

Seawater Electrochlorination Systems

On-site hypochlorite generation from seawater for biofouling control in power plants, desalination plants, LNG terminals.

Introduction

The purpose of on-site generation of sodium hypochlorite solution from seawater is to economically and safely produce this powerful biocide and disinfecting agent for use in industrial plants.

When injected in the cooling water circuits of electric power stations or industrial plants, on-site generated sodium hypochlorite solution provides efficient protection to the equipment against organic fouling without the undesirable side effects of commercial hypochlorite (such as the build up of hard deposits by reaction of excess alkalinity with the substances dissolved in water) or the safety hazard connected with the transportation, storage and handling of chlorine gas.



Because this technology eliminates dependency upon outside suppliers and the high costs of purchased commercial products, it finds application in a broad spectrum of industrial facilities requiring biological growth control in water systems.

SEACLOR®/SANILEC® systems for the on-site generation of sodium hypochlorite solution from seawater have demonstrated reliable, economic and maintenance-free operation in numerous installations throughout the world. Operating under a variety of environmental conditions, these installations range from supplying the sodium hypochlorite requirements for large scale land-based electric power plants and industrial plants down to smaller requirements for offshore marine facilities.

De Nora developed the SANILEC and SEACLOR technologies more than 30 years ago. De Nora Water Technologies (DNWT) offers three different mechanical configurations of electrolyzer cells (SEACLOR, SANILEC-Plate Type, SANILEC-Tube Type). DNWT will select and recommend the best cell configuration for the application. When selecting a cell configuration DNWT considers the application, seawater characteristics, cost, size, weight, pressure, and historical preference.

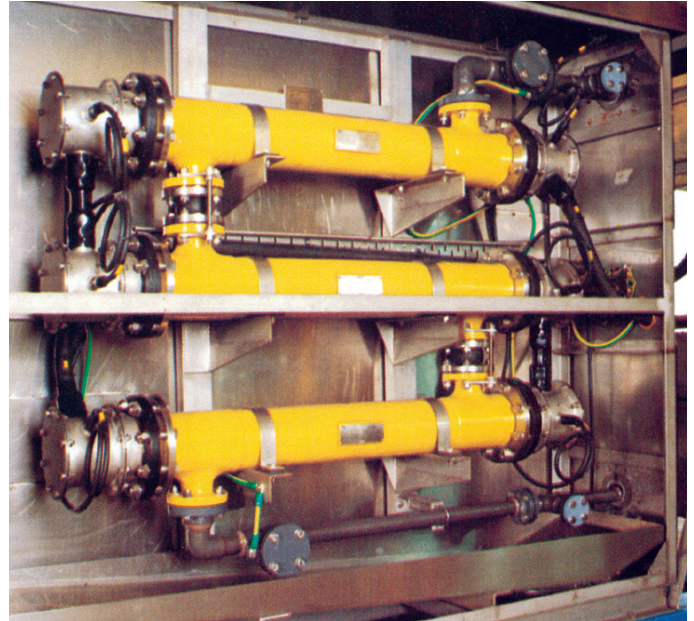
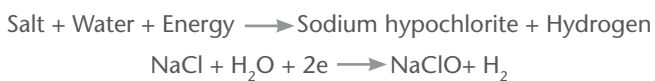
Process Description

Pressurized seawater, which can be supplied by DNWT, is delivered to the SEACLOR/SANILEC system where it is strained to remove suspended solids larger than 0.5 mm. The seawater passes through a flow control assembly, which may include a flow control valve and a flow transmitter with local indication and low flow shut-down protection. The seawater then passes through the electrolyzer cells and exits as sodium hypochlorite solution with the byproduct, hydrogen gas. This two-phase solution is piped to a tank or hydrocyclone where hydrogen gas is removed from the solution. The hydrogen is typically diluted with air using a set of redundant blowers to a safe level (typically less than 1% by volume which is 25% of the explosive limit). Finally, the sodium hypochlorite solution is injected at the required continuous and/or shock-dose rates.

