

19	CHLORINATION	1
19.1	GENERAL.....	1
19.1.1	Scope	1
19.1.2	References.....	1
19.1.3	Submittals	1
19.2	CHLORINATION SYSTEMS	2
19.2.1	General.....	2
19.2.2	Chlorinators.....	2
19.2.3	Ejectors.....	3
19.2.4	Motive Water Pumps	3
19.2.5	Chlorine Gas Cylinders	3
19.2.6	Chlorine Gas Header	3
19.2.7	Automatic Cylinder Change-Over Module.....	4
19.2.8	Automatic Isolation Valve.....	4
19.2.9	Chlorine Gas Header	5
19.2.10	Gas Feeder	6
19.2.11	Residual Chlorine Recorders	7
19.2.12	Chlorine Consumption and Recording Apparatus	7
19.2.13	Analyser Cells	7
19.2.14	Gas Leak Detection Equipment.....	8
19.2.15	Drum and Cylinders Handling	9
19.2.16	Pipework	9
19.2.17	Ventilation	9
19.2.18	Emergency Breathing Apparatus and Air Compressor	10
19.2.19	Warning and Safety Notices.....	10
19.3	ON SITE GENERATION OF CHLORINE	11
19.3.1	General.....	11
19.3.2	Salt Saturators.....	11
19.3.3	Brine Feed	11
19.3.4	Electrolyser	12
19.3.5	Sodium Hypochlorite Storage.....	12
19.3.6	Sodium Hypochlorite Dosing	12
19.3.7	Pipework	12
19.3.8	Electrical Installation	13
19.3.9	Transformer / Rectifier	13
19.3.10	Control Panel	13
19.4	ANALYSERS.....	14
19.5	NEUTRALISATION SYSTEMS	14
19.5.1	General.....	14
19.5.2	Neutralisation Tower	14
19.5.3	Circulating Pumping Units.....	14
19.5.4	Pipework and Electrical Connections.....	15
19.6	INSTALLATION AND COMMISSIONING	15

19 CHLORINATION

19.1 GENERAL

19.1.1 Scope

- 1 This part specifies the requirement for the design, manufacture, testing and commissioning of gaseous chlorination disinfection plants.
- 2 Related Sections and Parts are as follows:

- | | |
|------------|---|
| Section 1 | General |
| Section 8 | Drainage Works |
| Section 10 | Instrumentation, Control and Automation |
| Section 13 | Building Electrical Works |
| Section 21 | Electrical Works |

19.1.2 References

- BS 970 (ISO 683) Specification for wrought steels for mechanical and allied engineering purposes; (ISO 683-1 Heat-treatable steels, alloy steels and free-cutting steels — Part 1: Non-alloy steels for quenching and tempering; ISO 683-2 Heat-treatable steels, alloy steels and free-cutting steels — Part 2: Alloy steels for quenching and tempering; ISO 683-3 Heat-treatable steels, alloy steels and free-cutting steels — Part 3: Case-hardening steels; ISO 683-4 Heat-treatable steels, alloy steels and free-cutting steels — Part 4: Free-cutting steels; ISO 683-5 Heat treatable steels, alloy steels and free-cutting steels — Part 5: Nitriding steels; EN 10250-4: Open die steel forgings for general engineering purposes - Stainless steels; EN 10095 Heat resisting steels and nickel alloys; BS PD 970 Wrought steels for mechanical and allied engineering purposes. Requirements for carbon, carbon manganese and alloy hot worked or cold finished steels; EN 10089 Hot rolled steels for quenched and tempered springs. Technical delivery conditions; EN 10277 Bright steel products. Technical delivery conditions; EN 10278 Dimensions and tolerances of bright steel products; EN 10088-1 Stainless steels - List of stainless steels; EN 10088-3 Stainless steels - Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes;)
- BS 5345,.....Code of practice for selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosive processing and manufacture); (IEC 60079- Explosive atmospheres)
- BS 6739..... Code of practice for instrumentation in process control systems: installation design and practice

PWA – Chlorine Safety Guidelines – Liquefied Chlorine Gas

List of ‘Approved Suppliers’ prepared by the Public Works Authority

19.1.3 Submittals

- 1 In addition to the requirements of Part 1 of this Section, the Contractor shall reconfirm the information provided in the Technical Submission Schedules submitted with his Tender.

