



*This document is part of Appendix A, and includes Seawater Piping Biofouling Prevention: Nature of Discharge for the “Phase I Final Rule and Technical Development Document of Uniform National Discharge Standards (UNDS),” published in April 1999. The reference number is EPA-842-R-99-001.*

# Phase I Final Rule and Technical Development Document of Uniform National Discharge Standards (UNDS)

## **Seawater Piping Biofouling Prevention: Nature of Discharge**

April 1999

# NATURE OF DISCHARGE REPORT

## *Seawater Piping Biofouling Prevention*

### 1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)--either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

## **2.0 DISCHARGE DESCRIPTION**

This section describes the seawater piping biofouling control discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3). This report does not cover discharge of seawater cooling water from systems which use copper piping as the only biofouling preventative--this discharge is covered in the separate "Seawater Cooling Overboard Discharge" Nature of Discharge report.

### **2.1 Equipment Description and Operation**

The detrimental effects of marine biofouling on vessel performance have long been recognized by the Navy. The effects from biofouling are fouled surfaces of shipboard piping, heat exchangers and other related equipment used to distribute seawater aboard vessels resulting in flow restrictions and loss of heat transfer efficiency. Seawater cooling systems on vessels are used to provide cooling water for propulsion plant and auxiliary system heat exchangers. Heat exchangers remove heat directly from the main propulsion machinery, the electrical generating plants, air conditioning plants, and directly or indirectly from all other equipment requiring cooling. Seawater cooling systems draw seawater either directly, via a hull connection (sea chest), or indirectly, via a seawater header or the firemain that is supplied directly from a hull connection. The seawater is pumped through heat exchangers where the seawater absorbs heat and is then discharged overboard.

Preventing biofouling in seawater cooling system heat exchanger tubes is essential for maintaining peak heat exchanger operation and optimum propulsion plant performance. Marine biofouling prevention is accomplished on certain vessels with on-board chlorinators that inject low concentrations of sodium hypochlorite, a chlorine solution, at or near seawater cooling system intakes. See Figure 1 for a schematic diagram of a typical shipboard chlorinator treatment system. Chlorinators convert some chloride in seawater into a sodium hypochlorite solution in an electrolytic cell. The hypochlorite solution from the cell is then piped to the seawater intake or to junction piping at or near the seawater intake, where it is metered into the seachest. This provides treatment of the seawater prior to passing through the cooling system piping and components. The chlorine solution inhibits the growth of biofouling organisms or prevents them from attaching to the interior surfaces of seawater cooling system piping and components. A sampling connection at the outlet of the heat exchangers allows chlorine concentration levels to be monitored, and the injection rate to be modified as necessary.

In addition to chlorination, Military Sealift Command (MSC) vessels use two other methods to control biofouling; chemical dosing using an ethyl alcohol based chemical seawater dispersant, and anodic biofouling control systems.<sup>1</sup>

Chemical dosing as a means of biofouling control involves the periodic injection of a proportioned amount of an ethyl alcohol based chemical dispersant into the seawater cooling system at or near the point of seawater intake, usually a seachest, and is currently used on one MSC oiler. See Figure 2 for a schematic diagram of a typical shipboard chemical dosing

treatment system. The means of injection may include a gravity head tank and flowmeter, an eductor dosing system, or a pump and tank system directed to a seachest. The chemical is flushed through the system and then discharged with the seawater.

Anodic biofouling control systems are designed for continuous operation. See Figure 3 for a schematic diagram of a typical shipboard anodic biofouling control system. Several systems are currently in use. Each anodic system works on the same principle: an impressed current applied to copper anodes accelerates the dissolution of copper ions. The anodes are usually mounted in the sea chest of the vessel. Copper ions inhibit the propagation of marine life and prevent biofouling.

## **2.2 Releases to the Environment**

The purpose of chlorinating seawater is to protect the cooling system against biofouling caused by the attachment of living organisms. A chlorination system generates “free chlorine” in the form of a solution of sodium hypochlorite. This free chlorine reacts with various materials in seawater, including living tissue, as described in Section 3.3. Seawater discharged from cooling systems that are protected from biofouling with chlorine systems can contain residual free chlorine as well various reaction products resulting from the reaction of the free chlorine with organic material, ammonia, and bromide ion (see Section 3.3). In seawater, free chlorine and resulting reaction products are collectively called “chlorine produced oxidants” or CPO.