Chemistry

The process is based on the electrolysis of seawater as it flows through an unseparated electrolytic cell. The resulting solution exiting the cell is a mixture of seawater, sodium hypochlorite, hydrogen gas and hypochlorous acid. Electrolysis of sodium chloride solution (seawater) requires the passage of direct current between an anode (positive pole) and a cathode (negative pole) to separate salt and water into their basic elements. Chlorine generated at the anode immediately goes through chemical reactions to form sodium hypochlorite and hypochlorous acid. Hydrogen and hydroxides are formed at the cathode, the hydrogen forms a gas and the hydroxide aids in the formation of sodium hypochlorite with zero pH shift.

This overall chemical reaction can be expressed as follows:

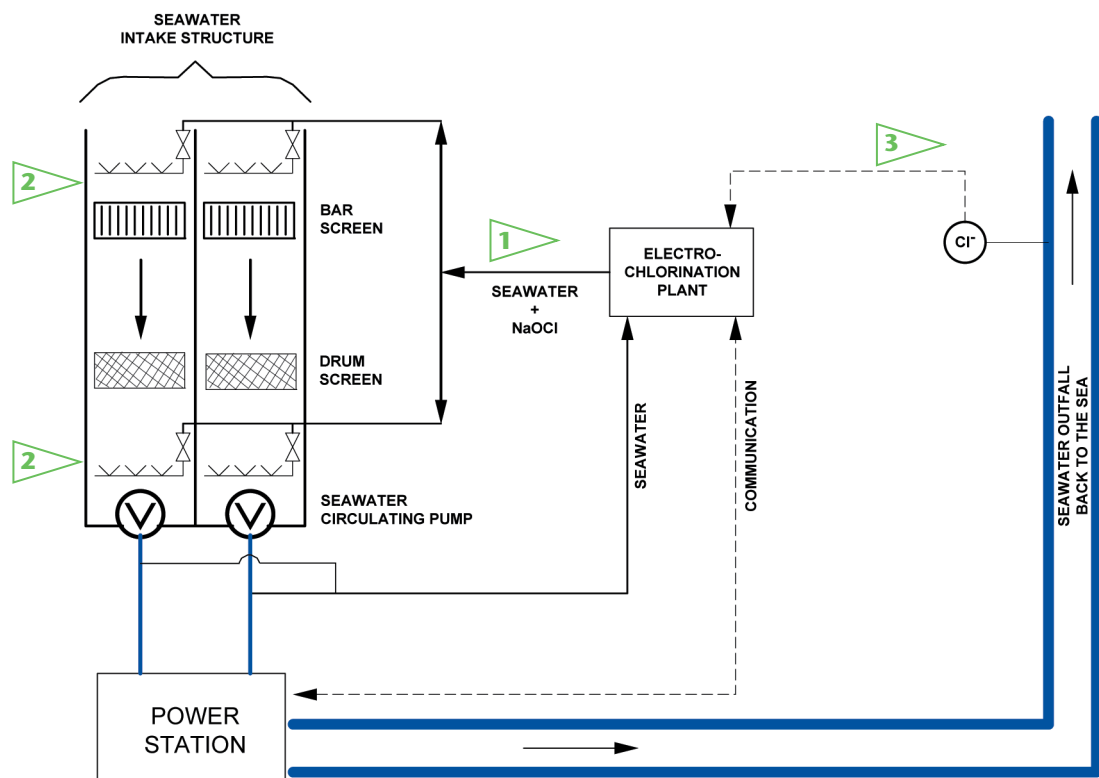


Power Plants

Thermal power plants powered by either nuclear energy or fossil fuel located along a seacoast normally use seawater as a coolant in the steam condensers. These are typically once-through cooling water systems.

By controlling the fouling of the steam condensers, the efficiency of power generation can be significantly increased. For example, in a typical 250 MW coal-fired power plant, an increase of 5 mm hg of mercury in condenser back pressure (due to fouling) can cost the utility as much as \$250,000 annually in fuel and replacement power costs.

Sodium hypochlorite is introduced into the seawater intake of the power station where it also prevents fouling of the mechanical equipment, such as the seawater circulating pumps, bar screens and drum screens of the power plant.



