

Multilateral Investment Guarantee Agency

Environmental Guidelines for

Chlor-Alkali Industry

Industry Description and Practices

There are three basic processes for the manufacture of chlorine and caustic soda from brine: the mercury cell, the diaphragm cell, and the membrane cell. *The membrane cell is the most modern and has economic and environmental advantages.* The two other processes generate hazardous wastes (containing mercury or asbestos).

In the membrane process, the chlorine (at the anode) and the hydrogen (at the cathode) are kept apart by a selective polymer membrane that allows the sodium ions to pass into the cathodic compartment and react with the hydroxyl ions to form caustic soda. The depleted brine is dechlorinated and recycled to the input stage. *The membrane cell process is the preferred process for new plants.* Diaphragm processes may be acceptable, in some circumstances if non-asbestos diaphragms are used. The energy consumption in a membrane cell process is of the order of 2,200-2,500 kiloWatt tons per metric ton compared to 2,400-2,700 kiloWatt tons per metric ton (kWh/t) of chlorine for a diaphragm cell process. *The World Bank Group does not finance mercury cell technology, which would preclude MIGA guarantees.*

Waste Characteristics

The major waste stream from the process is the "brine muds," which are the sludges from the brine purification step and which may contain magnesium, calcium, iron, and other metal hydroxides, depending on the source and purity of the brines. The muds are normally

filtered or settled, the supernatant is then recycled and the mud is dried and landfilled.

Chlorine is a highly toxic gas, and strict precautions are necessary to minimize risk to workers and possible releases during its handling. Major sources of fugitive air emissions of chlorine and hydrogen are vents, seals, and transfer operations.

Acid and caustic wastewaters are generated in both the process and the materials recovery stages.

Pollution Prevention and Control

The following pollution prevention measures should be considered:

- Use metal rather than graphite anodes to reduce lead and chlorinated organics.
- Resaturate brine in closed vessels to reduce the generation of salt sprays.
- Use noncontact condensers to reduce process wastewater quantities.
- Scrub chlorine tail gases to reduce chlorine discharges and to produce hypochlorite.
- Recycle condensates and waste process water to the brine system, if possible.
- Recycle brine wastes, if possible.

For the chlor-alkali industry, an Emergency Preparedness and Response Plan is required for potential uncontrolled chlorine and other releases. Carbon tetrachloride is sometimes used to scrub nitrogen trichloride (formed in the process) and maintain its levels below 4 percent to avoid explosion. However, substitutes for carbon tetrachloride may have to be used as the use of carbon tetrachloride may be banned globally.

Target Pollution Loads

Implementation of cleaner production processes and pollution prevention measures can provide both economic and environmental benefits. The following production-related targets can be achieved by measures such as those detailed in the previous section. The numbers relate to the production processes *before* the addition of pollution control measures.

Target Levels Per Unit of Production

Parameter	Diaphragm process (maximum load/t chlorine)	Membrane process (maximum load/t chlorine)
Lead	0.04 kilograms	N/A
Wastewater	1.6 cubic meters	0.1 cubic meters

N/A = Not Applicable.

Treatment Technologies

Caustic scrubber systems should be installed to control chlorine emissions from condensers and at storage and transfer points for liquid chlorine. Sulfuric acid used for drying chlorine should be neutralized before discharge.

Brine muds should be discharged to lined settling ponds (or equivalent) to prevent contamination of soil and groundwater. Effluents should be controlled for pH by neutralization. Settling and filtration are performed to control total suspended solids. Dechlorination of wastewaters is performed using sulfur dioxide or bisulfite.

Emission Guidelines

Emission levels for the design and operation of each project must be established through the Environmental Assessment (EA) process, based on country legislation and the *Pollution Prevention and Abatement Handbook* as applied to local conditions. The emission levels selected must be justified in the EA and acceptable to MIGA.

The following guidelines present emission levels normally acceptable to the World Bank Group in making decisions regarding provision of World Bank Group assistance, including MIGA guarantees; any deviations from these levels must be described in the project documentation.

The guidelines are expressed as concentrations to facilitate monitoring. Dilution of air emissions or effluents to achieve these guidelines is unacceptable.

All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours.

Air Emissions

Chlorine concentration should be less than 3 milligrams per normal cubic meter (mg/Nm³) for process areas including chlorine liquefaction.

Liquid Effluents

For membrane cell effluents, pH levels should be in the range 6-9.

For non-asbestos diaphragm plants, the following effluents levels should be achieved;

In some cases, bioassay testing of effluents may be desirable to ensure effluent toxicity is at acceptable levels, say toxicity to fish at a dilution factor of two.

Effluents from Non-Asbestos Diaphragm Plants

Parameter	Maximum value milligrams per liter (mg/L) except for pH
PH	6-9
Total suspended solids	20
COD	150
AOX	0.5
Sulfite	1
Chlorine	0.2

Note: Effluent requirements are for direct discharge to surface waters.

Ambient Noise

Noise abatement measures should achieve either the following levels or a maximum increase in background levels of 3 dB(A). Measurements are to be taken at noise receptors located outside the project property boundary.

Ambient Noise		
	Maximum Allowable L_{eq} (hourly), in dB(A)	
Receptor	Daytime 07:00 - 22:00	Nighttime 22:00 - 07:00
Residential; institutional; educational	55	45
Industrial; commercial	70	70

The emission requirements given here can be consistently achieved by well-designed, well-operated and well-maintained pollution control systems.

Monitoring and Reporting

Frequent sampling may be required during start-up and upset conditions. Once a record of consistent performance has been established, sampling for the parameters listed above should be as detailed below.

Daily monitoring for parameters other than pH (for effluents from diaphragm process) is recommended. The pH in the liquid effluent should be monitored continuously. Chlorine monitors should be strategically located within the plant to detect chlorine releases or leaks on a continuous basis.

Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Records of monitoring results should be kept in an acceptable format. These should be reported to the responsible authorities and relevant parties, as required, and provided to MIGA if requested.

Key Issues

The following box summarizes the key production and control practices that will lead to compliance with emissions guidelines:

- Give preference to the membrane process.
- Adopt the following pollution prevention measures to minimize emissions:
 - Use metal instead of graphite anodes.
 - Resaturate brine in closed vessels.
 - Recycle brine wastes.
 - Scrub chlorine from tail gases to produce hypochlorite.
 - Provide lined settling ponds for brine muds.

Further Information

The following are suggested as sources of additional information (these sources are provided for guidance and are not intended to be comprehensive):

Arthur D. Little, Inc. 1975. *Assessment of Industrial Hazardous Waste Practices, Inorganic Chemicals Industry*. US Environmental Protection Agency, Contract 68-01-2246.

Kirk-Othmer. 1980. *Encyclopedia of Chemical Technology*. Third Edition. New York: John Wiley and Sons.

World Bank, Environment Department. 1996. "Pollution Prevention and Abatement: Chlor-Alkali Industry." Technical Background Document.