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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2024
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DIVISION 44 - POLLUTION AND WASTE CONTROL EQUIPMENT

SECTION 44 13 10.13

VAPOR PHASE ACTIVATED CARBON ADSORPTION UNITS

05/20

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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2024
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SECTION 44 13 10.13

VAPOR PHASE ACTIVATED CARBON ADSORPTION UNITS
05/20

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NOTE: This guide specification covers the requirements for systems to transfer organic contaminants from a contaminated air/gas stream (e.g. landfill off gas, soil vapor extraction, air stripping, process tank vapors, thermal desorption) to activated carbon adsorption media.

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).
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PART 1 GENERAL

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NOTE: This specification only covers offsite disposal or regeneration of activated carbon; it does not cover onsite regeneration
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1.1 UNIT PRICES

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NOTE: On many hazardous, toxic and radioactive waste (HTRW) projects, the Contractor is required to treat contaminated air/gas, as well as furnish the

equipment. Measurement and payment and unit pricing may be necessary to cover treatment costs. Write the contract to provide an incentive for the Contractor to do the job efficiently. It may be preferable to base payment on the kg lbs of contaminants removed from the air/gas stream entering the carbon vessel. However, if carbon is being used to treat the air from an air stripper, the basis would be the volume of water treated in the air stripper or kg lbs of volatile organic chemicals in the water stream entering the air stripper. Or, if the mass of contaminant decreases during the long term operation of the unit, while at the same time the O&M expenses stay approximately constant, it may be preferable to base the payment on the volume of air/gas treated.

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Payment for contaminated air/gas treated will be as described in the Payment Schedule of the Bid Form.

1.2 REFERENCES

****

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

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

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

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

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

ASHRAE FUN IP	(2021) Fundamentals Handbook, I-P Edition
ASHRAE FUN SI	(2021) Fundamentals Handbook, SI Edition

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B40.100	(2022) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM D2652	(2011; R 2020) Activated Carbon
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 D2866	(2011) Total Ash Content of Activated Carbon
ASTM D2867	(2009; R 2014) Moisture in Activated Carbon
ASTM D3802	(2016) Standard Test Method for Ball-Pan Hardness of Activated Carbon
ASTM D4607	(2014) Determination of Iodine Number of Activated Carbon
ASTM D5228	(2016) Standard Test Method for Determination of the Butane Working Capacity of Activated Carbon

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1780	(2002) HVAC Systems - Testing, Adjusting and Balancing, 3rd Edition

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2023) Structural Engineering

1.3 SUBMITTALS

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

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office

(Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy and Air Force projects.

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

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

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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

Activated Carbon Adsorption Units; G[, [_____]]

SD-03 Product Data

Emissions

Activated Carbon Adsorption Units; G[, [_____]]

Vapor Phase Activated Carbon; G[, [_____]]

Posted Framed Instructions; G[, [_____]]

SD-05 Design Data

Activated Carbon Adsorption Units; G[, [_____]]

SD-06 Test Reports

Field Quality Control

SD-07 Certificates

Vapor Phase Activated Carbon

Certification of the activated carbon [supplier] [transporter] [regeneration facility]. [Copies of the Department of Transportation licenses of carbon transporter service.]

Activated Carbon Adsorption Units Carbon Vessel Fabrication

SD-08 Manufacturer's Instructions

Activated Carbon Adsorption Units

SD-10 Operation and Maintenance Data

Operating and Maintenance Manuals; G[, [_____]]

1.4 QUALIFICATIONS

1.4.1 Contractor

Provide documentation of having [a minimum of [2] [_____] years experience in the construction, startup and operation of industrial air pollution control devices] [installed a minimum of [2] [_____] vapor phase carbon adsorption units in the past [5] [_____] years].

1.4.2 Single Source Supplier

Assign to a single supplier full responsibility for furnishing of the activated carbon system. The designated single supplier, however, need not manufacture the system but coordinates the selection, assembly, installation, and testing of the entire adsorption system, including preheater, the blower and ductwork specified in other Sections. The supplier has [been in the business of manufacturing, fabricating or installing these systems for a minimum of [2] [_____] years] [manufactured and supplied a minimum of [5] [_____] vapor phase carbon adsorption units].

1.4.3 Carbon Vessel Fabricator

****

NOTE: Verification from a registered professional engineer should only be required for large systems which have to be bolted to the foundation. Delete this paragraph for small units which are on forktubes or a flat base and not fastened to the foundation.

****

Provide verification from a Registered Professional Engineer, licensed to practice mechanical or structural engineering, as appropriate, in the State in which the system is to be installed to verify that: 1) The fabrication drawings and pressure calculations for the vessels and appurtenances were done for the site conditions in accordance with the appropriate codes and standards. 2) The erection drawings for the shells and tank foundations and supports were done for the site conditions in accordance with the appropriate codes and standards. Submit certification from this Engineer documenting the verification.

