SPECIFICATIONS

EMERGENCY CHLORINE / SULFUR DIOXIDE GAS SCRUBBER SYSTEM

HEE ENVIRONMENTAL ENGINEERING, LLC
Sales Office: 2143 Convention Center Way Ste. 180, Ontario, CA 91764 * (909) 230-6120 * Fax (909) 230-6159
Corp Office & Manufacturing: 16605 Koala Road, Adelanto, CA 92301 * (760) 530-1409 * Fax (760) 530-1419
www.hee-llc.com

RTP LT1 EMERGENCY CHLORINE/SULFUR DIOXIDE GAS SCRUBBER SYSTEM SPECIFICATION

PART 1 – GENERAL

1.1 Scope

A. This specification covers the general requirements for operational and design conditions, materials of construction and performance of a chemical absorption emergency chlorine/sulfur dioxide gas scrubber system.

B. The system shall be a one-pass, pre-piped, wired, and packaged Emergency Gas Scrubber System including an absorber with vertical packed bed stages, mist eliminator, exhaust fan, integral caustic storage tank, recirculation pump, piping, valves, fittings, ductwork, anchorage system, stack, control panel and all other equipment, accessories, and appurtenances as described herein.

1.2 Process Description

A. The emergency chlorine/sulfur dioxide gas scrubbing system shall in the event of an accidental spill in the chlorine storage area act as a chlorine neutralizer. An induced draft fan shall pull gas vapor from storage area through a scrubber consisting of a series of co-current and counter-current packed bed spray system sections where intimate contact with recirculating caustic solution results in the complete absorption and removal of chlorine or sulfur dioxide gas. A high efficiency mist eliminator shall be located in the gas stream, prior to exhaust, to remove any residual caustic solution.

B. A chlorine detector or manual remote start switch shall activate the system in two steps. The recirculation caustic pump shall be activated first to permit proper wetting of packing in the scrubber stages before starting the exhaust fan, with a 0 to 5-second adjustable time delay. The time delay is typically set for 3 to 5 seconds. This feature allows the scrubber to be ready prior to passing any chlorine-laden gases through it.

C. The exhaust fan is placed downstream of the scrubber. This feature allows the complete system to be under negative pressure until the gases are completely scrubbed.

D. The emergency scrubber system consists of the following major system components:

1. FRP Scrubber Absorber
2. Integral Caustic Storage Tank
3. FRP Air Exhaust Fan
4. Caustic Recirculating Pump
5. Electrical Control Panel with Alarms
6. Piping and Single Unitary Construction

1.3 Qualifications

A. The scrubber manufacturer shall provide sufficient test data to demonstrate that a full-scale packaged gas scrubber has been successfully evaluated to determine its ability to neutralize an actual spill. Test data shall include a profile of temperatures and pressures throughout the spill room and scrubber system for the test cycle. The test data shall show an actual spill from a One Ton Chlorine Container with an average liquid release rate of 238 lbs. per minute over a release duration of a maximum of 592 seconds to ensure a gaseous chlorine rate of 78.34 lbs. per minute as set forth by the UFC. Testing shall have been carried out at a fully accredited national testing laboratory or at the Manufacturer's or other facility under suitable independent agency supervision. All costs associated with compliance to this specification are the responsibility of the scrubber Manufacturer.

B. The manufacturer of this equipment shall be one that is engaged in the production of FRP equipment, and shall manufacture the scrubber and fan in its entirety.

C. The equipment manufacturer shall have not less than ten (10) years experience in the system design, construction, and manufacturing of FRP fan and scrubber systems.

D. The Manufacturer shall maintain a regular production facility. This facility shall be open for inspection by a representative of the Owner or Engineer at any time during construction and testing of this equipment.

1.4 Submittals

A. A complete submittal package shall be submitted to the Engineer for review prior to the start of manufacturing including all piping, ductwork, valves, electrical requirements and instrumentation options and connections.

B. The proposed Manufacturer shall submit three (3) copies of shop drawings with the following information for approval before equipment is fabricated:

1. Drawings of the system showing assemblies, arrangements, piping, electrical, mounting details, equipment outline dimensions, fitting size and location, motor data, operating weights of all equipment and sufficient information to allow the engineer to check clearances, connections, and conformance with the specifications.
2. Materials of construction of all equipment.
3. Manufacturer's catalog data and operating literature. Specifications, performance data, and performance curves for caustic recycle pump, exhaust fan, and auxiliary components.
4. Complete instrumentation, control, logic and power wiring diagrams in sufficient detail to allow installation of the instrumentation, controls, and electrical components.

