SANILEC® SEAWATER ELECTROCHLORINATION SYSTEMS

Industrial Power and
Coastal Biofouling Control

Industrial Biofouling Control

SANILEC® seawater electrochlorination systems from De Nora Water Technologies are a reliable and economic solution for industrial biofouling control. The electrochlorination process is simple and straight forward, combining three common consumables (salt, water and electricity) to generate a disinfecting agent. SANILEC systems can be provided in any capacity to meet customer and application-specific needs. On-site generation of sodium hypochlorite is an economical and safe method to produce a powerful biocide and disinfecting agent for use in industrial applications. When injected into the cooling water circuits of electric power stations or industrial plants, on-site generated sodium hypochlorite provides efficient protection to the equipment against the growth of micro and macro organic fouling. This occurs 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. The technology eliminates dependency on outside suppliers and the heavy costs of purchased commercial products.

SANILEC seawater electrochlorination systems have demonstrated reliable, economic and maintenance-free operation in numerous installations throughout the world. Operating under a variety of environmental conditions, SANILEC systems meet the needs of large scale land-based electric power stations and industrial plants.

For more information on Sanilec® Seawater Electrochlorination Systems visit **www.denora.com**

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SANILEC® Process Description and Chemistry

Pressurized seawater is delivered to the SANILEC system where it is strained to 0.8 mm to remove suspended solids. 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 the cell as sodium hypochlorite solution and byproduct hydrogen gas. The solution is piped to a tank or cyclone where hydrogen 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%). Finally, the sodium hypochlorite solution is injected at required continuous and shock-dose rates.

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, hypochlorite, and hypochlorous acid. Electrolysis of sodium chloride solution (seawater) is 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 hypochlorite and hypochlorous acid. Hydrogen and hydroxide are formed at the cathode, the hydrogen forms a gas and the hydroxide aids in the formation of hypochlorite and increases the exit stream pH to approximately 8.5.

This overall chemical reaction can be expressed as follows:

(Salt + Water + Energy = Hypo + Hydrogen)

$$NaCl + H2O + 2e = NaOCl + H2$$

SANILEC® Features & Benefits

Superior Design

– Optimum cell design – not too big or too small
– Minimal operation and maintenance requirements
– Once-through flow design eliminating recycle requirements
– Use of corrosion-resistant materials of construction
– Customized layout and supply to meet site-specific requirements
– Guaranteed lowest power consumption

Safety

– Low-strength sodium hypochlorite solution is non-hazardous, safe and easy to handle
– Systems designed for low voltage requirements: less than 50 volts DC
– Automatic operation eliminating the potential for operator error
– Designed for hazardous areas, if required
– Safe hydrogen removal process

Reliability

– Active life of the DSA® anode is guaranteed
– Anodes can be recoated
– Long operating life with minimal downtime
– Control system ensures proper and safe operation
– Eliminates dependence on chemical suppliers