1 Typical product concentration of 500–2500 ppm of NaOCl (0.05–0.25%)

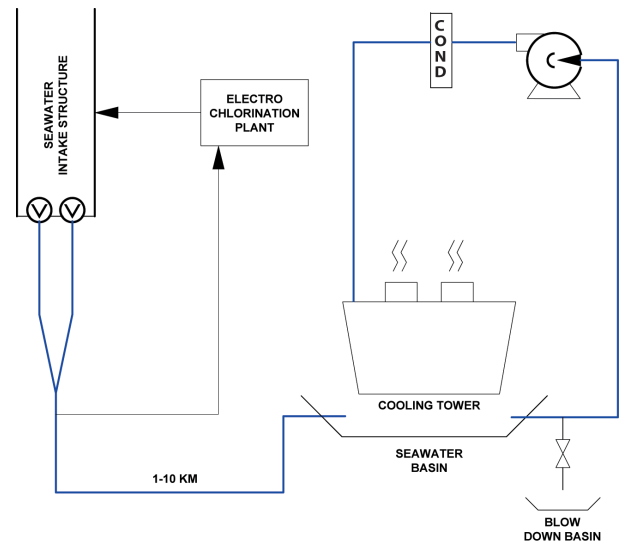
2 Typical continuous dosing rate of 1–2 ppm and typical shock dosing rate of 4–6 ppm for 15–20 minutes 2–4 times per day

3 Electrochlorination plant production can be fine-tuned to maintain outfall residual (typically 0.1–0.5 ppm)

Note: If chlorine in the effluent is an issue, it can be neutralized before discharge.

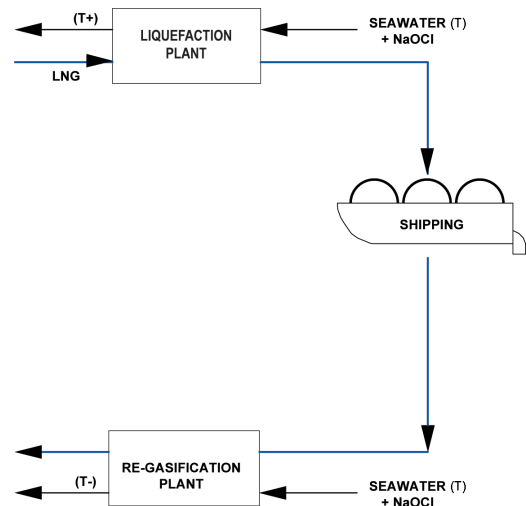
Cooling Towers

Open loop seawater cooling is a widely accepted practice for providing cooling water to a power plant. Cooling towers are typically used when the distance from the sea to the power plant is so great that the cost of pumping is prohibitive. Seawater is used for make-up water. Sodium hypochlorite is generally injected at the intake structure and the intake basin to control biological growth.



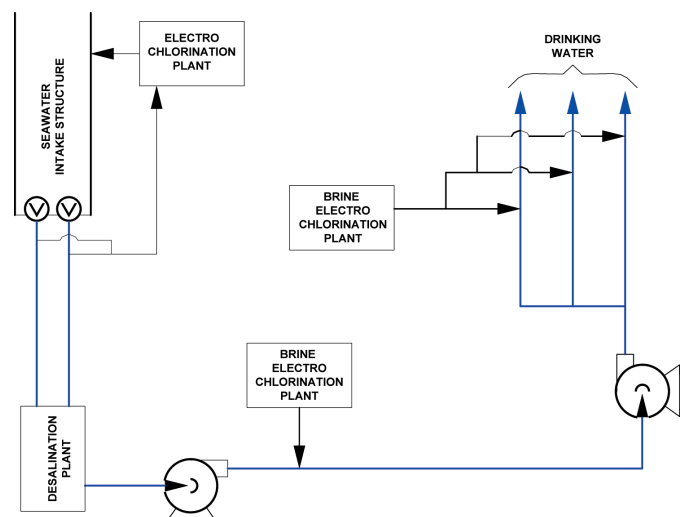
LNG Terminals

The LNG market is expanding throughout the world. The most common means of transportation is by ship. LNG must go through a liquefaction process prior to loading where chlorinated seawater is used as the cooling media. After unloading, a regasification process takes place where chlorinated seawater is used for the heating process.



