, erosive, and some petrol services. The designer should select the proper alloy (e.g., stainless steel 304, 316, etc.), rubber or other elastomer lining or plastic for these and other applications where the chemistry of the process shall dictate material selection.

****

Collector shall consist of a heavy steel plate fan housing constructed of low carbon steel. Fan shall have ASTM A240/A240M stainless steel blades and rivets. Blades shall be fastened to a heavy forged steel hub mounted on a forged, ground, and polished ASTM A302/A302M stainless steel shaft supported on ball or roller bearings. Shaft shall have a diameter and stiffness that will limit deflection at the maximum shaft loading to not more than 0.167 mm/meter 0.002 inch/foot of shaft. Impeller and driven units shall be lock-keyed to the shaft with the entire assembly dynamically balanced at all operating speeds. Fans shall be dynamically balanced and factory-tested in accordance with AMCA 204 at the design operating RPM to Fan Application Category BV-3, Balance Quality Grade G6.3

or approved equivalent. Housing and impeller shall be provided with components that will provide for uniformly covering rotating and stationary parts with a film of moving water to provide for wetting and capturing of centrifugally impinged particulates. Means shall be provided for separation from the air stream and drainage of the water and particulate slurry from the collector. Installed vibration levels shall not exceed the levels specified in AMCA 801.

2.14.2.2 Hopper Storage

****

NOTE: Determine hopper storage capacity and indicate an open drain or valved outlet. Omit entire paragraph if hopper is not required for an installation piped to drain filtrate to a coal recovery or ash pit.

****

Hopper storage capacity shall be as indicated. Unit shall be constructed of not less than 3.4 mm 10 gauge [welded black] [welded corrosion resistant] steel plate for the vertical sides and sloped bottom. Top shall be constructed to support the fan, motor, and drive without buckling or being resonated by the fan and shall be not less than 6.4 mm 1/4 inch thick. Hopper bottom shall be sloped for complete drainage of slurry of collected material; shall be free of ledges and pockets; and shall provide for full free flushing of particulate when operating wet. Hopper shall be provided with an inspection window, cleanout, and access door. Hopper shall be provided with electric heating coils, modules, or blankets to keep collected material dry and free flowing with the unit installed outdoors and out of service in a local winter outdoor design temperature of [_____] degrees C degrees F.

2.14.2.3 Nonstainless Components

Water wetted, nonstainless components shall be coated with a permanently bonded, abrasion and corrosion resistant rubber facing suitable for the operating temperature of the gas stream.

2.14.2.4 Water Supply Components

****

NOTE: If water supply is unlimited, the pressure gauges, rate adjustment, and flow meter within brackets are not needed and should be deleted.

****

Precipitator shall be provided with water supply components sized to meet equipment capacity requirements and shall include:

a. A stainless steel water supply strainer with removable screen, flow control valve [with rate adjustment] [pressure gauge] [low pressure alarm switch] [water meter].

b. Analog solenoid water flow control valve.

c. Adjustable water pressure control switch with contacts to open on low pressure to stop or prevent operation of the fan motor if water pressure is below the minimum required for efficient operation of the collector. [An additional set of contacts to close on low pressure to

permit operation of an annunciator alarm.] The adjustable range of the switch trip shall be from [_____] to [_____] kPa [_____] to [_____] psig.

d. Water pressure gauges with 0 to 690 kPa 0-100 psig range.

e. Adjustable automatic water pressure or water flow rate regulator to provide a steady controlled rate of water flow as required for optimum collector performance.

f. Water flow meter sized for rate required by the collector.

2.14.2.5 Test Connections

Pressure test connections shall be provided at the suction and discharge ducts connecting to the precipitator.

2.14.2.6 Drain Connections

Slurry drain connections shall be screwed or flanged pipe connections sized as recommended by the manufacturer.

2.14.3 Conical Dry Dust Collector

****

NOTE: The conical dry dust collector removes up to 80 percent by weight of particles, 10 micrometers and over, from a gas stream and is used primarily on general industrial dusts and occasionally to clean boiler flue gases since it has a temperature tolerance up to 371 degrees C 700 degrees F. It is not effective in removing gaseous pollutants or particles of 7 micrometers size and under. Its high air friction drop may require a booster fan. It normally is selected for pressure drops in the 890 Pa to 1652 Pa 3-1/2 to 6-1/2 inch water gauge range at operating conditions.

****

Unit shall be a mechanical collector consisting of a top horizontal involute scroll gas inlet and outlet mounted over a vertical cylindrical shell or cone which shall have a narrow angle cone below. Unit shall be specifically designed to impart a high velocity vortex spin to the incoming downflowing gas stream to throw particulates to the wall of the cylinder and cone before turning upward in an internal vortex to the outlet. Replaceable wear plates [are] [are not] required.

2.14.3.1 Scrolls, Cylinder, and Cone

****

NOTE: Delete inapplicable materials and equipment. Pipe, fitting, and valve materials listed in this section are suitable for water service, but not for corrosive, erosive, and some petrol services. The designer should select the proper alloy (e.g., stainless steel 304, 316, etc.), rubber or other elastomer lining or plastic for these and other applications where the chemistry of the process shall dictate material selection.

****

Scrolls, cylinder, and cone shall all be not less than [3.4 mm 10 gauge] [4.8 mm 3/16 inch] [9.5 mm 3/8 inch] [welded black] [corrosion resistant] steel. Inlet and outlet scrolls shall be connected for [clockwise] [counterclockwise] connection and rotation of the vortex when looking down on the collector. Four equally spaced, welded steel support brackets shall be provided on the bottom of the inlet scroll or on the vertical walls of the cylindrical section of the collector. The collector cone shall not be used for storage. Particulate shall be removed and collected, and cone bottom shall be provided with an air-tight seal. [A guillotine-type slide gauge] [A manually-operated rotary lock] [A motor-driven rotary lock] shall be provided on the [bottom of cone] [bottom of surge tank] [bottom of storage receptacle].

2.14.3.2 Test Connections

Pressure test connections shall be provided at the inlet and outlet ducts connecting to the collector.

2.14.4 Multitube, Centrifugal Dry Dust Collector

****

NOTE: The multitube centrifugal dust collector has similar performance to the conical dry dust collector except it removes more of both coarse and fine particulates. This collector is often used on stoker-fired boiler applications. The pressure drop range is normally 635 Pa to 1144 Pa 2.5 to 4.5 inches water gauge at operating conditions. Sixty degree hopper valley angle is considered adequate for worse case coal/ash scenario. If designer can confirm that application is less demanding, he should consider a lower valley angle 55 degrees or 45 degrees. In certain applications the size of the unit may require some subassembly in the field, negating the restrictions on field assembly.

****

Unit shall be a mechanical collector utilizing a number of parallel vertical or horizontal tubes of small diameter in an enclosure having a single gas inlet and single gas outlet.

2.14.4.1 Inlet Tube Assemblies, Casing and Hopper

Inlet tube assemblies shall be replaceable [cast iron] [wear resistant steel with replaceable cast iron spinner vanes and cones] [wear resistant steel with replaceable spinner vanes and cones]. Casing shall be [3.4 mm 10 gauge] [4.8 mm 3/16 inch] [6.4 mm 1/4 inch] [low carbon] [corrosion resistant] steel with the dust released into a [3.4 mm 10 gauge] [4.8 mm 3/16 inch] [6.4 mm 1/4 inch] [black] [corrosion resistant] steel sloped bottom dust hopper. Hopper valley angle shall be 60 degrees from the horizontal. The hopper shall be provided with a poke hole and access door. Hopper bottom outlet shall be provided with [a guillotine-type slide gate] [a gravity-type trip gate opened by the weight of the collected material] [a manually-operated rotary lock] [a motor-driven rotary lock]. Unit shall be provided with a welded steel support assembly for field erection with no additional work other than setting and bolting the unit in place.

2.14.4.2 Test Connections

Pressure test connections shall be provided at the inlet and outlet ducts connecting to the collector.

