WATER SUPPLIES DEPARTMENT
STANDARD SPECIFICATION EM-02-12
CHLORINE SCRUBBER SYSTEM

This specification shall be read in conjunction with the following WSD Standard Specifications :

(a) EM-02-01 - Chlorine Plant – General and Design;
(b) EM-02-08 - Chlorine Plant Control Panels; and
(c) EM-02-10 - Chlorine Room Ventilation

1. GENERAL

This specification specifies the general requirements of a chlorine scrubber system (hereafter called the "Scrubber") for neutralizing any leaked chlorine in the on-site chlorine generation plant room, chlorination room, evaporator room and/or chlorine storage areas (hereafter called the "chlorine areas"). The Scrubber shall be either a counter-flow or cross-flow design and comprises a wet type packed scrubber or a dry type packed scrubber.

The Scrubber shall be activated automatically on the detection of chlorine content in the air at or above 3 ppm by any one of the chlorine leak detectors strategically installed in the chlorine areas or in response to the activation of manual alarm call point or the emergency alarm push-button. Manual override of the Scrubber shall also be provided. Upon activation, air/chlorine mixture in the affected areas shall be drawn into the Scrubber by the scrubber fan via the intake duct connected to the duct of the normal ventilation system or of its own where applicable.

The Scrubber shall meet the latest requirements of Fire Services Department (FSD) and Environmental Protection Department.

The Contractor shall provide and display all appropriate labels in place to facilitate safe operation and maintenance of the Scrubber, such as type of pipework/air ducts, air flow direction, empty and fully loaded weight of the unit, the appropriate warning signs, DG store labels, material safety data sheets, etc.

2. NEUTRALIZING AGENT

The neutralizing agent used for scrubbing shall be classified as either one of the following:

i. Wet type — using homogeneous mixture of sodium hydroxide and water of not more than 12% weight by volume concentration (i.e. 12%w/v), held in a solution tank. During operation, the sodium

hydroxide solution shall be recirculated by a pump to react with the chlorine/air mixture in the Scrubber.

ii. Dry type using chemically impregnated activated alumina media.

Use of alternative neutralizing agent shall be subject to the substantiation by the Contractor and the approval/acceptance of the Engineer/Project Manager

3. SYSTEM PERFORMANCE

The Scrubber shall have system reliability and availability greater than 99%. The Contractor shall submit information to substantiate and to certify that the Scrubber provided, under proper preventive maintenance and testing schedule, can achieve the reliability and availability conditions.

3.1 Wet type scrubbers shall be capable of neutralizing chlorine released in air at 45kg/min with concentration up to 200,000 ppm. The scrubbing efficiency of the Scrubber shall be not less than 99.9985% in one pass through the Scrubber. The type test certificate of the system shall be provided. Foaming of the sodium hydroxide solution is not allowed during the Scrubber operation. The system shall be designed to minimize the formation of sodium carbonate precipitate.

At an ambient temperature of 35℃, the working temperature of the sodium hydroxide in the solution tank during and after scrubbing shall not be higher than 55℃. The Contractor shall submit the calculation to substantiate the volume of solution required for quenching throughout the entire reaction for the approval/acceptance of the Engineer/Project Manager. The minimum and maximum solution concentration and tank level should be advised by the Contractor in the submitted calculation.

3.2 Dry type scrubbers shall have minimal removal capacity of 10% for maximum design chlorine leak rate of 0.75 kg per minute. The overall removal efficiency of the Scrubber shall be not less than 99.999%.

4. CHLORINE SCRUBBER SYSTEM CONTROL

Under automatic control, the Scrubber and the ventilation system shall interact in the following manner.

The Scrubber shall remain in a state of readiness with all scrubber dampers closed and the control mode set to recycle position.

On detection of a chlorine leak at or above 3 ppm, or in response to activation of manual call point or emergency alarm push-button, the normal ventilation for the chlorine areas shall be stopped. All high level air inlet motorised louvres shall close automatically and the Scrubber shall be activated.

i. Wet type The sodium hydroxide recirculation pump shall start. The scrubber fan shall start no longer than 3 seconds after the solution flow is established.

ii. Dry type The scrubber fan shall start no longer than 3 seconds after the Scrubber is activated.