It is expected that the cooling water discharged from the MSC vessel that chemically doses its seawater cooling systems will contain the ethyl alcohol based dispersant. For those MSC vessels with anodic treatment systems, constituents from the copper anodes used are expected in the discharge.

## **2.3 Vessels Producing the Discharge**

Refer to Table 1 for Navy and MSC vessel discharges. All other Armed Force vessels do not use seawater piping biofouling control methods or equipment.<sup>2,3,4</sup>

## **3.0 DISCHARGE CHARACTERISTICS**

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

### **3.1 Locality**

Seawater biofouling treatment systems continuously discharge both within and beyond 12 nautical miles (n.m.) of shore as long as seawater cooling systems are in operation.

### 3.2 Rate

Table 1 presents estimated flow rates by ship class for pierside and underway conditions.<sup>3,4,5</sup>

Seawater cooling water flows vary with propulsion plant operating conditions and the system cooling requirements. There is a greater demand for cooling water when a vessel is underway because the propulsion plant is operating. However, the time spent underway while transiting within 12 n.m. is small compared to the time a vessel spends pierside and beyond 12 n.m. While pierside, the demand for seawater cooling is primarily from auxiliary equipment such as electrical generators, and air conditioning and refrigeration plants.

Anodic biofouling control systems are manually controlled systems normally pre-set for a current output of 0.2 amps,<sup>6</sup> which results in the generation of approximately 0.237 g copper/hr based on the following Faraday's Law calculation:

$$\frac{\{(0.2 \text{ amps}) (63.54 \text{ g copper/mole}) (1 \text{ coulomb/amp-sec}) (3,600 \text{ sec/hr})\}}{\{(2 \text{ equivalents/mole}) (96,484 \text{ coulomb/equivalent})\}} = 0.237 \text{ g copper/hr}$$

### 3.3 Constituents

Seawater dosed with sodium hypochlorite contains free chlorine in the form of hypochlorous acid (HOCl) and hypochlorite ion (OCl<sup>-</sup>). Free chlorine undergoes four important types of reactions in natural waters: (1) oxidation of reduced materials and subsequent conversion to chloride ion; (2) reaction with ammonia and organic amines to form chloramines, collectively called combined chlorine; (3) reaction with bromide to form hypobromous acid (HOBr) and hypobromite (OBr<sup>-</sup>), called "free bromine;" and (4) reaction with organics to form chloro-organics. Free bromine reacts in a manner similar to free chlorine, oxidizing reduced material or forming bromamines (combined bromine) or bromo-organics. Most common analytical methods for quantifying chlorine in water measure the sum of all free and combined chlorine and bromine in solution, but do not measure the chloro- and bromo-organics. The results of such measurements in seawater are reported as CPO. The Navy injects enough free chlorine to meet the chlorine demand, and ensure that there is sufficient excess CPO throughout the system to protect against biofouling.

Seawater treated with the chemical seawater dispersant contains primarily ethyl alcohol and ammonium chloride. Other constituents of this dispersant are unknown.<sup>1</sup>

For those MSC vessels with installed anodic biofouling control systems, components of copper ions are expected in the discharge.

Copper is the only priority pollutant in this discharge. There are no known bioaccumulators in this discharge.

### 3.4 Concentrations

On submarines, sodium hypochlorite solution containing hypochlorous acid and hypochlorite ion is injected continuously into seawater piping systems to maintain a CPO concentration of 100 µg/L at a sampling point within the system (i.e. before the point of discharge from the submarine). The actual CPO concentration at the point of discharge from the submarine is not measured. However, based on monitoring during initial system setup and system design data, the CPO concentration in seawater cooling overboard discharge is lower than the 100 µg/L concentration at the sample point. The concentrations of CPO discharged from MSC vessels are assumed to be similar to the concentrations discharged from submarines (i.e., 100 µg/L) because there are no available chlorine discharge data for MSC vessels.

