UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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SECTION 44 13 51

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SECTION 44 13 51

THERMAL OXIDATION EQUIPMENT
05/20

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NOTE: This guide specification covers the requirements for systems to destroy, by thermal oxidation, organic contaminants contained in an off-gas stream; with options to use concentration system, heat recovery and/or a catalyst to conserve fuel.

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

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

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

****

PART 1 GENERAL

1.1 UNIT PRICES

****

NOTE: Measurement and payment requirements will be specified for work subject to extreme variation in estimated quantity when unit price bidding is required. This paragraph is not used when quantities can be reasonably calculated from information included in the contract.

****

Measurement and payment and unit prices for quantities of off-gas treated will be determined in accordance with the Bid Schedule.

1.2 REFERENCES

****

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

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

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

****

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

AMERICAN GAS ASSOCIATION (AGA)

AGA ANSI B109.1	(2000) Diaphragm Type Gas Displacement Meters (Under 500 cubic ft./hour Capacity)
AGA ANSI B109.2	(2000) Diaphragm Type Gas Displacement Meters (500 cubic ft./hour Capacity and Over)
AGA ANSI B109.3	(2019) Rotary-Type Gas Displacement Meters
AGA Report No 3	(2016; 5th Ed) Orifice Metering of Natural Gas And Other Related Hydrocarbon Fluids; PART 2: Specification and Installation Requirements

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.15/CSA 9.1	(2009; Addenda A 2012, Addenda B 2013; R 2019) Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves

AMERICAN PETROLEUM INSTITUTE (API)

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

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 25-16	(2016) Earthquake-Activated Automatic Gas Shutoff Devices

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B16.33	(2012; R 2017) Manually Operated Metallic Gas Valves for Use in Gas Piping Systems Up to 125 psi, (Sizes NPS 1/2 - NPS 2)
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

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2017) Standard Methods for the Examination of Water and Wastewater

AMERICAN WELDING SOCIETY (AWS)

AWS B2.1/B2.1M	(2014; Errata 2015) Specification for Welding Procedure and Performance Qualification
AWS D1.1/D1.1M	(2020) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM E230/E230M	(2012) Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

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

MSS SP-25	(2018) Standard Marking System for Valves,

	Fittings, Flanges and Unions

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

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

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2021) Flammable and Combustible Liquids Code
NFPA 31	(2020) Standard for the Installation of Oil-Burning Equipment
NFPA 54	(2021) National Fuel Gas Code
NFPA 58	(2020; TIA 20-1; TIA 20-2; TIA 20-3) Liquefied Petroleum Gas Code
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 82	(2019) Standard on Incinerators and Waste and Linen Handling Systems and Equipment
NFPA 211	(2019) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST SP 250	(1991) Calibration Services Users Guide

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

29 CFR 1910	Occupational Safety and Health Standards
40 CFR 60	Standards of Performance for New Stationary Sources

1.3 SUBMITTALS

****

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

if the submittal is sufficiently important or complex in context of the project.

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

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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

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

SD-02 Shop Drawings

Detail Drawings; G[, [_____]]

SD-03 Product Data

Emissions

Temperature Sensors, Transmitters and Controllers; G[, [_____]]

Thermal Oxidation System; G[, [_____]]

Field Training

SD-06 Test Reports

Factory Tests

Field Quality Control/Tests

SD-07 Certificates

Motors

Manufacturer's Field Representative

SD-10 Operation and Maintenance Data

Thermal Oxidation System; G[, [_____]]

Maintenance; G[, [_____]]

1.4 QUALIFICATIONS

1.4.1 Contractor

Have had a minimum of [2] [3] [5] [_____] years of experience in the construction of industrial air pollution control systems, sanitary wastewater sludge digestion gas systems, landfill off-gas or vapor extraction off-gas handling systems.

1.4.2 Single Source Supplier

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

1.4.3 Manufacturer's Field Representative

Provide the 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. Submit names and qualifications of each manufacturer's field representative and training engineer with written certification from the manufacturer that each representative and trainer is technically qualified.

1.4.4 Welders

[Welders must have passed qualification tests using procedures covered in AWS B2.1/B2.1M or ASME BPVC SEC IX and have the appropriate certification.] [Qualifications of welders, and welding and nondestructive testing procedures for piping shall be as specified in Section 40 05 13.96 WELDING PROCESS PIPING.] [Structural members shall be welded in accordance with Section 05 05 23.16 STRUCTURAL WELDING.] Require any welder to retake the test when, in the opinion of the Contracting Officer, the work of the welder creates reasonable doubt as to proficiency.

1.5 REGULATORY REQUIREMENTS

****

NOTE: Add applicable regional, state, or local requirements. Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS includes basic requirements.

****

Abide by the following requirements: [_____].

1.6 PARTNERING OR PRE-INSTALLATION CONFERENCE

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

1.7 DELIVERY, STORAGE, AND HANDLING

Protect from the weather, excessive humidity, excessive temperature variation, and dirt, dust, or other contaminants all equipment delivered and placed in storage. Catalyst material shall be protected in accordance with the manufacturer's recommendations.

1.8 SEQUENCING AND SCHEDULING

****

NOTE: Testing of the thermal oxidation system should be concurrent with the start of gas flow from the landfill, vapor extraction system, or other source.

****

Installation of the thermal oxidizer shall be complete and the system operational prior to completion of the [gas collection system] [vapor extraction system] [landfill cap]. Point source release of untreated off-gas shall be avoided to the maximum extent consistent with completion of the contract. Perform sampling and analyses to demonstrate system performance and emission compliance.

1.9 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. Consider whether an initial operating period is included in the contract.

