

INSTALLATION, OPERATION AND MAINTENANCE
MANUAL

FIBERGLASS FUME SCRUBBER
HORIZONTAL CROSS FLOW – SERIES ECH **CE**



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INTRODUCTION

This Scrubber Installation, Operation and Maintenance manual has been written for you, the Installer, Operation and Maintenance Personnel. Although we have attempted to include each component on your scrubber, each scrubber system is unique and built on a custom basis. Furthermore, there are hundreds of different chemicals that can be scrubbed and your chemical scrubbing process is unique. Therefore, it is impossible to cover all components, operating conditions and chemical processes. In addition to this manual, separate manuals are available for accessory item such as pH controllers, flowmeters, heater controllers, etc. Do not hesitate to connect HEE or your Sales Representative for additional manuals or for any further assistance.

1.1 General Information

1. All parts of the scrubber equipment have been thoroughly inspected and pre-tested at the factory. Upon receipt of shipment, a complete inspection of the equipment is recommended to determine if any damage was sustained during shipment or parts have vibrated loose. If any damage is found, a claim should be immediately filed against the freight carrier.
2. It is advised to have equipment installed by personnel familiar with the installation of air handling equipment. In most cases, your sales person can recommend a qualified contractor.
3. Check the nameplates and tags on equipment for special instructions.
4. The scrubber should be mounted on a solid surface which completely supports the bottom of the scrubber. When the scrubber is to be mounted on a problem, the platform should be thoroughly braced. If the scrubber is roof mounted, consult a structural engineer to prevent overloading the roof structure. Refer to the scrubber drawing for the operating weight. Finally, we recommend the scrubber be mounted on a six (6) inch housekeeping pad. This will simplify the drain connection and assist in drainage. A six inch high structural steel scrubber base can be provided by HEE as part of the scrubber system.
5. Air temperatures at the inlet to the scrubber should never exceed 160 deg F unless the material of construction has been designed at a higher temperature. The water temperature of the recirculating liquid should not exceed 120 deg F for schedule 80 PVC construction (180 F for CPVC and 200deg F for Polypropylene). Consult the factory if unsure of operating conditions.
6. Equipment is constructed of fiberglass reinforced plastic (FRP) and thermoplastic materials. Care must be taken during handling and installation to prevent damage which may be caused by external stress or shock.
7. Certain accessory items such as pressure gauges, solenoid valves, controls and instrumentation may

have been shipped loose to prevent damage in transit. Install these items to the scrubber system as required.

8. Refer to Appendix B for a check list for start-up procedure. Refer to Appendix C for an exploded view of a horizontal scrubber.

INSTALLATION

2.01 Unloading and Rigging

Utilize nylon straps when lifting the scrubber from the truck bed to the final position. If lifting lugs are incorporated, use them. If there are no lifting lugs, place nylon straps around the scrubber flanges for lifting. These flanges are strong and will support the dry weight of the scrubber.

2.02 Packing Installation Procedure (when shipped loose)

There are many ways to install plastic random fill packing. Installation procedures vary depending on the column size, size of packing, packed bed height, and position of other internals. Generally, if common sense is used, problems can be avoided. The installation procedure is as follows:

1. Distribute packing pieces in a random manner and never let them free fall more than fifteen (15) feet. In cold water weather (below 45 deg F) particular care must be taken in handling and installing plastic packing since the brittleness of the plastic resin will be greatly increased.
2. Make sure the packing fills all the space in the packed bed section. Pay particular attention to the access doors and irregular spaces.
3. If workmen are in the scrubber, use plywood to distribute load over as large an area as possible. Never exert a concentrated load onto a few of the individual packing pieces. Check the structural integrity of the packing supports before placing men inside the tower.
4. Be careful not to leave any foreign materials in the packed bed section. Make sure all plywood, boxes and bags are removed.

2.03 Packing Inspection

Inspect the packing material to determine if damage, shifting or settling has occurred during shipment. Inspection can be made by looking in the access door or through the polypropylene access ports. The packing should be even across the top surface to prevent dry spots in the packing and prevent any air from passing over the top of the packing. Adjust as required. Should you require additional packing due to excessive setting, please contact HEE.

2.04 Mist Eliminator Section

Horizontal scrubbers usually have the mist eliminator blades contained in the outlet transition. The blades are held in place by a slotted holding bar. Verify the blades have not moved during transit or installation by viewing their position from the top access door.

2.05 Bolted Transitions and Flanges

Larger horizontal scrubbers require the installation of the inlet and outlet transitions. The outlet transition usually contains the mist eliminator and must be located on the down stream side of the scrubber. Tubes of butyl caulking compound and stainless hardware are provided by HEE. A single ribbon of caulking material should be applied on the inlet and outlet flanges and the scrubber main body. For best results, apply the caulking on the inboard side of the flange holes. The transitions are then installed to the scrubber body with the mounting hardware supplied. Tighten the hardware evenly around the perimeter of the flanges to ensure gradual and even flange compression. Repeat the same procedure for all scrubber flanges. For 3/8 inch diameter stainless steel bolts, the recommended bolt torque is between 15 – 20 Ft-Lbs. For 1/2 inch diameter bolts of the same type, the recommended bolt torque is between 20-30 Ft-Lbs. The above procedure is not required for the smaller one piece horizontal scrubbers.

2.06 Inlet Connection

To aid in the proper air flow into the scrubber, allow at least two (2) equivalent duct diameters or straight duct leading into the scrubber inlet.

Incoming duct can be connected to the inlet transition using either a flexible connector or a hard connection.

Hint: Be sure to slope the incoming duct into scrubber to allow proper drainage of any liquid from the inlet duct into the scrubber.