Every three days, over the course of one hour, twelve liters of the chemical dosing seawater dispersant is metered into a 9,200 gallons per minute (gpm) cooling water system aboard one MSC oiler.<sup>1</sup> Assuming all of the chemical added is also discharged, based on this ratio, a concentration of approximately 6 mg/L in the discharge would result. The ethyl alcohol based dispersant is expected to degrade rapidly and to be less than 6 mg/L after mixing with the receiving waters.

Copper ion emission concentrations resulting from the use of anodic biofouling control systems is dependent on the current (amperage) output and the seawater flow rate. The current output is manually set (0.2 amps typically) and is not adjusted when seawater pumps are put on or taken off line which changes the seawater flow rate. For a flow rate of 1,000 gal/min and current output of 0.2 amps, the resultant concentration will be 1.04 µg/L based on the unit conversion calculation below:

Concentration = (mass copper) / (volume water) mass copper = 0.237 g/hr volume water = 1,000 gal/min (3.785 L/gal) (60 min/hr) = $2.27 \times 10^5$ L/hr concentration = $(0.237 \text{ g/hr}) / (2.27 \times 10^5 \text{ L/hr}) = 1.04 \times 10^{-6} \text{ g/L} = 1.04 \text{ µg/L}$
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A flow rate of 1,000 gal/min, was used for this sample calculation only. 1,000 gal/min is a round number and close to the flow rate of many fire pumps. Similar calculations can be performed for other flow rates, with the resultant concentrations presented in Table 1.

### 4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality standards. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

#### 4.1 Mass Loadings

Mass loadings were calculated in Table 2 based on ship movement data and the flow rates of seawater estimated from Table 1.<sup>7</sup> Calculations in Table 2 assumed that a chlorine concentration of 100 µg/L is continuously present in the seawater discharge. Most common analytical methods for quantifying chlorine in water measure the sum of all free and combined chlorine and bromine in solution. The results of such measurements in seawater are reported as CPO. The Navy injects enough “free chlorine” to meet the chlorine demand, and ensure that there is sufficient excess CPO throughout the system to protect against biofouling. The total estimated mass loadings for chlorine as CPO in Table 2 were calculated to be 2,538 pounds per year. The following is a sample calculation for the SSN 688 at pierside:

Cl <sub>2</sub> Mass Loading	=(0.1 mg/L)(1.41x10 <sup>8</sup> gal/yr)(3.7854 L/gal)(2.2 lb/kg)(1 kg/1x10 <sup>6</sup> mg) =117 lb/yr
Cl <sub>2</sub> concentration	=0.1 mg/L (Mean concentration)
Flow rate	=141,000,000 gal/yr
Conversion gals to liters	=3.7854 L/gal
Conversion kg to lb	=2.2 lb/kg
Conversion mg to kg	=1 kg/1x10 <sup>6</sup> mg
Cl <sub>2</sub> Mass Loading	=117 lb/yr

The dispersant dosing treatment system injects 12 liters of dispersant 26 times per year.<sup>1</sup> At a weight of 8.23 pounds per gallon (lb/gal), a total of 678 pounds (82 gallons) of the dispersant are added to over 1.033 billion gallons of seawater cooling water while in port. It was assumed that with only 48 hours of transit time annually (with an average of 4 hours per transit), dispersant dosing evolutions would not take place during transit.

Dispersant Mass Loading	= (26 inj/yr)(12 L)(8.23 lb/gal)(.2642 gal/liters) = 678 lb/yr
Injections per year	= (78 days in port)/(Inject every 3 days) = 26 inj/yr
Amount Injected	= 12 liters per injection
Conversion gals to lb	= 8.23 lb/gal
Conversion liters to gal	= .2642 gal/liters
Dispersant Mass Loading	= 678 lb/yr

For the 19 MSC vessels with anodic biofouling control systems, using the copper discharge rate of 0.237 g copper/hr and the estimated annual seawater discharge flow rates from these vessels (Table 1 and 2), yields a total copper mass loading of 25.0 pounds per year.

#### 4.2 Environmental Concentrations

Table 3 compares the constituent concentrations from Section 3.4 with the Federal and most stringent state water quality criteria for CPO and copper. The estimated concentrations of

CPO exceed the most stringent state water quality criteria.