****

[An inventory of all equipment, tools, and items shall be provided to the Contracting Officer at the start of the operating period. The inventory shall be updated monthly. A current inventory shall be delivered to the Contracting Officer when the operating period is complete.] [Concurrent with delivery and installation of the specified equipment, auxiliary equipment and spare parts shall be furnished.] Furnish the following:

a. [Spare parts for each different item of material and equipment specified including all of the parts recommended by the manufacturer to be replaced after [1 year] [1 year and 3 years] service.] [Spare parts, replacement parts and other items duplicated or replaced during the operating period.]

b. For each type of grease, one lever type grease gun or other lubricating device.

c. [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.]

d. 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.

e. A [three] [six] month supply of lubricants, [fuel,] [and] [consumable items] at the end of the contract.

f. [_____].

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide a thermal (catalytic) oxidation system as a complete unit process for destruction of organic contaminants carried in the [off-gas] [vapor phase]. Equipment shall include, but shall not be limited to, a complete and operational thermal oxidation system, including supporting equipment and accessories.

2.1.1 Design Requirements

****
NOTE: Find the wind speed and seismic zone for the stack design in ASCE 7-16.
****

Provide the thermal oxidation system in conformance with section 60.18 of 40 CFR 60. Provide vertical and lateral supports for the stack in accordance with NFPA 82 and NFPA 211, as applicable, for the wind forces indicated. Design the system for the following parameters:

Altitude	[_____] m ft above mean sea level (MSL)
Stack discharge	[3] [_____] m [10] [_____] ft above [existing grade at the site] [MSL]
Minimum equipment [service] [design] life	[_____] years
Oxidizer system dimensions	
1) Maximum vertical projection, (excluding stack)	[_____] m ft
2) Maximum ground surface coverage	[_____] x [_____] m [_____] x [_____] ft
Soil bearing capacity	[_____] MPa psf
Seismic zone	[_____]
Wind speed (maximum)	[_____] km/h mph
Ground snow load	[_____] kPa psf
Ambient air temperature	

1) Maximum	[_____] degrees C F
2) Minimum	[_____] degrees C F
Groundwater temperature	
1) Maximum	[_____] degrees C F
2) Minimum	[_____] degrees C F

2.1.2 Inorganic Chemical Concentrations

****
NOTE: Indicate method in the first blank. The table is an example. Include all identified site contaminants.

Volatile metals, chlorine, fluorine, phosphorus, sulfur or freon at low concentrations will poison, foul or mask catalysts. More innovative technologies should be strongly considered when freon is present.
****

2.1.2.1 Estimated Influent Inorganic Chemical Concentrations

Determine estimated influent inorganic chemical concentrations in the [off-gas] [vapor phase] by [_____].

Influent Concentration	Minimum	Average	Maximum
Fluorides	[_____]	[_____]	[_____]
Total Metals (as CaCO3)	[_____]	[_____]	[_____]
Copper	[_____]	[_____]	[_____]
Lead	[_____]	[_____]	[_____]
Zinc	[_____]	[_____]	[_____]

2.1.2.2 Chemical Concentrations of Entrained [Water] [Groundwater] [_____]

Determine chemical concentrations of entrained [water] [groundwater] [_____] by AWWA 10084.

Concentration	Minimum	Average	Maximum
pH			

Concentration	Minimum	Average	Maximum
Total hardness (mg/L as CaCO3)			
Calcium (mg/L)			
Magnesium (mg/L)			
Total iron (mg/L)			
Ferric iron (mg/L)			
Ferrous iron (mg/L)			
Manganese (mg/L)			
Sodium (mg/L)			
Potassium (mg/L)			
Copper (mg/L)			
Total alkalinity (mg/L as CaCO3)			
Hydroxide alkalinity (mg/L as CaCO3)			
Carbonate (mg/L as CaCO3)			
Bicarbonate (mg/L as CaCO3)			
Nitrate (mg/L)			
Nitrite (mg/L)			
Sulfate (mg/L)			
Sulfide (mg/L)			
Phosphate (mg/L)			
Chloride (mg/L)			
Chloride (mg/L)			
Fluoride (mg/L)			
Free carbon dioxide (mg/L as CaCO3)			
Dissolved oxygen (mg/L)			
Free chlorine residual (mg/L)			
Silica (mg/L)			

Concentration	Minimum	Average	Maximum
Total solids (mg/L)			
Total dissolved solids (mg/L)			
Suspended solids (mg/L)			
Turbidity in nephelometric turbidity units (NTU)			
Color by platinum standard comparison			

2.1.3 Performance Requirements

****

NOTE: Coordinate controls with the blower specified in Section 43 11 00.10 OFF-GAS FANS, BLOWERS AND PUMPS.

Select the retention time appropriate for the oxidation device considering any regulated compounds.

****

Minimum retention time in the combustion chamber shall be [0.5] [1.0] [1.5] [2.0] [2.5] [_____] seconds at [1095] [982] [820] [760] [400] [260] degrees C [2,000] [1,800] [1,500] [1,400] [750] [500] degrees F minimum at maximum flow. The flow rate shall be [constant at [_____] cu m/second scfm] [off and on at [_____] cu m/second scfm maximum, with a turndown range of four to one (4:1)] [variable between [_____] cu m/second scfm minimum and [_____] cu m/second scfm maximum]. Flow rates shall be based on measurement at standard temperature and pressure (STP), 101.3 kPa at 15.5 degrees C 14.7 psia at 60 degrees F. Influent gauge pressure shall vary between [_____] Pa inch H2O minimum, [_____] Pa inch H2O average, and [_____] Pa inch H2O maximum. Inlet temperature shall vary between [_____] degrees C degrees F minimum, [_____] degrees C degrees F average and [_____] degrees C degrees F maximum. Materials of construction shall be compatible with the ambient and operating temperatures and long term exposure to untreated and treated gas constituents.

2.1.4 Off-Gas Composition

****

NOTE: Reduce the dew point to below 50 degrees C 120 degrees F ahead of the thermal oxidizer.