2.14.5 Electrostatic Precipitator (ESP)

****

NOTE: Electrostatic precipitators are highly effective with efficiencies up to 99.9 percent by weight in removing fine particulates down to 0.3 micrometers in size from gas streams having light loading of material by weight. They are frequently applied in gas streams of 371 degrees C 700 degrees F or higher but may require a precleaner such as a dynamic precipitator, conical, or multitube centrifugal to bring the gas stream down to an optimum loading. They require a relatively large space. They have a very low gas flow friction but are quite sensitive to having a uniform distribution of gas flow through the unit. The efficiency may sharply fall under a gas flow above design rate. Efficiency is also affected by dust particle electrical resistivity which can be too high or too low for maximum performance. Frequently in these situations the addition of relatively small quantities of flue gas conditioning agents have been very effective in improving precipitator performance. Depending on the particle electrical resistivity level, flue gas conditioning will be considered a viable option. Commercial systems are available for ammonia, sodium compounds (carbonate and sulfate), and sulfur trioxide flue gas addition. Pulse energization, the modification to a conventional precipitator power supply to include the capability to superimpose a high voltage pulse on the base voltage, is a second enhancement technique for high resistivity particle applications. Intermittent pulsation, the programmed interruption of normal high voltage waveform, is another enhancement technique. Optimization of precipitator energization and rapping systems through the use of microprocessor-based controls results in lower power levels, reduced electrode failure, and overall improved collection efficiency. Examples of control schemes that can be accomplished with properly programmed microprocessors include:

a. Spark Prediction and Advance

b. Back Corona Detection

c. Opacity Feed Back

d. Rapping Optimization

e. Electrical Power Conservation

Reentrainment of collected material can be limited by a proper balance of factors that affect performance, such as gas velocity through the plates; uniformity of gas velocity profile; ratio of plate height to depth; size of lumps of agglomerated material rapped from the collecting plates and discharge electrodes; and others. Control may also be achieved by a system of automatic programmed gas flow dampers coordinated to operate with related rappers for sequential cleaning of each of the chambers.

Power consumption is generally equivalent to the additional power required by other collecting methods. The pressure drop across units is typically less than 127 Pa 0.5 inch water gauge. Caution should be exercised in their use where combustible or explosive coal dusts or oil fumes may be present and could be ignited by a "spark-over" of the high voltage across the electrodes.

****

Unit shall comply with requirements of ICAC EP-1, ICAC EP-7, and ICAC EP-8, and shall remove [aerosols] [and] [particulates] from processed gas stream by impressing a polarized electrostatic charge to the contaminants causing them to be drawn to and deposited upon opposite polarity charged plates. Unit shall contain multiple chambers and be of gas-tight construction. Unit shall be provided with [insulator compartments] [penthouse]. Unit shall be provided with anti-sneak baffles to force all gas flow through ionizing gas passages and to prevent gas bypassing the precipitator sections. Assembly shall consist of discharging electrodes and opposite charged plates, high voltage power pack and controls, a rapping system for knocking dust from the discharge electrodes and collector plates, perforated gas distribution plates, sheet steel enclosure with dust collecting hopper bottom, dirty gas inlet, clean gas outlet, and structural steel frame. Precipitator systems shall include microprocessor based controls [flue gas conditioning systems] [pulse energization] [intermittent energization].

2.14.5.1 Discharge Electrodes

Discharge electrodes shall be [wires and weights] [rigid electrodes] [rigid frame]. Discharge electrodes shall be top supported with the bottom free to expand and contract with gas stream temperature changes. Electrodes shall be laterally restrained to maintain optimum spacing from the plates. Electrodes shall have a stiffness, length, or restraints required to prevent vibration or flutter when the unit is in service.

2.14.5.2 Collecting Plates

Collecting plates shall consist of vertical panels of multiple steel strips hanging edgewise in the horizontal air stream so as to form the equivalent of many vertical splits of the gas stream into many gas passages. The strips shall be convoluted, stiffened or constructed with raised ribs, to provide sufficient stiffness to prevent distortion of the plates and also present vertical ridges to support boundary layer edges to increase plate dust retention. Plates shall be top supported with the bottom free to expand and contract with changes of gas stream

temperature. Plate configuration and support system design shall be coordinated with the plate rapping system design and operation to shed collected material from the plates and to retain a consistent and optimum spacing from the discharge electrodes.

2.14.5.3 Power Supply and Control System

Power supply and control system shall be solid state microprocessor type. Control system shall provide for continuous monitoring and regulating of applied voltage for effective maximum performance of precipitation over the range of plate loadings with minimum sparking and arcing to the plates. Entire system shall be provided with a system of safety interlocks and grounding devices to prevent personnel physical contact with high voltage components. Voltage insulators shall be provided with heaters.

2.14.5.4 Rapping Systems

The rapping systems shall consist of multiple hammers or other impact devices to cause particulate shedding from the collecting plate. Rapping shall automatically be programmed so that a minimum number of collecting plates and discharge electrodes are rapped simultaneously. The unit shall be designed to limit reentrainment of collected material falling from the collecting plates and discharge electrodes during the rapping operation without exceeding the design cleaning efficiency.

2.14.5.5 Inlet and Discharge Ducts

Inlet and discharge ducts shall be provided with turning vanes, deflectors, and baffle plates to provide for uniform distribution of gas flow through all gas passages and in each gas passage in accordance with ICAC EP-7. Pressure test connections shall be provided at the inlet and discharge ducts connecting to the precipitator.

2.14.5.6 Dust Storage Hopper

The unit shall be provided with a [4.8 mm 3/16 inch] [6.4 mm 1/4 inch] [low carbon] [corrosion resistant] sloped steel bottom dust storage hopper having the dust holding capacity indicated. The hopper shall be arranged to prevent reentrainment of collected material into the gas stream. The hopper bottom shall be provided with rappers or fluidizing pads and a hopper valley angle of 60 degrees and shall be free of pockets, ribs, fins, or any other obstruction to hold or interfere with free release of collected material to the outlet. The outlet shall be provided with [a guillotine-type slide gate] [a manually-operated rotary lock] [a motor-driven rotary lock]. The hopper shall be provided with a poke hole and gasketed access door and shall have a collected material level indicator for [local indication] [local indication with terminals for wiring to a remote indicator]. [The level indicator shall include a high material level audible alarm.] [The hopper shall be provided with electric heating coils, modules, or blankets to keep collected material dry and free flowing with the unit installed outdoors and out of service in a local winter outdoor design temperature of [_____] degrees C degrees F]. [The capacity of the heating coil module or blanket shall be as shown.] [The heating coil module or blanket's size shall be based on the ambient temperature of [_____] degrees C degrees F].

2.14.6 Wet Scrubber

****

NOTE: Select scrubber type based on efficiency required. Wet scrubbers are used for the removal of gaseous pollutants such as sulfur oxides, nitrogen oxides, and other gaseous materials from boiler flue gases. Removal of sulfur oxides (flue gas desulfurization) is covered by Paragraphs "Wet Flue Gas Desulfurization System" and "Spray Dryer Flue Gas Desulfurization System". Wet scrubbers will also remove fumes, mists, dusts, and smoke particles from laboratory fume hood and welding booth exhausts. With appropriate adsorbents they can collect vapors of paint thinners and solvents. They can handle boiler flue gases as high as 371 degrees C 700 degrees F, but impose a heavy water demand for evaporative cooling causing a heavy water vapor plume from the chimney. This water use also increases flue and chimney condensation and possible corrosion damage. Those problems can be minimized with a heat exchanger with a pump and water coils to precool the hot flue gas to the scrubber and deliver the recovered heat to the relatively cool cleaned gas out of the scrubber, as required. Any surplus heat can be used for other heating applications. The scrubber requires a water and chemicals supply system with problems of slurry or sludge removal; chemicals storage, mixing, feeding, and monitoring; and corrosion prevention of wetted parts. Since the scrubber system is relatively costly to install and operate, care should be exercised to limit its use to the function that only it can perform. In addition to its primary function of removing gaseous pollutants, it will also remove particulates. In addition to water sources shown within brackets, there may be other sources such as recycled water from waste treatment plant among others. Insert source within brackets and delete the others.

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Unit shall comply with ICAC G-1, ICAC WS-1, ICAC WS-3, and ICAC WS-4 as a wet scrubber for removing gases, fumes, and particulates from the air exhausted from [welding] [and] [paint spray] booths [and from [_____]]. Scrubber shall be one of the types identified by ICAC WS-3 as a [venturi,] [spray,] [tray,] [fixed packed bed,] [mobile bed,] [impingement,] [or] [entrainment] type [or a combination of these types]. Unit shall employ a small quantity of water or chemical neutralizing water solution to provide for maximum scouring and pollutant removal of the gas stream. Water demand rates of less than 0.13 L/second per cubic meter per second one gpm per 1000 cfm of processed gases shall use [potable] [cooling tower blowdown] [_____] water with waste to drain. Water demand in excess of the above flow rate shall provide for recirculation of the washing liquor. Unit shall be provided with [an automatic water supply control valve,] [a float-operated water level control valve,] [a totalizing water meter,] strainer, and water pressure gauge.