The motorised scrubber intake and recycle dampers shall then open to admit air/chlorine mixture into the Scrubber. The scrubber exhaust damper to the atmosphere shall close at all time until the air/chlorine mixture after scrubbing is safe for discharge into the atmosphere, i.e. below 3 ppm. The scrubber exhaust damper can only be opened by manual actuation.

Each step of the control operation shall be verified by a feedback signal from the process prior to advancing to the next step. The following feedback signals as sequence interlocks shall be applicable:-

Operation of sodium hydroxide recirculation pump	- flow detected by flow switch
Operation of fan	- air flow detected by flow switch
Operation of scrubber air intake and recycle dampers	- opening position by limit switch
Solution tank (For wet type)	- level detected by level electrode and temperature by heat sensor

Use of alternative feedback and interlock design shall be submitted for the approval/acceptance of the Engineer/Project Manager.

Key operated selector switch(es) shall be provided in the local control panel for testing and manual override of sequence interlocks for system control/circulation pump control/fan control.

Standby unit shall be designed for automatic cut in when the duty unit fails to operate. Alarm/control function shall incorporate suitable time delay to prevent inadvertent initiation due to transients/surges under normal operation.

Once activated, the Scrubber shall continue to operate even when the chlorine leak alarm is reset. The Scrubber can only be stopped manually by operating the “scrubber reset” button. Control of all the equipment of the Scrubber shall be provided at the local control panel.

All motorised dampers shall close on failure of either the scrubber fans, the recirculation pumps or the mains power supply.

5. WET TYPE SCRUBBER DESIGN

5.1 General Design

The scrubber design can be either vertical or horizontal.

The vertical scrubber if provided shall be of a packed tower mounted on top of the sodium hydroxide solution tank and complete with access doors, spray headers, piping connections and nozzles, internal structure supports, packing and packing support plate.

Air/chlorine mixture shall enter the packed tower of vertical scrubber at the bottom via the scrubber intake duct and flow past the sodium hydroxide solution through the packing. The packing shall be designed and arranged to achieve high mass transfer efficiency and low pressure drop. The size of the packed tower and the corresponding depth of packing shall be designed with optimum absorption efficiency.

The horizontal scrubber if provided shall be of the multi-stage horizontal crossflow type. The Contractor shall provide detailed information on the performance for each stage of scrubbing and demonstrate that the Scrubber meets the design requirements of the specification as for the vertical scrubber.

A mist eliminator of efficiency higher than 90% shall be provided to remove liquid entrainment from the treated air in the Scrubber before it is discharged to the atmosphere or returned to the chlorine extraction points inside the chlorine storage area. Inspection window shall be provided for observing the spray condition and the mist eliminator. Access door shall be provided for maintenance of pipes and nozzles. The mist eliminator shall be readily detachable for routine maintenance.

The support structure for the packed tower of the vertical scrubber shall be designed such that the weight loading of the packed tower will not be imposed on the top cover of the solution tank.

The Scrubber shall be manufactured from fiberglass reinforced plastic (FRP) or equivalent corrosion resistant material, and shall comply with BS 476 : Part 6 or equivalent with fire propagation index meeting the latest FSD requirements.

5.2 Sodium Hydroxide Solution Tank

The solution tank shall be equipped with the following:-

(i) A suitable and accessible sampling point on the pipeline before the recirculation pumps.

(ii) An electric mixer to prevent the sodium hydroxide solution to form powder or flakes and maintain the solution in a well mixed condition.

(iii) A direct reading, transparent level gauge complete with protective cover, isolating stop cocks and drain. The scale shall be graduated in cubic metres. Overflow/maximum/minimum levels shall be marked on the level gauge.

(iv) A level sensing system to initiate high and low level alarms and for plant interlock purposes. The mixer, fan, and recirculation pump shall stop on detection of low level in the tank.