If the unit will be classified as a hazardous waste incinerator, required emission limits for specific compounds are given in the National Emission Standard for Hazardous Air Pollutants (NESHAP) Maximum Achievable Control Technology (MACT) Standard. The MACT standard is scheduled to be finalized the end of 1998 and will not appear in hard copies of the 40 CFR 63 until the July 1999 edition is issued by EPA. Until the 1999 CFR is available, it will be necessary for designers to obtain the Federal Register in which the new

standard is given.

Establishing and enforcing air regulations is primarily done at the State level; therefore, it is critical that designers research State specific requirements applicable to the unit.

The BDT control device is a combustion device capable of reducing NMOC emissions by 98 weight-percent or an outlet NMOC concentration of 20 ppmv or less. The EPA 98 percent DRE requirement applies to total emissions as determined by stack gas analysis (to include aerosols, particulates, VOCs, etc.), not individual contaminants, and may not be attainable on individual contaminants in long term performance.

Include appropriate off-gas discharge requirements (or DRE) and products of incomplete combustion (if appropriate). Use energy conservation/recovery on long term or high volume devices.

****

The system shall be capable of oxidation of the organic components of gaseous, solid and aerosol type emissions, as follows. Submit reports for permit compliance.

Off-Gas Constituent		Influent Estimate	Effluent Requirement	Destruction Requirement
Total Hydrocarbon (ppmv)	Maximum			NA
	Average			NA
	Minimum		NA	[98*] [_____] percent
Methane (ppmv)	Maximum			NA
	Average		NA	NA
	Minimum		NA	[98*] [_____] percent
Non Methane Organic Compounds (NMOC) (ppmv)	Maximum		[20**] [_____]	NA
	Average		NA	NA
	Minimum		NA	[98*] [_____] percent
[_____]	Maximum			NA
	Average		NA	NA
	Minimum		NA	[95] [_____] percent

Off-Gas Constituent		Influent Estimate	Effluent Requirement	Destruction Requirement
Carbon Monoxide (ppmv)	Maximum			NA
	Average		NA	NA
	Minimum		NA	[98*] [_____] percent
Nitrogen, NOX (ppmv)	Maximum			NA
	Average		NA	NA
	Minimum		NA	
Total Sulfur, as SO2 (ppmv)	Maximum		NA	NA
	Average		NA	NA
	Minimum		NA	NA
Sulfer, SOX (ppmv)	Maximum			NA
	Average		NA	NA
	Minimum		NA	
Total Chlorine, as HCl (ppmv)	Maximum			NA
	Average		NA	NA
	Minimum		NA	
HCl (ppmv)	Maximum			NA
	Average		NA	NA
	Minimum		NA	
Water Vapor (percent saturation)	Maximum	100 percent	NA	NA
	Average		NA	NA
	Minimum		NA	NA
Particulates (mg/m3 gr/dscf)	Maximum			NA
	Average		NA	NA
	Minimum		NA	

Off-Gas Constituent		Influent Estimate	Effluent Requirement	Destruction Requirement
Opacity (percent)	Maximum			NA
	Average		NA	NA
	Minimum		NA	NA
Oxygen (percent)	Maximum		NA	NA
	Average		NA	NA
	Minimum			NA
* Destruction percentage will be determined as follows: 100% x ((Influent mass - Effluent mass)/(Influent mass)).				
** Dry basis, as hexane at 3 percent oxygen.				

2.2 MATERIALS AND EQUIPMENT

****

NOTE: A life cycle cost analysis should be performed before selection of the equipment option: flare, enclosed combustor, thermal oxidizer, catalytic thermal oxidizer, regenerative thermal oxidizer, recuperative thermal oxidizer or catalytic recuperative thermal oxidizer.

****

2.2.1 Standard Products

Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.2.2 General Requirements

Equipment and appurtenances shall be as specified and as shown on the detail drawings, and shall be suitable for the service intended. Materials and equipment shall be new and unused, except for testing equipment. Components that serve the same function and are the same size shall be identical products of the same manufacturer. The system will be rejected upon failure to achieve both the minimum temperature and the minimum retention time specified in paragraph PERFORMANCE REQUIREMENTS.

Provide detail drawings containing complete flow diagrams, piping, wiring, schematic, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show capacities and pressure drop; heat and material balances; make and model; complete list of equipment and materials. Drawings shall show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for installation, maintenance and operation

2.2.3 Nameplates

Each major item 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 item of 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]

Belts, chains, couplings, and other moving parts shall be completely enclosed by guards, 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. Thermal insulation shall enclose high temperature components to prevent ignition of combustible materials and to preclude personnel contact.

2.3 FLARE

****
NOTE: See 40 CFR 60.18 for shroud requirements; edit this paragraph if shroud is not needed.
****

The [candlestick] [open] [ground] flare shall be composed of an open combustion chamber without enclosure or shroud.

2.4 ENCLOSED COMBUSTOR

****
NOTE: Enclosed combustors must demonstrate either 98 percent NMOC reduction or outlet NMOC concentration of 20 ppmv or less.
****

The enclosed combustor shall be composed of a vertical enclosed combustion chamber that maintains a constant temperature by controlling fuel and combustion air.

2.5 THERMAL OXIDIZER

****
NOTE: Catalytic oxidation operates at a reduced temperature and should be considered when the organic carbon is between 150 ppmv and 2,000 ppmv. Review the anticipated off-gas analysis for substances that mask or poison catalysts. Edit this paragraph as required.
****

The thermal oxidizer shall be composed of a horizontal enclosed combustion chamber, with catalyst, that maintains a constant temperature by controlling fuel and combustion air. Catalyst shall be suitable for use under the conditions listed in paragraph SYSTEM DESCRIPTION and shall be fabricated in modules for ease of installation in the combustion chamber.

Thermal oxidizer shall be compatible reduced temperature operation with the catalyst in place and high temperature operation without using the modular catalyst unit.