1.5 PARTNERING AND/OR PRE-SUBMITTAL MEETING

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NOTE: Remove this paragraph when a meeting is not required.

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

1.6 DELIVERY, STORAGE, AND HANDLING

Preassemble parts to the largest extent possible, compatible with transportation limitations and equipment protection considerations. Field assembly, if any, requires merely bolting together of match-marked components. Crate and deliver equipment to protect against damage during shipping. Protect flange faces from damage. Cover all openings to prevent entrance of dirt, water and debris. Properly protect all parts so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and until the units and equipment are ready for operation. Properly protect finished iron or steel surfaces to prevent rust and corrosion. Protect all equipment, delivered and designated for storage, from the weather (humidity and temperature), dirt and dust, and other contaminants.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

****

NOTE: Provide additional information about equipment preceding and following the carbon vessel. This is to provide the vendor with a complete picture of the unit's purpose and operation. Some paragraphs may be eliminated or modified if this Section is to be issued as a performance specification. Others will be eliminated or modified if it is to be issued as a design specification.

Laboratory adsorption studies are seldom done for air/gas adsorption. Estimates are obtained from isothermal data or from vendor computer programs. The ASTM Standards do not provide information on the minimum and maximum values that are acceptable for specifying carbon. Manufacturers may need to be contacted to determine the acceptable values. The characteristics for virgin and regenerated carbon will be different. Verify that the requirements are correct for the type of carbon specified.

****

Provide a vapor phase activated carbon adsorption system as a complete once-through forced flow system. Furnish system capable of reducing the levels of the listed organic contaminants to the values shown in paragraph Performance Requirements. Fill the unit with granular activated carbon for removal of organic contaminants from [landfill gas] [soil vapor extraction air/gas] [air stripping air/gas] [process tank vapor emissions] [low temperature thermal desorption air/gas] [_____]. Equipment includes, but is limited to, vessels containing activated carbon, supporting equipment and accessories. Terminology is in conformance with ASTM D2652. Provide complete system with [[2] [_____] parallel trains of [2] [_____] carbon vessels in [series] [parallel]] [[2] [_____] carbon vessels [in series] [parallel]], activated carbon, [blowers], instruments, controls, valves, piping, pre-heater/cooler and other specified appurtenances. Arrange the piping [as shown on the drawings] [_____] to allow any of the [2] [_____] units to serve as the primary unit and to also allow any unit to operate alone while the other units are being emptied and refilled with fresh carbon. Design the system to operate continuously, 24 hours per

day, 7 days per week.

2.1.1 Design Requirements

****

NOTE: The most difficult part of designing an activated carbon adsorption system may be determining the contaminant concentration in the air/gas stream to be treated. Many times design estimates are based on limited data. The actual rate, particularly after the unit has operated for a while, may be much different. An approach may be to design the process for easy addition or removal of carbon units as determined after startup.

Determine seismic parameters from paragraph Seismic Requirements, and wind speed from ASCE 7-16, Chapter 1, or UFC-3-301-01. Specify whether the unit will be installed inside or outside and any other conditions that will affect the operation of the unit. Coordinate this Section with other pertinent Sections to ensure that information is presented only once. Verify that the floor and footings are designed to support the equipment.

****

Meet the following requirements:

a. Minimum equipment design life: [_____] years.

b. Vessel type: [permanent with carbon] [replacement] [interchangeable canisters].

c. Adsorption system design requirements:

(1) Maximum vertical projection: [_____] m ft.

(2) Maximum ground surface coverage: [_____] by [_____] m ft.

d. Seismic parameters: [_____].

e. Wind speed (maximum): [_____] km/h mph.

f. Ground snow load: [_____] kPa psf.

g. Ambient air temperature:

(1) Maximum: [_____] degrees C degrees F.

(2) Minimum: [_____] degrees C degrees F.

2.1.2 Influent Air/Gas Conditions

****

NOTE: Remove this paragraph if the specification is to be issued as a design specification. Obtain an analysis of the air/gas to be treated giving appropriate information to be inserted in the blank spaces. The inlet air/gas composition may be

difficult to obtain. If the specification is to be issued as a performance specification the inlet composition will need to be estimated.

Oxygen and methane data are useful if the methane concentration is high enough to have a potential to be in the explosive range. If the concentration is well below this range, remove the methane and oxygen concentration lines. Provide all available information. All available pertinent site characterization data should be placed in an appendix of the technical specifications or on the drawings, and referenced here. Indicate the detail to which site characterization has been performed and indicate where data gaps exist. The information should also include soil gas data, chemical data, geotechnical data, sampling locations, and boring logs. Table must be edited to add contaminants not listed and delete those that are not applicable. Verify that carbon will adsorb the organic chemicals since many organic chemicals do not adsorb well on carbon.

