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**WATER SUPPLIES DEPARTMENT**

**STANDARD SPECIFICATION M-06-03**

**CHLORINE ABSORBER SYSTEM**

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## CHLORINE ABSORBER SYSTEM

### 1. GENERAL

This specification specifies the general requirements of a chlorine absorber system (hereafter called the "absorber") for neutralizing any leaked chlorine in the chlorination room, evaporator room and/or chlorine storage areas. The system shall be either a counter-flow or a cross-flow packed absorber utilizing sodium hydroxide solution as the neutralizing agent.

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

The absorber intake duct shall be fitted with an automatic damper which shall open on starting of the absorber fan and shall close when the absorber fan stops.

Stainless steel fire dampers / fire and smoke dampers shall be supplied and fixed at positions where ducts pass through walls, ceilings or floors in accordance with requirements of Fire Services Department (FSD). All fire dampers / fire and smoke dampers shall be of the approved type by the Director of Fire Services.

To prevent any inadvertent discharge of chlorine into air during scrubbing, a recycle duct shall be provided to return the treated air/chlorine mixture after neutralization to the chlorine area. Treated air shall only be discharged to 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 cubicle. 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 is segregated from the chlorine storage area, an opening complete with fire damper shall be provided on 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 absorber. Guy wires anchored to the roof slab shall be provided if necessary, to ensure that the stack will withstand typical wind speeds of up to 220 km/hr. The height of the exhaust stack shall be not less than 2 m above the roof level.

The neutralizing agent used for scrubbing shall be homogeneous mixture of sodium hydroxide and water of not more than 15% weight by volume concentration, held in a solution tank. During operation, the sodium hydroxide solution will be recirculated by a pump to react with the chlorine/air mixture in the absorber.

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

The absorber system shall meet with the approval of FSD and Environmental Protection Department.

## 2. SYSTEM PERFORMANCE

The system shall be capable of neutralizing chlorine contained in air up to 200,000 ppm. The scrubbing efficiency of the absorber shall be not less than 99.99% 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 absorber operation.

At an ambient temperature of 35°C, the working temperature of the sodium hydroxide in the solution tank during and after scrubbing shall not be higher than 50°C under all circumstances. The Contractor shall submit calculation to substantiate the volume of solution required for quenching throughout the entire reaction for the approval by the Engineer. The minimum and maximum solution concentration and tank level should be advised by the Contractor in the submitted calculation.

## 3. CHLORINE ABSORBER SYSTEM CONTROL

Under automatic control, the absorber and the ventilation systems shall interact in the following manner.

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

On detection of 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 stop. All high level air inlet motorized louvres shall close automatically and the absorber shall be activated. The sodium hydroxide recirculation pump shall start. The absorber fan shall start soon after the solution flow is established. The motorized absorber intake and recycle dampers shall then open to admit air/chlorine mixture into the absorber. The absorber exhaust damper to atmosphere shall close at all time until the air/chlorine mixture after scrubbing is safe for discharge into atmosphere, i.e. below 3 ppm. The absorber 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 signal 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 & pump running interlock
Operation of absorber air intake and recycle dampers	- opening position by limit switch
Solution tank	- level detected by level electrode and temperature by heat sensor

Key operated selector switches shall be provided in the local control cubicle for manual override of sequence interlocks for system control/circulation pump control/fan control.

Standby plant 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 absorber shall continue to operate even when the chlorine leak alarm is reset. The absorber can only be stopped manually by operating the "absorber reset" button. Control of all the equipment of the absorber shall be provided at the local control cubicle.

All motorized dampers shall close on failure of the absorber fans and on failure of mains power supply.

#### 4. **ABSORBER DESIGN**

The absorber design can be either vertical or horizontal.

The vertical absorber 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 will enter the packed tower at the bottom via the absorber intake duct and flow past the sodium hydroxide solution through the packings. 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 absorber 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 absorber meets the design requirements of the specification as for the vertical absorber.

A mist eliminator of efficiency higher than 90% shall be provided to remove liquid entrainment from the treated air in the absorber before it is discharged to the atmosphere or returned to the chlorine area. Inspection window shall be provided for observing the spray condition and the mist eliminator.