Desalination Plants

As the world's population expands, the need for freshwater continues to increase. For a typical desalination plant, sodium hypochlorite generated from seawater is injected in the intake structure and protects the equipment from organic fouling. After the desalination plant, sodium hypochlorite generated from brine is injected to achieve the desired chlorine residual. Additional brine based electrochlorination plants are added at each pumping station to maintain the residual chlorine as the drinking water moves through its distribution system.



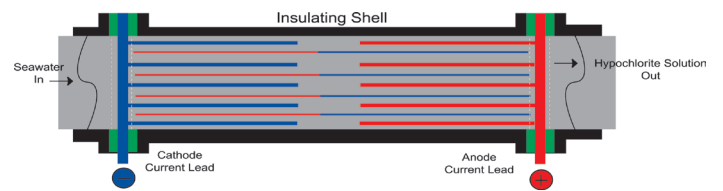
SEACLOR® Electrolyzers

SEACLOR electrolyzers consist of electrolytic cells of modular construction; these are combined electrically and hydraulically in series and fastened together to form an electrode assembly (at right), which is placed in a cylindrical electrolyzer body.

A unique feature of an electrode assembly is the ease of replacement of the electrode package installed in the electrolyzers; it can be inserted or removed from the electrolyzer body in a short time without need for special tools or specialized mechanics.

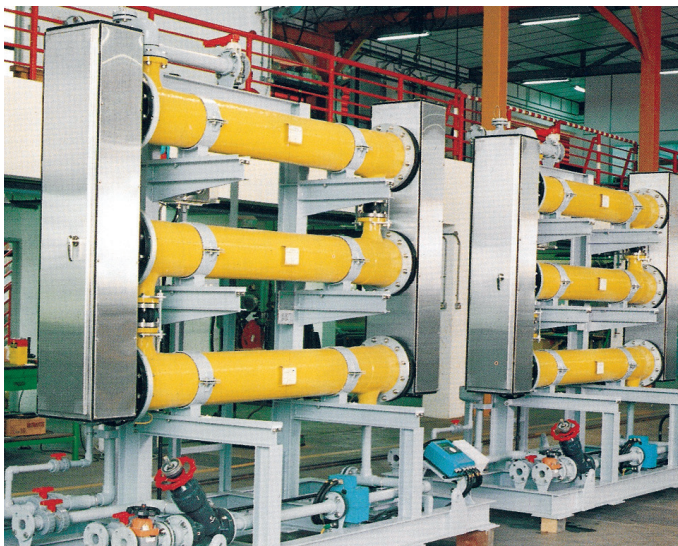
Electrolytic cells are bipolar in design. The flow paths of current, seawater and electrolysis products through the electrolyzers are shown (at right). The electrolyzers operate under constant seawater flow rate while the D.C. current is adjusted so that the generation of hypochlorite matches the water treatment demand.

- DSA® Coating
- Noble Metal Oxides of Platinum Group
- Bipolar Anode/Cathode
- Titanium Cathode
- PVC casing wrapped in FRP
- 6 barg rated
- Optimized per application
- Power Consumption typically less than 4.5 DC KWh/KgCl₂
- 5 year warranty



Generator Ratings (Per Train)					
Model	Production (kg/h)	Amount of Seawater to be Treated at 2ppm (m ₃ /h)	Output Concentration (ppm)	Seawater Flowrate (m ₃ /h)	AC KVA*
4H6.100	20	10,000	1500	13.3	125
3HX.100	50	25,000	2000	25	310
3HX.150	75	37,500	2000	37.5	460
3HX.200	100	50,000	2000	50	615
4HX.375	250	125,000	2000	125	1520
4VX.650	450	225,000	2000	225	2850
4VX.1300	900	450,000	2000	450	5650

All values based on seawater temperature of 25°C and 18,980 PPM chloride. *Values may change depending on rectifier efficiency.



