
USACE / NAVFAC / AFCEC / NASA UFGS-11 24 27 (October 2007)

Preparing Activity: USACE Superseding
UFGS-11 24 27 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2016

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DIVISION 11 - EQUIPMENT

SECTION 11 24 27

AIR STRIPPER

10/07

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AIR STRIPPER 10/07

NOTE: This guide specification covers the requirements for systems to transfer volatile compounds from a water stream to an air stream.

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 items(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

NOTE: This guide specification covers air strippers for removal of volatile substances from water. Refer to Design Guide (DG) 1110-1-2 Air Stripping.

1.1 UNIT PRICES

NOTE: If the Contractor is required to treat water, as well as to furnish the equipment, measurement and payment and unit pricing may be necessary to cover treatment costs.

Measurement and payment and unit prices for quantities of water 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 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 WATER WORKS ASSOCIATION (AWWA)

AWWA C653	(2013) Disinfection of Water Treatment Plants
AWWA D100	(2011) Welded Steel Tanks for Water Storage
AWWA D102	(2014) Coating Steel Water-Storage Tanks
AWWA D103	(2009; Errata 2010; Addenda 2014) Factory-Coated Bolted Steel Tanks for Water Storage
AWWA D120	(2009) Thermosetting Fiberglass-Reinforced Plastic Tanks

ASME INTERNATIONAL (ASME)

ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
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MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2013) Standard Marking System for Valves, Fittings, Flanges and Unions
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NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2
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2013; Errata 2 2013; AMD 3 2014; Errata
3-4 2014; AMD 4-6 2014) National
Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04

(2013) Seismic Design for Buildings

1.3 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated 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 submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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.

An "S" following a submittal item indicates that the submittal is required for the Sustainability Notebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

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" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Process Flow Diagrams
Process and Instrumentation Diagram (P&ID)
Equipment Installation

SD-03 Product Data

Air Stripping System
Qualifications
Field Training
Framed Instructions
Spare Parts

SD-05 Design Data

Calculations
Foundations

SD-06 Test Reports

Tests

SD-07 Certificates

Manufacturer's Representative
Materials and Equipment

SD-08 Manufacturer's Instructions

Air Stripping System

SD-09 Manufacturer's Field Reports

Air Stripping System

SD-10 Operation and Maintenance Data

Air Stripping System
Maintenance

1.4 QUALIFICATIONS

Submit qualifications of the installer, supplier's representative, and the people listed in the following subparagraphs.

1.4.1 Constructor

Have a minimum of [2] [3] [5] [_____] years experience in the construction of water treatment, wastewater treatment, and/or industrial wastewater treatment and/or industrial wastewater pretreatment plants.

1.4.2 Single Source Supplier

Assign to a single supplier full responsibility for the furnishing of the air stripping system. The designated single supplier, however, need not manufacture the system but shall coordinate the design, assembly, installation, and testing of the entire system as specified herein. Submit a complete list of material, including manufacturer's descriptive and technical literature, catalog cuts, drawings, and installation

instructions, performance charts, technical literature, catalog cuts for [packing,] [mist eliminator,] [perforated trays and number,] [perforated bubbler tubes,] [venturi design] stripper, instrumentation and controls, including capacities, make and model, materials of construction, valving, and pressure gauges. Also submit installation, operating and maintenance instructions as provided by the manufacturer, [_____] days prior to notice to proceed and field reports on completed installation, as provided by the manufacturer's representative.

1.4.3 Manufacturer's Representative

Provide the services of a manufacturer's field representative 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 Welding

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

[Piping shall be welded in accordance with qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with [_____]. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by [_____]. Notify the Contracting Officer 24 hours in advance of tests. Structural members shall be welded in accordance with Section 05 05 23.16 STRUCTURAL WELDING.] [Welding and nondestructive testing procedures for piping shall be as specified in Section 40 05 13.96 WELDING PROCESS PIPING.] [Welding qualifications for welding procedures, welders, and welding operators shall be in accordance with Sections 8.2 and 8.8 of AWWA D100 and Section 40 05 13.96 WELDING PROCESS PIPING.] [Procedures and welders shall be qualified in accordance with the code under which the welding is specified to be accomplished.]

1.4.5 [Pre-Installation Meetings] [Partnering Conference]

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

1.5 DELIVERY, STORAGE, AND HANDLING

Parts shall be preassembled to the extent practical, compatible with transportation limitations and equipment protection considerations. Field assembly, if any, shall require merely bolting together of match-marked components. Equipment shall be crated and protected against damage during shipping and delivery. Protect flange faces from damage. Cover openings to prevent entrance of dirt, water and debris. Parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and the units and equipment are ready for operation. Finished iron or steel surfaces shall be properly protected to prevent rust and corrosion.