2.6 REGENERATIVE THERMAL OXIDIZER

****

NOTE: This system is a high temperature operation that recovers energy by cycling exhaust and inlet gases through regenerative heat exchange media.

****

The thermal oxidizer shall be composed of a horizontal enclosed combustion chamber that maintains a constant temperature by controlling fuel and combustion air.

2.7 RECUPERATIVE THERMAL OXIDIZER

****

NOTE: This system consists of a high temperature operation, without catalyst, or low temperature operation, with catalyst, that recovers energy by counter current passing of the exhaust and inlet gases through the heat exchanger. Edit this paragraph as required for job conditions.

****

The thermal oxidizer shall be composed of a horizontal enclosed combustion chamber, with catalyst modules, that maintains a constant temperature by controlling fuel and combustion air. The thermal oxidizer shall be compatible with the temperatures of operation with or without using the modular catalyst unit.

2.8 CONTAMINANT CONCENTRATION SYSTEM

****

NOTE: Fuel costs for dilute or wet off-gas streams are substantially reduced by using a concentration system. Consider a concentration system if the organic carbon is less than 2,000 ppmv.

****

Inlet gas concentration of [total hydrocarbon] [methane] [non methane organic compounds (NMOC)] [_____] shall be increased by a minimum of [ten] [five] [two] times the initial concentration.

2.9 HEAT RECOVERY SYSTEM

****

NOTE: Use media for regenerative systems or heat exchanger for recuperative systems.

****

2.9.1 Media Chambers

Exhaust flow through media chambers shall recycle a minimum of [50] [_____] percent of the heat input at maximum operating conditions (maximum flow and temperature).

2.9.2 Heat Exchanger

The multiple pass, or single pass plate heat exchanger, or tube and shell heat exchanger shall recycle a minimum of [80] [_____] percent of the heat input at maximum operating conditions (maximum flow and temperature).

2.10 FLAME TRAP/ARRESTER

****
NOTE: This is a safety requirement that must be implemented.
****

Flame arrester, in accordance with FM APP GUIDE, shall be provided at the inlet to the oxidation system. The pressure drop across the flame arrester shall be a maximum of [_____] [1.5] kPa [_____] [6] in W.C. at maximum flow. The flame arrester shall have a clean-out cover to facilitate maintenance.

2.11 INLET PROTECTION

****
NOTE: The system should be protected by moisture reduction.
****

2.11.1 Knock-Out Pot

Knock out pot, with a minimum collection efficiency of [98] [98.5] [99] percent, shall be provided.

2.11.2 Mist Eliminator

A mist eliminator, with a minimum collection efficiency of [85] [98] [98.5] [99] [_____] percent of the impinging mist shall be provided.

2.12 IGNITION SYSTEM/BURNER ASSEMBLY

2.12.1 Pilot

****
NOTE: ASCE 25-16 applies to earthquake actuated systems.
****

Automatic gas shutoff system conforming to ASCE 25-16 shall be provided on the pilot supply. The pilot assembly shall be removable and shall be provided with pressure indicator, pressure regulator, solenoid valve, manual shutoff valve and pilot gas pressure manometer port. Pilot inlet nozzle shall be 150# ANSI, stainless steel, flanged.

2.12.2 Igniter

Electronic spark ignition shall be provided. The igniter assembly shall be removable from outside the combustion chamber without disconnecting conduit or wiring.

2.12.3 Burner Assembly

The primary air mixed burner shall be compatible with the specified fuel, shall have multiple small gas ports or jets, and shall be constructed of 304L/316L stainless steel, heat and corrosion resistant alloy steel, ceramic and/or castable refractory. The burner shall be of adequate capacity to maintain the required combustion temperature at the maximum flow with no fuel value in the off-gas.

2.12.4 Refractory Insulation

Removable, cast venturi burner lining assemblies shall be provided with a [1500] [_____] degrees C [2,700] [_____] degrees F rating. Refractory insulation shall be continuous, a minimum of 50 mm 2 inches of ceramic fiber insulation blanket surrounding the combustion cylinder, attached to the wall and floor with Inconel studs and washers, with plate retainers installed around all open edges of the blanket. The refractory insulation shall be coated with a high temperature, surface sealer protectant.

2.13 EXHAUST TREATMENT

2.13.1 Adsorber

****
NOTE: Adsorbers are not commonly required.
****

Exhaust gas shall be treated by an activated carbon adsorption system in accordance with Section 44 13 10.13 VAPOR PHASE ACTIVATED CARBON ADSORPTION UNITS.

2.13.2 Scrubber

****
NOTE: Scrubber is used only for high acid concentrations resulting from chlorine or sulfur in the feed or combustion of nitrogen.
****

Scrubber shall remove [85] [90] [95] [_____] percent of the acid gas formed.

2.14 STACK

2.14.1 Minimum Exit Velocity

The stack exit velocity shall be not less than [_____] m/sec ft/sec.

2.14.2 Minimum Elevation

The stack elevation shall be not less than stated in paragraph Design Requirements.

2.14.3 Lining

Stack shall be lined with ceramic and/or castable refractory.

2.14.4 Lightning Protection

An engineered lightning protection system with grounding shall be provided.

2.14.5 Lugs

Lifting lugs shall be provided at the top of the stack for ease of installation; each lug shall be capable of supporting the entire weight of the stack.

2.14.6 Access

Access to the interior of the stack shall be provided by an insulated, [hinged or supported 0.6 x 0.6 m 24 x 24 inch square or 0.6 m 24 inch diameter, manway] [150 x 150 mm 6 x 6 inch square or 150 mm 6 inch diameter, hand hole] located above the burners.

2.14.7 Ladder

An aluminum or galvanized steel fixed ladder shall be mounted to allow access for removal or replacement of each of the thermocouples. The ladder furnished with the system shall have side rails. Individual rung ladders are not acceptable. Ladder shall conform to 29 CFR 1910, Part 27 Fixed Ladders, except as specified herein. The safety cage shall be provided with locking device to prevent unauthorized access.