****

	Minimum	Average	Maximum	Unit of Measure
Oxygen			[_____]	percent
Methane			[_____]	percent
Relative Humidity	[_____]	[_____]	50	percent
Carbon Tetrachloride	[_____]	[_____]	[_____]	ppmv
Trichloroethene	[_____]	[_____]	[_____]	ppmv
Benzene	[_____]	[_____]	[_____]	ppmv
Toluene	[_____]	[_____]	[_____]	ppmv
Xylene	[_____]	[_____]	[_____]	ppmv
Carbon Monoxide	[_____]	[_____]	[_____]	ppmv
Ozone	[_____]	[_____]	[_____]	ppmv
[_____]	[_____]	[_____]	[_____]	ppmv

2.1.3 Performance Requirements

****

NOTE: Remove these paragraphs if the specification is to be issued as a design specification. Removal expressed as a percent is dependent on inlet concentrations which can vary. Ensure that the desired emission rates can be met before using

percent removal.

****

2.1.3.1 Physical Requirements

	Minimum	Maximum
Air/gas flow rate	0.0005 cu m/s1 scfm	
Air/gas temperature		60 degrees C140 degrees F
Inlet Pressure		70 kPa10 psig

2.1.3.2 Chemical Requirements

	Maximum Emission	Percent Removal
Carbon Tetrachloride	[_____] ppmv	[_____]
Trichloroethene	[_____] ppmv	[_____]
Benzene	[_____] ppmv	[_____]
Toluene	[_____] ppmv	[_____]
Xylene	[_____] ppmv	[_____]
[_____]	[_____] ppmv	[_____]

2.1.3.3 Carbon Replacement

Replace carbon at intervals no less than [_____] days.

2.1.4 Design Calculations

****

NOTE: Delete this paragraph when design is done by the Government.

****

Supply a copy of all the design calculations to the Contracting Officer before initiation of construction.

2.1.5 Conformance to Design

Provide calculations, layouts and drawings of the carbon adsorption system to clearly show the basis for the design; including isotherms, estimated breakthrough volumes, and calculations to show that the entire system will conform to paragraph Performance Requirements.

2.2 MATERIALS AND EQUIPMENT

2.2.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that

essentially duplicate items that have been in satisfactory use for at least [2] [_____] years prior to bid opening. Provide materials and equipment supported by a service organization that is located within [_____] km miles of the site.

2.2.2 Nameplates

Provide major equipment items such as adsorption vessels, blowers and motors with the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.3 VAPOR PHASE ACTIVATED CARBON

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NOTE: Performance specifications are recommended to allow the Contractor to install proven "off-the-shelf" units supplied by two or three reputable manufacturers. Determine if the first charge of carbon needs to be virgin carbon for liability requirements. Remove items not required below.
****

Provide material conforming to the following list; submit certificates attesting that the activated carbon furnished meets the specified requirements. Also, submit the type of activated carbon, with isotherms for the selected carbon, with each of the volatile organic compounds listed in the effluent requirements for the anticipated temperature range at 50 percent relative humidity. Use design calculations or vendor computer models to estimate the mass of carbon required and the breakthrough curves for the listed organic compounds in the carbon bed.

a. Provide an initial charge of carbon that is [virgin] [regenerated] [virgin or regenerated] carbon. Provide subsequent charges that are [virgin] [regenerated] [virgin or regenerated] carbon.

b. Furnish carbon adsorption system capable of reducing emissions for individual compounds to below the limits specified in SYSTEM DESCRIPTION.

c. Base approximate average volatile organic composition of the vapor stream on estimated influent component levels as specified in SYSTEM DESCRIPTION.

d. Provide minimum butane working capacity of new activated carbon of [23.8] [_____] percent by weight as determined by ASTM D5228.

e. Provide minimum iodine number of virgin or reactivated carbon of [1000] [_____] as determined by ASTM D4607.

f. Provide maximum moisture content of [2] [_____] percent by weight as determined by ASTM D2867.

g. Provide maximum total ash content of [10] [_____] percent by weight as determined by ASTM D2866.

h. Provide minimum hardness number of [90] [_____] necessary for the required life in vapor phase applications as determined by ASTM D3802.

i. Provide uniform activated carbon particle size for consistent pressure drop characteristics. Provide maximum particle size of 4.6 mm 0.2 inch diameter as determined by ASTM D2862.

j. The granular activated carbon must be of the type that can be accepted for offsite regeneration of the spent activated carbon by an approved carbon regeneration facility.

k. Provide minimum apparent density of [0.45] [_____] g/cc as determined by ASTM D2854.

l. Maximum pressure drop is [_____] kPa/m inches of water per foot of bed depth, measured in air at 21 degrees C 70 degrees F.

m. US Sieve size is [4 x 8] [_____].

n. Furnish material that is free from impurities that affect the serviceability and appearance of the finished product.