The support structure for the packed tower of the vertical absorber shall be designed as an integral part of the solution tank with its weight supported by the baseplate of the tank. No load shall be imposed on the top cover of the tank.

The absorber 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 latest FSD requirements.

## **5. SODIUM HYDROXIDE SOLUTION TANK**

The solution tank shall be equipped with the following:-

- (i) A suitable sampling point on the pipeline before the recirculation pumps.
- (ii) A mixer to facilitate the preparation of sodium hydroxide solution from 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 electrode system to initiate high and low level alarms and for plant interlock purpose. 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 temperature slightly higher than the maximum allowable temperature at 50°C for the sodium hydroxide solution for the protection of FRP tank.
- (vi) An 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 provision of chemical make up, water make up, overflow and drains shall be provided.

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 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 bunk wall for retaining of sodium hydroxide solution in case of tank leakage.

For situation where the solution tank of the absorber is not suitable for 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) - (ix) above shall also be provided by the Contractor except the removable taper piece for the man-hole as specified in sub-item (vi). The position mounting and the dimension of the solution preparation tank shall be submitted to the Engineer for approval.

## 6. 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 absorber.

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 shut down.

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, the submersible pumps shall be 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. Working platform for 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 both the suction and delivery 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 absorber. The flow switch shall have a degree of protection of IP64 to BSEN 60529. On detection of loss of flow at pump delivery, the duty pump will shut down and the standby pump will automatically cut in. If the loss of delivery situation remain unchanged after the standby pump cut in as detected by the no-flow switches, the absorber will 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.

A pressure gauge conforming to WSD Standard Specification E-86-12 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.

## 7. DISCHARGE STACK CHLORINE MONITOR

The discharge stack shall be equipped with a continuous chlorine monitoring instrument with a range of 0-30 ppm which shall give indication on the control panel at the local and remote control rooms.

The continuous chlorine monitor shall be installed at a point before the discharge/recycle changeover dampers. This instrument shall have an adjustable high level alarm between 0-30 ppm which shall give indication on the control panel at the local and remote control rooms.

The sensor shall be suitable for exposure to high chlorine concentration that may exist in the system. The monitor unit shall preferably be mounted separately from the discharge stack.



**8. ABSORBER FAN**

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

The absorber fans shall be installed at the gas outlet of the packed absorber in order to maintain a negative pressure inside the packed absorber and the associated intake duct.

At 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 absorber system. The Contractor shall submit calculation to substantiate the static pressure required for the absorber fan for the approval by the Engineer.

The fan housing and impellers 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 to the lowest point of the fan housing through which condensate will be removed from the housing and direct 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 will shut down and the standby fan will automatically cut in. If the loss of flow remains unchanged after the standby fan cut in, the absorber system will shut down automatically.

**9. MIXER**

Mixer impellers may be of single or dual arrangement. No bottom support bearing is to be incorporated in the tank and stabilizers. 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. Other components exposed to splashing shall be suitably protected to the Engineer's approval.

**10. ABSORBER DUCTWORK**

The ductwork for the absorber 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.

**11. LOCAL CONTROL CUBICLE**

A local control cubicle shall be provided for the absorber, which shall preferably be integrated with the ventilation control cubicle for the chlorine plant rooms and storage areas. The local control cubicle shall conform to WSD Standard Specification E-11-03 with enclosure of IP54 to BSEN 60529.

The following monitoring and control equipment shall be provided on the local control cubicle for the absorber:-

Indicators (Edgewise or digital with an accuracy class index 1.0 to BS 89)

discharge stack chlorine concentration (0-30 ppm)  
Sodium hydroxide solution temperature (0-60°C)

Indicating Lamps

on/off status of mixer, pumps and fans  
open/close status of dampers

Alarms

trip status of mixer, pumps and fans  
damper fault  
absorber system failed - both pumps or fans failed or solution tank level low  
sodium hydroxide solution temperature high  
sodium hydroxide solution tank level high/low  
no-flow solution to absorber  
power supply failed  
absorber system not on auto  
absorber system running  
absorber discharge chlorine concentration high

Controls

pump/fan/mixer start/stop  
damper close/open  
pump and fan duty selectors  
absorber control mode auto/manual (key switch)  
absorber reset (push button)

The push button controls may integrate with indicating lamps using illuminated push buttons.

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

- End of Specification -