Based on monitoring and system design data, CPO levels are estimated to be less than 100 µg/L for seawater discharges on submarines. There are no Federal water quality criteria for chlorine. The most stringent state water quality criteria is 7.5 µg/L. The concentration value of 100 µg/L is measured as CPO which is primarily chlorine but can also include a small amount of bromine.

A computer model was used that plotted chlorine plumes (using existing and planned chlorine discharge levels) from various vessels in Mayport, Florida. Mayport is the smallest of the five major naval ports. Plume dimensions at critical concentrations (7.5, 10, and 13 µg/L) were compared with mixing zone limitations enforced by the states of Virginia and Washington. Virginia and Washington are used because they are the only states with clearly defined mixing zones. Only the chlorine plume from the MSC vessels did not meet the mixing requirements of the selected states. This plume spread out during the later stages of mixing and exceeded certain mixing zone width requirements.<sup>8</sup> The computer model did not assume expected decay of CPO, which would result in smaller mixing zones.

#### **4.3 Potential for Introducing Non-indigenous Species**

Biofouling prevention systems do not present an opportunity for transport of non-indigenous species. The anti-biofouling systems are designed to prevent organisms from attaching to any part of seawater systems so they are discharged directly overboard in the same geographical area in which they are pulled into the system.

### **5.0 CONCLUSION**

Seawater piping biofouling control discharge has the potential to cause an adverse environmental effect. For chlorinator biofouling prevention systems, chlorine is discharged in significant amounts at concentrations expected to exceed ambient state water quality criteria. The use of anodic biofouling control systems results in the discharge of copper overboard. The copper concentration being significantly lower than water quality criteria, and the annual mass loading being very low, the discharges from anodic biofouling control have a low potential for causing adverse environmental effects.

### **6.0 DATA SOURCES AND REFERENCES**

Table 4 lists the data source of the information presented in each section of this NOD report.

#### **Specific References**

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2. Aivalotis, J., USCG, Personal communication with David Eaton, M. Rosenblatt & Son. April 25, 1997.
  3. Kurz, Richard J., SEA 92T251. Equipment Expert Meeting Structured Questions, “Seawater System Chlorination with Dechlorination,” September 5, 1996.
  4. UNDS Equipment Expert Meeting (October 2, 1996) Minutes. Chlorinator/Dechlorinator. October 11, 1996.
  5. UNDS Round Two Equipment Expert Meeting Minutes, Seawater Piping Biofouling Control Discharge, April 4, 1997.
  6. Cathelco Limited Information Packet, December 24, 1997.
  7. Pentagon Ship Movement Data for Years 1991 - 1995, Dated March 4, 1997.
  8. Malcolm Pirnie Inc., “Environmental Effects Analysis: Chlorination of Seawater Cooling Systems for Biofouling Prevention,” September 1997.

### **General References**

- USEPA. Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B). 40 CFR Part 131.36.
- USEPA. Interim Final Rule. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States’ Compliance – Revision of Metals Criteria. 60 FR 22230. May 4, 1995.
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Mississippi. Water Quality Criteria for Intrastate, Interstate and Coastal Waters. Mississippi Department of Environmental Quality, Office of Pollution Control. Adopted November 16, 1995.