2.4 ACTIVATED CARBON ADSORPTION UNITS

****

NOTE: General rules to the system designer for configuration of a vapor phase activated carbon system are as follows:

a. Two stage series operation to provide longer contact and more complete exhaustion of the carbon is preferred. In series operation, the unit with the freshest carbon at any given time should be in the lag position. For critical operations, lead, lag and standby units should be provided as specified in paragraph SYSTEM DESCRIPTION.

b. Multiple units in parallel operation are frequently used for high flows with low contamination levels when short contact times are adequate. Single units should be used only in installations in which the system can be shut down for change out of the activated carbon adsorption media. Multiple smaller units containing the same amount of carbon and providing equal contact are usually preferable to single large unit.

c. An appropriate piping configuration which can adapt the units for series or parallel operation should be considered. Arrangements that allow conversion from parallel to series and the reverse allow the flexibility to respond to differing conditions.

d. Surface loading ranges between 12 and 24 cu m/min/sq m 40 and 80 cfm/min/sq ft are often used.

e. Minimum bed depth at a given velocity is based on the minimum contact time required to achieve the required removal. Additional bed volume allows more time between carbon changes.

f. The relative humidity of the air/gas entering the carbon unit should be 50 percent or less. If the air/gas entering the unit has entrained water an air/gas-water separator should be used. Without this, the temperature of the air/gas will have to be elevated enough to vaporize the mist and lower the relative humidity to about 50 per cent. At this higher temperature the organic chemical may not adsorb well.

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2.4.1 Velocity

****

NOTE: In an up-flow system the velocity should generally be in the range of 12 to 24 m/sec 40 to 80 feet per minute; this depends on the particle size. In a down-flow system, the flow velocity is only limited by the allowable pressure drop.

****

The minimum and maximum acceptable flow velocities are as follows: 0.25 m/sec at [_____] cu m/sec minimum; and 0.375 m/sec at [_____] cu m/sec maximum 40 ft/min at [_____] scfm minimum; and 80 ft/min at [_____] scfm maximum.

2.4.2 Vapor Distribution/Collection Systems

Provide effective distribution across the bed throughout the stated capacity range. Provide a system to minimize short circuiting or channeling of contaminated air/gas through the carbon vessel. Design the system to evenly distribute the controlled contaminated air/gas flow across the cross section, with the nominal velocity under design conditions not exceeding 0.41 m/sec 80 fpm for up-flow systems. Adequately design the inlet and outlet to prevent local pressurization in excess of the vessel rating or design.

2.4.3 Shell Design

****

NOTE: Most carbon vessels are not designed for vacuum. Verify that a vacuum cannot be drawn on the vessel exceeding the manufacturer's recommendation. If the vessel will have internal pressure greater than 103 kPa 15 psig, it may need to be ASME rated. Vessels with less than this pressure may or may not need to be pressure rated depending on special ASME or State/local codes.

****

2.4.3.1 Corrosion Prevention

Use corrosion resistant steel, fiberglass, or other plastic for shell construction or a steel shell with a corrosion resistant [enamel] [_____] coating. Provide lining system with a corrosion resistant [epoxy or phenolic resin] [_____] coating. Furnish paint kits for use after assembly and finishing.

2.4.3.2 Manways

Minimum manway requirements, for access, addition and removal of carbon are [1] [_____] per adsorber and 610 mm 24 in minimum nominal diameter.

2.4.3.3 Insulation

****

NOTE: Insulation is optional. It may be needed if the carbon units are installed outside in cold climates. A high differential pressure across a fan or blower that precedes the carbon unit may result in a high air/gas discharge temperature. Pipes and fittings down stream may not need insulation. Plastic or fiberglass pipes and fittings should not be used if the discharge temperature can exceed that recommended for the material.

****

Install insulation [and heat tape] to prevent cooling of the air/gas in the system as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Insulate all outside surfaces of the following equipment: [adsorbers] [pipes] [fittings] [stacks] [_____].

2.4.3.4 Vessel

****

NOTE: If the specification is to be issued as a performance specification, remove adsorber diameter and carbon quality in this paragraph. Delete the minimum bed depth for a performance specification. Small units do not need inlet air/gas distributors. Add a paragraph requiring an outside access ladder if the top of the vessel must be accessed frequently. The number of carbon vessels should conform to those specified in SYSTEM DESCRIPTION.

****

Comply with the following requirements:

a. Minimum Number of Vessels: [2] [_____].

b. Minimum Adsorber Diameter: [_____] m ft.

c. Material of Construction: [carbon steel] [_____].

d. Maximum Allowable Working Pressure: [_____] kPa psig.

e. Minimum Carbon Quantity per Vessel: [_____] kg lbs.

f. Minimum Carbon Bed Depth: 922 mm 36 inches.

g. Flow Direction: [upflow] [downflow].

h. Outlet Collector: [_____].

i. Inlet Distributor: Integral

j. Min. Allowable Temperature: [_____] degrees C degrees F.