C. Complete design calculations shall be submitted and confirm the following:

1. The system design calculations must demonstrate a minimum overall system removal efficiency of 99.99%.
2. The pressure in the chlorine storage room must never exceed ambient atmospheric pressure from the beginning of the design leak event to the time the scrubber system turns off.
3. The unit shall be capable of withstanding the hydrostatic load of shop tests and the field conditions of being filled to the top of the caustic storage/recycle tank with 20% caustic solution.

PART 2 – PRODUCTS

2.1 Design and Performance Criteria

A. General

The Emergency Chlorine/Sulfur Dioxide Gas Scrubber System is designed and specified around a model RTP LT1 as manufactured by HEE Environmental Engineering, Inc. All costs associated with review of substitutions or deviations shall be borne by the Contractor. There shall be no additional costs to the owner due to substitutions or deviations.

B. Design Leak Event

The Emergency Chlorine/Sulfur Dioxide Gas Scrubber System shall be of sufficient size and design to treat a release of the entire contents of a stored chlorine one-ton cylinder. The system shall be designed for the following conditions:

Chlorine Stored Capacity:	2,350	lbs. (1-ton + overfill)
Liquid Release Rate:	78	lbs./min
Flash-off rate	100	% of liquid release
Minimum Ventilation Rate	3,000	acfm
Max. Outlet Chlorine Conc.	5	ppm

C. Design Description

The Emergency Chlorine/Sulfur Dioxide Gas Scrubber System shall be a single-pass system, which acts as a prime air mover to induce the flow of gas in the event of an accidental spill in the chlorine storage area. Chlorine gas from the storage room, evacuated through duct, shall enter the scrubber at 3000 cfm through an inlet plenum that divides the gas into two "trains" allowing complete and even distribution into the vertical packed beds. Upon entering the first scrubber section the gaseous chlorine rate may reach 291lbs. per minute. The first vertical bed shall be of co-current design, which prevents overloading of the scrubber that can result in foaming, thereby potentially rendering the scrubber inoperable.

After the gas vapor leaves the first packed bed section, it then enters the second section which is a vertical counter-current packed bed, followed by the final packed bed which is also vertical counter-current. This vertical co-current, counter-current, counter-current design allows for the impossibility of a "short circuit", or bypass of gas, and ensures a removal efficiency of 99.999%, which insures a maximum of 5 ppm at 291 lbs. of gaseous chlorine in an emergency situation.

After complete absorption and chlorine removal has occurred, the two trains are recombined and directed through the mist eliminator and discharged to the outside atmosphere.

D. Fiberglass scrubber vessel shall conform to the following structural design criteria:

Scrubber Pressure:	6" WC vacuum
Caustic Storage:	Hydrostatic load of sp. gravity = 1.2
Wind Load:	100 mph
Live Load:	200 lb/sq.ft

2.2 Construction

A. Packaged Gas Scrubber System

The gas scrubber system shall be pre-packaged consisting of an absorber with an integral caustic storage tank, spray header and nozzles, packing, mist eliminator, caustic recirculation pumps, and exhaust fan. The scrubber stages shall be vertical co-counter-flow/counter-current-flow/counter-current-flow.

B. Scrubber Section

The scrubber section shall consist of internal distribution piping, spray nozzles, packed beds, and a mist eliminator, and shall be an integral part of the caustic storage tank. Access manways shall be provided to allow access to the scrubber internals.

The spray nozzles shall be installed above the packing and shall be arranged and sized as required to ensure uniform distribution of scrubbing solution throughout the bed. Recirculation piping shall enter the scrubber through a flanged connection. Spray nozzles shall be specifically designed to be clog-resistant. Recirculation piping on the outside of the scrubber shall be arranged for easy removal. The internal distribution piping and spray nozzles shall be designed to produce the required caustic flow rate and drop size.

The packing shall be manufactured from a low weight, low resistance material; shall have a minimum surface area of 85 square feet per cubic foot; shall have a minimum void fraction of 90 percent.