SANILEC® Electrolyzers

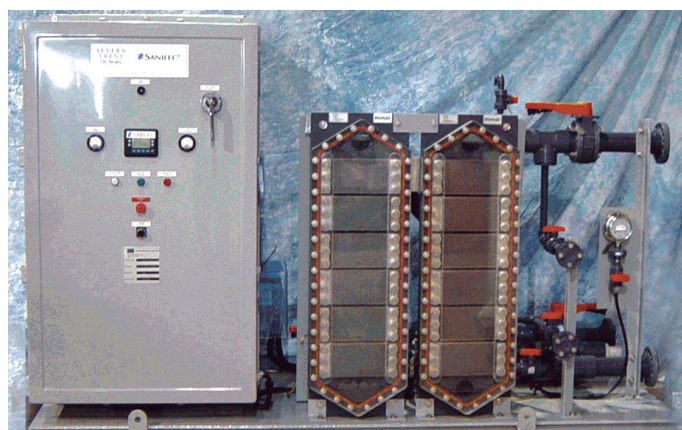
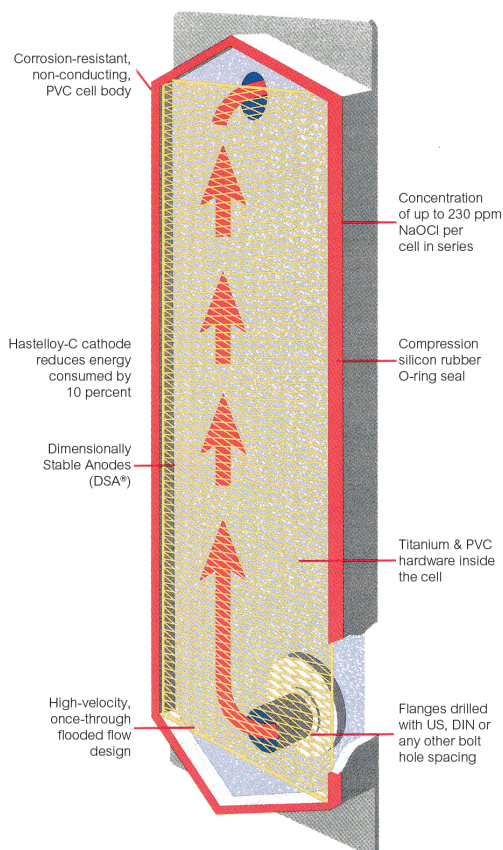
Design: Each cell with single electrode pack is monopolar in design. When supplied as 2, 3 or 6 electrode packs per cell, it becomes bipolar in nature. This cell arrangement provides maximum flexibility for electrical circuit configuration.

Cathodes: Hastelloy C-276 provides for excellent corrosion resistance to the seawater/hypochlorite solution produced in the cell and has 10% lower power consumption as compared to standard titanium cathodes. Furthermore, the Hastelloy cathodes will not hydride.

Cell Cover: Clear acrylic for visual inspection of the cell's internal components and observation of electrolysis during normal operations.

Gaskets: Viton O-ring seals around conductors and a silicon rubber O-ring seals the cell cover to the body. These gasket types have demonstrated long life and excellent sealing properties.

Hardware: Internal fasteners and hardware are titanium; external fasteners are 316 stainless steel.