19.2 CHLORINATION SYSTEMS

19.2.1 General

- 1 Gaseous dosing systems shall comprise pressurised and liquefied gas drums or cylinders complete with automatic changeover equipment, gas feeders and solution injection. All gas dosing systems shall be based upon the full vacuum and remote injection principle.
- 2 Unless otherwise stated the system shall comprise the following equipment:
 - (a) Chlorinator
 - (b) Ejector complete with diffuser
 - (c) Motive water pump
 - (d) Chlorine gas cylinders
 - (e) Chlorine gas header
 - (f) Automatic cylinder change-over module
 - (g) Remote vacuum controller for cylinders
 - (h) Pipework
 - (i) Gas feeder
 - (j) Dosing control
 - (k) Residual chlorine recorders
 - (l) Chlorine consumption recording apparatus
 - (m) Analyser cells
 - (n) Gas leak detection equipment
 - (o) Neutralisation equipment
 - (p) Lifting and moving facilities for cylinders
 - (q) Safety equipment
 - (r) Drench shower linked to SCADA system

19.2.2 Chlorinators

- 1 The Contractor shall supply and install the chlorinators, one as stand-by. The chlorinators shall be of the floor mounted vacuum type, and provided with evaporator of suitable capacity. The chlorinators shall feed ejectors with the adjusted dose of chlorine. A diffuser shall be connected to each ejector.
- 2 All interconnecting pipes between the chlorinators and ejectors shall be under vacuum, and pressure must be prevented from building up in the system by means of pressure relief valves.
- 3 Chlorinators shall be designed to shut-down automatically the chlorine supply to ejectors vacuum line at the following cases:
 - (a) The water supply to the ejectors fails.
 - (b) The ejectors vacuum line breaks.
 - (c) The water supply pipeline accidentally shuts down due to the closing of a valve or valves.
 - (d) The electric supply fails.
- 4 The chlorinators shall be of the compound loop system and suitable for automatic control by signals received separately from the flowmeter and the chlorine residual controller.

- 5 The accurate dosing scale of the apparatus should have a ratio of about 20:1 between the maximum and minimum dosing rates. The rate will be automatically adjusted by means of the chlorine residual controller according to the free chlorine residual needed. Provision shall be made for manual adjustment.
- 6 Best chlorine resisting materials shall be used through the whole parts of the system. The unit shall be of modular design, free standing with all control components protected within a rigid fibre-glass cabinet or similar.
- 7 The components within the cabinet shall be readily accessible from the front for ease of maintenance and shall be easily removable for examination or changing if required.

19.2.3 Ejectors

- 1 The ejectors shall be of the aspirator type to give maximum efficiency in mixing the chlorine with the water. The ejector water supply must be designed to suit the maximum rated output of the chlorinators offered.
- 2 Each ejector shall be connected to a diffuser for regular distribution of the chlorine solution at the injection point.
- 3 The ejectors shall be separated from the chlorinators to give flexibility of placing the chlorinators in their rooms and to inject the chlorine solution by the ejectors at the injection point.

19.2.4 Motive Water Pumps

- 1 The Contractor shall supply and erect electrically driven boosting pumps. The pumps shall be connected in parallel to supply water to the ejectors.
- 2 Motive water pumps shall be multi-stage, stainless steel, ring construction and provided on a duty/standby basis. Pumps shall be provided complete with isolation valves, reflux valves and delivery pressure gauges. Suction and delivery pressure gauges shall be provided on each pump and downstream of flow control valves where flow splitting is provided.
- 3 A filter shall be fitted to each suction pipeline.
- 4 The discharge and manometric head of each pumping sets shall be chosen to suit the working conditions of the ejectors at their maximum rated output.
- 5 The pumps shall be of the centrifugal type with high efficiency. Each pump shall be directly coupled to a totally enclosed air cooled electric motor, the motor shall be complete with its starter, rated for continuous running (24 hours) with class (F) insulation.
- 6 The pumps impellers, shafts, diffusers (if any), shall be made of stainless steel.
- 7 Ammoniator motive water systems shall be provided complete with base exchange water softeners, complete with local salt saturator for regeneration or from bulk salt saturators if employed at the site. The water softener shall be dual auto-rotation element units complete with auto-timers and regeneration controller.

19.2.5 Chlorine Gas Cylinders

- 1 Where specified in the Contract the Contractor shall supply chlorine gas cylinders of the pattern and size specified.

19.2.6 Chlorine Gas Header

- 1 The Contractor shall provide a suitable manifold and header system to convey gas from the cylinders via the changeover panel to the associated gas feeder.

- 2 The pipework shall include flexible connectors, isolating valves, interceptor traps, gas filters and all necessary mild steel pipework.
- 3 Each header shall be complete with electric heater. The heater shall be of suitable power to prevent the freezing of chlorine gas when its flow rate through the header is maximum.
- 4 On drum chlorine systems, a combined liquid trap and gas filter shall be provided complete with a self-regulating heater.
- 5 Pipework and valves shall be designed and constructed to withstand the pressure and corrosive nature of the gas. Welding, if used, shall be to the relevant British Standard or equivalent for pipework conveying corrosive liquids under pressure. Suitable isolating valves and couplings shall be provided to each major item of plant to facilitate removal for maintenance. Pressure testing of the pipework and valves shall be carried out by the contractor to the approval of the Engineer, and shall comply with the relevant British Standard or equivalent.
- 6 Each header shall be suitable for connecting two chlorine drums of capacity one ton each.