Each unit must be [skid-mounted. Fabricate skids of [cast iron] [steel] channels and design to support the equipment and to distribute the weight in transit and in service without loading on the tank or concrete slab;] [equip with lifting lugs] and pre-pipe internally. Secure each vessel to a structural steel frame suitable for shipment or transport with a forklift or crane and set on a level area for operation. Coat exterior structural steel surfaces with a suitable primer and top coat to resist corrosion due to water spray. Provide a minimum of one ground connection for each unit. If required, provide each unit with an inlet air/gas distributor. Provide sampling ports on the inlet and outlet pipes of each vessel to allow independent sampling and measurement of breakthrough for each unit.

2.4.3.5 Fire Sprinklers

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NOTE: A fire suppression system is needed if the carbon manufacturer believes the adsorbed contaminant can react and cause a fire.
****

Equip carbon vessels with an internal water sprinkler to suppress carbon fires.

2.4.3.6 Seismic Requirements

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NOTE: Provide seismic requirements, if a government designer (either Corps office or A/E) is the Engineer of Record, and show on the drawings. Remove the bracketed phrase if seismic details are not provided. Pertinent portions of UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR MISCELLANEOUS EQUIPMENT and 23 05 48.19 [SEISMIC] BRACING FOR HVAC properly edited, must be included in the contract documents.
****

Support and brace adsorption units to resist seismic loads as specified under UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR MISCELLANEOUS EQUIPMENT and 23 05 48.19 [SEISMIC] BRACING FOR HVAC [as shown on the drawings].

2.4.4 Unit Submittals

2.4.4.1 Layout and Detail Drawings

Drawings showing complete equipment layout, piping, wiring and schematic diagrams, and installation instructions and any other details required to show equipment relationships, clearances for maintenance and operation and to demonstrate that the system has been coordinated and will properly function as a unit. Process flow diagrams and instrumentation diagrams showing all major pieces of process equipment with controls. Details on the carbon adsorber shell including information on vapor diffusion, carbon contact shell dimensions, construction materials and structural and supporting design calculations.

2.4.4.2 Calculations and Modeling

Design calculations or computer modeling results for vapor phase carbon adsorption system indicating removals of each of the organic compounds listed. Demonstration of, or design calculations for, the total head loss through the carbon unit. Provide isotherm and design calculations or manufacturer's computer models to estimate the mass of carbon required and the breakthrough curves. Calculations showing how the vapor phase carbon adsorption system functions with the entire air/gas system including carbon vessel, [regeneration equipment], preheater, instrumentation and controls, dimensions, capacities, make and model, materials of construction, coating systems, pressure drop through each component of the system, including line sizing, valving, pressure and temperature gauges. Structural calculations for fabrication and erection drawings if requested (not needed for drum/canister applications).

2.4.4.3 System Supplier Testing

Submit certificate from system supplier showing that the equipment has been tested and has passed all quality control criteria.

2.5 ACCESSORIES

2.5.1 Blowers

Conform to Section 43 11 00.10 OFF-GAS FANS, BLOWERS AND PUMPS.

2.5.2 Preconditioning Equipment for Inlet Air/Gas Stream

****

NOTE: An air/gas preheater may not be needed if the carbon unit is preceded with a blower. Blowers heat the air/gas which reduces the relative humidity. A blower may raise the temperature of the air/gas more than needed. If this occurs, cooling will be required before entering the carbon unit. If a specific type of preheater is needed, specific information on the type of heater, materials of construction and type of energy source (electricity, steam, natural gas) should be indicated on the drawings or added to the specifications. Either the paragraph on the air/gas preheater or the air/gas cooler or both should be deleted.

****

[A preheater is required if the relative humidity is greater than [50] [_____] per cent. Provide preheater [of the type and size as shown on the schedule on the drawings] [_____]. The preheater must lower the relative humidity of the influent to [50] [_____] percent. Provide materials of construction and controls and cutoffs. Provide heating element that is [directly] [indirectly] heated.] [The vapor stream leaving a forced draft blower that precedes the carbon vessel must pass through a heat exchanger that cools the air/gas stream. Provide heat exchanger of the type and size as shown on the schedule on the drawings. The heat exchanger must lower the temperature enough to raise the relative humidity to no more than 50 percent.]

2.5.3 Carbon Storage and Transfer System

****

NOTE: Fresh carbon storage vessels and exhausted carbon storage vessels are not usually used in vapor phase systems. In large systems, the carbon is vacuumed or removed by eductor (water) and put into a truck. In smaller systems the carbon is usually removed by vacuum.