2.07 Outlet Connection

Connect the scrubber outlet to the exhaust fan or discharge dust as required.

NOTE: Using a flexible connection on the outlet duct connections will simplify equipment alignment, isolate fan vibration from the scrubber and allow equipment access for maintenance

2.08 Anchor Lugs

Seismic anchor down lugs are provided on the scrubber bottom. Use suitable hardware to secure these lugs.

DO NOT over tighten the anchor bolts used on the anchor lugs. Finger tight is all that is needed for anchor bolts.

CAUTION: HEE does not recommend cast-in-place concrete anchors. Set the scrubber in place, mark the location of each hole, and either core drill the cement or use expansion hardware.

2.09 Torque for Bolted Access Door Covers

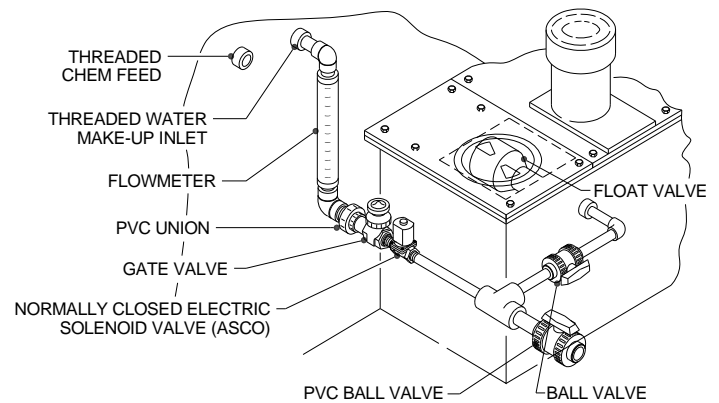
The hardware for access doors with a fiberglass cover should be torqued per the requirement in Section 2.05. Lexan covers should be torqued to 120-130 Inch-Lbs and includes a steel backer bar on the bottom flange.

2.10 Water Supply Connections

Install a one (1) inch water supply pipe per figure:

1. A gate valve, solenoid and flowmeter should be utilized as shown for the water make-up control. Install the piping as shown for the float valve located in the pump in the pump box still well per figure

2. Check with the city codes concerning installation or back-flow preventer. If these parts are not included, HEE can provide these parts for your scrubber system.



2.11 Water Make-up Piping System

The electric solenoid can be connected to the pump starter auxiliary contact. This will shut off the water make-up system when the pumps are not operating. The gate valve is used to regulate the amount of flow and the inline flowmeter provides a visible means of adjusting the flow to the desired amount.

2.12 Chemical Feeds System

A chemical feed system can be utilized to maintain a predetermined pH/ORP value in the modular scrubber sump liquid by adding a chemical agent. A complete system would consist of the following parts required for a standard chemical feed system:

- Chemical Tank
- Chemical Metering Pumps
- pH/ORP Controlling System

If a chemical feed system has been included by HEE, refer to the drawing provided by HEE for further details.

The chemical tank should be located as close as practical to the modular scrubber. The chemical feed pump is connected to the chemical tank. The inlet plumbing from the tank to the pump and outlet plumbing from the pump to the modular scrubber must be supplied and installed by the customer.

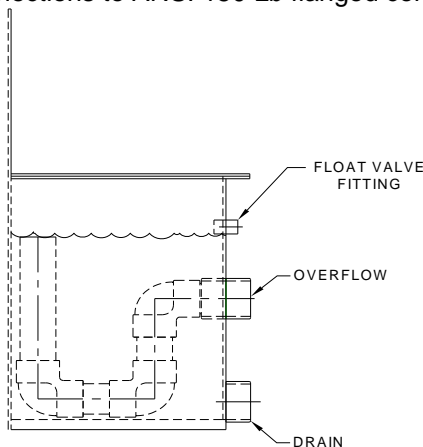
The pH/ORP controller is mounted in a convenient location and a pH/ORP probe is located in the modular scrubber. Refer to the manuals provided with the pH/ORP controller system for installation and wiring instructions. When wired properly, the pH/ORP controller signals the chemical feed pump when to pump chemical from the chemical tank into the modular scrubber.

NOTE: HEE does not recommend an in-line installation for a pH sensor system. For proper operation, the flow rate must be at 4 FPS or less, and the sensor must be installed with the electrode pointing downward to ensure adequate electrolyte flow (in the vertical position).

HINT: When connecting a pH probe to a controller, use flexible conduit and allow enough extra conduit to remove the probe for routine calibration.

2.13 Overflow and Drain Fitting

Install drainage piping to the overflow and drain fitting as shown per figure below. If required, include a vent on the drain line for proper drainage. The drain fitting requires a shut-off valve and the overflow fitting should NOT include a shut-off valve. Refer to Appendix E Bolt torque and Torque Sequence, for making connections to ANSI 150 Lb flanged connections.



2.14 Valve Position

Check all valves to ensure proper position. All spray header valves should be in the open position with the handles in line with the flow. The drain valve should be closed with the handle in a line across the fluid flow.

2.15 Sump Heater System

If a sump heater system has been included, it will consist of a heater controller, a temperature sensor mounted in the pump box, a screw plug heating element located in the sump, a heat sensitivities fuse link located in the heating element and a low sump level switch mounted on the pump box exterior. The low sump level switch and heat sensitive fuse link **must** be properly wired to the heater controller to prevent heater burnout and possible fire in the event of a low sump level condition or detection of an excessive temperature in the heating element. After wiring, test the circuit for proper operation.