Protect all equipment delivered and placed in storage from the weather, humidity and temperature variation, dirt and dust, and other contaminants.

PART 2 PRODUCTS

2.1 SYSTEM REQUIREMENTS

2.1.1 Design Requirements

NOTE: The contaminant concentration and flow rate to be used in the design are critical to this specification. Install multiple strippers to accommodate extreme variations from the design flow rate and contaminant concentrations or to maintain the groundwater gradient.

Determine design wind speed from ASCE 7; use 161 km/h 100 mph minimum. Use 1.2 kPa 25 psf snow load for most heavy snow climates; delete snow load where maximum snow is insignificant. Local climates and topography may dictate that a value greater than 1.2 kPa 25 psf be used for snow loading. Consult ANSI A58 and local codes. Wind speed and snow load can be deleted if the air stripper is installed inside.

Seismic criteria are given in paragraph Seismic Protection. Consult NFPA 780 to determine if lightning protection is needed.

Meet the following requirements:

	Maximum	Minimum
Water/wastewater flow rate	[_____] L/s gpm	[_____] L/s gpm
Water/wastewater temperature	[_____] degrees C F	[_____] degrees C F
Ambient air temperature	[_____] degrees C F	[_____] degrees C F
Air Stripper system dimensions Maximum vertical projection	[_____] mm ft	
Maximum ground surface coverage including blower, motor and other appurtenances	[_____] by [_____] mm [_____] by [_____] ft	
Soil bearing capacity	[_____] MPa psf	
Seismic parameters	[_____]	[_____]
Wind speed	[_____] km/h mph	
Ground snow load	[_____] kPa psf	[_____] kPa psf

	Maximum	Minimum
Design Life		[_____] years

2.1.2 Influent Inorganic Chemical Conditions

Measured influent inorganic chemical concentrations of [waste water] [water from surface impoundment] [ground water] [total] [filtered] have been:

	Average	Maximum
pH [_____] Minimum	[_____]	[_____]
Total Hardness as CaCO ₃	[_____] mg/L	[_____] mg/L
Total alkalinity as CaCO ₃	[_____] mg/L	[_____] mg/L
Hydroxide alkalinity as CaCO ₃	[_____] mg/L	[_____] mg/L
Carbonate	[_____] mg/L	[_____] mg/L
Bicarbonate	[_____] mg/L	[_____] mg/L
Total Dissolved Solids	[_____] mg/L	[_____] mg/L
Langelier Index	[_____]	[_____]
Total Suspended Solids	[_____] mg/L	[_____] mg/L
Total Iron	[_____] mg/L	[_____] mg/L
Dissolved Iron	[_____] mg/L	[_____] mg/L
Total Manganese	[_____] mg/L	[_____] mg/L
Dissolved Manganese	[_____] mg/L	[_____] mg/L
Calcium	[_____] mg/L	[_____] mg/L
Magnesium	[_____] mg/L	[_____] mg/L
Sodium	[_____] mg/L	[_____] mg/L
Potassium	[_____] mg/L	[_____] mg/L
Sulfate	[_____] mg/L	[_____] mg/L
Nitrate	[_____] mg/L	[_____] mg/L
Chloride	[_____] mg/L	[_____] mg/L
Fluoride	[_____] mg/L	[_____] mg/L

2.1.3 System Performance Requirements

2.1.3.1 Air to Water Ratio

Maximum at maximum flow	[_____] volume/volume
Minimum at minimum flow	[_____] volume/volume

2.1.3.2 Influent and Effluent Organic Contaminant Concentrations

NOTE: Either specify maximum effluent concentrations or percent removal requirements.

Maximum Influent	[_____] µg/L
Average Influent	[_____] µg/L
Minimum Influent	[_____] µg/L

[

Maximum Effluent	[_____] µg/L
------------------	--------------

] [

Removal Required	[_____] percent
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Determine removal percentage as follows: ((Influent concentration - Effluent concentration)/Influent concentration) times 100 percent

]

2.1.3.3 Operating Schedule

Capacity and design of the air stripper and accessories shall allow the system to operate continuously for [24 hours per day, 7 days per week] [_____].

2.1.4 Seismic Protection

NOTE: Provide seismic details on the drawings or remove the second bracketed sentence.

The air stripper shell and components shall be structurally designed for seismic forces [in accordance with UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT] [as indicated]. [The calculations and

drawings shall be stamped by a professional engineer qualified to practice at the site.]

2.1.5 Design Loads

Structurally design the air stripper and appurtenances for the wind loads listed in the system performance requirements, plus live and dead loads resulting from internally supported parts, weight of operating liquid when the shell is completely full of water, piping structural supports, and internal or external pressures with an appropriate safety factor. Design the concrete base in accordance with Section 03 30 00.00 10 CAST-IN-PLACE CONCRETE.