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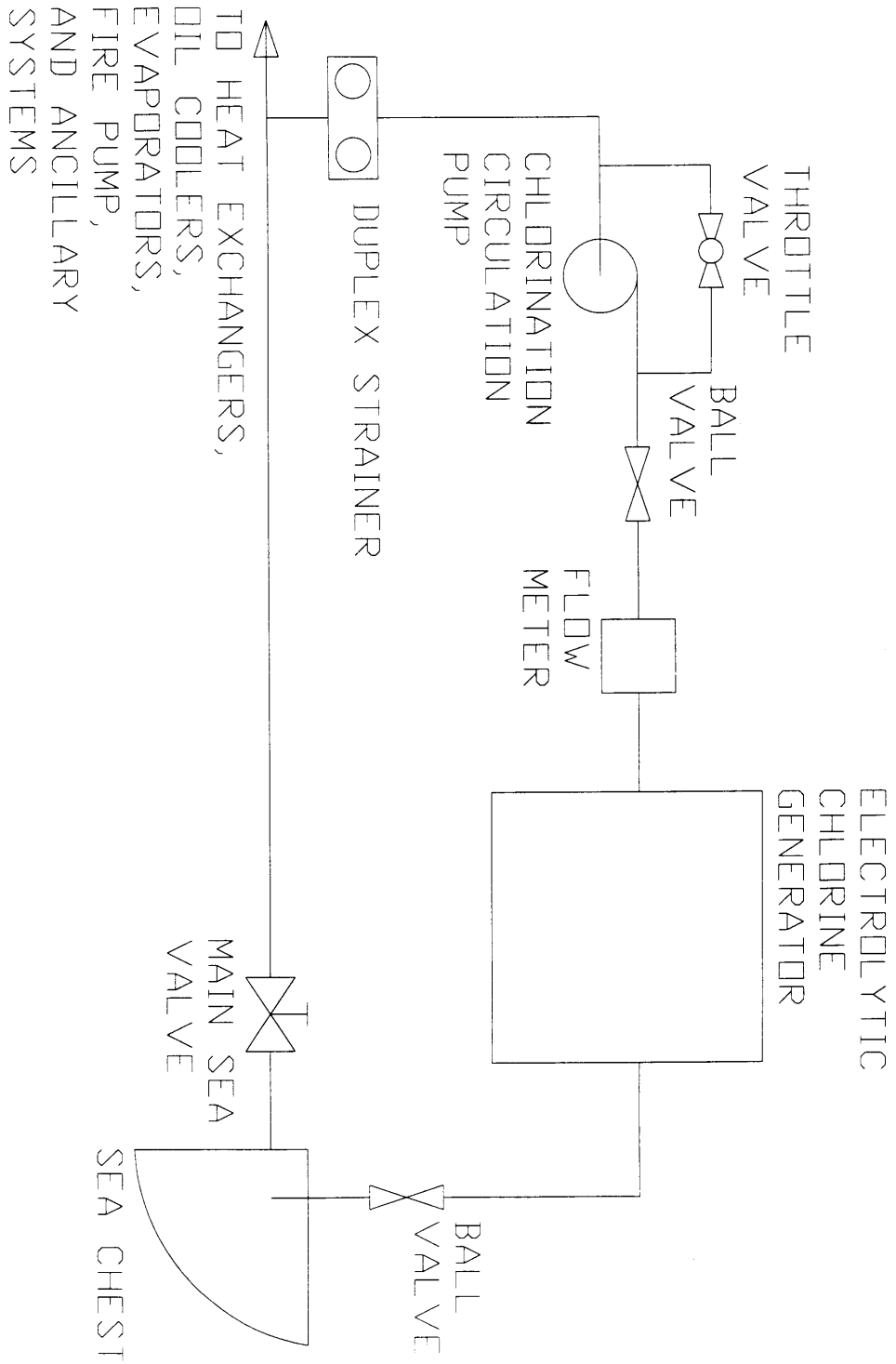
Texas. Texas Surface Water Quality Standards, Sections 307.2 - 307.10. Texas Natural Resource Conservation Commission. Effective July 13, 1995.