(v) A temperature sensor for local and remote indication together with an alarm set at a temperature slightly higher than the maximum allowable temperature at 55℃ for the sodium hydroxide solution for the protection of FRP tank.

(vi) A top access man-hole of minimum 600 mm in diameter for inspection purposes. The man-hole shall be equipped with a removable taper piece for preventing fall of person when the man-hole is used for filling of chemicals.

(vii) A proper access platform for loading of chemicals into the tank.

(viii) Labelling of all valves associated with the tank.

(ix) All necessary pipework and connections for chemical make up, water make up, overflow, and drains shall be provided. The design of pipework and connections should allow sufficient work space for preparation of sodium hydroxide solution and sampling activities. All pipework laid between the solution tank and the recirculation pumps should be mechanically protected against damages by stepping.

(x) The detailed plan for the collection and disposal of the exhausted sodium hydroxide solution shall be formulated by the Contractor for approval/acceptance by the Engineer/Project Manager.

The tank shall be fabricated from FRP or equivalent material, which shall comply with BS 476 : Part 6 or equivalent with fire propagation index meeting the latest FSD requirements, to give maximum resistance to aqueous solution of sodium hydroxide and sodium hypochlorite after reaction with chlorine. The tank construction shall be robust and suitable for installation on a concrete plinth. The solution tank shall be suitable for installation inside a compartment with a bund wall for retaining sodium hydroxide solution in case of tank leakage.

For situations where the solution tank of the Scrubber is not suitable for the preparation of sodium hydroxide solution, a separate solution preparation tank shall be provided by the Contractor at no extra costs. The requirement for the solution tank as per sub-items (i) - (x) above shall also be applicable to the solution preparation tank. The position mounting and the dimensions of the solution preparation tank shall be submitted to the Engineer/Project Manager for approval/acceptance.

5.3 Mixer

Mixer impellers may be of single or dual arrangement. The mixer design shall be such that no bottom support bearing is to be mounted onto the tank structure. The motor and gearbox shall be fixed to a combined baseplate.

The mixer shaft shall be of adequate stiffness to minimize flexing and so driven that no flexural load from the shaft is transmitted to the gearbox or motor.

All wetted parts, bedplates, and holding down bolts shall be of 316 stainless steel or superior materials suitable for sodium hydroxide solution application. Any components exposed to splashing shall be suitably protected for approval/acceptance by the Engineer/Project Manager.

5.4 Sodium Hydroxide Recirculation Pump

Two sodium hydroxide recirculation pumps with operation mode of one duty and one standby shall be provided. The pumps shall be either horizontal floor mounted type or vertical long coupled submersible type for transferring the sodium hydroxide solution from the solution tank to the distributor of the Scrubber.

The horizontal floor mounted pumps shall be centrifugal type and equipped with separate gland sealing water circuit for flushing the double mechanical seal. The gland sealing water supply line to each pump shall be fitted with an electrically operated isolation valve which will open prior to starting of the pump and close automatically after the pump shutdown.

Each horizontal floor mounted pump shall be provided with a manual isolation valve at the suction end and a check valve in line with a manual isolation valve at the discharge end.

The bedplate of the horizontal floor mounted pumpsets shall be coated with polyethylene (PE), rubber, epoxy, or similar corrosion resistant material.

Alternatively, submersible pumps, if used, shall be of the seal-less single stage centrifugal vertical sump type. Each pump shall be equipped with a check valve and an isolation valve, both required to be mounted outside of the solution tank to facilitate operation. No seal water shall be required. Pump design shall feature open impeller in the submerged casing. The pumps shall be driven directly by a vertical flange mounted motor on a cast iron pedestal sitting on a complete mounting plate. A working platform for the removal of the submersible pumps from the tank shall be provided. Shaft bearing shall be made from chemically resistant silicon carbide or equivalent. The thrust bearing shall be independent from the motor, located above the mounting plate. The lower bearing shall be lubricated from process fluid (submerged). No external flush seal water shall be required.