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 equipment that has been in satisfactory operation 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. Submit verification from a Registered Professional Engineer, registered in the state in which the system is to be installed, that the stack, [the shell, ladder, platform and cage calculations for the air stripper,] the foundation and lifting lugs were designed for the listed conditions in accordance with the appropriate requirements, codes and standards.

2.2.2 Nameplates

Major equipment items 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.

2.3 SYSTEM COMPONENTS

NOTE: Consider if the influent or the stripper must be acid cleaned or chlorine-treated in selection of materials. Stainless steel may not be appropriate if a chlorine solution will be used for extended periods of time. Galvanized steel or corrodible metal internals should not be used.

2.3.1 Pump

Pumps shall be in accordance with Section [43 21 39 PUMPS: WATER, VERTICAL TURBINE] [43 21 13 PUMPS: WATER, CENTRIFUGAL].

2.3.2 Blower

Fans, blowers and or vacuum pumps shall be in accordance with Section 43 11 00 FANS/BLOWERS/PUMPS; OFF-GAS

2.3.3 Pipe Connections

Influent pipe connections shall be full line diameter of the connecting pipe. Effluent pipe connections shall be made with standard reducing fittings only if there is adequate vertical run to avoid back-up. Air and off-gas piping shall be as specified in Section 31 21 00 PIPING; OFF-GAS. Liquid piping shall be as specified in Section 40 05 13 PIPELINES, LIQUID PROCESS PIPING.

2.3.4 Mist Eliminator

The mist eliminator shall have the minimum separation efficiency stated in the performance requirements. Materials shall be as specified for the stripper internals.

2.3.5 Exhaust Stack

**NOTE: Maintain velocities within limits to reduce
condensation/freezing on the stack surface.**

Exhaust stack shall be sized for gas velocity between 3 and 7.5 m/sec 10 and 25 feet/second. Materials shall be as specified for the stripper.

2.3.6 Off-Gas Control

**NOTE: An air pollution control device may not be
required depending on state and local regulations.
The air pollution control system is a separate unit
process, with different design requirements.**

Off gas from the air stripper column shall be conveyed to an air pollution control unit for treatment as specified in Section [43 13 13.13 VAPOR PHASE ACTIVATED CARBON ADSORPTION UNITS] [44 13 52 THERMAL (CATALYTIC) OXIDATION SYSTEMS].

2.3.7 Instrumentation and Controls

**NOTE: Specify the instrumentation and controls as
either direct-reading instruments at the column or
remote-reading at some other location.**

Instrumentation and controls shall conform to the requirements of Section 40 95 00 PROCESS CONTROL and the requirements specified for each piece of the equipment with the interlocks and control devices specified herein.

- a. Gauges shall have 150 mm 6 inch dials, shall be stem mounted, and shall conform to ASME B40.100. Accuracy of gauges shall be Grade A or better. Gauges shall be calibrated in kPa and psi psi in not more than 10 kPa and 2 psi 2 psi increments from 0 to 350 kPa and 0 to 50 psi 0 to 50 psi in excess of the normal operating pressure at the tank.
- b. Control to shut down the system and activate an alarm if the blower

fails.

- c. Interlock for concurrent operation of blowers and influent [pumps]
[control valves].
- d. Water flow indicators [_____] to [_____] L/second [_____] to [_____] gpm.
- e. Effluent water temperature gauge [_____] to [_____] degrees C [_____] to [_____] degrees F.
- f. Pressure drop instrument [_____] to [_____] mm [_____] to [_____] inch water.
- g. Direct reading pressure gauges in the air inlet and outlet throats.

2.3.8 Chemical Feed Systems

NOTE: Determine if there is an environmentally preferred alternative and evaluate the options for cleaning compounds. The potential for reuse of cleaning chemicals will depend on the fouling material composition and if the suspended biomass or chemicals can be easily removed by settling and/or filtration. Consider conventional acids (HCl, H2SO4) with environmentally safer products such as acetic and citric acids for chemical fouling. NaOCl may be needed for biological fouling.

Perform a cost/benefit study to select between alternative cleaning solutions, reusing the cleaning solution and disposal options. This specification does not include the disposal of sludge generated during the cleaning.

Chemical feed requirements shall be as specified in Section 43 32 69 CHEMICAL FEED SYSTEMS and/or Section 43 32 76 CHLORINE-FEEDING MACHINES (AUTOMATIC, SEMIAUTOMATIC AND MANUAL).

2.3.9 Cleaning Provisions

NOTE: The type of cleaning chemicals used to remove mineral deposits and/or biological growth which may foul the air stripper interior and adversely affect the unit's performance will be unique to each site and depends on whether the fouling is from biological growth or chemical deposition and on the materials of construction. Tests may be needed before or after the system is started to determine the best cleaning solution.