2.14.6.1 Chemical System

****

NOTE: Investigate user agency, facility operation, and maintenance standards and procedures; analyze the pollution control equipment's consumption of materials; confer with equipment suppliers; and determine the optimum time period for reserve capacity. Select the "reserve" time period, and delete all other periods. The above investigation will also determine if the last sentence within the brackets should be retained or deleted.

****

Each unit requiring neutralizing chemical additives shall be provided with a complete automatic chemical monitoring, control, mixing, feeding, and reserve storage system. The chemical system shall have a reserve capacity for [[24] [36] [48] hours] [[3] [7] [10] days] of continuous scrubber operation at design conditions without requiring servicing. [Components that must be taken out of service for routine maintenance or chemical loading shall be provided in duplicate arranged for transfer by manual operation of switches and valves.]

2.14.6.2 Scrubber

Scrubber shall be fluid-tight construction of [glass fibre reinforced polyester] [rolled low-carbon steel coated with coal-tar enamel] [ASTM A302/A302M stainless steel] [ASTM A240/A240M stainless steel]. Unit shall be provided with leak-tight viewing windows and access doors to permit appraisal of entire operation as well as full access for all service operations or parts replacement. Vanes, baffles, deflectors, or diffuser plates shall provide for uniform gas flow through the processing area. Scrubber shall be factory assembled, piped, and wired on floor mounted welded steel bases as indicated.

2.14.6.3 Recirculation Pumps

****

NOTE: Determine if facility will require continuous operation or if it can be shut down or if the pollution control equipment can be out of service for extended periods. If continuous operation is required, select wording for duplicate pumps and remove brackets.

****

Unit requiring recirculation of the scrubbing liquor shall be provided with [direct] electric motor centrifugal pumps [in duplicate] to conform to HI 3.1-3.5. Pumps shall develop the system pressure head required by the scrubber. Materials, construction, ratings, application, and testing shall conform to the standards and recommendations of HI 3.1-3.5 for corrosion resistant operation of pumping the scrubber liquor. [A manual selector switch shall be provided for selection of "Lead" and "Lag" operation of the duplicate pumps.] Each pump shall have a discharge pressure gauge appropriate for the pump head and a low pressure limit switch to [start the backup pump] [and] [close a circuit for an alarm]. Pumps shall be provided with corrosion-resistant strainers, valves, and piping suitable for the system and the gas to be processed. [Pumps for metering the feed rate of scrubber chemical additives shall be provided

with [manual] [automatic] means for varying the feed rate.]

2.14.6.4 Piping Materials

****

NOTE: Delete inapplicable materials and equipment. Pipe, fitting, and valve materials listed in this section are suitable for water service, but not for corrosive, erosive, and some petrol services. The designer should select the proper alloy (e.g., stainless steel 304, 316, etc.), rubber or other elastomer lining or plastic for these and other applications where the chemistry of the process shall dictate material selection.

****

Piping materials shall be compatible with the scrubber fluids.

2.14.6.5 Scrubber Collector System

Each scrubber requiring the use of chemical additives shall be provided with a system for removing and dewatering the collected material and chemical residues of the scrubber process. Related equipment and controls shall be provided. Pressure test connections shall be provided at the inlet and outlet ducts connecting to the collector.

2.14.7 Dry Fabric Collector for Boiler Flue Gases

****

NOTE: Dry fabric collectors are highly effective in removing up to 99.9 percent by weight of particulates of submicron size and larger from gas streams of more than 229 mg per cubic meter 0.1 grain (weight) per cubic foot. Emissions will consistently be less than 11 mg per cubic meter 0.005 grain/actual cubic foot. Fabrics are available for gas streams up to 288 degrees C 550 degrees F and are often used for particulate removal from coal handling operations and boiler flue gases. Fibre selection and fabric construction and finish are extremely critical to the performance and service life of a dry fabric collector. Chemical, temperature and abrasion resistance, strength, and dimensional stability are important fibre selection considerations. Fabric weave, weight, finish, and dimensional stability are major fabric requirements. Fabric filters can be harmed by corrosive chemicals. It may be necessary to scrub the gas prior to the dry fabric collector. ICAC F-2 summarizes fibre and fabric selection parameters. The space requirement is rather large and pressure drop is typically in the 1.02 kPa to 1.53 kPa 4 to 6 inch water gauge range. An important consideration is whether the processed stream can be interrupted, such as a nonproduction type welding facility exhaust, or if it must remain in continuous operation, such as for a base boiler plant. If the process is relatively small and the dust loading is relatively light, or if the process is intermittent,

it may be desirable and economic to use replaceable deep pocket type or automatic moving media type filters. If the loading is high and process must not be interrupted, a cleanable baghouse type unit may be desired.
****

Unit shall be type identified as [an unsupported tubular [unibag] [multibag] [side entry] [top entry] type] [a supported filter element [tubular] [or] [envelope] type]. Fabric collectors shall comply with ICAC F-2 and ICAC F-3. The collector provided shall be coordinated with the boiler combustion control and safety system so as to assure that the boilers operate within design conditions throughout entire operating range at design capacity of the collector. The collector shall be an ICAC [standard collector, Type III, medium-to-heavy duty, usually continuous service cleaning gases at [_____] degrees C degrees F] [special or custom-designed collector, Type IV, heavy duty continuous service cleaning gases at [_____] degrees C degrees F].

2.14.7.1 Filter Cleaning

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NOTE: In the last sentence, three filter cleaning methods are available, any or all of which may be allowed depending upon site conditions and available utilities. Under the present state of the art, the use of compressed air pulse jet cleaning should be limited to systems below 142 cubic meter per second 300,000 acfm (actual cfm). Efforts to reduce flue gas pressure drop in fabric collectors have led to the development of more vigorous cleaning methods, in particular, the use of sonic horns in combination with conventional air exchange cleaning methods, such as reverse air, pulsed jet, or shake/deflate. Up to 60 percent reduction in pressure drop has been realized using sonic horns with no deterioration in particulate emission levels. Pressure level, frequency, power levels, and spatial distribution of horns within the collector compartment are all important specification criteria.
****

Filter element cleaning shall be automatically initiated and executed [on an adjustable programmer time cycle] [by operation of an adjustable high filter pressure drop switch]. Cleaning shall be accomplished by powered vibrator or shaker devices, reverse cleaned air flow with [positive] [negative] air pressure in the unit, a combination of shaker and reverse air flow [or compressed air pulse jet cleaning]. [Filter element cleaning shall include sonic horns.]

2.14.7.2 Filter Enclosure

Filter enclosure shall be fabricated of [4.8 mm 3/16 inch] [6.4 mm 1/4 inch] [low carbon] [corrosion resistant] steel of welded or bolted construction or combinations thereof. Enclosure sheets shall be given supporting strength and rigidity by folding or bending or shall be supported on supplemental structural steel shapes. Unit shall be provided with gas inlet and outlet connections and baffles, vanes, deflectors, or low friction diffuser plates that will insure uniform gas flow to all

elements of the fabric system without causing flutter, vibration, or erosion of the fabric. Hinged, latched, and gasketed access doors shall be provided for all parts and areas that require inspection or service. Fabric elements shall be secured and supported by internal rings or equivalent method so that the entire fabric surface is so deployed that gas flow and particulate collection will be uniform over entire working surface. Dust shedding properties shall be uniform so that entire fabric surface will be equally cleared by a cleaning operation without damage to media other than normal service wear. Media shall be arranged in elements, sections, pockets, or tubes that can be handled, removed, replaced, and secured without special facilities.

2.14.7.3 Collector Cleaning

Units shall be provided with means for isolating a compartment or section for cleaning while other compartments are performing their normal dust removal function. Compartment isolation shall effectively prevent reentrainment of the particulate during the cleaning operation. Unit rating shall be based upon operation with one section out for cleaning. Cleaning operation shall be [operator initiated and executed by manually operating the cleaning cycle on each compartment in sequence until all filters have been cleaned] [operator initiated to have the filters cleaned automatically one compartment at a time until all filters have been cleaned] [automatically initiated by an adjustable filter air pressure drop switch operating at a high pressure set point to initiate the filter cleaning operation] [automatically initiated by a timer to initiate the filter cleaning operation]. Once started, the cleaning operation shall progressively clean one compartment at a time until all filters are cleaned. Removal of collected particulate shall be by discharging from a hopper below. Collector manufacturer shall provide all of the components required for the entire cleaning operation including [manual rappers] [motorized rappers] [rotary air valve] [manual dampers] [motorized dampers] [compressed air surge receiver] [air compressor with receiver, motor drive, and controls] [blast or pulse jet controls, nozzles, and valves] [shaker or flutter blower, motor, drive, and controls]. [Automatic operations shall be provided with a manual override for starting, stopping, interrupting, and restarting operation.]