The recirculation pump motor shall comply with WSD Standard Specification

E-51-04 with degree of protection IP55 or better. The motor shall be installed at a level above the bunk wall so as to avoid flooding of the motor. The Contractor shall design the system to suit this motor installation level.

Strainers shall be fitted to the suction side of the pump to remove solid precipitate in the aqueous sodium hydroxide.

No-flow switch shall be fitted to the discharge end of each pump and the entry to the distributor of the Scrubber. The flow switch shall have a degree of protection of IP64 to IEC 60529. On detection of loss of flow at pump delivery, the duty pump shall shut down and the standby pump shall automatically cut in. If the loss of delivery situation remains unchanged after the standby pump cut in as detected by the no-flow switches, the Scrubber shall shut down automatically. The no-flow switch shall be suitable for use in sodium hydroxide solution. The no-flow switch shall be fitted with two pairs of changeover contacts rated at 220V 5A 50Hz. Alternatively, pressure switch could be used subject to the approval/acceptance of the Engineer/Project Manager.

A pressure gauge shall be installed on the downstream side of the delivery isolation valve to provide local indication on pump discharge pressure.

The pump impeller, casing, and wetted parts shall be constructed from corrosion resistant material and suitable for use with dilute sodium hydroxide, sodium hypochlorite, and sodium chloride solution.

6. VENTILATION

6.1 General

The scrubber intake duct shall be fitted with an automatic damper which shall open on starting of the scrubber fan and shall close when the scrubber fan stops. In case a scrubber serves more than one extraction zone with multiple automatic intake dampers, the scrubber intake control logic shall take into account the multi-zone extraction requirement which may be particular for each individual design.

All dampers shall be conforming to the WSD Standard Specification EM-02-10. Fire dampers shall be supplied and fixed at positions where ducts pass through walls, ceilings or floors in accordance with the latest requirements of FSD.

To prevent any inadvertent discharge of chlorine into open air during scrubbing, a recycle duct shall be provided to return the treated air/chlorine mixture after neutralization to the chlorine extraction points inside the chlorine storage area. Treated air shall only be discharged to the atmosphere above roof level when the chlorine concentration after neutralizing is assured to be below 3 ppm. Selection between recycling and discharging to atmosphere shall be effected by means of a pair of electrically operated changeover dampers controlled manually from the local control panel. In the normal state the dampers will be set at the recycle position. Both the recycle and the discharge dampers must be operated in pair such that one cannot

open unless the other is close.

For situation where the evaporator room/ chlorination room is segregated from the chlorine storage area, an opening complete with fire damper shall be provided in the partition wall between the two areas at high level for balancing the pressure in case of a chlorine leak.

A suitable weather cowl shall be provided and installed on the exhaust stack of the Scrubber. Guy wires anchored to the roof slab shall be provided if necessary, to ensure that the stack will withstand typical wind speed of up to 220 km/hr. The height of the exhaust stack shall be not less than 2 m above the roof level.

Access doors shall be provided for the maintenance and inspection of equipment (e.g. chlorine detector, motorised dampers, fire and smoke dampers) installed in the ductwork. Access platforms shall be provided for such equipment items when they are located at high level.

6.2 Scrubber Fan

Two centrifugal fans with the operation mode of one duty and one standby shall be provided to extract air/chlorine mixture from the chlorine areas and convey to the Scrubber for neutralization.

The scrubber fans shall be installed at the gas outlet of the packed scrubber in order to maintain a negative pressure inside the packed scrubber and the associated intake duct. Non-return damper shall be provided at the discharge end of each fan.

For the designed flowrate, each fan shall provide sufficient margin for the static pressure to the air/chlorine stream to overcome the head loss due to friction in the extraction ducts, intake dampers and the scrubber system. The Contractor shall submit the calculation to substantiate the static pressure required for the scrubber fan for the approval/acceptance of the Engineer/Project Manager.

The fan housing and impeller shall be constructed from corrosion resistant materials and suitable for handling air/chlorine mixture with up to 200,000 ppm moist chlorine. Metal exposed to the air/chlorine stream shall be epoxy coated.