[Furnish the air stripper with a cleaning package that can be operated periodically. The system shall include tanks, pipes and valves to allow flushing with chemical cleaners, biocides or disinfectants. The package shall include a corrosion resistant pump, chemical addition port, [cleaning solution storage tank] and plumbing accessories to allow the re-circulation

of cleaning solutions through the stripper.] [Design the air stripper for a cleaning procedure during which the air stripper will be isolated and filled or flooded with a [[10] [_____] percent maximum [sulfuric] [hydrochloric] [_____] acid solution] [_____] cleaning solution.]

2.3.10 Assembly

The system shall be factory pre-assembled into reasonably sized modules for easy field assembly and mounted on a skid. The skid shall have a welded steel frame with [2.4] [6.4] mm [3/32] [1/4] inch thick steel plate or fiberglass reinforced plastic (FRP) grating with ultraviolet (UV) inhibitors decking.

2.3.11 Lifting Lugs

Provide [trays] [columns] [stacks] and other major components with lifting lugs, as necessary for easy handling with a crane or similar device during installation, maintenance and replacement of column internals.

2.3.12 Guy Wires

NOTE: Size of the columns should be taken into account. In temporary installations, or in areas of high seismic activity, guy wires may be acceptable.

Air strippers and air stripper stacks shall be free standing and supported entirely by anchoring in a concrete base and shall be compatible with the dimensional constraints indicated. Each column air stripper [and stack] shall be self supporting. A superstructure or frame not extending beyond the foundation will be permitted. No guy wires shall be used except as directed by the Contracting Officer.

2.3.13 Freeze Protection

NOTE: When cold dry air is used for stripping, the evaporative cooling may chill the water more than the conduction of heat through the shell of the stripping column. If evaporative calculations show that this will significantly lower the rate at which the volatiles are removed from the water, the problem can be eliminated by stripping with re-circulated air.

[Provide insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The system shall be insulated and jacketed to prevent freezing under the most severe conditions stated in the performance requirements with a water temperature drop of less than 3 degrees C 5 degrees F.] [Air from the stripper that had the volatilized contaminants removed by the subsequent air pollution control device may be re-circulated into the bottom of the column].

2.3.14 Sump

Each air stripper shall have a sump to receive and store the treated effluent. Sump shall be sized to provide a minimum residence time of [2]

[5] [10] minutes when the stripper is operating at the specified capacity. [An inspection port] [and] [A 13 mm 1/2 inch diameter (minimum) drain/sample port with manually operated valve] shall be provided at the bottom of the sump to completely drain the air stripper.

2.3.15 Electrical Work

NOTE: Show NFPA 70 hazardous area classification on the drawings. If the potential for an explosive atmosphere exists, the wiring, blower, motor and other electrical equipment must meet the applicable explosive prevention standards.

Electrical equipment shall conform to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Equipment and wiring shall be in accordance with NFPA 70, with proper consideration given to environmental conditions such as moisture, dirt, corrosive agents, and hazardous area classification. Equipment located outdoors, not provided with climate controlled enclosure, shall be capable of operating in the ambient temperature range indicated in paragraph Design Requirements unless otherwise specified. Electrical motor-driven equipment specified herein shall be provided complete with motor control centers, panels, motor starters, etc.

2.4 STRIPPER

NOTE: See DG 1110-1-3 Air Stripping for recommendations.

The stripper system shall consist of [1] [2] [_____] [packed column] [perforated plate (sieve tray)] or [enclosed low profile mass transfer mechanism] air stripper to transfer volatile organic compounds from the water phase to the air base. Use manufacturer's standard size units whenever possible.

2.4.1 Materials

NOTE: Limit the materials of construction to those that will not be corroded or dissolved by the contaminants in the water or cleaning solutions (acids).

2.4.1.1 Shell

NOTE: Use coated steel for short term applications only, since cracking of the coating could allow the column to corrode.

Construct the air stripper of [polyethylene (HDPE) seamless one piece molded modular sections,] [polyvinylchloride (PVC) with ultraviolet (UV) inhibitors,] [fiberglass reinforced plastic (FRP) with ultraviolet (UV) inhibitors,] [structural grade aluminum,] [304 stainless steel,] [316

stainless steel,] or [steel with internal and external coating as specified,] of suitable thickness to prevent deformation. Steel tank materials shall conform to the applicable provisions of Section 2 of AWWA D100 or Section 2 of AWWA D103 or AWWA D120. Design, fabrication, and erection shall be in accordance with the applicable requirements of AWWA D100 or AWWA D103 except as modified herein and in the design requirements of this specification. Shop Fabrication shall conform [to Section 9 of AWWA D100 or Section 7 of AWWA D103 or AWWA D120] [the manufacturer's recommended fabrication procedures].