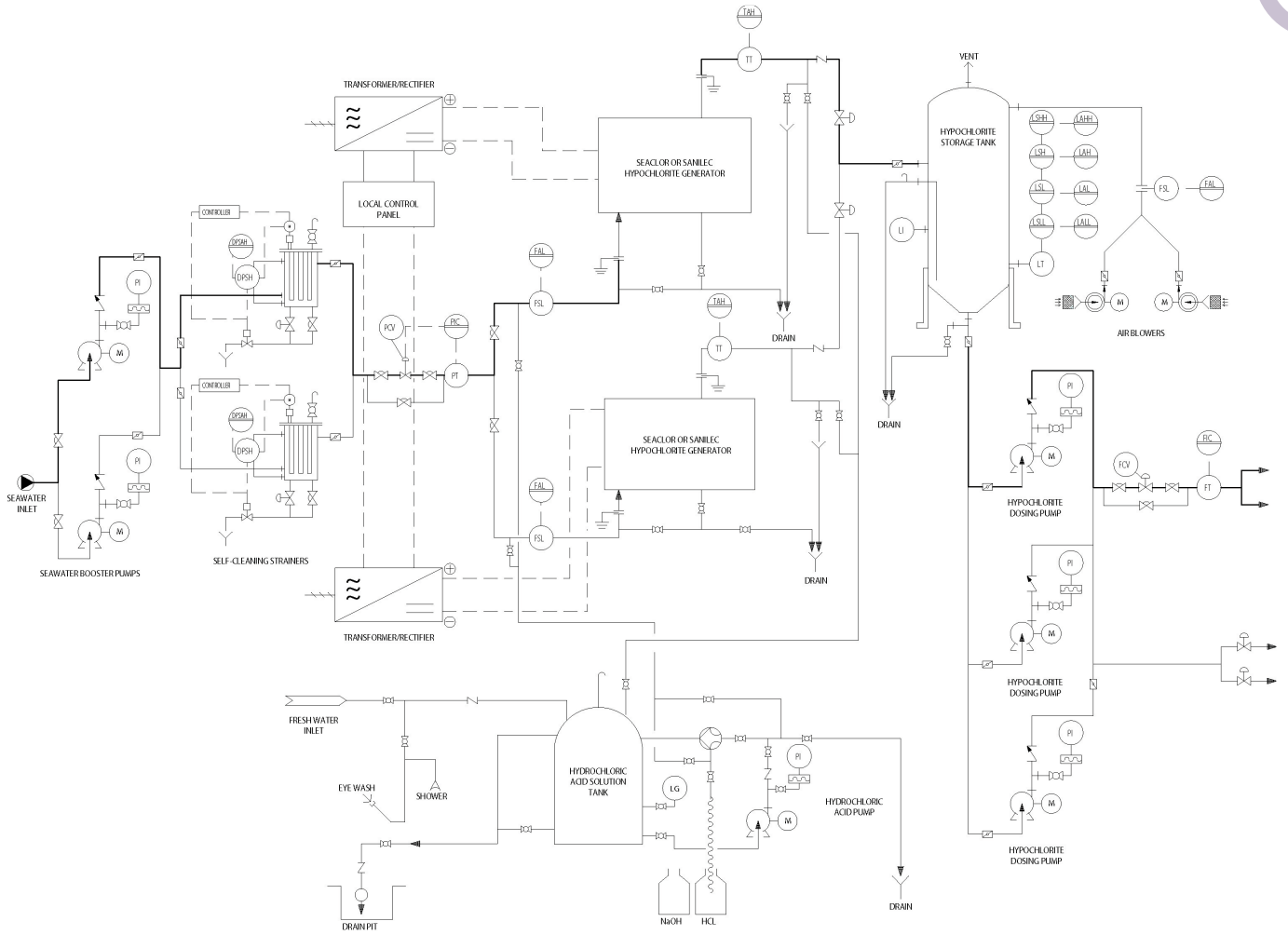


- Anodes have DSA® coated titanium
- Noble Metal Oxides of Platinum Group
- Monopolar Anode/Cathode
- Hastelloy C-276 Cathode
- PVC Body
- Clear Acrylic Cover
- Standardized Models
- Available Inventory of cells
- Power Consumption typically less than 4.0 DC KWh/KgCl₂
- 5 year warranty

Generator Ratings (Per Train)					
Model	Production (kg/h)	Amount of Seawater to be Treated at 2ppm (m ₃ /h)	Output Concentration (ppm)	Seawater Flowrate (m ₃ /h)	AC KVA*
SC500	10	5,000	294	34.1	62
SC1000	20	10,000	589	34.1	124
SC1500	30	15,000	879	34.1	183
SC2100	40	20,000	1176	34.1	245
SC2600	50	25,000	1472	34.1	308
SC3100	60	30,000	1764	34.1	369
SC3700	70	35,000	2064	34.1	437

All values based on seawater temperature of 25°C and 18,980 ppm chloride. *Values may change depending on rectifier efficiency.

Typical Flow Diagram





ISO 9001 - Cert. n. 2736

WATER MADE EASY

MARINE

ENERGY

MUNICIPAL

INDUSTRIAL



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