2.15 PROVISIONS FOR OBSERVATION AND SAMPLING

2.15.1 Observation Ports

Observation ports or sight glasses with removable tempered glass covers and cooling holes shall be provided. View port diameter shall be a minimum of [75] [50] mm [3] [2] inch. Ports shall be located to allow viewing the pilot flame, the base of the main flame, and a view of each of the thermocouples.

2.15.2 Inlet Sample Port

Inlet sample port [50] [_____] mm [2] [_____] inch minimum diameter, with cap and cooling holes, shall be located upstream of all contributing flows, with the exception of the off-gas.

2.15.3 Outlet Sample Port

Outlet sample port [50] [_____] mm [2] [_____] inch minimum diameter, with cap and cooling holes, shall be located [upstream of the cooling or dilution air inlet] [and] [two stack diameters from the top of stack].

2.15.4 Sampling Equipment

****
NOTE: Add sampler requirements.
****

Provide the following equipment: [_____].

2.16 CONTROLS

****

NOTE: Blower controls are in Section 43 11 00.10 OFF-GAS FANS, BLOWERS AND PUMPS. Omit last sentence if not applicable to the project.
****

Set points, signals and control functions and dampers shall be linked by a central programmable logic controller (PLC) located in the control panel. Control signals shall be 4-20 ma or 0-10 Vdc, compatible with the controller and sensor or control device. Burner control diagnostics shall be included. For parameters specified to be continuously recorded, digital data shall be recorded at intervals not exceeding one minute. Sensors shall be calibrated with standards traceable to NIST and in conformance with NIST SP 250. Each alarm shall be connected to an [auto-dialer] [or] [telemetry] system.

2.16.1 Ultraviolet (UV) Flame Scanner

Ultraviolet scanner shall be furnished, installed and calibrated to provide for safety shutdown on the absence of flame. The signal from each scanner shall incorporate a time delay appropriate to the control sequence. The burner flame scanner shall monitor the burner flame. The pilot flame scanner shall monitor the pilot flame.

2.16.2 Timers

Automatic timers shall provide independent adjustment of the start and duration of each step in the control sequence.

2.16.2.1 Purge Timer

The minimum purge cycle shall be set at four changes of [air] [or] [inert gas]. Purge cycle shall have both automatic and manual start.

2.16.2.2 Igniter Timer

****
NOTE: The spark duration adjustment extends the life of the plug, transformer and other pilot components.
****

An igniter timer, with [manual] [automatic] adjustment of the spark duration, shall be provided to set the time and duration of the igniter spark during the ignition cycle, and to compensate for the distance of the pilot gas supply from the oxidizer.

2.16.2.3 Pilot Timer

At the end of the purge, the pilot timer shall begin automatic ignition. If the UV sensor fails to sense the pilot flame, the pilot solenoid valve shall close, the pilot flame shall be extinguished, the system shall shut down and the pilot fail alarm shall be activated.

2.16.2.4 Main Flame Timer

The main flame timer shall extend beyond the pilot timer cycle. When the burner flame lights and the temperature exceeds the low temperature set point on the temperature controller, the pilot flame shall be shut off. The system shall shut down, and the main flame fail alarm shall be

activated, if the UV sensor fails to sense the pilot flame or the flame temperature does not reach the low temperature set point by the end of the main flame step.

2.16.3 Temperature Sensors, Transmitters and Controllers

Submit detailed manufacturer's data on the 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, off-gas transport tubing, sampling pump, moisture removal system, analyzer calibration systems, and data recorder. Process and instrumentation diagrams (P&IDs).

2.16.3.1 Thermocouples

****

NOTE: Narrow temperature ranges are more responsive than broad ranges because the sensitivity is a percentage of the range.

****

Thermocouples shall conform to ASTM E230/E230M, Type K, suitable for continuous operation and control at temperatures up to [50] [100] [150] [_____] degrees C [80] [180] [260] [_____] degrees F above the temperature specified in the performance requirements and accurate to 0.75 percent of the maximum temperature. Each thermocouple used for control shall be provided with high and low set points and an adjustable time delay before initiation of each control action. A thermocouple located in or immediately downstream of the combustion chamber shall control burner operation and shall [indicate] [and] [record] combustion chamber temperatures. [Three] [_____] additional thermocouple ports shall be spaced at vertical intervals equal to the stack diameter, starting two stack diameters from the top of the stack. Compensating lead wire connecting the thermocouple to the read out shall be 16 gauge with a weatherproof braid.

2.16.3.2 Thermometers

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

2.16.3.3 Combustion Chamber Temperature Controller

The combustion temperature control shall [record the combustion chamber temperature] [and] [maintain the temperature between the adjustable high temperature and low temperature set points]. The controller shall control the [damper actuator motors] [blowers]. Control logic shall include auto position signal and automatic switch over capabilities.

a. The system shall shut down and not attempt to restart if the temperature exceeds the allowable combustion chamber temperature range. A high temperature shutdown shall activate the high temperature alarm.

b. During operation, the system shall shut down and not attempt to restart if the temperature falls below the allowable combustion chamber temperature range. During the ignition cycle, if the temperature does not reach or exceed the low temperature shutdown

setting, the system shall shut down and not attempt to restart. A low temperature shutdown during operation or during the ignition cycle shall activate the low temperature alarm.

2.16.3.4 Primary Combustion Air Control

****
NOTE: For this and the following paragraph, refer to Section 43 11 00.10 OFF-GAS FANS, BLOWERS AND PUMPS for combustion air control.
****

Fully adjustable air dampers on each burner shall be furnished with remote operation by external lever control, sized to provide a minimum of [100] [115] percent of theoretical stoichiometric air as primary air. Dampers shall allow the operator to adjust the primary air/fuel ratio while burner is in operation.