WARNING: The Sump Heater System must be properly installed and tested for proper operation. Improper installation and failure to test the circuit could result in heater burnout and possibly ignite the scrubber on fire and result in equipment destruction

2.16 Electrical Connection

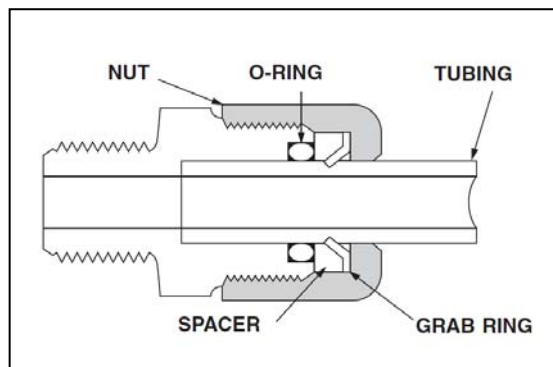
Make the necessary electrical connection as required using qualified personnel. All electrical work should be done according to the National Electrical Code. Also, check with the city for the proper codes.

2.17 Pressure Gauge Assembly

If an optional pressure gauge assembly has been included in the scrubber system, it will consist of an isolation valve, gauge guard filled with glycerin and a liquid filled pressure gauge. The assembly has been shipped loose for field installation. Prior to installation, check the level of glycerin in the gauge guard. Remove the pressure gauge and bleed screw and fill with glycerin to remove all air. This can be achieved by pouring the oil into the upper gauge cavity and tilting the gauge guard in several positions to be sure that no air is trapped within. After filling completely, turn the gauge guard over quickly and screw in the pressure gauge. Any excess oil will come out of the bleed screw. Install the bleed screw and assemble the pressure gauge assembly to the recalculating line. If a pressure gauge was not included in your system, HEE can offer one to suit your needs.

2.18 Differential Pressure Static Pressure Ports

If the scrubber includes static pressure ports for measuring pressure differential (for the packing, mist eliminator or total differential), these ports have been installed on the scrubber wall. Internal tubing is connected from these ports to the various measuring points inside the scrubber. For larger scrubbers, the interior tubing will include Fast & Tite® coupling connectors to facilitate shipment. Reconnect these fittings per the following instructions.



1. Review the above figure and identify the various internal parts which include the O-ring, spacer, grab ring (metal) and nut.
2. Re-assemble these parts in the sequence shown in the figure. Place the nut, grab ring, spacer and tube support, in that order on the tube. Seat the O-ring in the body.
3. Moisten end of the tube with water and push the tube straight into the fitting until it bottoms on the fitting shoulder. Tighten the nut by hand. Additional tightening should not be necessary, but 1/4 additional turn may be added if desired. **Do**

not over tighten nut as the threads will strip and the fitting will not function properly

2.19 Removal of Debris

The scrubber should be thoroughly cleaned after installation is complete to remove any construction debris foreign object. Spray water on the packed bed, mist eliminator section, scrubber body, and transition with a hose spray nozzle and wash the material out of the scrubber.

2.20 Pump Rotation

In most applications vertical sump pumps are used for the recirculating system. Prior to adding water to the scrubber sump, check the pump rotation. The motor should operate in a clockwise direction when viewed from the top. The label on the motor also indicates the proper rotation.

HINT: For FPI penguin pumps, remove the fan cover using the three screws located on the side of the motor. Bump start the motor.

2.21 Pump Motor Rotation – Three Phase

If the pump motor is rotating in a clockwise rotation when looking at motor fan, rotation is correct. If rotation is not correct, interchange any two main power leads to obtain the correct rotation.

WARNING: Reverse rotation will damage thermoplastic vertical sump pumps such as FPI Penguin pumps. Check pumps rotation before filling the scrubber sump!

2.22 Water addition to the Scrubber Sump

After the above has been completed, water can be added to the scrubber sump using the float valve.

2.23 Check for leaks and Loose Fittings

Start the scrubber pump (s) and check for loose ball valves, check valves and union. Use a strap wrench to tighten any fittings that may have vibrated loose during shipment. Also check all piping, flange connections and access doors for leaks.

HINT: Before locating a fan on the positive side (inlet) of a scrubber, consider the following. A negative pressure scrubbing system is always preferred for several reasons: The fan is located on the clean side; a small leak in the exhaust system will not allow fumes to escape; access doors can be opened without allowing fumes to escape; pressure differential gauges will not be damaged by corrosive fumes.

OPERATION

3.01 Principles of Operation

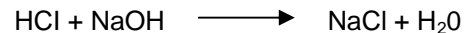
A wet packed bed scrubber is designed to promote the contact of a gas and a liquid stream. Air contaminants are removed from a gas stream by dissolving or absorbing them in a liquid in which they can be more concentrated.

The process of absorption depends on intimate contact of gas and liquid under conditions which maximize the exposure of surface of gas and/or liquid to each other. This requires breaking up the liquid into many tiny slow-flowing films which form and re-form through a volume of gas.

A wet packed bed scrubber is capable of removing many air contaminants through one of three methods. The simplest method of removing some contaminants is by the process of mist elimination. The HEE wet packed bed scrubbers are rated to remove all mist and fume particles at 99 percent down to 5 microns. Mist elimination is accomplished by impinging the particle onto the packing and by physical capture. The recirculating scrubber liquid (usually water), continuously washes the particles off the packed and the particle are dissolved in the scrubbing liquid.

The second method is called mass transfer and is the process of transferring a gas or vapor from the gas phase to the liquid phase using a recirculating liquid such as water. The rate of this transfer is affected by four factors..... the packing depth, water recirculation rate, air velocity and type of packing. For some chemicals, the addition of the chemical additive will improve the rate of transfer. The third method requires the addition of a chemical additive such as an acid, caustic or oxidizing agent and changes the air contaminant into a new species through a chemical reaction.