19.2.7 Automatic Cylinder Change-Over Module

- 1 Where specified in the Contract the Contractor shall supply and erect an automatic changeover panel which will change from duty gas supply to standby in the event of low pressure on the duty supply. The changeover panel shall include duty/standby indication, bottle change required, and the pressure of gas in the duty cylinder.
- 2 The changeover panel shall be mechanically operated and be complete with pressure reducing valves to prevent re-liquification of the gas and changeover valve block heater. The line between the changeover panel and the gas feeder incorporate individual failsafe vacuum gas regulator valves.
- 3 The automatic change-over module shall not permit a return to the initial source until the secondary source is exhausted.
- 4 The Contractor shall also supply a remote vacuum controller for each cylinder on duty to shutdown the cylinder on indication of loss of vacuum.

19.2.8 Automatic Isolation Valve

- 1 The discharge from drums shall be protected by an automatic isolation valve system. The system shall either be a proprietary system, or it shall comply with the following Clauses.
- 2 The automatic control of the isolation valve system shall be from the gas leak detection equipment.
- 3 For gas leak testing purposes, a remotely mounted manual opening facility shall be provided for each isolation valve. These shall be spring return push buttons with engraved labels "Press and Hold to Open Drum No 1 (No 2) Valve" and shall be incorporated into a shutdown control panel (mounted in a safe area) with the following features.
 - (a) Lamp (Green)-Drum No 1 Valve Open
 - (b) Lamp (Green)-Drum No 2 Valve Open
 - (c) Hand/Off/Auto Selector-Drum No 1 Valve
 - (d) Hand/Off/Auto Selector-Drum No 2 Valve
 - (e) Push Button-Press and Hold to Open Drum No 1 Valve
 - (f) Push Button-Press and Hold to Open Drum No 2 Valve
 - (g) Push Button-Reset System

- 4 The isolation valve shall be a two way PTFE taper plug valve suitable for use with dry chlorine. The body shall be of LCB carbon steel and plug of monel metal.
- 5 The automatic isolation valve shall be a spring return, giving fail safe operation in the event of loss of air supply.
- 6 The Contractor shall be responsible for the air supply to the valve. The supply line shall incorporate a moisture trap and drain located as near as possible to the electrically operated solenoid valves to be used for isolation valve control.
- 7 The solenoid valves shall operate from a **110 volt** 50 Hz electricity supply and shall be mounted outside the control box. Valve terminal enclosures shall be fully shrouded and fitted with a propriety cable compression gland. Final connection to these valves shall be via short lengths of flexible multicore cable from an adjacent termination box.
- 8 The air supply to the automatic isolation valves shall be suitably rated nylon tubing supported in 25mm PVC conduit.
- 9 A sufficient length of tubing shall be provided adjacent to the automatic isolation valve in order to facilitate maintenance and valve height adjustment.
- 10 The connections to the automatic isolation valves shall be 2 No special elbows with a 3/4" BSP female rotary union for connection to the existing drum valve and a 3/4" BSP male taper for connection to the isolation valve are required for this purpose.
- 11 A 3/4" male/male nipple shall be provided on the upstream side of the isolation valve for connection to the gas header pipework system.
- 12 The pneumatically operated isolation valves shall be supported in a manner which facilitates adjustment in three planes to relieve the pipework connections adjacent to the valve of the weight of the valve and actuator.
- 13 The Contractor shall supply and install a robust tubular guard rail to protect the vulnerable valve and pipework arrangement on the discharge side of the drum from swinging drums.
- 14 The framework shall be fabricated in mild steel tubular sections and painted in accordance with Section 8 Part 8 the Specification.
- 15 The frame floor anchor plates and holding down bolts shall be designed to withstand an impact from a swinging chlorine drum.
- 16 The guard railing may be utilised for the support of the automatic isolation valves.

19.2.9 Chlorine Gas Header

- 1 The Contractor shall provide a suitable manifold and header system to convey gas from the cylinders via the changeover panel to the associated gas feeder.
- 2 The pipework shall include flexible connectors, isolating valves, interceptor traps, gas filters and all necessary mild steel pipework.
- 3 Each header shall be complete with electric heater. The heater shall be of suitable power to prevent the freezing of chlorine gas when its flow rate through the header is maximum.
- 4 On drum chlorine systems, a combined liquid trap and gas filter shall be provided complete with a self-regulating heater.