The mist eliminator shall be sized to remove entrained droplets from the gas stream. The mist eliminator shall have a minimum removal efficiency of 98 percent of 2 microns and larger.

Recirculation pipe supports shall be provided on the scrubber package. All internal piping, packing, mist eliminator, and appurtenances shall be constructed of materials suitable for use with the scrubbing fluid and gas.

C. Caustic Storage Tank

The caustic tank shall be capable of storing the amount of 18 to 25 percent sodium hydroxide solution to provide a minimum of 50 percent excess caustic over theoretical requirements to neutralize the gas. The final sodium hypochlorite concentration after complete neutralization shall not exceed 12 percent by weight.

The caustic storage tank shall be a rectangular box shape fabricated from fiberglass-reinforced plastic in accordance with ASME RPT-1, ASTM D4097 or D3299. The construction of the tank top shall be adequate to support the additional weight of the scrubber section, caustic recirculation pump, piping, and controls. The tank shall be fabricated of fiberglass reinforced plastic Derakane 411-45 or equal vinylester resin with MEKP cure in a double Nexus veil with a four hour post cure and 100 mil glass corrosion barrier surrounded by an outer structural layer. No sandwich construction shall be allowed.

The standard flanged fittings shall be used on all installations. The data following applies also to other nozzles that are given separate designations because of their specialized style or function. These would include pump mounting boxes and access ports.

Flanged nozzles shall be used for piping-up to reinforced plastic tanks. They shall be made of the same resin and constructed the same as the tank, be properly bonded into the tank wall and offer the same degree of corrosion resistance. Through-bolting shall be used in lieu of metallic thread inserts or studs.

Flanged nozzles shall be hand laid-up as separate components with the flange face and the pipe neck formed on the mold as an integral piece. Installation shall be performed after the tank structure has been fabricated. Because this is a post-fabrication installation, exacting laminate amounts and sequences must be established to ensure proper rebuilding of strength in the area of the nozzle cutout. The installation laminate must maintain continuity of the inner "corrosion barrier" of the tank wall right out to the flange face.

Flanged nozzles are classified as either Type 1 or Type 2 depending upon the method of installation.

Type 1 nozzles shall be used for top installations particularly where a directed flow stream into the tank is required.

Type 2 nozzles shall be used in all other installations that do not meet the Type 1 criteria, i.e. side or bottom installations. The cut edge of the pipe neck shall be more positively covered with the inside lay-up. Where flow rates are critical, or where accessories, such as thermal wells, are to be inserted, a larger pipe size should be used.

The standard nozzle projection shall be 4" from the face of the flange to the closest point on the tank wall.

Flange face and bolting correspond to ASA Standard B16.5 for 150 lb. steel flanges. Flange thickness corresponds with 25 psi rated fiberglass pipe and flanges.

Flanged nozzles shall be designed for use only with soft, full-face gaskets. Gaskets shall be 1/8" thick and between 40 and 60 durometer EPDM.

Reasonable care should be exercised in piping up to reinforced plastic nozzles. Even torque should be applied to all bolts. The weight of connecting valves and piping should not be supported on the nozzles, but should be supported independently from the foundation or from pipe hangers.

All flanged liquid connections shall be gusseted to the tank wall with ¼ inch thick flat plate gussets.

The tank shall be equipped with permanently attached lifting lugs suitable for lifting and transporting the tank without structural damage. Tie down or support lugs shall be designed to anchor the tank and contents as required.

2.3 Caustic Recirculation Pump

Pump shall be a seal-less single stage centrifugal vertical sump pump. No seal water shall be required. Pump design shall feature open impeller in the submerged casing. The pump shall be driven by a “C” face motor, mounted on a bracket, sitting on pump mounting plate and connected to pump shaft via flexible coupling.

Recirculation pumps shall deliver the flow necessary to meet the performance requirements specified herein.

The casing and impeller shall be molded from CPVC or premium grade vinylester resin. There should be no metal wetted compounds. Wetted bolts shall be made of the same material as pump casing and column.

Pump shafts shall be machined from centerless ground 304 SS, encapsulated with plastic sleeving, either of the same material of pump.