EXAMPLE: The chemical reaction of hydrochloric acid and sodium hydroxide results in sodium chloride and water:



There are several hundred different types of air contaminants that can be removed using a HEE wet packed scrubber using one of the three above methods. HEE can assist you in determining the suitability of scrubbing various air contaminants using computer programs and a large chemical data base.

3.02 Mist Eliminator

Check the Scrubber drawings for the type of mist eliminator provided.

The most common type of horizontal mist eliminator utilized is a PVC blade type mist eliminator in the shape of a sine wave mounted on one inch centers. The mist eliminator is capable of removing droplets down to 15 microns at a velocity of 900 FPM.

An alternate mist eliminator type provided could be a composite mesh pad such as a Kimre TI-29 capable of removing 99% of 2 microns and larger at a velocity of 600 FPM.

3.03 Water Make up

Fresh water must be continuously added to the scrubber recirculation system to 1.) Maintain the quality of the recirculating liquid 2.) Provide a source of

water for humidifying the incoming air, and 3.) Minimize of minerals inside the scrubber.

Normally the addition of fresh water is controlled by using a solenoid valve, gate valve and an inline flow meter. The solenoid can be connected to the pump starter auxiliary contact. The gate valve is used to regulate the amount of flow and the inline flow meter provides a visible means of adjusting the flow to the desired amount.

As fresh water is added to the scrubber recirculation system, excess contaminated water will flow through the overflow fitting located on the pump box. The rate at which this water flows out is commonly called the blow down rate.

3.04 Make up Water Rate

The amount of make up water required will depend upon 1.) The amount of air contaminant being processed through the scrubber, 2.) The humidity of the incoming air and, 3.) The hardness of the water.

If the inlet loading of the air contaminant is known, the make up water rate can be calculated using the solubility of the chemical in water, usually enough fresh water should be added to the scrubber sump to maintain the solubility of the contaminant within approximately twenty (20) or thirty (30) percent of the solubility limit of the contaminant or end product in water.

EXAMPLE: If the solubility of the contaminant is 10 per cent by weight in water, enough fresh water should be added to maintain the solubility at 2-3 per cent by weight.

A small amount of the water make up is also used to fully humidify the incoming air. Since the air is being washed by water, the relative humidity of the air will increase to about 100 per cent (about 2 per cent by weight). The amount of water used will depend upon the relative humidity of the incoming air.

Since most water supplies contain various minerals, and only pure water will evaporate from the scrubber recirculating liquid, the concentration of these minerals in the scrubber recirculating system will increase over time. To avoid this gradual buildup, the scrubber system is completely shutdown, thoroughly cleaned and fresh water is added. This procedure should be performed at least twice per year.

For most applications, the above water make up rates are not calculated. As a general rule, use a water make up rate of 1 – 5% of the recirculating liquid rate.

3.05 Pumps

In most applications, horizontal sump pumps are used for recirculating scrubbing liquid. These horizontal pumps are either CPVC or 316 stainless steel. Since they have no seals, they can operate dry without harm. As a result, they are virtually maintenance free.

For a CPVC vertical sump pump, a restricted suction will cause damage to the impeller and the shaft. Also

do not run the pump against a closed discharge valve for more than five (5) minutes. This will cause overheating of the fluid in the pump and will damage all CPVC parts.

Always make sure there is enough liquid in the reservoir and the level is high enough considering the capacity of the pump unit. Inadequate liquid will cause a vortex in the pump box. A vortex occurs when air mixes from the surface into the fluid, which can disturb the flow and also prevent the pump from priming.

After operating the pumps, check the running amps versus the full load amps. If they exceed the full load amps, gradually close the spray line valves until the running amps are within the full load amps.

3.06 Liquid Level

For horizontal sump pumps, the correct pump box liquid level is very important. A liquid level which is too high could cause motor damage since liquid could enter the weep hole in the pump housing and cause the lower motor bearing to fail. During start up or priming of the pump, the pump impeller housing must be covered with water. Once the pump is primed, the sump level will drop since the water is being pumped into the plumbing line and packing area. The float valve will make up for the drop in water level. Each time the pump is turned off, the extra water added will flow out of the overflow fitting.

If the exhaust fan is located on the discharge side of the scrubber (negative system), you will notice the water level in the pump box will drop. Therefore, it is a good idea to start the pump first, and then the exhaust fan. Under a positive pressure system (fan located on the inlet of the scrubber), the water level in the pump box will be raised slightly.

3.07 Float Valve

The float valve acts as a control for a low water level condition. The float valve is used only to fill the scrubber sump initially, add water for evaporation control and act as a back-up in case the make up water supply has been turned off. It should not be used in place of make-up control.

3.08 pH Control

If your scrubber includes a pH system, it will monitor the pH of the recirculation liquid. A pH system can also be used to control the addition of a chemical additive. The addition of caustic such as sodium hydroxide will improve the scrubber of many acid contaminants. Use a range of 7-8 pH for normal inlet loadings and 9-10 pH for inlet loadings with occasional spikes. Other contaminants may require the addition of an acid such as sulfuric acid and the pH can be maintained at 2-3.

HEE can recommend whether a chemical additive is required for your application and provide a complete chemical feed system. For additional information on the pH system, refer to the operation manuals provided for your system.

this level will cause excessive temperature which will pose a significant fire hazard.

3.09 Chemical Feed System

The pH controller system will monitor and control the solution pH in the scrubber sump. For scrubbing many acids, the ideal pH in the sump is 7 to 10. For other chemicals, the pH must be maintained at 2-3. When the recalculating sump pH reaches the control set point, the pH controller signals the chemical feed pump to pump a chemical additive from the chemical feed tank to the scrubber sump. The metering pump will continue to pump until the pH controller signals it to stop.