2.4.1.2 Internals

The air stripper internals shall be constructed or [polyethylene (HDPE)] [polyvinylchloride (PVC)] [fiberglass reinforced plastic (FRP)] [aluminum] [304 stainless steel] [316 stainless steel] or copper.

2.4.2 Perforated Plate (Sieve Tray) Stripper

NOTE: Determining the number of trays needed in a perforated plate air stripper is more difficult than determining the height of packing in a packed column air stripper. The efficiency of each tray must be known or estimated to determine the number of trays required. The designer may have to rely on the manufacturer's test data or other estimation methods. These methods may be empirical, scale up from smaller units or more theoretical mass transfer calculation methods.

The stripper shall have the following features: Vertically stacked trays with horizontal perforated plate (sieve trays) bottoms that are enclosed in a shell and are separated vertically. Contaminated water is introduced at the top, flows across a perforated plate, over a weir and down to the next lower plate. The process is repeated for each tray until the water reaches the bottom of the unit and enters the sump. Air is introduced at the bottom of the unit and is forced up through the perforations in the trays to form bubbles. Volatile organic chemicals in the water phase transfer to the bubbles in the air phase. The air phase containing the volatile chemicals then leaves the top of the column. Submit calculations to clearly show the basis for the selected number of trays (each tray contains one perforated plate), size and number of the perforations on each plate, tray spacing, size of trays and tray efficiency. The data may be actual performance data from the manufacturer or calculation methods. Submit design calculations indicating removals of each of the listed volatile compounds; air and water pressure drops through each component of the system, including line sizing, hydraulic loading (L/sq. m gal/sq. ft), air volume (cubic m/second CFM, air to water ratio (dimensionless and with appropriate units).

2.4.2.1 Perforated Plates (Sieve Trays)

NOTE: Stainless steel is recommended on large units. Plastic materials are acceptable for small low profile air strippers; plastic materials on large air strippers may warp and then leak between the trays.

If frequent fouling is anticipated, stainless steel should be used as it is easier to clean. Plastic can be damaged by scraping and steam or high pressure water cleaning.

Materials for perforated plates, downcomers, downcomer seals, baffles and other components shall be constructed of materials allowed by paragraph Internals, of suitable thickness to prevent deformation. Tray design shall prevent short-circuiting of air or water. The number and size of perforations shall provide for maximum mass transfer.

2.4.2.2 Gaskets

The trays shall have gaskets that prevent air and water leakage in and out of the shell and between trays. Gaskets shall be of a material compatible with the influent and with the cleaning methods.

2.4.2.3 Disassembly

NOTE: Once disassembled, high pressure water, steam or physical scraping can be used to clean the trays.

The strippers shall be easily disassembled for cleaning or shall have hatches for access to the individual trays or other internal components for inspection and cleaning.

2.4.3 Enclosed Low Profile Mass Transfer Mechanisms

NOTE: Enclosed low profile mass transfer mechanism air strippers employ a variety of methods to facilitate the mass transfer of volatile chemicals from the water phase to the air phase. Calculation methods for these air strippers are unique to each design and may not be readily available. Designers may have to rely heavily on manufacturer supplied performance data, or use mass transfer calculation methods developed for other processes, such as distillation or waste water aeration, to verify the performance. If manufacturer supplied performance data are relied on, the designer should determine whether the computer models use theoretical equations calibrated to actual test data, or whether they are based only on theoretical equations or empirical data.

Furnish a low profile (such as perforated bubbler tubes or the venturi design principle), non-perforated plate, air stripper that is enclosed, uses mass transfer mechanisms which include, but are not limited to, perforated bubble tubes or the venturi design to transfer (volatilize) contaminants from the water phase to the air phase.

2.4.4 Packed Column

NOTE: Calculations must be provided to clearly show the basis for the diameter and packing height. Base the diameter of the column on a maximum liquid loading rate of 60 to 80 per cent of the flooding loading rate. Data for the mass transfer coefficient (K_{La}) and pressure drop/flooding calculations must be obtained from a pilot plant run with this packing on the same or similar pollutants or vendor supplied data run with this packing on the same or similar pollutants.

These data and the requirement that the Contractor must meet the removal efficiencies or effluent criteria specified in the system performance requirements should assure that the column is sized properly.

Furnish a packed column air stripper with the following features: A column filled with packing material that has a large surface area to volume ratio. The contaminated water is pumped to the top of the column above the packing and is distributed uniformly over the packing. Air is forced up through the bed of packing at the same time the water is "trickling" down through the packing (i.e. countercurrent flow). As the water and air pass each other, the volatile chemicals in the water leave the water (volatilize) and enter the air stream. The air stream then carries the volatile chemicals up and out of the top of the column.