Sleeve bearings shall be chemically resistant Polyphenylene Sulfide vs. Ultra Pure Aluminum Oxide. The thrust bearing shall be independent from the motor, located in brackets above the mounting plate.

The sleeve bearings shall be lubricated by process fluid. No external flush water shall be required.

The unit shall be built with casing cover and impeller assembly modified for thermal fluctuation enabling the pump to be used through the full range of temperature settings.

Motors shall be "C" face, 460V, 3PH, 60Hz, TEFC motor manufactured in the United States. Motors larger than 20 HP shall require reduced voltage starters.

Pump assemblies, including motor, shall be free of excessive noise, vibration, and cavitations.

The pump shall be Fybroc vertical fiberglass pump or equal.

2.4 Exhaust Fan

Fan shall be a Harrington Environmental Engineering, Inc. HPCA series fiberglass reinforced plastic centrifugal airfoil, manufactured from a premium grade vinylester resin. The fan wheel shall be statically and dynamically balanced at the factory. The fiberglass construction shall conform to PS 15-69 product standards. Fan resin shall be suitable for exposure to the specific service conditions.

Fan housing shall be constructed of fiberglass and reinforced with rigid bracing to increase structural integrity. Bearing support brackets shall be positioned to directly oppose belt tension forces.

Fan housing shall be curved scroll design with a 1-inch NPT drain connection at the bottom of the fan scroll. Fan outlet shall be flanged and the fan shaft shall be stainless steel.

Fan shall have self-aligning grease-packed bearings, with neoprene shaft seal and OSHA approved weatherproof motor/drive cover.

The fan shall be designed for the following specifications:

Air Flow Rate:	3000,	acfm
S.P. up to the Scrubber Inlet:		____in. WC
Pressure Drop through Scrubber:	3.5 in.	WC
Total S.P. Drop:		____in. WC
Motor HP:		5.0 HP

The fan shall have a 3-phase, 60 Hz, 230/460, TEFC, 1,800-rpm motor with a 1.15 service factor. The fan shall be a Harrington Environmental Engineering, Inc. HPCA or HPR series fiberglass fan. Fan shall be tested in accordance with AMCA.

2.5 Recycle Piping

All exposed caustic recirculation piping shall be CPVC, unless the normal recirculation line pressure is greater than 40 psig. In that case, the piping shall be FRP.

Fiberglass Pipe: Pipe shall be manufactured by Bondstrand. The pipe and fittings shall be made using the same type polyester resin and be suitable for at least 150 PSI at 175º F.

2.6 System Activation

A. The Emergency Chlorine/Sulfur Dioxide Gas Scrubber shall operate manually in response to hand switches or automatically in response to contact closures at remote leak detectors. The system shall normally remain in automatic mode for standby conditions. System response for manual and automatic modes is described below.

B. Manual Control

1. The control system shall provide for manual control of the following items:

a. System Start
b. System Stop
c. Scrubber Exhaust Fan
d. Caustic Recirculation Pump

2. Manual control shall be enabled by turning a “HAND-OFF-AUTO” switch for the respective piece of equipment to the “HAND” setting. The selected device shall start, and a pilot light will energize to denote that it is operating.

3. The scrubber system shall be able to be started manually if desired by turning a “START” switch. The scrubber shall function the same as during automatic mode if the scrubber is started in this manner.

C. Automatic Control

1. The control system shall provide for automatic control of the scrubber such that when the “HAND-OFF-AUTO” switches noted above are set to “AUTO”, the scrubber system shall operate automatically based on a digital

2. signal from a Chlorine/Sulfur Dioxide Detector in the Chlorine/Sulfur Dioxide storage area.

3. When the Local Control Panel receives a start signal from the Chlorine/Sulfur Dioxide Detector, the caustic recirculation pump and fan shall start. Status lights shall energize to indicate that the fan and pump are operating.

2.7 <u>Control Panel</u>

A. The scrubber system shall be furnished with a scrubber mounted Local Control Panel with a 316 stainless steel NEMA 4X enclosure to house the required controls.