3.10 Flow Meter

If an optional flow meter has been included in the scrubber system, they are either a horizontal inline flow meter with a float, or a paddle wheel design with an analog or digital display. The flow meter will include the total water recirculation rate. If a flow meter was not included in your system, HEE can offer one to suit your needs.

3.11 Pressure Gauge

If a pressure gauge has been included in the scrubber system, it will consist of an isolation valve, gauge guard filled with glycerin and a liquid filled pressure gauge. The pressure reading is unique for each system and will measure the hydraulic pressure at the installation point, not the pump discharge pressure. If a pressure gauge was not included in your system, HEE can offer one to suit your needs.

3.12 Pressure Differential Gauge

If an optional scrubber pressure drop gauge has been included in your scrubber system, it will provide a reading of the total scrubber pressure drop in inches of water column. If a pressure drop indicator was not included in your system, HEE can offer one to suit your needs.

3.13 Sump Heater

A sump heater system is designed to prevent the sump liquid from freezing. If an optional sump heater system has been included in the scrubber system. It will consist of a heater controller, RTD temperature sensor located in the pump box, a screw plug heating element, a heat sensitive fuse link and a low sump level switch. The low sump level switch and heat sensitive fuse, when properly wired to the heater controller, will prevent heater burnout in the event of a low sump level condition or detection of an excessive temperature in the heating element.

The heater controller will indicate the sum liquid temperature, and a temperature control point can be entered in the heater controller. Our initial suggested setting is 45 degrees Fahrenheit, and can be adjusted to suit your requirements.

CAUTION: The level of solution must be kept above the hot zone at all times. Allowing solution to fall below

MAINTENANCE

4.01 General Maintenance Instructions

Adequate access has been engineered into the unit to create a minimum of work when cleaning or servicing is required. Reference to the exploded view drawing (Appendix C) will help to identify the scrubber components.

Appendix A contains the recommended maintenance frequency for the various scrubber components and devices.

4.02 Mist Eliminator Access

The smaller top bolted cover allows access to the mist eliminator section. The mist eliminator profiles can be removed individually by sliding them out the top of the unit. Removal may be difficult since blade replacement can be difficult. Therefore, we recommend periodic inspections during shut down periods. The maintenance should include:

1. Visual check out of internal blade elements for solids build-up
2. Clean all areas with high pressure hoses as required, being careful not to damage the blades

When re-installing the transition, use butyl caulking on the flanges for proper sealing.

4.03 Pumps-Removal and replacement

The pump (s) should rarely require maintenance because they have no seals or bearings in the fluid to wear out, and can be run dry indefinitely without harm. There are times when, due to inadvertent installation or maintenance miscalculations, removal and replacement may be required.

The pump (s) is mounted on a polypropylene plate which is bolted to the sump box. The pump (s) is plumbed to the spray piping with unions. To remove the pump:

1. Turn off electrical power to the pump at the main disconnect switch.
2. Disconnect electrical wiring from pump motor.
3. Turn off ball valve, unscrew union nut on ball valve connecting pump outlet pipe to spray header piping.
4. Remove bolts that attach pump plate to sump box.
5. Remove pump and return to factory for repair or replacement.
6. Reverse above steps to re-install pump (s).
7. Be sure to reconnect wiring for proper pump rotation. Turn the ball valve back on.

CAUTION: All electrical power to the motor should be disconnected prior to pump removal.

For additional information on pump maintenance, request the installation, operation and maintenance manual for the specific pump.

HINT: *If change in flow reading is observed, it probably indicates the presence of debris or foreign material in the pump inlet housing. This condition can also cause pump cavitations as indicated by excessive pump noise. This condition must be corrected to prevent pump impeller damage. Finally, the debris may also have lodged in another part of the recirculating system.*

4.04 Pump Motor Maintenance

Cleaning and Inspection: A clean motor runs cooler. The motor should be cleaned and inspected at regular intervals. Operating conditions involving continuous running, hot, dirty or dusty surroundings, etc., require frequent attention. Always check motor shaft bearings when any unusual noise or vibration develops in the motor.

Inspect bearings for roughness by removing the pump from the sump box and turning the pump impeller by hand, if the bearings feel "rough" or stick in spots, replace them.

4.05 Float Valve

The operation of the float valve should be checked weekly. A scale deposit could develop allowing the float valve to stick. Open up the access door to the float valve located in the still well, and push down on it to verify operation.

4.06 pH System

A pH system will require regular maintenance. A pH probe will need to be calibrated once per month. Also check for buildup on the pH glass membrane. Finally, a pH electrode degrades with time and usage and just like a battery, it has a limited life. The first indication of a depleted electrode is a reading that constantly drifts or takes a long time to stabilize (>10 seconds) while in the pH solution. The same symptoms can indicate a problem in the meter.

HINT: *Check the millivolt offset of the pH sensor while it is in a buffer solution of 7.0 pH. An electrode offset of 50 mV or greater indicates cleaning or replacement is required.*

Refer to the pH manuals provided with your pH system for calibration, cleaning and additional information.