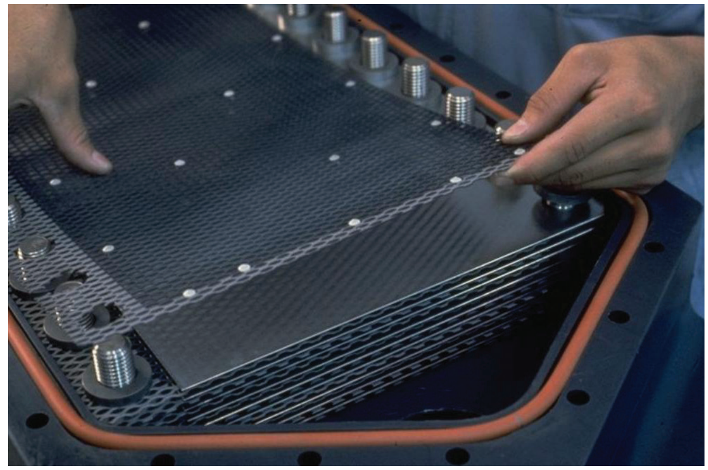
Service

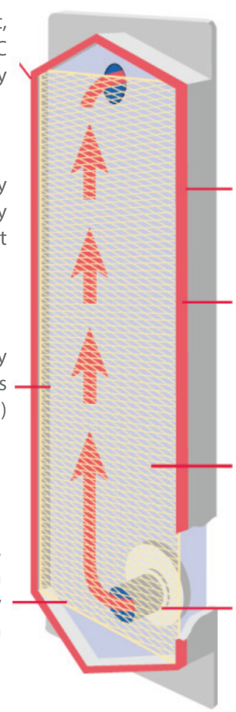
– Installation and construction consultation available
– Experienced service staff for start-up and commissioning
– Maintenance and service agreements available
– Single source for supply of spare parts
– Training services available
– Pre-project consultation available for budgetary capital estimates, project feasibility studies, equipment selection and specification and proposal evaluation

Seawater Electrolytic Cell Specifications

- **Design:** Each cell is monopolar in design and comes standard as 1, 3 or 6 packs per cell. This cell arrangement provides maximum flexibility for circuit configuration.
- **Cell Body:** PVC with ultraviolet stabilizers for good corrosion resistance and outdoor stability. Flanged inlet and outlet for positive sealing to seawater piping.
- **Anodes:** Dimensionally stable, of expanded titanium metal with precious metal oxide coating (DSA®). Anode mesh is supplied with PVDF spacers to maintain a 2.5 mm gap between anode and cathodes.
- **Cathodes:** Patented Hastelloy cathode reduces energy consumed by 10 percent.
- **Cell Cover:** Clear acrylic for visual inspection of the cell internal components 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:** All internal fasteners and hardware are titanium; external fasteners are stainless steel.

SANILEC has PVC cell bodies using an innovative construction manufactured entirely of machined Type I PVC (ASTM Specification D-1784). This design offers superior strength and corrosion resistance. DNWT offers a five-year warranty against corrosion or stress-related leaks. PVC is a field-proven, electrolytic cell construction material, which DNWT has used for over 25 years in demanding, high concentration, sodium hypochlorite applications.