2.4.4.1 Packing

The column shall be filled with high efficiency open packing, either structured "arranged" or random "dumped" polypropylene, PVC, stainless steel, ceramic or other media that is durable under the service conditions. Packing diameter shall not exceed 20 percent of the column diameter and shall be as near 9 percent of the column diameter as is feasible with the type of media supplied. Packed section of the column shall be between [_____] and [_____] mm [_____] and [_____] feet in diameter and the height of the packing shall be between [_____] and [_____] mm [_____] and [_____] feet.

2.4.4.2 Water Distribution and Re-distribution System

NOTE: Columns that are wider relative to their depth need more distributor and re-distributors than are considered in the manufacturer literature

Water distribution system shall be [PVC] [[304] [316] stainless steel] [aluminum] full solid cone spray nozzle or distributor tray that distributes the water over the fill area of the packing. Water distribution system shall produce a minimum of [125] [50] [_____] streams/sq. m [12] [4.8] [_____] streams/sq. ft at the normal pumping rate. The distribution system shall be designed for easy removal and replacement. If a full solid cone spray nozzle is used, it shall be placed at the correct distance from the top of the packing to distribute the spray

uniformly over the top of the packing. Water re-distribution systems shall be as recommended by the manufacturer. Distance between re-distributors shall not exceed [_____] mm ft and shall be less if recommended by the packing manufacturer.

2.4.4.3 Packing Support

Packing support shall be [PVC] [HDPE] [fiberglass reinforced plastic] [aluminum] [[304] [316] stainless steel]. If the bed depth exceeds the packing manufacturer's recommended maximum vertical depth of packing, an intermediate support shall be installed. The support shall be of suitable thickness to prevent deformation when the packing becomes plugged and the entire shell above the packing support fills with water.

2.4.4.4 Access

NOTE: View ports should be considered if the column is tall and the water can become poorly distributed or if biological, iron, manganese, or calcium fouling is likely to occur.

The top of each column shall be bolted to provide access to tower internals from above. View ports shall be installed at the [top] [and bottom] of the column to check the water distribution and to check for fouling. The stripper shall be designed for easy removal of the packing.

2.4.4.5 Manholes and Pipe Connections

NOTE: Additional ports should be provided if packing fouling is expected to be a problem.

Number, type, location, and size of manholes and pipe connections shall be as shown on the drawings and as specified herein. Section 7 of AWWA D100 and Section 5 of AWWA D103 contain the minimum requirements for manholes and pipe connections. Flanged access ports, [460] [525] [600] mm [18] [21] [24] inch in diameter, shall be provided, shall be water and vapor tight, and able to withstand all loads and internal pressures during construction, operation, and cleaning. One or two access ports shall be at the top of the column for access to the mist eliminator and liquid distributor, and one shall be located near the bottom of the column to provide removal of the packing and packing support; and one shall provide access to the sump.

2.4.4.6 View Ports

NOTE: View ports may not be necessary if the concentration of minerals in the water is low and iron, calcium or biological fouling is not expected to be a problem.

View ports shall be at the top and bottom of the packing to allow checks of the distribution and check for fouling.

2.4.4.7 Ladders, Platforms and Cages

NOTE: Ladder should start 2.5 m 8 feet above the ground, if the area is not secured. Ladders, platforms and cages may not be appropriate for small units.

The air stripper shall be provided with a platform at the top of the column, and an access ladder. A platform shall provide access to each access port. Provide catwalks, ladders, cages, and guardrails where indicated or required for safe operation and maintenance of equipment and in accordance with Sections 7.4 and 7.5 of AWWA D100 or Sections 5.4 and 5.5 of AWWA D103. Provision shall be made for the attachment of a scaffold cable support at the top of the roof on welded tanks. Ladders shall have side rails and have non-slip rungs that are a minimum of 19 mm 3/4 inches in diameter and 406 mm 16 inches long. The access ladder shall start at [ground level] [2.5 m 8 feet] above the ground. The distance between rungs shall not exceed 305 mm 12 inches. The ladder and platform shall bolt onto brackets that are welded to the columns, or shall be welded directly to the column. Platforms shall be designed to support a uniform live load of 3.6 kPa 75 psf plus the dead load of the structure. The platform shall be a minimum of 915 mm 3 feet wide and fabricated from steel, aluminum, or fiberglass reinforced plastic. Grating openings shall have no dimension greater than 25 mm 1 inch.

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 FOUNDATIONS

NOTE: Coordinate with paragraph System Design Requirements.

The footprint and the piping connections for the air stripper on the floor plan, and height required may vary considerably depending on the type of air stripper. The designer should allow enough space for any of the three types of air stripper that the Contractor can select.

