This document is part of Appendix A, and includes Freshwater Layup: 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)

Freshwater Layup: Nature of Discharge

April 1999

NATURE OF DISCHARGE REPORT

Freshwater Layup

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)~~eit~~her 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 freshwater layup 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).

2.1 Equipment Description and Operation

Seawater cooling systems on vessels provide cooling water for propulsion plant and auxiliary system heat exchangers. Heat exchangers remove heat directly from the main propulsion machinery and the electrical generating plants, and directly or indirectly from all other equipment requiring cooling. The primary purpose of the main seawater system is to provide the coolant to condense low pressure steam from the main turbines and the generator turbines.[1]

When nuclear-powered submarines and aircraft carriers remain for an extended period and the seawater cooling systems are not circulated, the main condensers are placed in a freshwater layup.[1] The purpose of placing the condensers in a freshwater layup is to prevent the accumulation of biological growth and the resultant loss of condenser efficiency while the seawater cooling system is not in use. The propulsion plants of nuclear-powered vessels generally require a 2- to 3-day cooling down period prior to being laid up.[1]

The layup is accomplished by blowing the seawater from the main condensers with low pressure air and isolating the condensers.[1] The condensers are then filled with potable water from port facilities, a process that takes 1 to 2 hours, or more, to complete.[2] The potable water remains in the condensers, uncirculated, for approximately 2 hours. After this period of time, the potable water fill is blown overboard with low pressure air, which takes approximately an hour to accomplish.[1,2] The condensers are then considered flushed of any residual seawater (seawater or potable water). The condensers are then refilled with potable water for the actual layup. This process can be referred to as a double fill and flush cycle.

After 21 days, the initial fill water is discharged overboard and replaced.[1] The layup is discharged and refilled on a 30-day cycle thereafter.[1] This process can be referred to as a refill cycle. The freshwater layup may be terminated at any point during these cycles to support equipment maintenance or ship's movement.[1]

During a ship check and sampling episode aboard USS Scranton (SSN 756), it was observed that the main seawater condensers were filled indirectly with freshwater from port facilities.[3] The crew filled the forward potable water tank from the pier connection and then transferred the freshwater to the aft potable water tank.[3] The main condensers were then put in freshwater layup from the aft potable water tank.[3] The initial freshwater layup process lasted greater than 5 hours (e.g., from the beginning of initial fill to initiating the low pressure air blow to remove the initial freshwater flush).[3]

The main steam condensers on submarines are constructed either of titanium or 70/30 copper/nickel alloy.[4] Aircraft carrier main seawater condensers are constructed of 90/10 copper/nickel alloy. The condenser boxes for the 70/30 copper/nickel alloy condensers are constructed of a nickel/copper alloy and can be lined with a tin/lead solder and have zinc anodes installed for corrosion control.[4] The seawater piping that carries cooling water from the condensers to overboard discharge is constructed of 70/30 copper/nickel piping.[4]

2.2 Releases to the Environment

These discharges occur in port at pierside when the submarine's nuclear power plant has cooled and the main seawater cooling system is unable to be circulated for more than 3 days. Also, this discharge can occur if the ship will be in port for greater than 7 days (i.e., It takes 72 hours to cool down a reactor and 72 hours to ramp up a reactor which translates to six days, or roughly one week.) and the seawater cooling system can not be circulated. The freshwater is discharged from the seawater cooling piping openings located below the waterline of the ship. The discharge occurs when the fresh water is pushed out by low pressure air applied to the seawater cooling piping system. It is expected that this discharge will contain many of the constituents found in the fresh water (typically supplied by port facilities) used for the layup, as well as metals leached from the ship's piping system while the water is held during the layup, and any residual seawater remaining in the system after the double fill and flush.

2.3 Vessels Producing the Discharge

All attack submarines (SSNs), ballistic missile submarines (SSBNs), and nuclear-powered carriers (CVNs) generate this discharge. A total of 89 SSNs and SSBNs, and eight CVNs are currently in service in the Navy. While the three existing nuclear guided missile cruisers (CGNs) also produce this discharge, these are scheduled to be removed from service by 2003/2004, and therefore, will not be considered further. The Navy is the only member of the Armed Forces that operates nuclear-powered vessels.

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

This discharge only occurs when vessels are in port.