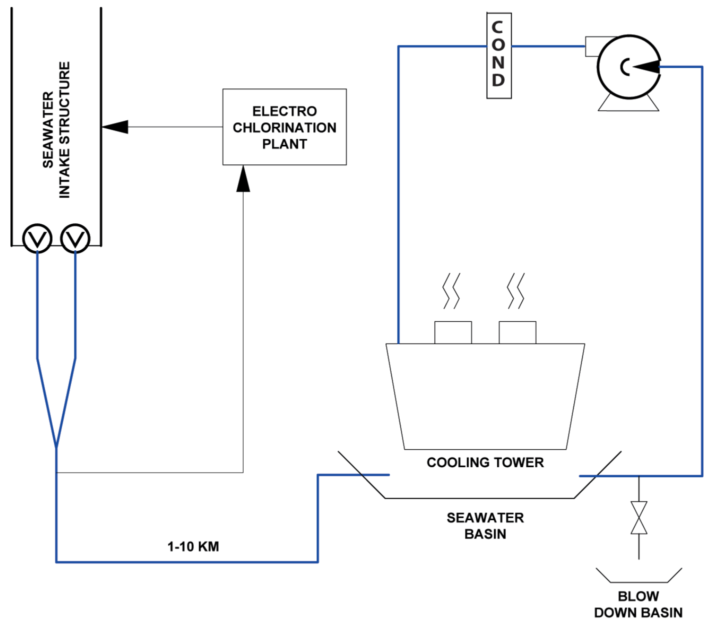




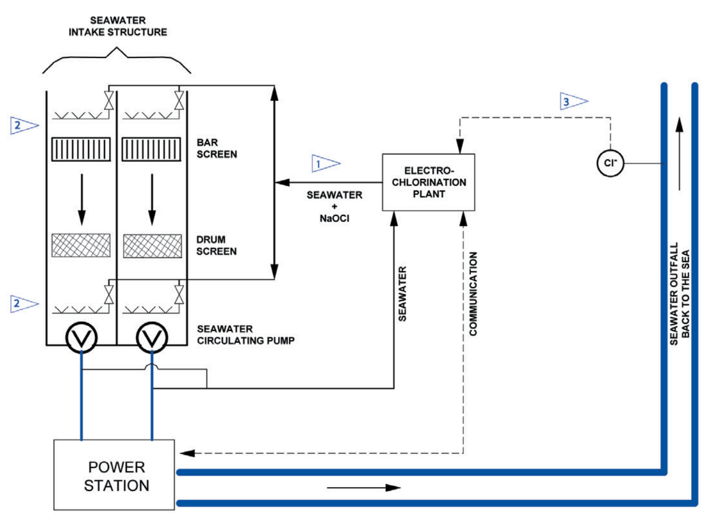
Electrolyzer Model	Six Pack				Three Pack		One Pack				
	SC-60/6	SC-120/6	SC-240/6	SC-320/6	SC-300/3	SC-360-3	SC-75/1	SC-150/1	SC-300/1	SC-330/1	SC-400/1
Output											
Available Chlorine Production lbs/day (kg/day)	60 (27.2)	120 (54.4)	240 (108.9)	320 (145.2)	300 (136.1)	360 (163.3)	75 (34.0)	150 (68.1)	330 (149.7)	330 (149.7)	400 (181.5)
Hydrogen Production scfm (normal m^3/hr.)	0.2 (0.4)	0.4 (0.7)	0.8 (1.4)	1.1 (1.9)	1.1 (1.8)	1.3 (2.1)	0.3 (0.4)	0.5 (0.9)	1.1 (1.8)	1.2 (2.0)	1.4 (2.4)
Sodium Hypochlorite Concentration (ppm)	120	170	170	180	210	200	160	210	210	230	220
Electrical											
DC Amperage (Nominal)*	185	365	730	960	1800	2160	1375	2750	5500	6050	7200
DC Volts* (@20°C, 19,000 ppm Cl*)	27.0	27.0	27.0	27.0	13.5	13.5	4.5	4.5	4.5	4.5	4.5
*Note: Consult DNWT for exact amperage and voltage based on seawater conditions.											
Cells per Electrolyzer Body	6	6	6	6	3	3	1	1	1	1	1
Cathodes per pack	2	4	8	11	9	11	2	4	8	9	11
Total Cathodes per cell	12	24	48	66	27	33	2	4	8	9	11
Anodes per pack	3	5	9	12	10	12	3	5	9	10	12
Total Anodes per cell	18	30	54	72	30	36	3	5	9	10	12
Active sides per cell	24	48	96	132	54	66	4	8	16	18	22
Active Anode Area m^2 (ft^2)	0.720 (7.750)	0.720 (15.50)	2.880 (31.00)	3.960 (42.63)	3.564 (38.36)	4.356 (46.89)	0.848 (9.128)	1.696 (18.26)	3.392 (36.51)	3.816 (41.08)	4.664 (50.20)
Dimensions											
Height mm (inches)	1270 (50)	1270 (50)	1270 (50)	1270 (50)	1270 (50)	1270 (50)	1270 (50)	1270 (50)	1270 (50)	1270 (50)	1270 (50)
Width mm (inches)	403 (16)	403 (16)	403 (16)	403 (16)	403 (16)	403 (16)	403 (16)	403 (16)	403 (16)	403 (16)	403 (16)
Thickness mm (inches)	204 (8)	217 (9)	248 (10)	219 (9)	248 (10)	219 (9)	204 (8)	218 (9)	255 (10)	255 (10)	270 (11)
Weight											
Dry kg (pounds)	81.00 (178.4)	86.00 (189.4)	115.0 (253.3)	128.0 (281.9)	119.0 (262.1)	128.0 (281.9)	81.0 (178.4)	86.0 (189.4)	115.0 (253.3)	119.0 (262.1)	128.0 (281.9)
Operating kg (pounds)	88.0 (193.8)	100.0 (220.3)	132.0 (290.7)	151.0 (332.6)	138.0 (304.0)	151.0 (332.6)	88.0 (193.8)	100.0 (220.3)	132.0 (290.7)	138.0 (304.0)	151.0 (332.6)
Volume											
liters (gallons)	3.5 (0.9)	6.1 (1.6)	10.9 (2.8)	14.4 (3.7)	12.1 (3.1)	14.4 (3.7)	3.5 (0.9)	6.1 (1.6)	10.9 (2.8)	12.1 (3.1)	14.4 (3.7)
Design Data											
Temperature Increase °C (°F)	<0.5 (<1)	<0.5 (<1)	<0.5 (<1)	<0.5 (<1)	<0.5 (<1)	<0.5 (<1)	<0.5 (<1)	<0.5 (<1)	<0.5 (<1)	<0.5 (<1)	<0.5 (<1)
Velocity m/sec (ft/sec)	0.6 (2)	0.6 (2)	0.6 (2)	0.6 (2)	0.6 (2)	0.6 (2)	0.6 (2)	0.6 (2)	0.6 (2)	0.6 (2)	0.6 (2)
Pressure Drop bar (psig)	0.14 (2)	0.14 (2)	0.14 (2)	0.14 (2)	0.14 (2)	0.14 (2)	0.14 (2)	0.14 (2)	0.14 (2)	0.14 (2)	0.14 (2)
Max. Operating Pressure bar (psig)	3.0 (45)	3.0 (45)	3.0 (45)	3.0 (45)	3.0 (45)	3.0 (45)	3.0 (45)	3.0 (45)	3.0 (45)	3.0 (45)	3.0 (45)
Flowrate m^3/hr (gal/minute)	9 (40)	14 (60)	27 (120)	34 (150)	27 (120)	34 (150)	9 (40)	14 (60)	27 (120)	27 (120)	34 (150)