If there is no onsite storage, two trucks are needed, one empty to receive the used carbon and one with fresh carbon. Economics should dictate whether to install extra vessels at the site or to have an empty truck accompany the truck with the fresh carbon. It is often desirable to size the vessels to hold a full truck load of activated carbon to reduce shipping costs. On many small systems, the entire vessel containing the used carbon is replaced with a vessel containing fresh carbon. Vessels are sometimes filled from 400 to 450 kg 900 to 1000 pound sacks or 90 kg 200 pound drums. In this situation, no storage tanks are needed. Remove the paragraph on fresh Carbon Storage Tank and Exhausted Carbon Storage Tanks if these will not be required.

****

2.5.3.1 Fresh Carbon Storage Tanks

Provide a fresh carbon storage system. Minimum capacity of the system must provide storage of [_____] kg pounds of dry carbon at a bulk density of [_____] kg/cubic meter pcf.

2.5.3.2 Exhausted Carbon Storage Tanks

Provide an exhausted carbon storage supply system. Minimum capacity of the system must provide storage of [_____] kg pounds of wet carbon saturated with organic chemicals.

2.5.3.3 Sampling Valves

Provide sampling valves at the inlet and outlet of each carbon unit.

2.5.3.4 Piping

Furnish piping in accordance with Section 31 21 00 OFF-GASSING MITIGATION.

2.6 ACTIVATED CARBON INSTRUMENTATION AND CONTROLS

****

NOTE: These paragraphs can be used in conjunction with Sections 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION and 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC modified as required for this application. An instrumentation and control Guide Specification for hazardous waste systems is being written.

****

2.6.1 Sensors and Transmitters

****

NOTE: The humidity interlock will prevent condensation of water vapor in the carbon during startup if conditions exist that could allow high humidity air to the carbon unit.

****

Provide sensors and transmitters that have a range selected for the application, using the smallest range available from the controls manufacturer that will meet all expected sensed conditions in the sequence of control. Provide sensors and transmitters consisting of the following:

2.6.1.1 Relative Humidity Sensors

Provide relative humidity sensing element with a relative humidity sending range from 0 to 100 percent (condensing). Provide sensor capable of sensing a condensing air stream (100 percent RH) without affecting the sensors calibration or harming the sensor. Provide sensing elements with an accuracy of plus or minus 5 percent of full scale within the range of 20 to 80 percent relative humidity. Mount all sensors in locations that are accessible for calibration and fit for ease of calibration and re-calibration.

2.6.1.2 Airflow Measuring

****

NOTE: Pitot-tube type flow measuring devices can malfunction if the air/gas contains water droplets.

****

Provide velocity sensing elements that are the [RTD or thermistor type, with linearizing means. Distribute the sensing elements across the pipe in the quantity and pattern set forth for measurements and instructions in ASHRAE FUN SIASHRAE FUN IP and SMACNA 1780 for traversing of ducted airflows. The resistance to airflow through the airflow measurement station must not exceed 2 mm 0.08 inch water gauge at an airflow of 600 m/min 2,000 fpm. Station construction must be suitable for operation at airflows of up to 1500 m/min 5,000 fpm over a temperature range of 4 to 60 degrees C 40 to 140 degrees F, and an accuracy of plus or minus 3 percent over a range of 40 to 760 m/min 125 to 2,500 fpm scaled to air volume.] [multiple pitot tube type with averaging manifolds. Distribute the sensing elements across the pipe in the quantity and pattern set forth for measurements and instruments in ASHRAE FUN SIASHRAE FUN IP or SMACNA 1780 for the traversing of ducted airflows. The resistance to airflow through the airflow measurement station must not exceed 2 mm 0.08 inch water gauge at an airflow of 600 m/min 2,000 fpm. Station construction must be suitable for operation at airflows of up to 1500 m/min 5,000 fpm over a temperature range of 4 to 60 degrees C 40 to 140 degrees F, and an accuracy of plus or minus 3 percent over a range of 150 to 760 m/min 500 to 2,500 fpm scaled to air volume. Do not use this device if the required velocity measurement is below 210 m/min 700 fpm.]

2.6.1.3 Pressure Gauges

Provide pressure gauges conforming to ASME B40.100.

2.6.1.4 Thermometers

Provide dial type thermometers, 88 mm 3-1/2 inch diameter, chromium plated case; remote or direct-type bulb as required; plus or minus 0.5 degree C 1 degree F accuracy; white face with black digits graduated in 1 degree C 2 degree F increments. Provide thermometer wells of the separable socket type for each thermometer with direct-type bulb. Range of thermometers is [_____] to [_____] degrees C degrees F.

2.6.2 Controllers

Provide controllers that have set point, action, proportional band, authority throttling range, ratio, and remote set point adjustment as required to meet requirements of the sequence of control. Mount controllers on a unit control panel located [in the same room as the system being controlled] [near the carbon vessels].

2.6.2.1 Relative Humidity Controllers

Provide space-type humidity controllers that take full control action for a relative humidity change of plus or minus 5 percent of the setting of the controller. Set point adjustment range is approximately [20] [_____] percent to [80] [_____] percent relative humidity. Provide controllers with adjustable throttling ranges. Mount insertion type controllers in the interior of piping and fit with air shields where so recommended by the manufacturer.