2.16.3.5 Total Combustion Air Control

[Motor operated louver dampers shall be provided. Actuators shall cause louvers to fail open on loss of signal or power.] [Two multistage centrifugal blower trains, each with a suction valve, discharge valve, and discharge check valve shall be provided.]

2.16.3.6 Quenching/Dilution Air Control

Motor operated louver dampers shall be provided. Actuators shall cause louvers to fail open on loss of signal or power.

2.17 FLOW METERS, TRANSMITTERS AND FLOW CONTROLLER

The flow control system shall include an automatically actuated main fuel valve with fail-closed feature and limit switches for position indication. The flow rate metering system shall include recording, totaling and alarm capabilities.

2.17.1 Off-Gas Flow Meter

Flow metering for the off-gas shall conform to AGA Report No 3.

2.17.2 Supplemental Fuel Flow Meter

****
NOTE: Supplemental fuel meters should be sized on peak requirement. Off-gas meters should be based on blower size.
****

Gas meters shall conform to [AGA ANSI B109.1] [AGA ANSI B109.2] [AGA ANSI B109.3].

2.18 PRESSURE MEASUREMENT AND CONTROL

One differential pressure sensor with large diameter sensing holes shall be furnished. A differential pressure transmitter shall be provided and shall be mounted within 1 m 3 feet of the sensor. A compound vacuum/pressure gauge shall be installed on each blower. The compound gauges shall be furnished with a differential pressure range of [0.1 to

100] [_____] kPa [0.015 to 15] [_____] psig. The piping from the sensor to the transmitter shall be 3 mm 1/8 inch stainless steel tubing with stainless steel drain valves on each pipe, at low points. Piping shall be plumbed so that condensate will drain back into the pipe. The transmitter shall be equipped with zero and span adjustment, and shall provide a standard volumetric output rate reading to the chart recorder (included with the control system) without the need for separate compensating pressure or temperature transducers. A pressure gauge shall be installed on the discharge side of each blower. The pressure gauges shall be furnished with a range of 0 to 34 kPa 0 to 5 psi. The gauges shall be weatherproof, with 113 mm 4-1/2 inch dials and Type 316 stainless steel Bourdon tubes. The gauges shall be furnished with pressure snubbers and diaphragm seals and valves. Isolation valves shall be installed between the process pipe and the seal. Diaphragm seals shall be furnished with top and bottom housings and diaphragms of Type 316 SS. The diaphragm cavities shall be liquid filled with silicone.

2.18.1 Draft Gauges

Draft gauges shall be Type I, Class 1 or 2, as applicable, conforming to ASME B40.100 with a diaphragm or bellows actuating system and a circular scale. The gauges shall have a zero adjustment screw. Suitable shutoff cocks shall be provided.

2.18.2 Pressure Gauges

Pressure gauges shall conform to ASME B40.100 and be of pressure detecting Class, single Bourdon tube style, and suitable for detecting air pressure.

2.18.3 Pressure Switches

Pressure switches shall be provided to activate the blowers.

2.18.4 Pressure Release

A pressure release valve shall be located on the off-gas line upstream of the oxidizer.

2.19 EXPLOSIMETER

****

NOTE: The fuel concentration should be greater than 30 percent of LEL. Combustion air should be less than 30 percent of LEL.

****

A combustible gas analyzer, with a minimum of four in-line sensors, calibrated to methane shall be located in the control panel.

2.19.1 Lower Explosive Limit (LEL)

The lower explosive limit of the fuel and of the off-gas shall be continuously indicated. The lower explosive limit of the off-gas shall be continuously recorded.

2.19.2 Upper Explosive Limit (UEL)

The upper explosive limit of the combustion air and of the off-gas shall be continuously indicated.

2.20 OXYGEN METERING AND MAKE-UP AIR CONTROL

2.20.1 Oxygen Meter

The upper oxygen level of the combustion air and of the off-gas shall be continuously indicated.

2.20.2 Methane Monitor

The methane level of the combustion air and of the off-gas shall be continuously indicated.

2.21 OPERATING INDICATORS AND ALARMS

Simulated running lights to indicate normal operating conditions and alarms shall be displayed at the control panel.

2.21.1 Visible Alarms

Each visible alarm shall be indicated at the control panel and by a red light at the device.

2.21.2 Audible Alarms

Each audible alarm shall be located at the device.

2.21.3 Remote Alarms

****

NOTE: The Contractor should respond to alarms for the duration of the contract.

****

Remote alarms shall activate the programmable auto dialer. A prerecorded message shall provide specific information to the operator about the alarm condition. At contract close out, the dialer shall be reprogrammed to the number indicated by the Contracting Officer.

2.22 ELECTRICAL WORK

****

NOTE: Hazard classifications in accordance with NFPA 70 should be indicated on the drawings.

****

All electrical equipment, wiring and controls shall comply with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and with NFPA 70, with proper consideration given to environmental considerations such as moisture, dirt, corrosive agents and proper NFPA 70 hazardous area classification. Lightning and surge protection shall be provided.

2.22.1 Motors

Electric motor driven equipment shall be provided complete with starters and alternating current motors conforming to NEMA MG 1. Fractional horsepower motors shall be 115-volt, single-phase, 60 cycle. Integral horsepower motors shall be three-phase, 60 cycle. Motor starters shall be provided complete with properly sized thermal overload protection and

other appurtenances necessary for the motor specified. Each motor shall be designed for operation in ambient temperatures up to 40 degrees C 104 degrees F. Submit manufacturer's certificates attesting that the motors meet the NFPA 70 requirements for the hazardous area classification.

2.22.2 Control Panels

A complete control panel with options for various control schemes and control wiring shall be included. Manual or automatic controls, protective or signal devices and control wiring for the controls and devices required for the operation specified shall be provided. Motor controls shall conform to NEMA ICS 1. Enclosures for power and control panels shall conform to NEMA ICS 6. Panels located outdoors shall be [NEMA 4X] [NEMA 4] and shall be weatherproof.