Biofouling Control for the Power Market

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 injected at the intake structure and the intake basin to control biological growth.



Coastal or inland thermal power stations powered by nuclear energy or fossil fuel typically use seawater as a coolant in steam condensers. Controlling the fouling of the steam condensers in once-through cooling water systems can greatly increase the efficiency of power generation. For example, in a typical 250 MW coal-fired power plant, an increase of 0.2 inches of mercury in condenser back pressure (due to fouling) can cost the utility as much as USD $250,000 annually in fuel and replacement power costs.



Sodium hypochlorite is introduced into seawater intake of a power station to prevent fouling of the mechanical equipment, such as the seawater circulating pumps, bar screens and drum screens of the power station.

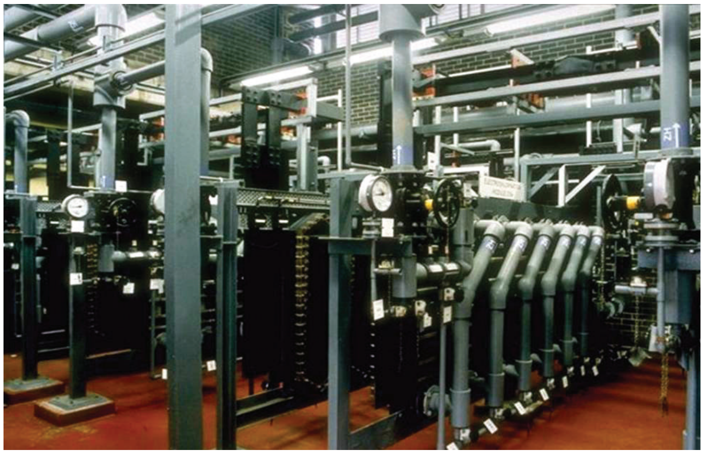
- Typical production rate of 500 – 2500 ppm of NaOCl
- Typical continuous dosing rate of 1 – 2 ppm and typical shock dosing rate of 4 – 6 ppm for 15 – 20 minutes 2 – 4 times per day
- Electrochlorination plant automatically controls sodium hypochlorite output to maintain typical outfall residual of 0.1 to 0.5 ppm