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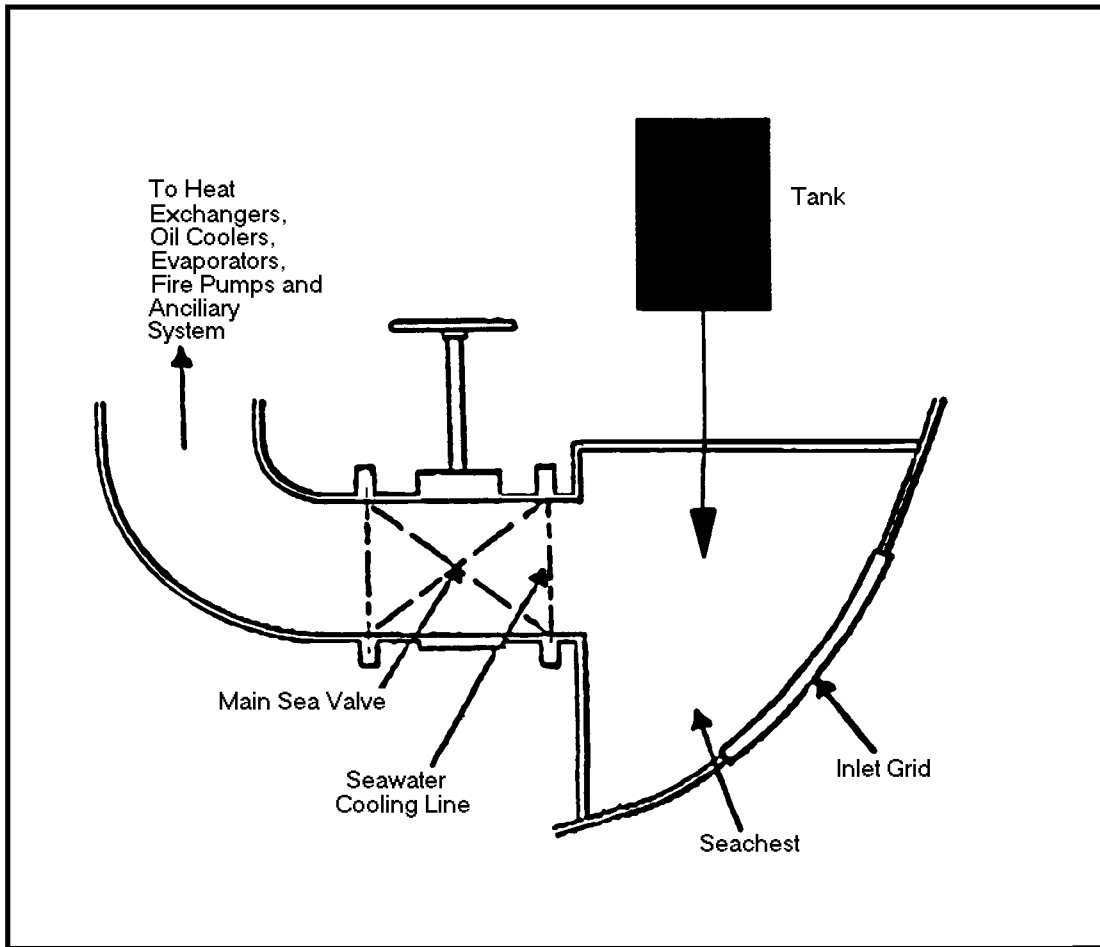
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Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

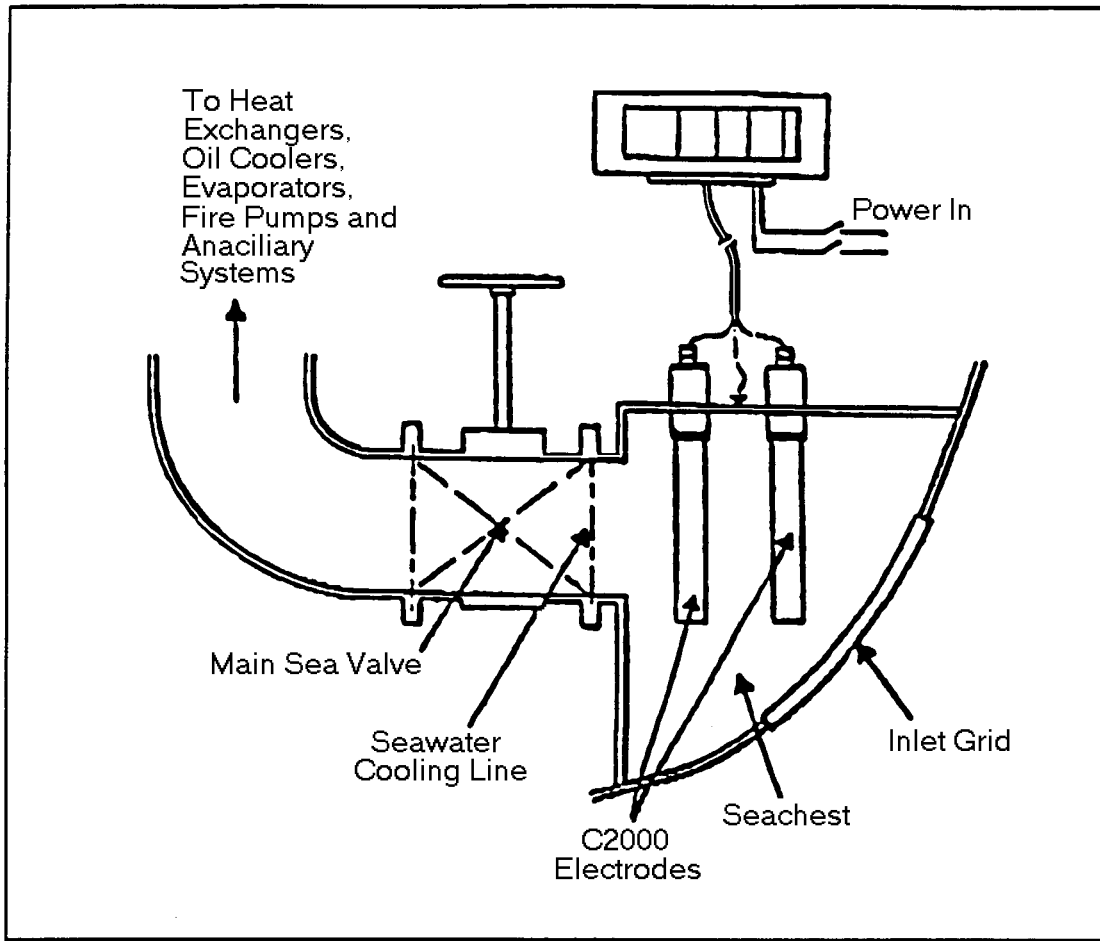
The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. March 23, 1995.