- 5 Pipework and valves shall be designed and constructed to withstand the pressure and corrosive nature of the gas. Welding, if used, shall be to the relevant British Standard or equivalent for pipework conveying corrosive liquids under pressure. Suitable isolating valves and couplings shall be provided to each major item of plant to facilitate removal for maintenance. Pressure testing of the pipework and valves shall be carried out by the contractor to the approval of the Engineer, and shall comply with the relevant British Standard or equivalent.
- 6 Each header shall be suitable for connecting two chlorine drums of capacity one ton each.

19.2.10 Gas Feeder

- 1 Chlorine shall be dosed via duty/standby gas feeders, of the all vacuum/remote ejector principle.
- 2 The gas feeder shall dose gas automatically in proportion to flow, chlorine levels, super or residual whichever may be applicable.
- 3 Gas feeders shall be located such that access for maintenance is unobstructed. Rear access is acceptable providing a minimum of 1 metre free space is available for egress in emergencies.
- 4 The gas feeder shall incorporate the following features:
 - (a) Positive Gas Shut Off - in the event of loss of vacuum, gas shall be prevented from entering the system.
 - (b) High Level Vent - in the event of gas vent, gas shall be directed to a high level external non-hazardous area.
 - (c) Vacuum Gauge - indicating system vacuum state.
 - (d) Flowmeter - indicating as flow thorough feeder.
- 5 Microprocessor based process controllers shall provide automatic control, changeover monitoring and transmission facilities for disinfection control. The unit shall not be susceptible to memory corruption during normal electrical supply transients and shall be protected by a stabilised power supply.
- 6 The unit shall provide a continuous display of the actual chlorine residual and also indicate set residual parameters on demand. A separate readout shall also be provided to give operational data including alarm settings etc.
- 7 Each unit shall be provided complete with its own residual signal transmitter.
- 8 An integral printer shall provide the following status data on its respective system, on demand or at pre set intervals.
 - (a) Date
 - (b) Time
 - (c) Residual chlorine levels
 - (d) Water Flow
 - (e) Gas Flow
 - (f) Alarm Conditions (high and low residual)
- 9 In addition a 4-20 mA analogue signal shall be provided to drive a pen of a three pen recorder (the two other pens being driven from the two other controllers associated with its respective pumping system). The pen recorder shall be a 7 day circular recorder and each pen shall be arranged to operate at different radii despite have similar residual chlorine levels. The recorder shall be wall mounted adjacent to the chlorination equipment.

- 10 The residual chlorine of the effluent shall be measured, indicated and controlled. It is required to supply and erect two chlorine residual sampling, measuring and controlling units, one as stand-by. Each unit shall be mounted with the chlorinator in one panel.
- 11 The residual chlorine measuring unit shall be of the amperometric type with suitable bi-metallic electrodes to measure free available residual chlorine.
- 12 The electrodes shall be continuously cleaned by a suitable mechanical means. The electrodes shall be stationary and not to be allowed to move during the continuous cleaning operation.
- 13 The measuring cell shall be designed to measure "free available" chlorine. The signal generated in the measuring cell shall be fed to the recorder for recording. The measuring cell assembly contain equipment for regulating the pressure, flow and pH of the sample water before being passed through it.
- 14 The instrument shall include control components to provide automatic control of residual chlorine by adjusting the feed rate of chlorinators.
- 15 The sampling and measuring components shall be complete with all necessary pipe work, sampling pumps, valves and fittings.

19.2.11 Residual Chlorine Recorders

- 1 The measured values of residual chlorine shall be automatically recorded by residual chlorine recorders. It is required to supply two recorders (one as stand-by).
- 2 The recorders shall be of the servo type which receive the residual chlorine signals from the residual measuring unit.
- 3 These signals shall be current proportional to the residual chlorine. The current shall then be indicated and recorded by the conventional self-balancing amperometric recorder head on a suitable diameter weekly inkless (pressure sensitive) chart.
- 4 The recorder shall have the same range for residual chlorine as the residual measuring apparatus, which is from "0" to 2.0 mg/l.
- 5 The reading of residual chlorine shall be transferred to the chlorine apparatus.

19.2.12 Chlorine Consumption and Recording Apparatus

- 1 Duty and standby continuous measurement and totalising chlorine consumption measuring and recording apparatus shall be provided.