HINT: *Keep the glass electrode tip of the pH sensor completely submerged and wet at all times. When out of the process and not in use, place the electrode tip in pH 4 buffer. Exposure to air will dehydrate the sensor and damage the electrode. If the sensor dehydrates, soak the sensor tip in pH 4 buffer for 24 to 48 hours. Severely dehydrated electrodes cannot be restored to normal operation and must be replaced.*

4.07 Flowmeter

Check the operation of the flow meter and clean as required. If the flow meter is a paddle wheel sensor with an analog or digital display, remove the flow sensor from the recirculating line and check the o-rings and replace them when necessary. The paddle wheel must always turn freely. Be sure the connections to the indicator and additional cable are still intact. Lubricate the barrel and o-rings with G.E. silicone compound #G660 every three months. Keep the paddlewheel and pin free of any lubricant. A spare rotor kit consisting of a paddlewheel, O-rings and a pin is available. It is suggested that you check your flowsensor periodically until some history of your specific application can be created.

The paddlewheel is designed to rotate on the shaft; the shaft should not rotate with respect to the housing. The paddlewheel must turn freely. If it does not, clean the paddlewheel assembly as follows:

1. Remove the flowsensor from the pipe and insert a plug into the pipe fitting. Clean any external debris from the paddlewheel.
2. For the MK 515, using a small flat-bladed screwdriver, gently pry one of the paddlewheel mounting ears away from the pin.
3. When one end of the pin is free, gently work the paddlewheel and pin out of the remaining mounting ear.
4. Thoroughly clean the pin, paddle, and pin holes with a wire brush and/or toothpick along with alcohol and/or soap and water.
5. To reinstall the paddlewheel and pin, reverse steps 1, 2, and 3.
6. After cleaning, the paddlewheel should spin freely without binding sticking.

4.08 Pressure Gauge

The pressure reading should be checked weekly and recorded. An increase in pressure indicates a gradual plugging of the recirculating system. Usually, the spray nozzles should be inspected for debris and possible scale buildup.

4.09 Pressure Differential Gauge

Check the scrubber pressure drop on a monthly basis, and record the reading. An increase in pressure drop indicates a gradual fouling of the packing media and scrubber interior. When the pressure drop increases by 50%, it is time to perform maintenance. Refer to the packing maintenance section.

The differential gauge requires no lubrication or periodic servicing. The interior should be protected from duct, dirt, corrosive gases and fluids. Zero adjustments should be checked and reset occasionally to maintain accuracy. Use the zero adjusting screw located at the bottom of the front cover, while the high and low pressure taps are both open to atmosphere.

4.10 Sump Heater System

Once a month, verify the proper operation of the low sump level by pressing down on it and simulating a low sump level condition. The sump heater should not energize in the event of a low sump condition.

Tank sludge, if allowed to build up around the heaters, will reduce heater life substantially. Inspected for and remove all sediment and sludge BEFORE they contact the heater surfaces.

Inspect heater surface regularly and chemically remove any material that build up on the surface. Scraping heater surface can shorten the life of the material heaters.

4.11 Draining the Recirculating Lines

Certain older models scrubbers have a check valve with two holes drilled in the check valve. If present, this will allow liquid to drain from the plumbing lines into the sump prior to maintenance on the recirculating system. Newer scrubbers are now equipped with a small drain lines and valve. This valve should remain closed during normal operation. Prior to performing maintenance on the recirculation system, open this valve and allow liquid to drain into the sump. If your scrubber system has no provisions for drainage, and upgrade kit can be shipped to you via UPS at no charge for field installation including installation instructions. Please contact HEE and ask for your free upgrade kit.

4.12 Sump – Pump Filter

The sump – pump filters are located between the sump box and the main unit body. They are white perforated polypropylene, with handles at the top, which slide in a track. Removal of the filter (s) from the unit will allow cleaning. The filters should be checked and cleaned once a week.

4.13 Sump Access

On larger horizontal scrubber, an optional access door is provided into the sump area. This access is also used when replacing packing materials. The sump access is located in the inlet transition, and is a sliding panel for scrubbers operating under negative pressure. Positive pressure systems will have a bolted door.

The sliding door must not be opened during operation or the door may not re-seal.

4.14 Packing Access

The top of the unit has cover which is bolted to the main body. Removal of the cover will allow complete access to the packed section. The system must not be in operation while this cover is being removed.

4.15 View Ports

Round polypropylene viewing ports are located in area to allow observance of the spray nozzles. Inspect the nozzle once a month for proper spray patterns.

4.16 Spray Nozzle Access

The spray headers are individually removable for a scrubber operating under negative system to aid in the servicing of the spray nozzles. The unit does not have to be shut down to service the spray headers or nozzles. To remove the spray headers:

1. Turn off the ball valve supplying the spray harness.
2. Unscrew the union nut on the outlet side of the valve to free the harness.
3. Remove the hardware holding the round flange to the scrubber body.
4. Rotate the spray header 90 degrees and pull the remove.
5. Unscrew the nozzles for maintenance.
6. Reverse the above steps to re-install the spray headers.
7. Remember to turn ball valve back on

Do not over tighten the hardware holding the flange to the scrubber body and union nuts on the ball valves. The recommended torque is 30 - 40 inch-pounds (note the units) for the hardware on the spray line flanges.

4.17 Spray Nozzles

If required, the spray nozzles can be removed for cleaning. A scale buildup can usually be removed by soaking the spray nozzles in a dilute solution of muriatic acid. A small steel wire brush can also be used.

HINT: It is always a good idea to keep some spare spray nozzles in stock. This will allow you to thoroughly soak and clean the plugged up spray nozzles, and continue normal scrubber operation.

4.18 Ball Valve

To prevent the buildup of scale and maintain free operation of the valve, operate them at least once per week.

4.19 System Cleaning

The entire scrubber system should be completely cleaned at least twice a year. During this process, the liquid should be drained and the entire scrubber interior be cleaned.