1. The control panel shall include the following switches and lights:

a. System “HAND-OFF-AUTO” Switch
b. System “READY” Status Light
c. Fan “HAND-OFF-AUTO” Switch
d. Fan “RUN” Light
e. Pump “HAND-OFF-AUTO” Switch
f. Pump Lead-Lag Selector Switch
g. Pump “RUN” Light
h. Fan “FAIL” Light
i. Pump “FAIL” Light
j. Caustic “Low Level”
k. Lapse Timer
l. Required relays for remote signaling

2. A low-level switch for caustic storage shall indicate an alarm light and audible alarm. A reset button shall be provided to silence the alarm.

3. The control panel shall include 480V to 110V transformer and the required motor starters for fan and pump.

C. The control panel shall include relays, auxiliary contacts, or other hardware as required to provide digital contact outputs for remote indications. These remote contacts shall be wired to a terminal block and be accessible for external wiring to remote locations such as local panels, distributed controllers, or computers. Remote signals to be provided shall include the status of the following conditions:

1. System Ready
2. Fan Running

3. Pump Running
4. Fan Failed
5. Pump Failed
6. Caustic Level Low

2.8 Optional Equipment

A. Stand-by pump (Reference 2.3 of Specifications)

B. Secondary Containment

When required, the complete scrubber system shall be enclosed in a built-in FRP true dual wall reservoir secondary containment vessel designed to allow free flowing of any liquid in the event of a leak in the primary tank, and to contain 100% of the contents. The dual wall reservoir shall consist of a typical reservoir and integral packed-bed section with the addition of an air space approximately 3" between the reservoir (primary tank) and the double walled (secondary containment) tank. There shall also be a secondary containment floor. Fiberglass grating shall be used for support between the primary and secondary tank bottoms to create an air space completely around the reservoir tank. "Sandwich construction", or foam in between two FRP skins *shall not* constitute secondary containment.

PART 3 – EXECUTION

3.0 Factory Testing

A. Inspect control panels for required construction, electrical connection, and intended function.

B. Test all equipment and control panels actually furnished.

C. The scrubber systems to be furnished shall be factory tested for compliance with the specifications and to demonstrate that all components function properly, and that the unit produces the required airflow rate. The factory test shall be performed using air and water. The gas scrubber shall be operated continuously, for a minimum of two (2) hours.

3.1 Functional Acceptance Test

A. Operation and Maintenance manuals shall be submitted to the Owner prior to final acceptance of the equipment.

B. Upon completion of installation of the scrubber systems, the Equipment Manufacturer's Service Representative shall be responsible for performing an acceptance test to verify the satisfactory operation of the system and the design performance requirements of the specification. As a minimum the test shall include but not be limited to the following:

1. The test shall be witnessed by the Owner.
2. Airflow, pressure, and motor amperage shall be measured and recorded.
3. Caustic storage tank shall be leak tested prior to filling with caustic.
4. System component operation shall be tested by energizing Chlorine/Sulfur Dioxide Leak Detector.

3.2 Training

The Manufacturer of the scrubber system shall furnish a qualified instructor to provide adequate training in the operation to the Owner of the systems, including safe chemical handling procedures.

3.3 Warranty

The Manufacturer shall guarantee the complete scrubber system, both in material and workmanship, for a period of one year from the day of final acceptance, not to exceed 18 months from delivery at jobsite.

3.4 Identification

The caustic storage tank shall be identified with the health, flammability, and reactivity of hazardous materials as required by codes.

3.5 Initial Fill of Caustic

A. The Contractor shall provide the initial fill of sodium hydroxide for the emergency chlorine scrubber, as recommended by the equipment supplier, prior to completion of the factory start-up and acceptance of the equipment. The Contractor shall coordinate delivery with the requirements of the start-up personnel to allow hydrotesting of the scrubber prior to chemical delivery.

B. The Contractor shall provide 2100 gallons of 20% sodium hydroxide.

C. The solution shall be free of dissolved elements or impurities at concentrations that could negatively impact operation. Dilution, if necessary, from standard stocked concentrations shall be made with deionized or soft water (with less than 1 grain of hardness per gallon). The chemical supplier shall provide certification of such dilution methods and water quality.

HEE ENVIRONMENTAL ENGINEERING, LLC
Sales Office: 2143 Convention Center Way Ste. 180, Ontario, CA 91764 * (909) 230-6120 * Fax (909) 230-6159
Corp Office & Manufacturing: 16605 Koala Road, Adelanto, CA 92301 * (760) 530-1409 * Fax (760) 530-1419
www.hee-llc.com