2.14.7.4 Test Connections

Pressure test connections shall be provided at the inlet and outlet ducts connecting to the collector.

2.14.7.5 Flue Gas Dust Collectors Designed for In-Place Cleaning

Dust collectors designed and constructed for in-place cleaning of the fabric shall be provided with a [3.4] [4.8] [6.4] mm [10 gauge] [3/16 inch] [1/4 inch] [low carbon] [corrosion resistant] steel sloped bottom dust storage hopper having the dust holding capacity as indicated. Collector and hopper system shall be constructed to minimize reentrainment of collected material into the gas stream. The hopper bottom shall be provided with rappers or fluidizing pads and shall have a hopper valley angle of 60 degrees from the horizontal and shall be free of pockets, ribs, fins, or any other obstruction to hold or interfere with free and complete release of all collected material to the outlet. Outlet shall be provided with [a guillotine-type slide gate] [a motor-driven rotary lock] [automatic lock hoppers]. Hopper shall be provided with a poke hole and gasketed access door, and shall have a collected material level indicator for [local indication] [local indication with terminals for wiring to a

remote indicator]. Level indicator shall include a high material level audible alarm. [Hopper shall be provided with electric heating coils, modules, or blankets to keep collected material dry and free flowing with the unit installed outdoors and out of service in a local winter outdoor design temperature of [_____] degrees C degrees F].

2.14.8 Dry Fabric Collector for Dust Control

****

NOTE: Dry fabric collectors are highly effective in removing up to 99.9 percent by weight of particulates of submicron size and larger from gas streams of more than 229 mg per cubic meter 0.1 grain (weight) per cubic foot. Emissions will consistently be less than 11 mg per cubic meter 0.005 grain/actual cubic foot. Fabrics are available for gas streams up to 288 degrees C 550 degrees F and are often used for particulate removal from coal handling operations and boiler flue gases. Fibre selection and fabric construction and finish are extremely critical to the performance and service life of a dry fabric collector. Chemical, temperature and abrasion resistance, strength, and dimensional stability are important fibre selection considerations. Fabric weave, weight, finish, and dimensional stability are major fabric requirements. Fabric filters can be harmed by corrosive chemicals. It may be necessary to scrub the gas prior to the dry fabric collector. ICAC F-2 summarizes fibre and fabric selection parameters. The space requirement is rather large and pressure drop is typically in the 1.02 kPa to 1.53 kPa 4 to 6 inch water gauge range. An important consideration is whether the processed stream can be interrupted, such as a nonproduction type welding facility exhaust, or if it must remain in continuous operation, such as for a base boiler plant. If the process is relatively small and the dust loading is relatively light, or if the process is intermittent, it may be desirable and economic to use replaceable deep pocket type or automatic moving media type filters. If the loading is high and process must not be interrupted, a cleanable baghouse type unit may be desired.

****

Unit shall be type identified as [an unsupported tubular [unibag] [multibag] [side entry] [top entry] type.] [a supported filter element [tubular] [or] [envelope] type.] Fabric collector shall comply with ICAC F-2 and ICAC F-3. The collector shall be an ICAC EP-1 [unit, Type I, for light duty, intermittent service cleaning gases at or near room temperature.] [standard collector, Type II, for light-to-medium duty [intermittent] [continuous] service cleaning gases at continuous temperatures from room temperature to 135 degrees C 275 degrees F] [standard collector, Type III, for medium to heavy duty 260 degrees C 500 degrees F] [special or custom designed collector, Type IV, heavy duty continuous service cleaning gases at [_____] degrees C degrees F].

2.14.8.1 Filter Cleaning

****

NOTE: The choice of filter cleaning methods should be based on site conditions, available utilities, and operational requirements. For example, dust control of coal bunkering is usually intermittent as related to arrival of coal transporters and does not warrant a fully automatic continuous operation facility. Under the present state-of-the-art, the use of pulse jet cleaning should be limited to systems up to 142 cubic meters per second 300,000 acfm (actual cfm).

****

Filter cleaning of collector units processing air or gas streams at or near ambient temperatures, shall be [manually initiated and executed by [operating the required dampers and cleaning devices]] [automatically initiated and executed [on an adjustable or timed cycle] [by operation of an adjustable high filter pressure drop switch]]. [Powered cleaning shall be for [intermittent] [continuous] service employing [powered vibrator or shaker devices] [reverse air flow with atmospheric air and] [reverse cleaned air pressurized air flow with] [positive] [negative] air pressure in the unit [compressed air pulse jet cleaning] [of individual or a few elements] [of an entire compartment].] [Filter element cleaning shall include sonic horns.]

2.14.8.2 Filter Enclosure Construction

The filter enclosure shall be fabricated of [3.4] [4.8] [6.4] mm [10 gauge] [3/16 inch] [1/4 inch] [low carbon] [corrosion resistant] steel of welded or bolted construction or combinations thereof. Enclosure sheets shall be given supporting strength and rigidity by folding or bending or shall be supported on supplemental structural steel shapes. Unit shall be provided with gas inlet and outlet connections and baffles, vanes, deflectors, or low friction diffuser plates that will insure uniform gas flow to all elements of the fabric system without causing flutter, vibration, or erosion of the fabric. Hinged, latched, and gasketed access doors shall be provided for all parts and areas that require inspection or service. Fabric elements shall be secured and supported in a manner to have the entire fabric surface so deployed that gas flow and particulate collection will be uniform over the entire working surface. Dust shedding properties shall be uniform so that the entire fabric surface will be equally cleared by a cleaning operation without damage to the media other than normal service wear. Media shall be arranged in elements, sections, pockets, or tubes that can be handled, removed, replaced, and secured without special facilities.

2.14.8.3 Intermittent and Continuous Service Units

[Intermittent service units shall be equipped with [washable] [cleaning-in-place] fabric filters.] [Continuous service units shall be provided with means for isolation of a compartment or section for cleaning while other compartments are performing their normal dust removal function. Compartment isolation shall effectively prevent reentrainment of particulate during the cleaning operation.] Unit rating shall be based upon operation with one section out for cleaning. Cleaning operation shall be [operator initiated and executed by manually operating the cleaning cycle on each compartment in sequence until all filters have been

cleaned] [operator initiated to have the filters cleaned automatically one compartment at a time until all filters have been cleaned] [automatically initiated by an adjustable filter air pressure drop switch operating at a high pressure set point to initiate the filter cleaning operation] [automatically initiated by a timer to initiate filter cleaning operation]. Once started, the cleaning operation shall progressively clean one compartment at a time until all filters are cleaned. Removal of collected particulate shall be by [raking out] [removal and dumping of a particulate pan or tray] [draining from a hopper below]. Collector manufacturer shall provide all of the components required for the entire cleaning operation including [manual rappers] [motorized rappers] [manual dampers] [motorized dampers] [compressed air surge receiver] [air compressor with receiver, motor, drive, and controls] [blast or pulse jet controls, nozzles, and valves] [shaker or flutter blower, motor, drive, and controls] [traveling ring components]. [Automatic operations shall be provided with a manual override for starting, stopping, interrupting, and restarting operation.]

2.14.8.4 Test Connections

Pressure test connections shall be provided at the inlet and outlet ducts connecting to the collector.

2.14.8.5 Dust Collectors Designed for In-Place Cleaning

Dust collectors designed and constructed for in-place cleaning of the fabric shall be provided with a [3.4] [4.8] [6.4] mm [10 gauge] [3/16 inch] [1/4 inch] [low carbon] [corrosion resistant] steel sloped bottom dust storage hopper having the dust holding capacity as indicated. Collector and hopper system shall be constructed to minimize reentrainment of collected material into the gas stream. Hopper bottom shall be provided with rappers or fluidizing pads and the hopper valley angle shall be 60 degrees from the horizontal and shall be free of pockets, ribs, fins, or any other obstruction to hold or interfere with free and complete release of all collected material to the outlet. Outlet shall be provided with [a guillotine-type slide gate] [a manually-operated rotary lock] [a motor-driven rotary lock] [automatic lock hoppers]. Hopper shall be provided with a poke hole and gasketed access door, and shall have a collected material level indicator for [local indication] [local indication with terminals for wiring to a remote indicator]. Level indicator shall include a high material level audible alarm. [Hopper shall be provided with electric heating coils, modules, and blankets to keep collected material dry and flowing with the unit installed outdoors and out of service in a local winter outdoor design temperature of [_____] degrees C degrees F].