**Figure 1. Chlorination Systems Schematic**



**Figure 2. Typical Installation of Chemical Dosing System**



**Figure 3. Typical Installation of Anodic Biofouling Control System**

**Table 1 - Estimated Annual Seawater Cooling Water Discharge Volumes for Vessels With Seawater Piping Biofouling Control Systems**

Ship Class	Biofouling Control System	No. of Ships	No. of Transits per Year <sup>(1)</sup>	No. of Days In Port <sup>(1)</sup>	No. of Hours In Transit (<12 n.m.) <sup>(2)</sup>	Estimated Flow by Ship Class Pierside (gal/min)	Estimated Flow by Ship Class Underway (gal/min)	Concentrations (µg/L) pierside <sup>(3)</sup> U/W	Total Estimated Discharge Pierside (gal/year)	Total Estimated Discharge In Transit (<12 n.m.) (gal/year)
SSN 688 (Mod 25)	Chlorinator	4	14	183	56	133	192,000	100 <sup>(6)</sup>	141,000,000	1,790,000
T-AH	Chlorinator	2	8	184	32	2,000	40,500	100 <sup>(6)</sup>	1,070,000,000	156,000,000
T-AFS	Chlorinator	3	14	148	56	2,000	40,500	100 <sup>(6)</sup>	1,280,000,000	408,000,000
T-AO	Chemical Dosing <sup>(4)</sup>	1	12	78	48	9,200	40,500	6,000 <sup>(7)</sup>	1,030,000,000	117,000,000
T-AGS	Anodic <sup>(5)</sup>	5	12	96	48	1,500	6,840	0.69 0.15 <sup>(8)</sup>	1,040,000,000	98,500,000
T-AGOS 1 Class	Anodic <sup>(5)</sup>	6	8	70	32	1,500	6,840	0.69 0.15 <sup>(8)</sup>	907,000,000	78,800,000
T-AGOS 19 Class	Anodic <sup>(5)</sup>	4	10	107	40	1,500	6,840	0.69 0.15 <sup>(8)</sup>	924,000,000	65,700,000
T-AGM	Anodic <sup>(5)</sup>	1	8	133	32	2,000	40,500	0.52 0.026 <sup>(8)</sup>	383,000,000	77,800,000
T-ATF	Anodic <sup>(5)</sup>	3	34	166	136	1,650	7,500	0.63 0.14 <sup>(8)</sup>	1,180,000,000	184,000,000

- (1) In accordance with information presented in Reference 7.
- (2) Assuming an average transit time of 4 hours per vessel.
- (3) Differing pierside and underway (U/W) concentrations apply to vessels with anodic biofouling control systems
- (4) It is assumed that the same volume of chemical dispersant injected is also discharged (representing worst case).
- (5) Anodic biofouling control system concentrations were calculated based on a copper generation rate of 0.237 g/hr (Section 3.4)
- (6) Concentration of Chlorine as CPO
- (7) Concentration assuming the dispersant is 100% ethanol (representing worst case)
- (8) Concentration of copper