19.2.13 Analyser Cells

- 1 Sampling point shall be selected by the Contractor and agreed with the Engineer. The Contractor shall include in his supply individual analyser cells. These units shall be supplied with buffer pump and container together with pressure switches and sample/by pass facilities.
- 2 The filter shall be mounted outside the unit in a convenient location and in a way which does not require dismantling of the access cover.
- 3 Sufficient buffer solution shall be provided for preliminary testing and tests before completion.
- 4 The system shall provide for triple validation of the analyser cells and supply lines.
- 5 Residual Chlorine analyzers shall be used to monitor the amount of free residual chlorine in final effluent/irrigation water. Each residual chlorine analyzer system shall comprise of a sensor, transmitter, buffer solution and other accessories. The analyzer should be provided with a flow regulating/isolation valve, sample flow indicator (VA type) 'Y' strainer and associated pipework, skid mounted and installed in a GRP enclosure. The analyzer shall have a maximum response time of ten seconds for step change of 90%.

- 6 Transmitter shall comprise 3½ digits LCD, have a measurement accuracy of ±2%. These shall be fields selectable from 0-0.5 to 0-20 mg/l. complete width. Automatic compensation for temperature. They shall have an isolated 4-20 mA d.c. output, and be suitable for surface mounting or digital signal if a data bus is specified. The enclosure shall be protected to IP66.
- 7 The sensor shall be of the Amperometric type sensor with flow through installation, and be complete width with an internal temperature sensor for automatic compensation. The sensor shall be complete with bottle of buffer solution and interconnecting cable.

19.2.14 Gas Leak Detection Equipment

- 1 Drum stores, bottle stores and chlorinator rooms shall be provided with a gas sensing alarm system.
- 2 Each store/room shall be provided with sensors mounted in positions to achieve maximum effectiveness with chlorine sensors mounted at a low level. Multiple sensors shall be provided in larger stores/rooms where single sensor may not effectively sense all leaks.
- 3 Alarm control panels shall be mounted in a safe area outside the rooms, and shall operate via an integral battery back up system. Where available, the system may be powered from a central uninterruptable Power Supply (UPS) system.
- 4 Alarm control panels shall incorporate:
 - (a) Meter displaying the concentration of the gas leak in mg/l.
 - (b) Warning lamps or LED's for each gas sensor to indicate:
 - (c) 1st stage leak at 3.0 mg/l
 - (d) 2nd stage leak at 10.0 mg/l
 - (e) Alarm/control contacts for:
 - (f) Controlling Drum Shutdown Systems (where applicable)
 - (g) Controlling Ventilation Fans
 - (h) Controlling Door Access Warning Lamps
 - (i) Signalling to Central Control Room or SCADA System
 - (j) Signalling to a Site Telemetry Outstation
 - (k) Instrument fault lamp or LED and warning contact.
 - (l) Audible/visual warning device.
 - (m) Power 'ON' or instrument 'HEALTHY' lamp or LED.
- 5 The automatic Chlorine drum change-over system shall be arranged to change from the duty drum to the standby drum when the 1st stage leak level of 3.0 mg/l is reached. Further drum change-over shall be inhibited until the system is manually reset.
- 6 Chlorine drums shall be automatically isolated when the 2nd stage leak level of 10 mg/l is reached and the evaporators shall continue operating until the gas pressure reduced to zero. Once isolated, drums shall remain isolated until the system is reset and the drum automatic isolation valves manually re-opened. Operation of the automatic isolation system shall initiate a works shut down.
- 7 Ventilation fans in the affected room shall automatically be switched ON when the 1st stage leak level of 3.0 mg/l is reached. Ventilation fans in the affected room shall automatically be switched OFF when the 2nd stage leak level of 10.0 mg/l is reached. If the leak level falls below the 1st stage leak level, the ventilation fans shall continue to run on for 10 minutes before stopping.

- 8 Each access door to stores or rooms shall be provided with warning lamps to permit or prohibit entry. A green lamp shall indicate that it is safe to enter, at leak levels below the 3.0 mg/l threshold: A red lamp shall indicate that a 1st or 2nd stage leak has been detected. Each lamp box colour shall be provided with a minimum of two lamps so that a single lamp failure does not render the indication in-operative.
- 9 Each building containing a store or room shall be provided with an external flashing/rotating beacon coloured RED and an audible warning device. The audible device shall produce an output of 106dB(A) at 1 metre and shall remain sounding until such time as the alarm is accepted/cancelled, and it shall self cancel after 5 minutes. The flashing/rotating beacon shall remain operational whilst 1st or 2nd stage leak persists.
- 10 The location of the external flashing/rotating beacon shall be such that it is readily visible to persons entering the site via the main access route.