4.20 Recommended Spare Parts

1. Spray nozzles, complete set
2. Flow sensor paddle wheel
3. Chemical metering pump rebuild kit (KOP)
4. Ball and check valve, one each size
5. Solenoid valve, ASCO
6. Dwyer gauge
7. Recirculation pump, if standby pump is not included

Note: A spare pH sensor is not recommended since it has a 1-2 year shelf life.

PACKING MAINTENANCE

5.1 Inspection and Cleaning of Packing Face Area

Inspection of the packing face area should be performed on a semi annual basis. Observe for a build up of scale and chemical deposit. Often the chemical being scrubbed will build up on the packing face area. In the air stream, the concentration of the containment being scrubbed will be very dilute, but will be highly concentrated after a deposit has built up on the packing face area. Under these conditions, many chemicals can attack the packing material and will require packing replacements. To avoid this, cleaning can be done with chemical acid baths, high pressure hosing, or a combination of both. Check the chemical resistance of the packing material before using any chemicals to clean the packing.

5.2 Maintenance and Cleaning

Inspection of the packing should be done on a regularly scheduled basis. Maintenance of the packing is determined by the amount of fouling (collection of deposit such as iron, carbonate, and bacteria) which has accumulated on the packing. Past experience indicate a minimum inspection period of six (6) months to check for excess fouling. The optimum inspection time will vary from area to area depending on the rate of concentration of deposits from your water source. The packing can be removed and cleaned if fouling is not permitted to get excessive. The packing should always be kept wet until cleaning can be done to prevent the deposits from solidifying and becoming much more difficult to remove. Cleaning can be done with chemical acid baths, high pressure hosing, or a combination of both. Check the chemical resistance of the packing material before using any chemical to clean the packing.

5.3 Packing Material Cleaning Procedure

Under some circumstances the packing media may foul with iron oxide, manganese oxide, calcium carbonate and/or algae. If the proper steps are taken in a timely fashion, the fouling can be reversed. If these procedures are too time consuming or the manpower is not available to perform these duties, contact HEE Environmental Engineering. There are services companies throughout the United States and HEE can provide recommendations.

5.4 Cleaning Procedure for Iron Oxide, Manganese Oxide and Calcium Carbonate

The pressure drop through the packed bed should be monitored on a weekly basis. Once the pressure drop has increased by fifty percent (50%) of the original reading, it is time to clean the system.

Shut down the scrubber and drain it. Inspect the sump for salt formation, remove the salt and flush the sump with water. Close the drain and fill the sump with a water solution of three percent (3%) muriatic acid (HCl). This solution should be recirculated over the packing using the existing recirculation pump until the packing is clean...approximately two to three (2-3) hours WITHOUT running the fan. (Nobody wants HCl raining down on them). Again, drain the column after the packing is cleaned and thoroughly flush the system with water. The scrubber can now be placed back in operation.

5.5 Cleaning Procedure for Algae and Biological Growth

The growth of organic matter in a scrubber is a direct function of water quality. If the water used in a scrubber is treated (chlorinated) by a municipal treatment plant, you will probably not experience problems. If this is not the case, than algae growth may occur. The addition of chlorine tablets obtained from a swimming pool supply can be used to increase the amount of chlorine. You can also use a chlorine test kit to monitor and control the chlorine level.

Close the sump and fill it with a water solution of 0.05% chlorine. This solution should be recirculated over the packing using the existing recirculating pump until the packing is clean...approximately one (1) hour WITHOUT running the fan. Again, drain the sump after the packing is cleaned and thoroughly flush the system with water. The scrubber can now be placed back into operation.

Depending on the water quality, this procedure might have to be performed once a week, once a month, or never. This procedure should be performed as a maintenance procedure before algae growth become a problem.

If the existing equipment has had a history of excessive fouling, or if new installation develops frequent need for cleaning due to biological growth, contact HEE for information about technology in using a pre-treatment system to reduce or eliminate fouling deposits.

Appendix A

MAINTENANCE FREQUENCY

	Weekly	Monthly	Semi Annual	Annual
Record Flowmeter Reading	X			
Inspect and Clean Sump Filter	X			
Verify Operation of Float Valve	X			
Operate Ball Valves	X			
Calibrate pH Probe		X		
Inspect Spray Nozzle Pattern		X		
Record Pressure Drop Reading		X		
Inspect Sump Heater Operation		X		
Verify low Sump Level Switch Operation		X		
Inspect Pump Inlet Filter		X		
Check Water Make-Up Rate		X		
System Cleaning			X	
Inspect Flowmeter Paddlewheel Assembly			X	
Check Pump Motor Amps			X	
Clean and Inspect Pump Motor			X	
Inspect Packing Face for Build up			X	
Inspect Packing for Build up			X	
Inspect Mist Eliminator for Build up				X

*Suggested frequency until some history of your specific application can be created

APPENDIX B

Scrubber Check List for Start - Up Procedures

- Check for packing settling or shifting
- Missing items
- Check for liquid leaks in water and chemical supply piping
- Caulking on Flanges
- Clean Scrubber Sump and Pump Box
- Water supply to Float Valve
- Water supply to Water Make-up
- Drain and Overflow Connection
- Drain Installed with a Vent
- Check Pump Motor Rotation
- Piping cracks/breakage or leaking
- Adjust Water Make-up Rate
- Check Pump Motor Amps
- Calibrate at pH 7 and 10 or pH of 7 and 4
- Sump Heater System (If Included)
 - Enter Alarm and Operating Points Sump Heater System
 - Test Low Sump Level Switch
 - Enter Temperature Operating Point

Appendix D

Scrubber Water Quality Requirements

Specific water requirements are difficult to specify for the following two reasons:

1. It is good engineering practice to conserve fresh water by using low-quality reclaimed water in scrubbers.
2. There are no real thresholds for key water quality parameters, one of them being the hardness of the water. Hard water has high concentrations of calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions and will form a scale deposits on the interior of the scrubber. We cannot say that if the water hardness of the scrubber water supply is below a certain value, that there will be no maintenance problems due to scale deposits. Or if the water hardness exceeds that value, that the scrubber will develop scale deposits. Harder water will form scale deposits faster than softer water will, but the point at which a quantitative difference becomes a qualitative difference depends on many parameters besides the scrubber water supply. Those include the scrubber packing selected, the pH set point, the blowdown and evaporation rates, the contaminants being removed from the air, and the operating schedule of the facility. Of course using soft water in scrubber will greatly reduce scale formation and can be considered, but this is not a necessity.