2.14.9 Gaseous Emissions Control Unit

****

NOTE: The gaseous emissions control units are to be used for cleaning particulate and gaseous solvent materials from the exhaust air at laboratory fume hoods, welding booths, water curtain paint spray booths, and other similar type problems. The fabric prefilter will collect a reasonable amount of particulates and the carbon will adsorb the gaseous vapors. The unit may be used without the prefilter to collect gasoline vapor from small storage tank vents, but the tank should be installed underground

or be shaded to minimize boil-off. Project conditions may make regeneration of the carbon desirable. A typical gaseous emission control with carbon regeneration unit consists of two or more adsorber vessels with deep bed (typically 450 to 600 mm 18 to 24 inches) of high grade gas phase activated carbon. The manufacturer should provide the bed depth as part of his design, and should consider the life cycle cost when sizing the adsorbent unit. The dampers and control valves will be pneumatically operated, based on timer operation or solvent sensor operation. Once the adsorption bed is saturated with solvent vapors, the flow into the adsorber is automatically diverted to the second adsorber. Low pressure steam is used to desorb the saturated adsorber, regenerating the carbon and producing a steam and solvent mixture which is condensed in a shell and tube condenser. Water insoluble solvents should be separated in a decanter for reuse. The system must be complete with adsorber vessels, blower, filter, condenser, and controls. Deposition of the waste effluents is dependent on the specific project and cannot be determined in the guide specification.
****

Unit shall comply with ICAC G-1 and shall consist of a dry type particulate removal precleaner followed by an adsorption unit of activated carbon or other approval adsorbent material.

2.14.9.1 Prefilter

Prefilter shall be [cleanable] [replaceable]. Prefilter shall have a cleaning performance equal to or exceeding ASHRAE 52.2 of 95 percent arrestance by weight, 80 to 90 percent atmospheric dust spot efficiency, and a dust-holding capacity of not less than 530 grams per 1 cubic meter per second 250 grams per 1,000 cfm cell. Media shall comply with UL 900 and shall be provided with a support frame or shall be constructed to be self-supporting without sagging either with or without gas flow. Each cell shall be securely held in place with applied pressure leak-tight joint between the media, media flange, and media collar, and the filter shall be secured to the media bulkhead with latches or clips to permit removal, replacement, and securing without special tools.

2.14.9.2 Adsorbent Unit

Adsorbent section shall consist of a system of trays, hollow panels, canisters, or other means of holding a deep bed of activated carbon conforming to ASTM D2854 and ASTM D2862, or other adsorbent material, to cause the processed gas to pass through a uniform depth of material in the gas flow direction. Trays, panels, and canisters shall be designed to assure that the adsorbent bed will be uniform, full and free of voids or thin spots and supported and contained to prevent movement, pulverizing, abrasion, or dusting of the adsorbent and easy and full recharging without special facilities or tools. Adsorbent units shall be secured leak-tight in a bulkhead forcing all gas to pass through the adsorbent bed.

2.14.9.3 Prefilter and Adsorbent Assemblies

Prefilter and adsorbent assemblies shall be enclosed in a welded, bolted, or riveted sheet metal enclosure that limits both in-leakage or out-leakage of gas. Enclosure access doors or panels shall be bolted, or gasket-sealed and latched to provide independent access to the prefilter and the adsorbent plenums. The enclosure shall be designed for the maximum differential pressure (positive or negative) under any mode of operation.

2.14.9.4 Inlet and Outlet Ducts

Unit shall be provided with inlet and discharge vanes, baffles, diffusers, or other devices to assure uniform gas flow through the processors. Pressure test connections shall be provided at the inlet and outlet ducts connecting to the collector.

2.14.10 Petrol Vapor Recovery Unit

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NOTE: The petrol vapor recovery unit is intended for use at fuel depots or fuel distribution terminal facilities. It is used to recover fuel vapors by refrigerated condensation of the material from tank and transporter vents. Underground storage tanks at petrol dispensing stations do not commonly require refrigerated petrol recovery units but are equipped to have the unloading fuel displace a like volume of vapor from the underground tank into the transporter through a vent hose and manifold which are integral with the transporter vehicle. The transporter then hauls this vent gas to the local depot for recovery as the transporter is reloaded. Some jurisdictions may require vehicle tank venting back to the storage tank as the vehicle is loaded. Gaseous emission activated carbon emission control units, with and without carbon regeneration, can be used in this application.

****

Unit shall be a complete air-cooled mechanical refrigerated electric-operated unit designed for condensing the fuel vapors vented from gasoline system storage tanks. Recovery process shall be in two steps. The first step shall precool the vent gas to slightly above water freeze point to remove most of the water vapor without a defrost cycle. The second step shall cool the gas to the required vapor pressure with minimum frost collection. System shall include storage capacity and circulation system for defrosting fluid. Refrigerants shall be classified as nontoxic, nonflammable, conforming to ASHRAE 15 & 34, Group 1.

2.14.10.1 Defrosting

[Fuel handling operation will allow defrosting for about [4] [5] [6] hours after midnight.] [Fuel handling operation will not allow time for defrosting and a duplicate cooler shall be provided with automatic controls to alternate the units between cool and defrost modes with status indication of each.]

2.14.10.2 Unit Operation and Control

Unit shall be provided for [complete monitoring and control at the unit] [operation and control at the unit with remote indication of ON-OFF position of unit power supply switch] [operation and control at the unit with remote indication of operating and control of the unit with complete process indication with maintenance and service operation at the unit]. [[Visible] [and] [audible] alarms shall be provided on critical functions [locally] [and at remote station].]

2.14.10.3 Design and Fabrication Requirements

Unit shall be from single supplier and of coordinated design, fully assembled and subjected to factory tests before shipment. Unit shall be skid mounted on a permanent steel base with pick-up lugs and anchor bolt holes for installation on a concrete foundation. Electric power connection, vent gas inlet, return line for condensed hydrocarbons, and drain for aqueous liquids shall be provided. Components shall be installed in a ventilated weather proof enclosure with full accessibility for operation and service through hinged access doors with latches or removable panels. Doors shall be used for access to all operating functions. Cold components and piping of the entire system subject to sweating or frosting shall be insulated. Electrical equipment and installation work shall conform to requirements of hazardous locations for Class I, [Division I,] [Division II,] Group D, of NFPA 70 and NFPA 496, and Type X shall conform to UL 5, UL 674, UL 1203, and UL 823 requirements. Inlet vent gas flow to the unit shall be through a 0.075 mm 200 mesh removable ASTM A240/A240M stainless steel or equal strainer. Refrigeration work shall comply with ASHRAE 15 & 34 and ASME B31.5. Petrol vapor, condensed hydrocarbon returns, and aqueous waste piping shall comply with ASME B31.3.

2.14.11 Gravel Bed Filter

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NOTE: Electrostatically enhanced gravel beds, combining granular filtration and electrostatic collection, are highly effective with collection efficiencies in excess of 99 percent on submicron particles. Gravel beds without electrostatic enhancement have collection efficiency greater than 95 percent on coarser particulate. They are frequently applied to gas streams in excess of 371 degrees C 700 degrees F and are particularly suitable for the collection of high resistivity particulates with potential fire and explosion hazards. Gravel beds are more compact then electrostatic precipitators or fabric filters for comparable applications. The unit is relatively insensitive to variations in gas flow and temperature excursions, and, in most cases, chemical makeup of the exhaust gas and particulate. Pressure drop across the gravel bed ranges from 763 Pa to 1271 Pa 3 to 5 inches water gauge. Carbon steel is the normal material of construction although high temperature and/or corrosive environments require the use of alloys or stainless steel.

****

The system shall remove particulates from process gas streams through granular filtration in a moving bed of filter media supplemented by electrostatic collection resulting from the application of high voltage power to [an electrical grid located in the bed] [an ionization grid located upstream of the bed in addition to an electrical grid located in the bed].