2.22.3 Resistance Heaters

****
NOTE: The designer should select the most cost effective heat source for the application.
****

Electric resistance pre-heaters and dryers shall be used where indicated on the drawings.

2.23 AUXILIARY FUEL SYSTEM

****
NOTE: The designer should select the most cost effective heat source for the location.
****

2.23.1 Feed Capability

The auxiliary fuel system shall have direct feed capability to the thermal destruction system with meters, pressure gages and controls to maintain the specified operating conditions. Design shall be in conformance with the applicable requirements of NFPA 30 and NFPA 31, NFPA 54 or NFPA 58, as appropriate to the fuel type.

2.23.2 Auxiliary Fuel Regulator

Auxiliary fuel rate shall be controlled by the temperature of the combustion chamber.

2.23.3 Secondary Containment

Fuel storage tanks shall be provided with secondary containment as required by NFPA 30, paragraph 2-3.4 Control of Spillage from Aboveground Tanks.

2.24 VALVES

Design of valve operators and mechanisms shall avoid initial surges and sudden inrushes by gradually allowing flows to increase.

2.24.1 Butterfly Valves

Butterfly valve shall be cast iron body with resilient seat, 316 stainless

steel disc and shaft and actuator. Valve shall have fail-safe closing in ease of a power failure. Valve shall have location limit switch for use in the control system.

2.24.2 Other Valves

Other valves shall conform to API Spec 6D, ANSI Z21.15/CSA 9.1 or ASME B16.33 as appropriate for the type.

2.25 JOINTS

2.25.1 Dielectric Fittings

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

2.25.2 Isolation Joints

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

2.25.2.1 Sleeve Type Couplings

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

2.25.2.2 Split Sleeve Couplings

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

2.25.3 Bolts, Nuts, and Fasteners

Bolts, anchor bolts, nuts, washers, plates, bolt sleeves, and all other types of supports necessary for the installation of the equipment shall be furnished with the equipment and shall be galvanized unless otherwise indicated. Anchor bolts shall be provided with square plates at least 100 by 100 by 9 mm 4 by 4 by 3/8 inch or shall have square heads and washers and be set in the concrete forms with suitable sleeves. Expansion bolts shall have malleable-iron and lead composition elements. Unless otherwise specified, stud, tap, and machine bolts shall be of refined bar iron. All threads shall conform to ASME B1.1. Bolts, anchor bolts, nuts, and washers specified to be galvanized, shall be zinc coated, after being threaded, by the hot-dip process in conformance with ASTM A123/A123M or ASTM A153/A153M. Bolts, anchor bolts, nuts, and washers indicated to be stainless steel shall be Type 316 stainless steel.

2.26 FACTORY TESTS

Skid mount and assemble the thermal oxidation system equipment in the shop, to the maximum practical extent, in the configuration outlined in the detail drawings and specifications. Perform a factory pressure test at [125] [250] [_____] percent of the rated pressure of the equipment. Perform continuity check and process simulation at the factory before shipping the control panel. Test fire the system with the specified fuel and air and maintained at the temperature specified in paragraph PERFORMANCE REQUIREMENTS for [two] [_____] hours. Submit test reports [with the equipment] [to the Contracting Officer prior to shipment of the equipment].

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 PREPARATION

All equipment and products shall be inspected for defects in workmanship and material. Debris and foreign matter shall be cleaned out of valve openings and seats. Each operating mechanism shall be operated to check proper functioning. Each nut shall be checked for tightness. Valves and other equipment that do not operate easily or are otherwise defective shall be repaired or replaced.

3.3 FOUNDATIONS AND SKID BASES

Foundations for the thermal oxidizer and appurtenances, and pads for skid bases, shall be constructed of concrete, reinforced where necessary, in conformance with the applicable requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE, except as otherwise shown or specified. Concrete surface shall be [75] [_____] mm [3] [_____] inch above grade in outdoor locations. Mounting feet shall be provided so that appropriate anchorage can be provided. Anchor embedment depth and spacing shall be sufficient for seismic attachment to the foundation and for prevention of overturning. Concrete pad shall extend [150] [_____] mm [6] [_____] inch beyond the equipment.

3.4 ERECTION

3.4.1 Welding

****

NOTE: Use second set of brackets when critical pipe welding is required.

****

[Welding procedures shall be as specified in AWS D1.1/D1.1M] [Welding and nondestructive testing procedures for piping shall be as specified in Section 40 05 13.96 WELDING PROCESS PIPING] [Structural members shall be welded in accordance with Section 05 05 23.16 STRUCTURAL WELDING].

3.4.2 Painting/Corrosion Prevention

All ferrous surfaces shall be coated or painted. Exposed ferrous surfaces shall be painted in accordance with Section 09 90 00 PAINTS AND COATINGS. Color shall be as indicated on the paint schedule or as otherwise approved.

3.4.2.1 Factory Primed Surfaces

Factory primed surfaces shall be solvent-cleaned before painting.

3.4.2.2 Touch-Up Painting

Factory painted items shall be touched up as needed. Factory painted items requiring touching up in the field shall be thoroughly cleaned of foreign material, primed and top coated with the factory finish.

3.4.2.3 Field Painting

Equipment which did not receive a factory finish shall be prepared, primed and painted, as specified in Section 09 90 00 PAINTS AND COATINGS.

3.4.2.4 Corrosion Resistant Metals

Painting of corrosion resistant materials such as copper, brass, bronze, copper-nickel, and stainless steel is not required unless otherwise specified.

3.5 INSTALLATION

3.5.1 Insulation

Equipment and piping shall be insulated in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.5.2 Utilities

****

NOTE: Points of connection are normally shown on the drawings. Occasionally, the name, address and telephone number of each utility company is shown on the drawings. Delete the following paragraphs if the information is shown elsewhere.