Some general considerations are as follows:

1. The hardness and silica content of scrubber water are usually of more concern than the TDS/TSS, sulfates, phosphates, chlorides or fluorides in it. An acid scrubber using caustic addition to maintain pH greater than 7 will absorb small amounts of CO_2 from the air, and as a result, magnesium and calcium will nearly all get precipitated as carbonates because they have extremely low solubilities in water. (If a scrubber is removing HF from the air, calcium fluoride may precipitate along with CaCO_3 .) Most of those precipitates will show up as fine suspended solids in the scrubber blowdown, but part of them will form a layer of scale on wetted surfaces in the scrubber.
2. Hardness minerals are less likely to cause problems if acid fumes are scrubbed using water only, without caustic addition, because the minerals tend to remain in solution at pH less than 7. That is because solubility of these minerals is higher at a pH less than 7.
3. It's hard to generalize about the effect of total suspended solids in make-up water. The fouling potential of suspended solids varies widely, depending on their particle size and their tendency to agglomerate. For example, micron-sized grains of crystalline silica could be carried right through a scrubber with little chance of deposition, and so cause no problems. However, the "silica" in reclaimed water from some semiconductor processes consists of a fluffy gel of hydrated silica (silicic acid, H_4SiO_4) that is hard to filter or settle out, but can trap CaCO_3 or other precipitates to form larger, denser particles inside a scrubber.
4. As for dissolved solids in the make-up water, the two we often have to watch out for are sodium fluoride (water solubility <4%) and sodium bicarbonate (water solubility <8%). Other sodium salts, including sulfates, phosphates, and chlorides, are more soluble, so they don't tend to cause plugging problems. In most cases, NaF and NaHCO_3 come mainly from neutralization of absorbed acid gases—not from the make-up water. The rate of formation of these byproducts often determines the minimum blowdown rate needed to operate a scrubber without risk of rapid plugging by precipitated solids.
5. When a scrubber is operated at low blowdown rates to conserve water, evaporative losses become important. For example, if a scrubber treats 50,000 acfm of air coming in at 70°F and 40% r.h., it will lose 1.4 gpm of water by evaporation. If some of the air being scrubbed is outdoor air, then evaporative losses can be considerably greater in hot weather. If the scrubber operates with a blowdown rate of 0.2 gpm but loses 1.4 gpm by evaporation, the make-up water feed rate will have to be 1.6 gpm. Dissolved and suspended solids in the make-up water will get concentrated by a factor of $(1.6 \text{ gpm}) / (0.2 \text{ gpm}) = 8$. If the scrubber make-up water is reclaimed water which is already almost saturated with silica or calcium carbonate, then concentration by evaporation can significantly increase the risk of scrubber fouling.

Therefore, it is hard to generalize. Each of these parameters needs to be examined on a case-by-case basis.

Appendix E

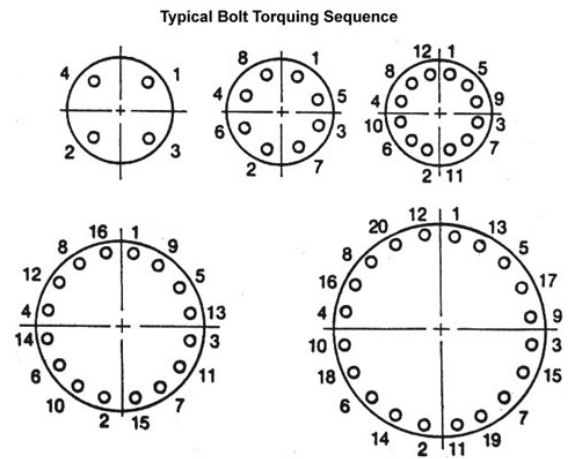
ANSI 150 Lb Flanged Nozzles – Torque and Torque Sequence

Flanged nozzles have standard ANSI 150 Lb flange bolt hole arrangement. Full face gaskets are to be used. Gasket material exceeding 70 durometer (and less than 1/8" thick) should not be used. Metal washers should be used under all bolt heads and nuts which would otherwise be in contact with the FRP flanges. Nut and bolt threads should be lubricated prior to tightening. Bolting take-up torque should be applied uniformly, alternating 180 degrees and rotating as near 90 degrees as possible. Refer to Table 1 for recommended torque requirement. Refer to Figure 3 for the recommended bolt torque sequence.

TABLE 1. RECOMMENDED TORQUE REQUIREMENTS – ANSI 150 Lb Flanges

Nominal Flange Diameter, Inches	Torque Increments, Ft-Lbs	Recommended Torque Full Pressure Seal, Ft- Lbs
1/2 – 1-1/2	5	20
2 - 12	10	25
14 - 16	10	30
18 - 22	10	35
24	10	40
Manways	10	30

FIGURE 3. RECOMMENDED BOLT TORQUE SEQUENCE





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