2.14.12 Wet Flue Gas Desulfurization System

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NOTE: A flue gas desulfurization (FGD) system is used to reduce emission of sulfur dioxide from solid waste incinerator and boiler flue gases. It can also reduce other acid gas emissions such as hydrochloric acid and hydrofluoric acid. FGD systems are classified as either wet or dry processes. In the wet process, the flue gas reacts with a sorbent solution, producing a liquid product. The reagent selected will result in either a waste product, which must be disposed of, or a by-product, in which the sulfur recovered is in useable form. In general, the capital cost of regenerative systems may be up to twice the cost of non-regenerable systems.

****

System shall remove sulfur dioxide, [hydrochloric acid] [hydrofluoric acid] [particulates] [and] [_____] from processed gas stream. System shall be [non-regenerative] [regenerative] and shall use wet scrubbing process. System shall include all equipment required for a complete, operable FGD system, including wet scrubbing system, complete reagent feed system, [waste] [by-product] handling system, and instrumentation and controls for safe, reliable operation of the system.

2.14.12.1 Wet Scrubber System

Wet scrubber shall comply with ICAC G-1, ICAC WS-1, ICAC WS-3, and ICAC WS-4. Scrubber shall be one of the types identified by ICAC WS-3 as a [venturi,] [spray,] [tray,] [fixed packed bed,] [mobile bed,] [impingement,] [or] [entrainment,] type [or a combination of these types]. Scrubber shall be fluid-tight construction of [glass fiber reinforced plastic] [rolled low-carbon steel coated with coal-tar enamel] [ASTM A302/A302M stainless steel] [ASTM A240/A240M stainless steel] [_____]. Unit shall be constructed with leak-tight viewing windows and access doors to permit appraisal of scrubbing process as well as full access for all service operations or parts replacement. Vanes, baffles, deflectors, or diffuser plates shall provide for uniform gas flow through the scrubbing chamber. Scrubber internal components shall be designed to minimize scaling and plugging inside the tower. Mist eliminator shall be of fluid-tight construction. Vanes, baffles, or deflectors shall provide for uniform gas flow to the mist eliminator elements. Mist eliminator shall be designed to minimize reentrainment of liquid into the gas stream. Mist eliminator shall be provided with a water washing system to prevent solids buildup on the blades. Washing nozzles shall be sized and oriented to spray entire mist eliminator area. System shall be provided with clean gas reheater upstream of stack to prevent acidic condensation and corrosion in the stack.

2.14.12.2 Reagent Feed System

Reagent feed system shall include all components required for storage of dry reagent, preparation of reagent slurry, delivery and re-circulation of the selected reagent. One reagent feed system shall serve all scrubbers. Reagent feed system shall have a reserve capacity for [[24] [36] [48] hours] [[3] [7] [10] days] of continuous FGD operation at design capacity without servicing. [Components that must be taken out of service for routine maintenance or reagent loading shall be provided in duplicate, arranged for transfer by manual operation of switches and valves.] System shall include all tanks, agitators, pumps, piping, valves and other equipment required by a specific system design. System equipment shall be of design, material and construction appropriate for scrubbing solution delivery and for re-circulation of scrubbing effluent. Piping shall be designed to prevent settling of scrubbing solution inside the pipes. Design shall include provisions for drainage and clean-out of feed system components, including pumps and piping.

2.14.12.3 Waste Handling System

Waste handling system shall include all equipment required for pre-disposal treatment of the scrubbing effluent, including tanks, agitators, liquid-solid separator, vacuum filter, solid waste holding bin, pumps, piping, and valves as required.

2.14.12.4 Test connections

Pressure test connections shall be provided at the inlet and outlet ducts connecting to the scrubber.

2.14.13 Spray Dryer Flue Gas Desulfurization System

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NOTE: A flue gas desulfurization (FGD) system is used to reduce emission of sulfur dioxide from solid waste incinerator and boiler flue gases. It can also reduce other acid gas emissions such as hydrochloric acid and hydrofluoric acid. FGD systems are classified as either wet, wet/dry, or dry processes. The spray dryer FGD process is a wet/dry process, in which the flue gas reacts with an alkaline reagent, usually a lime slurry, and the reaction product is in dry form. The reagent selected will result in either a waste product, which must be disposed of, or a by-product, in which the sulfur recovered is in useable form. In general, the capital cost of regenerative systems may be up to twice the cost of non-regenerable systems.

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System shall remove sulfur dioxide, [hydrochloric acid] [hydrofluoric acid] [particulates] [and] [_____] from processed gas stream. System shall be non-regenerative and shall use a spray dryer scrubbing process. System shall include all equipment required for a complete, operating FGD system, including spray dryer scrubbing system, complete slurry feed system, waste handling system, particulate collecting unit consisting of [fabric filter collector,] [electrostatic precipitator,] and instrumentation and controls for safe, reliable operation of the system.

2.14.13.1 Spray Dryer System

Spray dryer shall comply with ICAC G-1 and ICAC FGD-1. Spray dryer shall be of gas-tight construction. Unit shall be constructed with leak-tight viewing windows and access doors to permit appraisal of scrubbing process as well as full access for all service operations or parts replacement. Spray dryer system shall include flue gas preheater prior to spray dryer inlet. Vanes, baffles, deflectors, or diffuser plates shall be designed to provide complete mixing of flue gas and chemical reagent, and to provide adequate time for chemical reaction and evaporation of liquid in spray dryer chamber. Atomizing system shall be [rotary] [or] [dual fluid] and shall provide uniform dispersion of the chemical reagent in the spray dryer chamber and prevent gas droplet deposition on spray dryer walls. [Dual fluid nozzle atomizers shall use compressed air as the atomizing fluid. A dedicated air compressor system shall be provided for dual fluid atomizing system.] Scrubber internal components shall be designed to minimize scaling inside the tower.

2.14.13.2 Reagent Feed System

Chemical reagent feed system shall include all components required for storage, preparation, delivery and re-circulation of the chemical reagent. One reagent feed system shall serve all scrubbers. Reagent feed system shall have a reserve capacity for [[24] [36] [48] hours] [[3] [7] [10] days] of continuous FGD operation at design capacity without servicing. [Components that must be taken out of service for routine maintenance or reagent loading shall be provided in duplicate, arranged for transfer by manual operation of switches and valves.] System shall include all tanks, agitators, filters, pumps, piping, valves and other equipment required by a specific system design. System equipment shall be of design, material and construction appropriate for reagent delivery and for re-circulation of spray dryer effluent. Piping shall be designed to prevent settling of solids inside the pipes. Design shall include provisions for drainage and clean-out of feed system components, including pumps and piping.

2.14.13.3 Particulate Collecting Unit

Particulate collecting unit shall be designed to collect spray dryer products and fly ash remaining in the gas stream exiting the spray dryer. Particulate collection unit shall consist of [fabric filter collector] [electrostatic precipitator]. [Fabric filter collector shall be in accordance with Paragraph "Dry Fabric Collector for Boiler Flue Gases"]. [Electrostatic precipitator shall be in accordance with Paragraph "Electrostatic Precipitator (ESP)"].

2.14.13.4 Test connections

Pressure test connections shall be provided at the inlet and outlet ducts of each spray dryer and fabric filter collector.

2.14.14 Selective Catalytic Reduction (SCR) System

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NOTE: All fossil fuel burning processes produce nitrogen oxides (NOx). Selective catalytic reduction (SCR) reduces NOx to N2 in the presence of a catalyst. The reducing gas is usually ammonia

(NH3), and the catalyst may be composed of various materials, such as oxides of vanadium or tungsten. The catalytic reduction reaction requires temperatures in the range of about 300 to 425 degrees C 600 to 800 degrees F. Selection of the catalyst material and configuration, as well as the operating temperature, depends on the type of fuel being burned. The catalytic reactor will receive a high dust, low dust, or tail end gas stream, depending on its location in the system. In the high dust location, the catalyst is located upstream of an electrostatic precipitator. Location of the SCR system downstream of an electrostatic precipitator results in a low dust environment for the catalyst. In the tail end location, the SCR system is located downstream of an electrostatic precipitator and/or a flue gas desulfurization system, which provides the cleanest gas to the catalyst. Location of the SCR in the system will have an impact on catalyst life.

Efficiency of conventional SCR equipment in removal of NOx is about 80-90 percent. SCR may be used in conjunction with combustion modifications, such as low NOx burners. A potential complication of SCR using ammonia when high sulfur coal is burned is the formation of ammonium bisulfate. When unreacted ammonia passes through the catalytic reactor, called ammonia slip, it will combine with SO3 present in the flue gas, forming ammonium bisulfate. Ammonium bisulfate, a sticky, corrosive material, will condense on downstream equipment. Ammonia slip is a major design concern when burning high sulfur coal.