2.6.2.2 Alarms

Alarm annunciation must be by [visual] [and] [audible] indication. Alarm signals must be locked in and require manual reset. [Furnish an auto dialer] [Telemeter alarms to the master control panel in the control room].

2.6.2.3 Relative Humidity Alarms

Install relative humidity alarms immediately upstream from the carbon vessels to alert the operator of relative humidity exceeding [50] [_____] percent.

2.6.2.4 Pressure Alarms

Install pressure [alarms] [indicators] on each side of the carbon vessels to alert the operator of excessive pressure drop.

2.6.2.5 Temperature Alarms

****
NOTE: Temperature or carbon monoxide alarms can be used to monitor for fire in the carbon bed.
****

Provide temperature on excursions (drop or rise) of [10] [_____] degrees C [18] [_____] degrees F outside the control range in the duct leaving the carbon vessel.

2.6.2.6 Carbon Monoxide Alarms

Provide carbon monoxide alarms to alert the operator of concentrations in excess of [100] [_____] ppm in the exit gas.

2.6.2.7 Timing Interlock

Provide a timing interlock to delay starting the blower until the preheater has been turned on for [15] [_____] seconds. Provide interlock to prevent saturation of the carbon during startup procedures and to delay blower stops after every shut performed.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 EQUIPMENT INSTALLATION

Install equipment as shown and in accordance with written instructions of the manufacturer. Each vessel must be [anchored to a footing isolated from the floor slab] [mounted on a skid base]. Provide anchor brackets, anchor rods or straps to hold the shell to anchors in the footing. Design reinforced concrete foundations for each carbon unit to support the unit and in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.3 PAINTING FOR CORROSION PREVENTION

Paint equipment which did not receive a factory finish, unless specified otherwise. Apply paint system to the outside of the tank in accordance with Section 09 90 00 PAINTS AND COATINGS. Prime surfaces that have not been factory primed and top coat with the manufacturer's standard factory finish. Provide factory painting conforming to manufacturer's standard factory finish. Repair all defects in the finish prior to or during installation of the equipment as specified in Section 09 90 00 PAINTS AND COATINGS. Paint all exposed ferrous surfaces not painted in the factory in accordance with Section 09 90 00 PAINTS AND COATINGS. Painting of corrosion resistant materials such as copper, brass, bronze, copper-nickel, and stainless steel is not required, unless otherwise specified. Coat or paint all ferrous surfaces. Provide color as indicated on the paint schedule or as otherwise approved.

3.4 POSTED FRAMED INSTRUCTIONS

Post installation instructions, sequences, and precautions, including tolerances for level, horizontal, and vertical alignment as specified. Submit for approval prior to posting: Grouting requirements, including grout spaces and materials; wiring and control diagrams; system layouts and isometrics; instructions and other sheets; operating instructions explaining preventive maintenance procedures and checks to assure the system is operating normally and safely. Methods of checking the system for normal safe operation; procedures for operating the system; and prepare procedures for safely starting and stopping the system in typed form, framed and posted beside the diagrams. Write instructions for any required sampling, carbon transfer and shipping of activated carbon to regeneration or disposal facility. Catalog cuts are not acceptable.

3.5 FIELD QUALITY CONTROL

Submit reports on tests performed to show compliance with instructions.

Include in the test reports all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria. Indicate in each test report the final position of all controls. Reflect performance test data in the operating instructions.

3.5.1 Equipment Tests

After installation of the carbon adsorption system is complete, carry out operating tests to ensure that the unit installed operates properly. Inspect all products carefully for defects in workmanship and material; clean debris and foreign matter out of all equipment; test all operating mechanisms to check their proper functioning; and check all nuts and bolts for tightness. Repair or replace valves and other equipment which do not operate easily or are otherwise defective. Assure that there is no vibration, or noise from any parts. If deficiencies are revealed during tests, correct such deficiencies and reconduct the tests at the Contractor's expense.

3.5.2 Performance Tests

****

NOTE: Running the unit to exhaustion should only be required if this is expected to occur within the test period. Some vessels may not get to exhaustion for a long period of time. Verify that the sample ports are addressed in Section 31 21 00 OFF-GASSING MITIGATION. Coordinate sampling requirements of this paragraph with the sampling requirements of other units/processes in the entire treatment train.

****

After installation of the activated carbon adsorption system, carry out operating tests to ensure that the system operates properly. Include the adsorption units, all accessories and instruments and controls. If any deficiencies are revealed during any tests, correct such deficiencies and repeat the tests. Run[each] [a typical] adsorber at a constant flow rate of approximately [_____] cubic meters/second scfm [until the maximum emissions as listed in paragraph Chemical Requirements occur] [for [24] [_____] hours]. Make a complete log of each test run, giving the following data: date, time of readings and sampling. Determine total chemicals removed by analyses of the inlet and outlet for the chemical requirements listed in paragraph Performance Requirements. Take samples of the emissions for analysis after [each [_____] cubic meters feet have been run through the adsorber] [[_____] hours of operation]. Use results of the tests in determining the capacity and performance of the adsorption unit. Submit the reports to document emissions permit compliance. Perform sampling and analyses in accordance with [_____].