19.2.15 Drum and Cylinders Handling

- 1 The Contractor shall provide a travelling crane complying with Part 7 of this Section 9 as stated in the Particular Specification.
- 2 Drums shall be moved using a roller system. Each roller shall comprise a set of four trunnions which shall be used as a method of positioning the outlet valves of the drums and also for spacing and supporting the drums. The trunnions shall be fixed to steel I-beams, which shall be fixed rigidly to the floor of store.
- 3 Cylinders shall be set in racks and provided with positive restraint clamps. These clamps shall be either profile clamps or chain restraints which prevent movement of the cylinders from the stored position.
- 4 The handling system shall be designed so that it is not possible to pass a hoisted drum over a drum in use.
- 5 The Contractor shall supply one weighing balance for weighing of the chlorine cylinders. The balance shall be of the spring type with three (3) tons measuring capacity.

19.2.16 Pipework

- 1 The Contractor shall provide and install all pipework and valves etc. necessary for the complete installation for the chlorination equipment system.
- 2 Pipework shall be provided with the necessary valves, bends, tees and unions for easy dismantling. Pipework materials should be provided in accordance with the chlorination equipment manufacturers recommendations and shall comply with international industry standards. Typically uPVC pipe will be used for water and chlorinated water and carbon steel for liquid chlorine.
- 3 All pipework shall be neatly laid and securely fixed in position. Similarly all valves shall be securely fixed, clearly numbered and labelled in accordance with the operating instructions.
- 4 Pipework shall be clean, dry and free from oil and grease and shall not be cleaned with organic solvents.

19.2.17 Ventilation

- 1 Drum stores, bottle stores, and chlorinator rooms shall all be provided with forced ventilation systems, design to produce at least 6 volume changes of air per hour, and arranged to provide a negative pressure within the rooms.
- 2 Automatic control of the extract fans shall be from the gas leak detection equipment.

- 3 Manual control of the fans shall be provided from a safe area outside the rooms. Manual control shall be available regardless of the action of the gas leak detection equipment. The manual control shall be arranged so that it is not possible for ventilation fans to be turned off when the automatic system is calling for the fans to be turned on.
- 4 Extract grills and fans shall be positioned at a low level with the fan exhaust arranged to discharge the vented gas away from pedestrian walkways and roadways. If necessary, ducting to a point above building eaves level shall be provided to achieve this, subject to approval by the Engineer.
- 5 Intake grills shall be positioned at a high level and arranged so that the entire contents of the room are fully replenished with fresh air when the extract fans are running.

19.2.18 Emergency Breathing Apparatus and Air Compressor

- 1 The Contractor shall supply Masks with air bottles (cylinders) to allow for working in contaminated air for 30 minutes. Their size shall be according to requirements of personnel dealing with chlorine gas. They shall be stored in cupboard.
- 2 The Contractor shall supply a motor driven portable air compressor. The compressor shall be mounted on a carriage with 2 pneumatic tyred wheels and handles for trailing. Also it shall be provided with an air reservoir of ample capacity. The set (air compressor and air reservoir) shall be complete with safety valves, pressure gauges, valves, piping and necessary safety devices.
- 3 The air intake shall be from the free atmospheric air.
- 4 The compressor shall be provided with suitable connection to allow for filling the air bottles (cylinders) of the masks. The compressed air must be free of any lubricating oil traces.
- 5 The capacity of compressor shall be enough to fill the air bottle of the mask-up to its working pressure in 5 minutes.

19.2.19 Warning and Safety Notices

- 1 The Contractor shall provide and fix engraved labels with white lettering 20mm high on a Red background. Externally mounted labels shall be provided with a stainless steel backplate for added support. The labels shall be:
 - (a) External to the gas store:

WARNING:
CHLORINE AND SULPHUR DIOXIDE STORE
DO NOT ENTER WHEN WARNING LIGHT
AND ALARM IS ON
 - (b) Internal to the Gas Store, in a prominent location:

WARNING
IF ALARM SOUNDS ALL
PERSONNEL MUST VACATE
THIS DRUM STORE
- 2 The Contractor shall display first aid advice in Arabic & English and protective clothing for personnel who deal with chlorine equipment. As a minimum notices shall say:

*Chlorine is a highly irritating gas immediately affecting the eyes, nose, throat and chest.
Anyone so affected must be removed to fresh air and medical treatment sought.*

- 3 Warning lamps with alarm to be provided at the entry to the evaporator room and chlorinator room for alerting the personnel in case of a gas leak. Lamps shall indicate
- Red > 9 ppm chlorine
Yellow > 3 - 9 ppm chlorine
Green < 3 ppm chlorine

19.3 ON SITE GENERATION OF CHLORINE

19.3.1 General

- 1 Sodium hypochlorite generation, batching, dosing and dechlorination shall be automatically controlled. The Transformer/Rectifier and control panel shall be located in a separate room from the electrolyser and hypochlorite storage tanks where mounted internally. The location of plant within the generation room shall take into account local zoning restrictions.
- 2 Generation rooms shall be provided with either one full wall free air ventilator or automatic forced extract air systems. High level ventilators shall be provided.