Design the reinforced concrete foundations to support the stripper full of water in accordance with Sections 03 30 00.00 10 CAST-IN-PLACE CONCRETE and 03 20 00.00 10 CONCRETE REINFORCING and in accordance with Section 12 of AWWA D100 or Sections 11 and 8.5 of AWWA D103 for earth, with the bearing value stated in the design requirements. Provide an AWWA D100 Type 1 or an AWWA D103 Type 1 or Type 2 foundation for the stripper. Factor of safety on overturning under design wind load shall be 1.5 minimum. When a footing is required, an inverted truncated pyramid of earth with 2 on 1 side slopes above top of footing may be used in determining overturning stability. The elevation at the top of the foundations shall be not less than 200 mm 8

inches above the finished grade. Submit calculations for the shell and concrete foundations, mounting and support details including the seismic analysis, where appropriate.

3.3 ANCHORS

3.3.1 Number of Anchors

An adequate number of anchors designed to prevent overturning of the [stripper] [shell] when empty shall be installed. If anchor bolts are used, the nominal diameter shall be not less than 25 mm 1 inch, plus a corrosion allowance of at least 6 mm 1/4 inch on the diameter. If anchor straps are used, they shall be pre-tensioned before welding to the shell.

3.3.2 Anchor Bolts and Straps

Bolts shall be a right angle bend, hook, or plate washer, while anchor straps shall have only a plate welded to the bottom. The anchors shall be inserted into the foundation to resist the computed uplift.

3.3.3 Attachment

Attachment of anchors to the shell shall not add localized stresses to the shell in excess of the material tolerance. The method of attachment shall consider the effects of deflection and rotation of the shell. Anchors shall not be attached to the shell bottom. Attachment of the anchor bolts to the shell shall be through stiffened chair-type assemblies or anchor rings of adequate size and height.

3.3.4 Seismic Requirements

Anchors shall be in accordance with UFC 3-310-04 and Section 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

3.4 EXCAVATING, FILLING, AND GRADING

Excavating, filling, and grading shall conform to the applicable requirements of Section 31 00 00 EARTHWORK.

3.5 EQUIPMENT INSTALLATION

Install equipment as shown and in accordance with the written instructions of the manufacturer, under the direct supervision of the manufacturer's representative, and in accordance with the applicable provisions of Section 10 of AWWA D100 or Section 8 of AWWA D103 or Section 7 of AWWA D120. Submit drawings containing complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

3.6 PAINTING FOR CORROSION PREVENTION

NOTE: Some state and local health agencies have listings of acceptable paint materials for the interior of potable water tanks; they will also apply to the interior of the air stripper. The designer must contact the appropriate state and

local authorities to determine if the proposed paint systems are acceptable. If these systems are not acceptable, the designer must determine the best acceptable system and revise this specification accordingly. Any deviation from this specification and AWWA Standards must be submitted with justification to CEMP-RT for approval.

3.6.1 Welded Tanks

3.6.1.1 Exterior Surfaces

The paint system applied to the outside of the tank air stripper shall be in accordance with Section 09 90 00 PAINTS AND COATINGS. Factory primed surfaces shall be solvent-cleaned before painting. Surfaces that have not been factory primed shall be prepared and primed in accordance with the paint manufacturer's recommendations.

3.6.1.2 Interior Surfaces

Tank interior surfaces shall be coated in accordance with Sections 3.2, 3.3, 3.4, 3.5, 3.6 or 3.7 of AWWA D102.

3.6.2 Touch-up Painting

Factory painted items shall be touched up as needed. These items shall be cleaned of all foreign material and shall be primed and top coated with the manufacturer's standard factory finish.

3.6.3 Field Painting

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

3.6.4 Corrosion Resistant Metals

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

3.7 MANUFACTURER'S FIELD SERVICE

Prior to startup, the equipment shall be inspected for alignment and connections by a factory representative. The manufacturer's representative shall inspect the final installation and supervise the adjustment and testing of the equipment. The manufacturer's representative shall demonstrate that the system meets the performance requirements.

3.8 FRAMED INSTRUCTIONS

Post framed instructions, under glass or in laminated plastic, for installation instruction procedures, sequences, and precautions, including tolerances for level, horizontal, and vertical alignment. Also grouting requirements, including grout spaces and materials, including process flow diagrams and wiring and control diagrams showing the complete layout of the entire system, where directed. Submit process flow diagrams showing all major pieces of process equipment with flow rates and material balances. Condensed operating instructions explaining preventive maintenance

procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams and posted beside the diagrams. Posted diagrams, instructions, and other sheets shall be submitted prior to posting. Submit [one] [_____] framed process and instrumentation diagram (P&ID) showing all instrumentation and control locations, functions and settings; major process equipment, pumps, pipes, valves, instruments direction of flow, flow rates pressures and temperatures.