3.5.3 Spent Activated Carbon Sampling and Analyses

Perform sampling and analyses of the spent activated carbon media in accordance with requirements [for spent carbon transport and requirements of the regeneration facility] [of the RCRA permitted treatment, storage and disposal facility].

3.5.4 Carbon Testing

Test the carbon to be used during the performance testing to ensure it

meets the requirements of [_____].

3.5.5 Breakthrough Monitoring

****
NOTE: Continuous emission monitors are not addressed in this Section. If continuous emission monitors are required, verify that the detector used is specific for the chemicals to be monitored.
****

Monitoring the emissions for the chemicals listed in paragraph CHEMICAL REQUIREMENTS once every [7] [_____] days to determine when to replace the granular activated carbon. Record the volume of air/gas that was treated, from the time that the vessel was placed in the upstream position until breakthrough was consistently determined, as the breakthrough volume. Breakthrough volume is the volume of air/gas that was treated before the concentration of any one of the chemicals in paragraph Chemical Requirements was exceeded. The criteria for determining when to replace granular activated carbon may be modified as more data are generated.

3.5.6 Noncompliance with Performance Requirements

Removals must meet or exceed those specified in the performance requirements of this specification. If at any time during the first [12] [_____] months of operation the results of the organic analyses of the air/gas emissions are not in compliance with maximum emissions levels listed in paragraph CHEMICAL REQUIREMENTS, except for periods when the carbon is saturated, flow through the unit and the system is inoperable. If at any time the operation of the system does not meet the flow rate requirements, instrumentation or control requirements set forth in this contract, stop flow through the system. Proceed immediately to repair or modify the system for compliance with the contract documents. Make repairs or modifications entirely at the Contractor's expense. Notify the Contracting Officer one day before the system is to be restarted and retested.

3.6 OPERATION AND MAINTENANCE SUPPLIES

3.6.1 PARTS, TOOLS AND HANDLING EQUIPMENT

Submit a complete list of parts, supplies, special tools, instruments and accessories and special lifting and handling devices required for periodic maintenance, repair, adjustment and calibration and recommended spare parts for each different item of material and equipment specified, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after [one] [_____] and [three] [_____] years of service.

3.6.2 EXTRA MATERIALS

Within 30 days of system approval, furnish a spare parts list for each different item of material and equipment specified with the shop drawings submitted. Include in the list parts, supplies, prices and sources schedule. Furnish those spare parts and special tools which are recommended by the manufacturer. Also provide 12 months supply of any expendable items and frequently replaced parts, except for carbon, as identified by the manufacturer. Following completion of the startup and operating period [replenish the spare parts inventory and provide a twelve

month supply] [supply the [carbon regeneration] [carbon disposal] facility name, address and price schedule].

3.7 MANUFACTURER'S FIELD SERVICE

Provide the services of the manufacturer's representative, who is experienced in the installation, adjustment and operation of the equipment specified, for a minimum of [16] [_____] hours at the site. Supervise the installation, adjustment, and testing of the equipment. Prior to startup, inspect the equipment for alignment and connections by a factory representative. Inspect the final installation and supervise the adjustment and testing of the equipment. Schedule and coordinate the testing to coincide with the later phases of the carbon column testing, to prove out the complete installation in the presence of a Government representative. After completion of all testing, assist the plant operators in plant startup.

3.8 CLOSEOUT ACTIVITIES

3.8.1 Operating and Maintenance Manuals

Submit [six] [_____] complete copies of operating instructions outlining the step-by-step procedures required for system startup, operation and shutdown. Include in the instructions layout, wiring, and control diagrams of the system as installed. Also the manufacturer's name, model number, service manual, parts list, brief description of all equipment and their basic operation features, and operating instructions for each piece of equipment and bulletins, cut sheets and descriptive data. [Six] [_____] complete copies of maintenance instructions listing routine preventative maintenance procedures, possible breakdowns and repairs, and trouble shooting guides list showing lubricants for each item of mechanical equipment, approximate quantities needed per year and recommended lubrication intervals.

3.9 FIELD TRAINING

Conduct a training course of operating staff as designated by the Contracting Officer. Start the training period, for a total of [24] [36] hours of normal working time, after the system is functionally complete but prior to final acceptance tests. Cover the topics included in the Operating and Maintenance Manuals. Also provide [16] [_____] hours of training, as directed by the Contracting Officer, following completion of the [one year] [_____] operating period for the follow-in Contractor.

-- End of Section --