19.3.2 Salt Saturators

- 1 Salt saturators shall be provided for the storage of fully saturated salt solution (brine). The total storage capacity shall be not less than 1 month's consumption at maximum works output. The salt saturators shall be approved with regard to FDA Regulations for use of non-toxic materials.
- 2 The saturators shall be rated for the peak salt consumption requirement of overnight generation of sodium hypochlorite and incorporate an internal suction discharge limiter to prevent tracking of partially saturated salt solution. The units shall be supplied and installed complete with the filter bed gravel and first salt fill on foundations prepared by the Civil Contractor to the Contractors requirements. The saturators shall be suitable for outdoor use.
- 3 The saturators shall include
- (a) Inlet and Outlet connection manifolds.
 - (b) Tanker charging connection and manifold.
 - (c) Overflow to drain.
 - (d) Vent pipe complete with dust arrester
 - (e) Upper and lower level manway inspection points.
 - (f) Shrouded inlet float valve.
 - (g) Surrounding bund of not less than 110% of the Saturator Volume.
 - (h) Visual indication of salt level

19.3.3 Brine Feed

- 1 Brine feed through the electrolyser to the hypochlorite storage tank shall be provided on a duty/standby basis. Fixed speed, manually adjustable stroke pumps shall be suitable for this application.
- 2 The feed line shall be fitted with a flow monitor and a sampling point for brine testing. The contract shall include a brineometer for this purpose.

19.3.4 Electrolyser

- 1 Rating of the electrolyzers shall be dependant on the requirement for generation of sodium hypochlorite during the off peak period. Multiple electrolyzers shall be provided to achieve the required capacity. Standby shall be provided by either one spare unit or 25% of the capacity whichever is the greater, held in store at the site.
- 2 The anode/cathode is a consumable item within the generation package. Manufacturers offer a five year guarantee with regard to life consumed during a five year cycle of operation. The Contractor shall transfer this guarantee to the Purchaser which shall become effective from the date of the Take-Over. The Contractor shall therefore ensure that the current density value is commensurate with a five year cycle of operation.
- 3 The electrolyzers shall be rack mounted such that access to all connections is within view of maintenance staff. Disconnection and replacement shall be possible without associated pipework disturbance.
- 4 Hydrogen release from the electrolyzers shall be manifolded for transportation with the sodium hypochlorite for high level discharge in the hypochlorite storage tank. The sodium hypochlorite feed line shall incorporate a flow switch, for process shut-down in the event of low flow, a temperature switch for over temperature shut down of the process and a sample point for sodium hypochlorite sampling.
- 5 Any equipment which is in the defined Potentially Explosive Atmosphere shall be selected in accordance with BS 5345.
- 6 The water feed to the electrolyser shall be 'softened' as required via duty/standby water softeners with automatic changeover.
- 7 A heat exchanger shall be included with the electrolyser to transfer heat generated in the product to the incoming diluted brine solution in order to maximise the overall efficiency of the unit. Where this may not be sufficient, pre-heating with an electric immersion heater shall be provided.

19.3.5 Sodium Hypochlorite Storage

- 1 The sodium hypochlorite storage tanks shall be provided on a duplicate basis. The capacity shall be sufficient for 48 hours consumption at the maximum works output. The tank shall be suitable for external application and shall include forced ventilation for hydrogen dispersion. The tank(s) shall be installed in bund(s) of not less than 110% of the tank volume.
- 2 Duty/Standby ventilation fans shall be provided to supply air into the storage tank for high level discharge with dispersed hydrogen from the gaseous space above the stored liquid. Flow sensors shall monitor fan operation and shut down the generation process in the event of low flow detection.

19.3.6 Sodium Hypochlorite Dosing

- 1 Dosing of sodium hypochlorite shall be via duty/standby dosing pumps. Control of the pumps shall be related to the flowrate through the works chlorine disinfection requirements, and residual requirements.
- 2 Overall control of the whole system shall be by means of a programmable logic controller (PLC) which shall be configured so that failure of the PLC shall not result in danger to personnel or equipment.

19.3.7 Pipework

- 1 All pipework fittings and valves associated with the generation equipment shall be rigidly fixed and supported, pipe routes over floor areas shall be adequately protected against accidental damage.

19.3.8 Electrical Installation

- 1 The electrical installation shall be in accordance with Section 21 of this specification.