3.9 TESTS

NOTE: Avoid further mention of sampling or analytical methods in this section. Always refer to the chemistry section to avoid conflicts.

3.9.1 Hydrostatic Tests

Hydrostatically test each unit by completely filling the shell with water and inspecting for leaks. Repair leaks and retest the column. Check equipment for leaks after it has been filled for at least one hour. Shell inspections and testing shall be in accordance with Section 11 of AWWA D100 or Section 9 of AWWA D103. [Mill and shop inspections shall be performed by an approved commercial inspection agency.] [Perform radiographic inspections of the welded shell .] Perform the hydrostatic test and the vacuum box leak test of the tank bottom. Final leak test and hydrostatic test shall be performed before painting.

3.9.2 Performance Testing

Operate each unit at the maximum flow specified in the performance requirements for at least one hour prior to sampling. Submit performance reports in booklet form, upon completion of testing of the installed system. Test reports shall include all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria. Each test report shall indicate the final position of all controls. Performance test data shall be reflected in the operating instructions.

3.9.3 Influent and Effluent Sampling

Collect samples in the presence of the Contracting Officer and transport the samples to the laboratory for analysis in accordance with Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL.

3.9.4 Influent and Effluent Analyses

Inspect and test all equipment under operating conditions after installation. Demonstrate the unit to run without operator intervention for 72 contiguous hours. If inspection or test shows defects, such defects shall be corrected, and inspection and test shall be repeated. Performance shall be tested in accordance with [Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL] [_____].

3.9.5 Discharge

NOTE: A holding/mixing tank requirement can be deleted if an NPDES or sewer discharge permit has been secured.

During the performance testing, the effluent from the air stripper system shall be contained within the holding/mixing tank with no flow discharged to the [system] [stream] [sewer].

3.9.6 Noncompliance

Removals shall meet or exceed the specified system performance requirements. If at any time the result of the organic analyses of the influent and effluent water indicate that the air stripping system is not in compliance with Contract Documents, flow through the air stripper shall be stopped and the system shall be declared inoperable. If at any time the operation of the air stripping system does not meet the hydraulic, instrumentation, or control requirements set forth in this contract, flow through the air stripping system shall be stopped and the system shall be declared inoperable. Upon notification of the air stripping system non-compliance, immediately proceed to repair or modify the system to meet compliance. Make repairs or modifications entirely at the Contractor's expense. Notify the Contracting Officer one day before the air stripping system is to be restarted and retested.

3.10 STARTUP

NOTE: Modify this paragraph for Contractor operation.

After completion of all testing, the manufacturer's representative shall assist the plant operators in plant startup.

3.11 FIELD TRAINING

Conduct a training course of operating staff as designated by the Contracting Officer. The training period, for a total of [24] [36] [_____] hours of normal working time, shall start after the system is functionally complete but prior to final acceptance tests. The field instructions shall cover the topics included in the Operating and Maintenance Manuals. Submit training course curriculum and training instructions, [14] [_____] days prior to the start of training.

3.12 ADJUSTING, CLEANING, AND DISINFECTING

Make adjustments, within the control range, to obtain optimum performance under actual field conditions. For potable water systems, cleaning [is] [and disinfection in accordance with AWWA C653 are] required prior to placing the unit in service.

3.13 MAINTENANCE

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

- a. 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 onsite [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.
- b. Provide spare parts for each different item of material and equipment specified, including all parts recommended by the manufacturer to be replaced after [1 year] [and] [3 years] service. Submit spare parts data for each different item of material and equipment specified, after approval of the related submittals, and not later than [_____] months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply. List of all special tools, instruments, accessories, and special lifting and handling devices required for periodic maintenance, repair, adjustment, and calibration.
- c. The following information can either be included in the manual or manufacturer literature that contains the information and is furnished with the O&M Manuals. Each manual shall have an index listing the contents. Manuals shall be bound in sturdy three-ring, loose-leaf binders.
 - (1) Submit [six] [_____] complete copies of operating instructions outlining the step-by-step procedures required for system startup, normal operation, short- and long-term deactivation, and shutdown. An introduction and overall equipment description, purpose, functions, and simplified theory of operation shall be included in the beginning of the instructions. The instructions shall include the manufacturer's name, model number, service manual, parts list and brief description of each piece of equipment and its basic theory and operating features. The instructions shall include piping and component layouts and wiring and control diagrams for the systems as installed. Performance test data shall be reflected in the operating instructions.
 - (2) Submit [six] [_____] complete copies of maintenance instructions listing routine maintenance procedures, calibration procedures, possible breakdowns and repairs and trouble shooting guides. Procedures for cleaning and removal of scale shall be included.

-- End of Section --