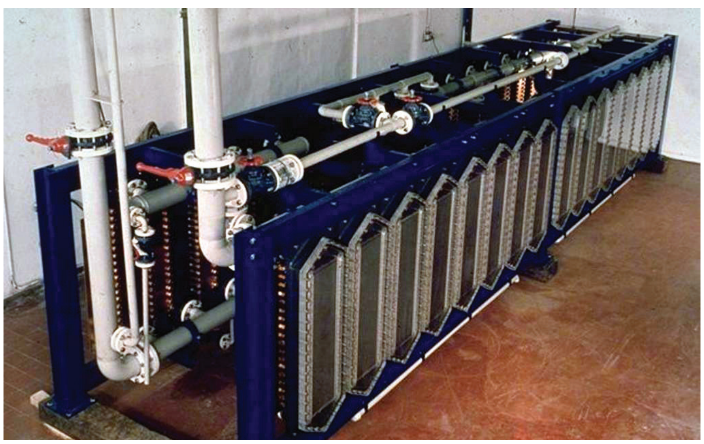
SANILEC® Partial Installation List

Project/Client	Location	Total Capacity (kg/day) of Available Chlorine	Year Commissioned
Gladstone Power Station: Queensland Electric Generating Board	Australia	2268	1985
Angra II: Electric Nuclear	Brazil	8500	1999
Dalian Power Station: HIPDC	China	3628	1997
Ling Ao Nuclear Power Station: Guangdong Nuclear Power	China	8400	2001
Andres Power Station: AES Aurora	Dominican Republic	3000	2002
Ataka Power Station Unit 3: Canal Electricity Company	Egypt	3220	1985
Lavrion Power Station: Public Power Corporation	Greece	3384	1997
Blackpoint Power Station: China Light & Power	Hong Kong	12442	1995 / 1997
Paiton Power Station: PLN	Indonesia	8707	1997
Kori Power Station Units 3 & 4: Korea Electric Power Corporation	Korea	5445	1982
Yonggwang Unit 3 & 4: Korea Electric Power Corporation	Korea	10884	1991
Yonggwang Unit 5 & 6: Korea Electric Power Corporation	Korea	14694	1996
Misurata Power Station: Hyundai	Libya	15460	1985
Jana Manjung Power Station: Tenaga Nasional Berhad	Malaysia	16400	2001
Port Klang Phase II: Tenaga Nasional Berhad	Malaysia	22452	1997
Laguna Verde: Comision Federal de Electricidad	Mexico	3270	1994
Hub River Power Station: National Power	Pakistan	8400	1995
Illigan: Korea Electric Power Corporation	Phillipines	7348	2000
Ras Abu Fontas "B": Ministry of Electricity and Water	Qatar	12240	1997
Jubail United PetroChemical CO: United Olifins Complex	Saudi Arabia	3386	2004
Tuas : Public Utility Singapore	Singapore	4979	2000
Pulau Seraya Power Station Phase III: Power Senaya Limited	Singapore	5064	1995
Banias Generation Company	Syria	4320	1998
Taichung Power Station: Taiwan Power Company	Taiwan	10776	1989
Um Ul Nar West Units 9 & 10: Abu Dhabi Water and Electricity Department	U.A.E.	3267	1978
Kingsnorth Power Station: Power-Gen	United Kingdom	7728	1985
Tacoa Power Station: La Electricidad de Caracas	Venezuela	3492	1982

SANILEC®
Seawater Electrochlorination Systems

Installation Photos





For more information on Sanilec® Seawater Electrochlorination Systems visit **www.denora.com**

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