19.3.9 Transformer / Rectifier

- 1 A duty transformer/rectifier shall provide low voltage DC for the electrolyser. The unit shall be free standing, the input shall be 415V, 3ph, a.c., output should not be greater than 24V dc with full wave rectification.
- 2 The unit be in accordance with the specification Section 21 and be capable of operation in ambient temperatures up to 50°C. Cooling shall be via natural convection ventilation.
- 3 The rectifier shall include:-
- (a) A dc voltmeter
 - (b) A dc Ammeter
 - (c) A dc Centre zero voltmeter
 - (d) Lockable input isolator
 - (e) Main input contactor
 - (f) On/Off push buttons
 - (g) Hand/Off/Auto selector
 - (h) Current level setting
 - (i) Mains "on" lamp
 - (j) DC "live" lamp
 - (k) Hours run meter
- 4 All status and alarms shall be provided at the signals and alarms marshalling box.

19.3.10 Control Panel

- 1 A control panel shall be mounted adjacent to the Transformer/Rectifier to provide overall system control. The panel shall be in accordance with Section 21 - Factory Built Assemblies of Switchgear and Control Gear and Section 10 - Instrumentation, control and Automation.
- 2 The Panel shall include indication and control equipment for the process.
- 3 In particular the following alarms shall be provided locally and at the signals and alarms marshalling box:-
- (a) Improper voltage
 - (b) Rectifier failure
 - (c) Protection voltage failure
 - (d) Storage tank low level
 - (e) Low/high electrolyte temperature
 - (f) Low electrolyte level
 - (g) Low air flow
 - (h) Bund flood
 - (i) Low water flow

19.4 ANALYSERS

- 1 Residual Chlorine analyzers are used to monitor the amount of free residual chlorine in final effluent/irrigation water. Each residual Chlorine analyzer system comprises of a sensor, transmitter, buffer solution and other accessories. The analyzer should be provided with a flow regulating/isolation valve, sample flow indicator (VA type) 'Y' strainer and associated pipework, skid mounted and installed in a GRP enclosure. The analyzer shall have a maximum response time of ten seconds for step change of 90%.
- 2 Transmitter shall comprise 3½ digits LCD, have a measurement accuracy of $\pm 2\%$. These shall be fields selectable from 0-0.5 to 0-20 mg/l. complete width. Automatic compensation for temperature. They shall have an isolated 4-20 mA d.c. output, and be suitable for surface mounting. The enclosure shall be protected to IP66.
- 3 The sensor shall be of the Amperometric type sensor with flow through installation, and be complete width with an internal temperature sensor for automatic compensation. The sensor shall be complete with bottle of buffer solution and interconnecting cable.

19.5 NEUTRALISATION SYSTEMS

19.5.1 General

- 1 The neutralisation system shall include the following:
 - (a) Neutralisation tower.
 - (b) Circulating pumping units.
 - (c) Air exhaust system.
 - (d) Caustic soda ash enough for two (2) times use.
 - (e) Necessary pipes, fittings, valves.
 - (f) Necessary electric connections.
- 2 When the concentration of the chlorine gas in the air reaches four (4) mg/lit, by volume, the chlorine leak detectors shall operate the neutralization system.
- 3 Caustic soda solution prepared at the bottom part of the neutralization tower shall be sucked by the pumps and delivered to the spraying nozzles at the top of the tower. In the same time contaminated air shall be delivered to the lower part of the tower by the extraction fans. Contact shall happen, between the contaminated air and the caustic soda solution, through the contact rings and the neutralized solution shall be collected back at the bottom of the tank. The process shall continue until the concentration of the chlorine gas in air becomes normal. The neutralized solution shall be drained out from the lower part of the tower and another volume shall be prepared to be ready for emergency cases.

19.5.2 Neutralisation Tower

- 1 The tower shall be made from reinforced fibre glass. The neutralizing solution shall be prepared at the bottom of the tower by using of caustic soda ash. In the upper part of the tank, the spraying system with its nozzles shall be installed.
- 2 Porcelain or P.V.C. rings shall be placed on certain brackets inside the tower for increasing the contact area between the contaminated air and the sprayed neutralization solution.

19.5.3 Circulating Pumping Units

- 1 One duty and one stand-by pump shall be used to circulate, the neutralization solution from the bottom of the tower to the spraying installations.

- 2 The pumps shall be of discharge and head to suit the supplied installations.
- 3 The pumps shall be manufactured from suitable materials to withstand the corrosion action of the handled media.

19.5.4 Pipework and Electrical Connections

- 1 The price of neutralization system shall include all air ducts, caustic soda pumps, pipes and electric connections required. Air ducts shall be of uPVC complete with necessary valves and fittings.
- 2 The caustic soda pump suction and delivery pipes including valves and fittings shall be of PVC.

19.6 INSTALLATION AND COMMISSIONING

- 1 Installation and commissioning shall be in accordance with Part 1 of this Section 9.

END OF PART