Drains complete with manual cock shall be provided at the lowest point of the fan housing for collecting condensate which will be further drained out from the housing to the auto drain traps at the ground level.

No-flow switch shall be fitted to the discharge end of each fan. On detection of loss of flow, the duty fan shall shut down and the standby fan shall automatically cut in. If the loss of flow condition remains unchanged after the standby fan cut in, the Scrubber shall shut down automatically.

6.3 Scrubber Ductwork

The ductwork for the scrubber intake, discharge and recycle shall be manufactured from fiberglass reinforced plastic (FRP) or equivalent material, which shall comply with BS 476: Part 6 or equivalent with fire propagation index meeting latest FSD requirements. The associated fittings and gaskets shall be fabricated from corrosion resistant material as appropriate.

Access points shall be provided along the scrubber ductwork for air flow measurement. Access doors shall be provided wherever maintenance/inspection of plant/equipment in the ductwork is required (e.g. thermostats, fire dampers, and fire and smoke dampers). Hangers and accessories for the ductwork shall be provided.

Access platforms shall be provided for routine inspection of the plant/equipment with access doors/ access points installed at high level.

6.4 Motorised Damper

The motorised dampers shall be constructed from corrosion resistant materials and suitable for handling air/chlorine mixture with up to 200,000 ppm moist chlorine. Metal exposed to the air/chlorine stream shall be epoxy coated. The motorised damper shall be of the butterfly type. The damper shaft shall be fully encapsulated within the damper blade and supported with top and bottom bearings. The motorised dampers shall be designed to be closed on failure of the scrubber fans or mains power supply. Position indicator shall be provided and fitted on the motorised damper.

6.5 Discharge Stack Chlorine Monitor

The discharge stack shall be equipped with a continuous chlorine monitoring instrument which shall give indication on the control panels at the local and remote control rooms.

The chlorine monitoring unit shall be of triple validated type and mounted separately from the discharge stack. The chlorine gas detectors shall be installed before the discharge/recycle changeover dampers and suitable for exposure to high chlorine concentration that may exist in the discharge stack. The detectors shall have adjustable high level alarm between 0-20 ppm.

7. LOCAL CONTROL PANEL

A local control panel shall be provided for the Scrubber. The local control panel shall conform to WSD Standard Specification E-11-03 with enclosure of IP54 to IEC 60529.

The following monitoring and control equipment shall be provided on the local control panel for the Scrubber:-

Analogue Indicators (Digital with an accuracy class index 1.0 to IEC 60051)

Discharge stack chlorine concentration (0-20 ppm) – three indicators
Sodium hydroxide solution temperature (0-60℃) and pH (1-14)
Solution tank level

Indicating Lamps

"On/Off" status of mixer, pumps and fans (one for each equipment)
"Open/Close" status of dampers (one for each equipment)

Alarms

Mixer/pump/fan tripped (one for each equipment)
Damper fault (one for each equipment)
Scrubber system failed - both pumps or fans failed or solution tank level low
Sodium hydroxide solution temperature high
Sodium hydroxide solution tank level high/low (one for each)
No-flow of solution to Scrubber
No air flow at the discharge stack outlet
Power supply failed
Scrubber system not on auto
Scrubber system running
Scrubber discharge chlorine concentration high
Chlorine leak in scrubber room

Controls

Pump/fan/mixer "Start/Stop" (individual control for each equipment)
Damper "Close/Open" (individual control for each equipment)
Pump and fan duty selectors (individual control for pumps and fans)
Scrubber control mode "Auto/Manual/Dry Test" key operated selector switch
Scrubber test push button
Scrubber reset push button

The "Start/Stop" and "Close/Open" controls may integrate with indicating lamps using illuminated push buttons.

When the Scrubber is set at the automatic mode, pressing the test push button shall start up the normal automatic sequence of the Scrubber. When the Scrubber is set at the dry test mode, pressing the test push button shall start up the automatic sequence without running the pumps to test the air circuit only.

Provisions, including volt-free contacts, shall be provided for the alarms, indications, and controls to be relayed to the Control Room.

- End of Specification -