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System shall be designed to reduce nitrogen oxides from processed gas stream. System shall use ammonia as the reducing agent. System shall include all equipment required for a complete, operable SCR system, including, but not limited to, ammonia delivery system, catalytic reactor [with sootblowers], ash removal system, instrumentation and controls for safe, reliable operation of the system, and other pollution control devices as required.

2.14.14.1 Ammonia Delivery System

Ammonia delivery system shall include all components required for storage, preparation, and delivery of ammonia to the flue gas stream downstream of the economizer, prior to the catalytic reactor. The ammonia delivery system shall be designed to automatically deliver ammonia based on the quantity of NOx detected in the gas stream. Ammonia vaporizers shall be designed to ensure uniform ammonia distribution in the gas stream. Ammonia vaporizers shall be located in ductwork at a sufficient distance upstream of the catalytic reactor to provide complete mixing of ammonia and flue gas prior to the catalytic reactor inlet.

2.14.14.2 Catalytic Reactor

Catalytic reactor shall provide environment for chemical reaction between ammonia and nitrogen oxides, to produce elemental nitrogen and water as

the products. Catalytic reactor configuration shall provide for uniform gas flow through all elements of the reactor. Catalytic reactor shall be of gas tight construction Catalytic reactor shall be located between boiler economizer and boiler air preheater. [Catalytic reactor shall be located [upstream of an electrostatic precipitator] [downstream of an electrostatic precipitator] [downstream of a flue gas desulfurization system] [downstream of an electrostatic precipitator and a flue gas desulfurization system].] [Catalytic reactor shall be provided with sootblowers.] Ammonia slip shall be limited to [_____] ppm.

2.15 EMISSION MONITORING SYSTEM

****

NOTE: Provide in-situ opacity monitoring equipment where applicable to insure emission compliance of the particulate control equipment.

State and local regulatory authorities should be contacted at an early stage of the project design to determine if they consider the test methods cited to be adequate, and if they have any additional requirements.

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Emission monitoring system complete with all components, accessories, analyzers [analyzer calibration system] [and recorders,] [alarms], and free-standing factory assembled panel shall be provided to [monitor opacity, sulfur dioxide, nitric oxide, nitrogen dioxide, and carbon monoxide emissions in boiler flue gases.] [In-situ opacity monitoring.] [_____]. System shall [continuously monitor] [time program monitor as indicated] [be manually operated to monitor] the emissions. Submit reports for emissions permit compliance. Emissions shall be indicated [and recorded] in ppm and percent of sample.

2.15.1 Gas Sampling System

Sampling locations for air pollution control equipment performance shall be in accordance with 40 CFR 60, Appendix A. A vacuum pump shall draw a gas sample through a filter probe mounted inside the stack, a prefilter, and a moisture separator/drier. It shall discharge the sample through a flow meter on each analyzer to atmosphere as indicated. Equipment and necessary tubing shall be provided for automatically purging pollutants from sampling tubing, stack probe, and drier tubing, and for automatic regeneration of the drier. Cleaning and drying operation shall be time programmed.

2.15.2 Analyzing System

System shall provide simultaneous measuring and analyzing of sample gas by each analyzer with independent flow meters, valves, piping, and accessories. Each analyzer shall indicate ppm of the measured pollutant. [A recorder shall be provided for each analyzer with 30-day, 125 mm 5 inch strip chart with pressure sensitive stylus.] Each analyzer shall be provided with a visual color coded, panel mounted, high limit alarm with a single audible alarm with silencing button for all alarms. A relay on each analyzer shall be provided for connection to a remote alarm.

2.15.3 System Mounting

Gas sampling, analyzing [, and recording] systems shall be piped, wired, and mounted within a factory fabricated 2.657 mm 12 gauge cold rolled black steel enclosure with angle frame support and key-locked doors for [wall] [floor] mounting. Entire system shall be suitable for 120 Vac, 60 Hz, single-phase electric service.

2.15.4 Calibration

Calibration gas tanks of capacities indicated complete with regulators, valving, and tubing shall be provided for the specified emissions.

2.16 FACTORY APPLIED INSULATION

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NOTE: Insert equipment and related piping, casings, and enclosures requiring insulation as applicable.

****

The following equipment and appurtenances shall be insulated with materials, jacketing, and finishes, as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS:

a. [_____]

b. [_____]

2.17 PAINTING AND FINISHING

Equipment and component items shall be factory primed and finish coated with the manufacturer's standard finish. Items located outside the building shall have weather resistant finish. Damaged finish surfaces shall be refinished with an identical type of finish used at the factory.

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

Work shall be installed as indicated and in accordance with manufacturer's diagrams and written instructions. [A factory installation specialist shall be at the site for erection of [electrostatic precipitator,] [baghouse,] [scrubber,] [wet flue gas desulfurization system] [spray dryer flue gas desulfurization system] [selective catalytic reduction system] [and] [petrol vapor recovery unit].] Field applied insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.3 OPERATION AND PERFORMANCE REQUIREMENTS

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NOTE: Select the appropriate performance data forms required for the equipment selected. Fill in the data on the forms. Delete or retain the topic items

as appropriate. EPA Technical Report AP-42 including Supplements 1 through 9 (and later supplements if issued) will be used to determine the properties or qualities and quantities of uncontrolled emissions from the various polluting equipments, systems, and operations to be corrected under this guide specification. Show in tables on drawings operating performance requirements for fans, pumps, motors, and other auxiliaries, indicating cfm, gpm, hp, etc. Fill out separate table for each air pollution control equipment selected for a given project in accordance with the following guide:

Table	Type Effluent	Applicable Equipment
I	General Dust	Dry Dynamic Centrifugal Fabric, Fabric, or Wet Dynamic
II	Boiler Fly Ash	Dry Dynamic, Centrifugal Fabric, or ESP
III	Boiler Flue Gases & Other Fume Sources	Scrubber, Flue Gas Desulfurization System, Selective Catalytic Reduction System
IV	Petrol & Other Vapor	Refrigeration Unit or Sources Fabric Prefilter with Activated Carbon with Regeneration

****

Air pollution control equipment shall process and remove pollutants from exhaust gas streams to produce an effluent that will conform to 40 CFR 50 and other federal, state, and local regulations, without degrading the performance of related system components. The air pollution control equipment installed shall perform the cleaning operation as indicated on the Air Pollution Equipment Performance Data forms attached to this section.

3.4 FRAMED INSTRUCTIONS

Framed instructions containing wiring and control diagrams under glass or in laminated plastic shall be posted where directed. The instructions shall show wiring and control diagrams and complete layout of the entire system. The instructions shall include, in typed form, condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation and procedures for safely starting and stopping the system. The framed instructions shall be posted before acceptance testing of the system.

3.5 FIELD QUALITY CONTROL

3.5.1 System Performance Test

Upon completion, and prior to acceptance of the project, the air pollution control equipment and monitoring system shall be tested in accordance with 40 CFR 60, Appendix A and state and local codes by [the Contractor] [an independent testing organization] to demonstrate indicated performance. [A factory startup specialist shall be at the site to direct and monitor startup for testing of [electrostatic precipitator,] [baghouse,] [scrubber,] [wet flue gas desulfurization system] [spray dryer flue gas desulfurization system] [selective catalytic reduction system] [and] [petrol vapor recovery unit].] Notify the Contracting Officer [_____] days in advance of the test date. [An independent testing organization shall furnish all instruments and personnel required for the tests.]Submit a proposed performance test procedure, 30 days prior to the proposed test date, containing a complete description of the proposed tests and sample locations, with calibration curves or test results by an independent testing laboratory of each instrument, meter, and gauge to be used in the tests. The test shall not commence until the procedure has been approved. Electricity and water will be furnished by the Government.

3.5.1.1 Retesting

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

3.5.1.2 Reporting

Submit test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to provide compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.

3.5.2 Manufacturer's Field Service

Services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the specified equipment shall be provided. The representative shall supervise the installing, adjusting, and [testing] [testing start-up] of the equipment.

3.6 CLOSEOUT ACTIVITIES

3.6.1 Training

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NOTE: Insert number of hours required to train personnel for the equipment operations.
****

Conduct training course for operating staff as designated by the Contracting Officer. The training period, of a total of [_____] hours of normal working time, shall start after the system is functionally completed, but prior to final acceptance tests. The field instructions shall cover all of the items contained in the operating and maintenance instructions, as well as demonstrations of routine maintenance operations. Submit training course curriculum and training instructions [14] [_____] days prior to the start of training.