****

Fuel and utilities shall be provided at locations shown on the drawings. Verify availability and locations of utilities and compensate the utility company for connection and usage. Fuel, water, sewer, power and any other utility bills shall be paid on receipt.

3.5.2.1 Electricity

The power [utility] [company] is [_____], telephone number [_____].

3.5.2.2 Water

The water [utility] [company] is [_____], telephone number [_____].

3.5.2.3 Natural Gas

The natural gas [utility] [company] is [_____], telephone number [_____].

3.5.3 Fuel System

****
NOTE: Coordinate requirements for the fuel source specified in paragraph Feed Capability.
****

Fuel system installation and testing shall comply with the applicable requirements of NFPA 30 and NFPA 31, NFPA 54 or NFPA 58, as appropriate to the type of fuel.

3.6 POSTING FRAMED INSTRUCTIONS

****
NOTE: If the user preference is known, show the location on the drawings and edit this paragraph.
****

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

3.7 FIELD QUALITY CONTROL/TESTS

3.7.1 Pressure and Leakage Test

****
NOTE: Testing of pipe and fittings should be specified in the pipe specification. The test pressure for vessels should not exceed the rated pressure.
****

After installation, test all piping, equipment, joints and connections for gas tightness. Test connections and piping by subjecting the complete system to pneumatic pressure of not less than [[105] [_____] kPa [15] [_____] psi] [the pressure indicated in the schedule] for 6 hours. During the test, the system must be disconnected from the source of pressure and, with corrections made for barometric and temperature changes, the pressure must remain constant for the test period, as indicated by a test gauge. Test joints using a soapy water solution to detect leaks.

3.7.2 Operational/Performance Tests

****
NOTE: Coordinate with the blower specification and the design sequence of operation. Testing requirements should be edited to fit the intended mode of operation for the system. Flow rates for operating capacity tests will be inserted in the

blank spaces provided.
****

After installation and pressure testing, the entire off-gas system shall be subjected to [an operational test] [a performance test] to demonstrate satisfactory functional efficiency. Results of the tests shall be used in determining the capacity and performance of the oxidation unit. Correct any deficiencies revealed during the tests and repeat the tests.

3.7.2.1 Constant Flow Tests

****
NOTE: This procedure is appropriate for a system without blowers or with a single constant speed blower.
****

Operate each unit at a constant flow rate of approximately [_____] cubic m/second cubic feet/second (actual) for the capacity test. Take samples of the influent and effluent at [[1] [8] hour] [1 day] [1 week] intervals for analysis.

3.7.2.2 Variable Flow Tests

****
NOTE: This procedure is appropriate for a system with variable speed blowers regulated by a pressure controller.
****

Operate each unit at flow rates varying between [_____] and [_____] cubic m/second [_____] and [_____] cubic feet/second (actual). Take samples of the influent and effluent at the high flow rate and [1 intermediate rate] [[2] [3] [_____] intermediate rates] for analysis.

3.7.2.3 Cyclic Flow Tests

****
NOTE: This procedure is appropriate for a system with constant speed blowers operated by on/off control.
****

Put each unit through a complete cycle of operation [at a constant flow rate of approximately [_____] cubic m/second cubic feet/second (actual)] [through the complete range of flows]. Take samples of the influent and effluent at the beginning and end of each cycle and at [1 intermediate time] [[2] [3] [_____] intermediate times] for analysis.

3.7.3 Sampling and Analyses

Collect samples of influent and effluent off-gas and analyze for the parameters listed in Paragraph OFF-GAS COMPOSITION in accordance with the Sampling and Analysis Plan.

3.7.4 Test Logs and Reports

Provide a complete log of each test, giving the following data: date, time of each reading and each sampling event, fuel use, and total off-gas

treated. Upon completion and testing of the installed system, submit test reports, with corresponding logs and in booklet form, showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria. Indicate the final position of controls on each test report.

3.7.5 Manufacturer's Field Service

Emplay services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified. The representative must supervise the installation, adjustment, calibration, commissioning, start-up and operational/performance testing of the equipment.

3.8 CLOSEOUT ACTIVITIES

3.8.1 Operating Instructions

Provide complete copies of detailed operating instructions with step-by-step procedures and sequences for system startup, operation and shutdown. The instructions shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and the operating features of each element. The instructions shall include as-built drawings of the piping layout, equipment layout, and simplified wiring and control diagrams of the system as installed. Describe automatic controls, functional logic, control loops, set points and alarm signals. Include flow diagrams in the instructions.

3.8.2 Maintenance Instructions

Provide complete copies of maintenance instructions listing maintenance procedures, possible breakdowns and repairs, and trouble shooting guides.

3.8.3 Field Training

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NOTE: Complexity of the system and experience of the user operators should be taken into consideration.

****

A field-training course shall be provided for designated operating and maintenance personnel. Submit the training course curriculum and training instructions, [14] [_____] days prior to the start of training. Training shall be provided for a total period of [_____] hours of normal working time and shall start after the system is functionally complete but prior to the [performance] [operational] test. Field training shall cover each item contained in the operating and maintenance manuals, as well as demonstrations of routine maintenance operations.

3.9 MAINTENANCE

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NOTE: Select the option that is compatible with the Bid Schedule.

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Manage, operate, maintain, and monitor the off-gas control system [until contract close out] [for at least [one year] [_____] after construction,

startup and performance testing are complete]. At a minimum, an operator shall be on site [eight] [_____] hours per week to operate, maintain, and calibrate the equipment and instruments, and to collect samples for analyses. A qualified person shall be on call to respond to emergencies and alarm conditions at the off-gas system within two hours of alarm conditions. Compliance and monitoring records and reports shall be prepared and maintained for the Contracting Officer and regulatory agencies. The operator shall maintain a log of the actions taken.

-- End of Section --