**Table 2 - Estimated Annual Mass Loading Calculations for Seawater Cooling Water Discharges from Vessels With Seawater Piping Biofouling Control Systems Currently Installed Onboard**

Ship Class	Biofouling Control System	Total Estimated Discharge Pierside (gal/year)	Total Estimated Discharge In Transit (<12 n.m.) (gal/year)	Estimated Flow by Ship Class Pierside (gal/min)	Estimated Flow by Ship Class Underway (gal/min)	Concentrations $\mu\text{g/L}$ pierside <sup>(1)</sup> U/W	Estimated Mass Loading Pierside (lb/yr)	Estimated Mass Loading In Transit (lb/yr)	Total Mass Loading by Type of System Pierside (lb/yr)	Total Mass Loading by Type of System In Transit (lb/yr)
SSN 688 (Mod 25)	Chlorinator	141,000,000	1,790,000	133	133	100 <sup>(4)</sup>	117	1.5	2,066	472
T-AH	Chlorinator	1,070,000,000	156,000,000	2,000	40,500	100 <sup>(4)</sup>	883	130		
T-AFS	Chlorinator	1,280,000,000	408,000,000	2,000	40,500	100 <sup>(4)</sup>	1,066	340		
T-AO	Chemical Dosing <sup>(2)</sup>	1,030,000,000	117,000,000	9,200	40,500	6,000 <sup>(5)</sup>	678	Note (7)	678	Note (7)
T-AGS	Anodic <sup>(3)</sup>	1,040,000,000	98,500,000	1,500	6,840	0.69 0.15 <sup>(6)</sup>	6.02	0.125	24.48	0.54
T-AGOS 1 Class	Anodic <sup>(3)</sup>	907,000,000	78,800,000	1,500	6,840	0.69 0.15 <sup>(6)</sup>	5.25	0.100		
T-AGOS 19 Class	Anodic <sup>(3)</sup>	924,000,000	65,700,000	1,500	6,840	0.69 0.15 <sup>(6)</sup>	5.35	0.083		
T-AGM	Anodic <sup>(3)</sup>	383,000,000	77,800,000	2,000	40,500	0.52 0.026 <sup>(6)</sup>	1.66	0.017		
T-ATF	Anodic <sup>(3)</sup>	1,180,000,000	184,000,000	1,650	7,500	0.63 0.14 <sup>(6)</sup>	6.21	0.213		

- (1) Differing pierside and underway (U/W) concentrations apply to vessels with anodic biofouling control systems
- (2) It is assumed that the same volume of chemical dispersant injected is also discharged (representing worst case)
- (3) Anodic biofouling control system concentrations were calculated based on a copper generation rate of 0.237 g/hr (Section 3.4)
- (4) Concentration of Chlorine as CPO
- (5) Concentration assuming the dispersant is 100% ethanol (representing worst case)
- (6) Concentration of copper
- (7) It is assumed that with only 48 hours of transit time annually (with an average of 4 hours per transit), chemical dosing evolutions would not take place during this time.

**Table 3. Environmental Concentrations and Water Quality Criteria (µg/L)**

Constituent	Concentration (µg/L)	Federal Chronic WQC (µg/L)	Most Stringent State Chronic WQC (µg/L)
CPO	100	-	7.5 (CT, HI, MS, NJ, VA, WA)
Copper	0.52 - 0.69	2.4	2.4 (CT, MS)

Notes:

Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)

Where historical data were not reported as dissolved or total, the metals concentrations were compared to the most stringent (dissolved or total) state water quality criteria.

CT = Connecticut  
 HI = Hawaii  
 MS = Mississippi  
 NJ = New Jersey  
 VA = Virginia  
 WA = Washington

**Table 4. Data Sources**

NOD Section	Data Source			
	Reported	Sampling	Estimated	Equipment Expert
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment			X	X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	X
3.3 Constituents	X		X	X
3.4 Concentrations	X		X	
4.1 Mass Loadings			X	
4.2 Environmental Concentrations	X		X	
4.3 Potential for Introducing Non-Indigenous Species			X	X