3.6.2 Operations and Maintenance

Submit complete copies of operation manual outlining the step-by-step procedures required for system startup, operation, and shutdown. The manuals shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and its basic operating features. Also, submit complete copies of maintenance manual listing routine maintenance procedures, possible breakdowns and repair, and troubleshooting guides. The manuals shall include piping layout, equipment layout, and simplified wiring and control diagrams of the system as installed. Operation and maintenance manuals shall be approved prior to training course.

3.7 SCHEDULES

a. TABLES I and II: List any or all properties of particulate materials such as corrosive, toxic, abrasive, sticky, flammable, explosive, abrasive, friable, spherical fibrous, and hygroscopic.

b. TABLES I and III: Delete reference to particulates if the scrubber is to be installed with a particulate precleaner.

c. TABLE III: Delete reference to water supply data if not applicable for equipment selected.

d. TABLES III and IV: The volume to be listed here is the total volume of exhaust or ventilation air flow with which the pollutant is mixed. Add or delete items under Analysis of Gaseous Pollutants.

TABLE I. AIR POLLUTION CONTROL EQUIPMENT PERFORMANCE DATA	
Type Collector:	[_____]
Contaminate Stream:	[_____]
Collector Inlet Conditions:	
Elevation:	[_____] meters feet
Gas Density:	[_____] kg per cubic meter pcf
Volume:	[_____] actual cubic meters per second cfm [stoichiometric] [pitot]
Pressure:	[_____] Pa inches of water gauge
Temperature:	[_____] degrees C F
Grain Loading:	[_____] mg per actual cubic meters grain/acf
	[_____] mg per standard cubic meter grains/scf
	[_____] nanograms per J pounds/10^6 Btu

TABLE I. AIR POLLUTION CONTROL EQUIPMENT PERFORMANCE DATA	
Moisture:	[_____] percent
Analysis of Particulates:	
Specific Gravity:	[_____]
Bulk Density:	[_____] kg per cubic meter pcf
Physical Properties:	[_____]
Paricle Size Distribution, µm microns	Percent by Weight of Dust in Range
0-5	[_____]
5-10	[_____]
10-20	[_____]
20-30	[_____]
30-40	[_____]
<40	[_____]
Chemical Analysis	
Collection Efficiency:	[_____] percent
Allowable Outlet Emission:	[_____] mg per actual cubic meters grains/acf
	[_____] mg per standard cubic meter grains/scf
	[_____] nanograms per J pounds/10^6 Btu
Allowable Collector Pressure Drop:	[_____] Pa inches water gauge Inlet Flange to Outlet Flange
Hopper Capacity:	[_____] cubic meter feet
Collector Internal Pressure Relative to Atmosphere	
Positive	[_____] Pa inches of water gauge
Negative	[_____] Pa inches of water gauge
Water Supply:	
Pressure:	[_____] kPa psig
Flow Rate:	[_____] L/sec gpm
Water Analysis:	[_____]

TABLE II. AIR POLLUTION CONTROL EQUIPMENT PERFORMANCE DATA	
Type Collector:	[_____]
Contaminate Stream:	[_____]
Type of Fuel-Percent by weight as fired:	
Volatile Matter:	[_____]
Fixed Carbon:	[_____]
Moisture:	[_____]
Sulfur:	[_____]
Ash:	[_____]
J/kgBtu/pound	[_____]
Fuel Firing Rate	[_____] kg per hour pounds per hour
Collector Inlet Conditions:	
Elevation:	[_____] meters feet
Volume:	[_____] actual cubic meters per second acfm [stoichiometric] [pitot]
Pressure:	[_____] Pa inches of water gauge
Temperature:	[_____] degrees C F
Grain Loading:	[_____] [mg per actual cubic meter] [mg per standard cubic meter] [nanograms per J] [grains/acf] [grains/scf] [pounds/10^6 Btu]
Analysis of Paticulates:	
Specific Gravity:	[_____]
Bulk Density	[_____] kg per cubic meter pcf
Physical Properties:	[_____]
Paricle Size Distribution, µm microns	Percent by Weight of Dust in Range
0-5	[_____]
5-10	[_____]
10-20	[_____]

TABLE II. AIR POLLUTION CONTROL EQUIPMENT PERFORMANCE DATA	
20-30	[_____]
30-40	[_____]
<40	[_____]
Chemical Analysis	
Collection Efficiency:	[_____] percent
Allowable Outlet Emission:	[_____] mg per actual cubic meters grains/acf
	[_____] mg per standard cubic meter grains/scf
	[_____] nanograms per J pounds/10^6 Btu
Allowable Collector Pressure Drop:	[_____] Pa inches water gauge Inlet Flange to Outlet Flange
Hopper Capacity:	[_____] cubic meter feet
Collector Internal Pressure Relative to Atmosphere	
Positive	[_____] Pa inches of water gauge
Negative	[_____] Pa inches of water gauge

TABLE III. AIR POLLUTION CONTROL EQUIPMENT PERFORMANCE DATA	
Maximum Outlet Emission:	[_____] mg per actual cubic meters grains/acf
	[_____] mg per standard cubic meter grains/scf
	[_____] nanograms per J pounds/10^6 Btu
Type Collector:	[_____]
Contaminate Stream:	[_____]
Type of Fuel-Percent by weight as fired:	
Volatile matter:	[_____]
Fixed Carbon:	[_____]
Moisture:	[_____]
Sulfur:	[_____]
Ash:	[_____]

TABLE III. AIR POLLUTION CONTROL EQUIPMENT PERFORMANCE DATA	
Fuel Firing Rate:	[_____] kg per hour pounds per hour
Collector Inlet Conditions:	
Elevation:	[_____] meters feet
Volume:	[_____] actual cubic meters per second cfm [stoichiometric] [pitot]
Pressure:	[_____] Pa inches of water gauge
Temperature:	[_____] degrees C F
Grain Loading:	[_____] mg per actual cubic meters grain/acf
	[_____] mg per standard cubic meter grains/scf
	[_____] nanograms per J pounds/10^6 Btu
Moisture:	[_____] percent
Analysis of Particulates:	
Specific Gravity:	[_____]
Bulk Density:	[_____] kg per cubic meter pcf
Physical Properties:	[_____]
Paricle Size Distribution, µm microns	Percent by Weight of Dust in Range
0-5	[_____]
5-10	[_____]
10-20	[_____]
20-30	[_____]
30-40	[_____]
<40	[_____]
Chemical Analysis	
Analysis of Gaseous Pollutants:	
Sulfur Dioxide	[_____] ppmv dry
Nitrous Oxide	[_____] ppmv dry
Hydrocarbons	[_____] ppmv dry

TABLE III. AIR POLLUTION CONTROL EQUIPMENT PERFORMANCE DATA	
Moisture Content	[_____] percent
Collection Efficiency:	[_____] percent
Allowable Outlet Emission:	[_____] mg per actual cubic meters grains/acf
	[_____] mg per standard cubic meter grains/scf
	[_____] nanograms per J pounds/10^6 Btu
Allowable Collector Pressure Drop:	[_____] Pa inches water gauge Inlet Flange to Outlet Flange
Collector Internal Pressure Relative to Atmosphere	
Positive	[_____] Pa inches of water gauge
Negative	[_____] Pa inches of water gauge
Water Supply:	
Pressure:	[_____] kPa psig
Flow Rate:	[_____] L/sec gpm
Water Analysis:	[_____]

TABLE IV. AIR POLLUTION CONTROL EQUIPMENT PERFORMANCE DATA	
Type Collector:	[_____]
Contaminate Stream:	[_____]
Collector Inlet Conditions:	
Volume:	[_____] actual cubic meters per second cfm [stoichiometric] [pitot]
Pressure:	[_____] Pa inches of water gauge
Temperature:	[_____] degrees C F
Relative Humidity:	[_____] percent
Analysis of Gaseous Pollutants:	
Sulfur Dioxide	[_____] ppmv dry
Nitrous Oxide	[_____] ppmv dry

TABLE IV. AIR POLLUTION CONTROL EQUIPMENT PERFORMANCE DATA	
Paint Solvents	[_____] ppmv dry
Hydrocarbons	[_____] ppmv (by species) dry
Moisture Content	[_____] percent
Analysis of contaminants which must be filtered out upstream of carbon bed.	
Allowable Emissions (by species).	

-- End of Section --