3.2 Rate

The volume of the initial fill and flush of a nuclear-powered submarine is approximately 6,000 gallons of freshwater. This 6,000 gallons of freshwater is discharged overboard after a 1- to 2-hour layup in the main seawater condensers and refilled with an additional 6,000 gallons of freshwater as described in Section 2.1.[5] The total volume of freshwater required for the fill, flush, and refill of the condenser for freshwater layup on nuclear submarines is approximately 12,000 gallons, of which 6,000 gallons is discharged overboard.[5] The volume of this discharge will vary with the volumes of the main steam condensers for each submarine class.[5]

The amount of time that a submarine is in port, and hence, the number of layup cycles required, is dependent upon many factors, the most critical being the submarine's current mission. Each mission requires varying times in port for preparation, repairs, or modifications to support the mission specifics. In addition, many submarines undergo overhauls or other maintenance and/or repair activities that extend their time in port (e.g., must put their seawater systems into a dry layup condition).

Attack submarines (SSNs) average about 10 layup cycles per year, including five double fill and flush cycles and five refill cycles.[5] Each double fill and flush cycles and each refill cycle discharges approximately 6,000 gallons of freshwater per evolution. This results in 60,000 gallons of freshwater for each of the Navy's 72 SSNs per year. Therefore, fleet-wide discharge for the SSNs is 4,320,000 gallons of freshwater layup discharge per year, of which half is from the initial fill and half is from the refill cycles, or 2,160,000 gallons for each.

Ballistic missile submarines (SSBNs) have extended layovers of 1 to 1 1/2 months approximately three or four times per year. The volume of seawater systems in ballistic missile submarines are comparable to those of attack submarines. These submarines have an estimated three initial flush and fill cycles per year and approximately six refill cycles per year.[5] For an SSBN, this totals 54,000 gallons per submarine per year. The Navy operates 17 SSBNs. Therefore, the total freshwater layup discharged for all SSBNs is estimated to be 918,000 gallons per year, of which 306,000 gallons is from the initial fill and flush and 612,000 gallons is from refill cycles.

A total estimated volume of 5,238,000 gallons of freshwater layup is discharged in U.S. ports from the 89 SSN and SSBN hulls. The initial fill cycle accounts for 2,466,000 gallons and the refill cycles account for 2,772,000 gallons.

Nuclear powered aircraft carriers do establish freshwater layups in their various condensers, but the effluent is dumped into the bilges of the ship rather than being discharged directly overboard. Hence, the residual water from the aircraft carriers' layup is covered under the Surface Vessel Bilgewater/OWS Nature of Discharge report.

3.3 Constituents

The freshwater used in the freshwater layup can contain disinfectants from potable water treatment. The most common disinfectant is chlorine. Some municipalities, however, are switching over to chloramine disinfection to reduce the amount of disinfectant by-products formed. This switch could be permanent or seasonal, with the chloramines added during the warmer months when formation of disinfectant by-products are more prevalent. It is noted that the constituent make-up of the freshwater used to conduct the layup will have a significant effect on the discharge.

The constituents that can be present in freshwater layup from nuclear-powered submarines include: copper, lead, nickel, chlorine, ammonia, nitrogen (as nitrate/nitrite, and total kjeldahl nitrogen), phosphorous and related disinfectants, chromium, tin, titanium and zinc. Chromium, copper, lead, nickel, and zinc are priority pollutants. None of these constituents are bioaccumulators. The freshwater layup of a single submarine was sampled to determine the constituents that are present in the discharge.

3.4 Concentrations

The water used to fill the main condensers, the initial layup discharge, and an extended, 21-day discharge were sampled from USS Scranton (SSN 756).[3] A total of 17 metals were measurable in the initial and extended layup discharges from the sampling event. The vast majority of the metals detected have sources from either the materials within the main steam condenser or from the domestic water treatment/distribution system. The metals and classical parameters detected in the discharge are compiled in Table 1. In addition, the mass loadings are estimated for those constituents that were detected in either the 2-hour or 21-day layup discharges. Three priority pollutant metals, copper, nickel and zinc, were detected in the discharge at elevated concentrations. Total chlorine was also detected in the initial layup discharge (28 μg/L), but not in the discharge after 21 days. The domestic water from the pier connection was also sampled for total and free residual chlorine levels and contained 1,200 μg/L and 1,000 μg/L, respectively.[3] Nitrogen (as nitrate/nitrite, and total kjeldahl nitrogen), ammonia, and phosphorous were detected in both the 2-hour layup and the 21-day layup discharges.

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 criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Based upon the concentrations of the metals reported for the layup effluents in Table 1 and the estimated discharge volumes in Section 3.2, the mass loadings were calculated using the estimated volumes of freshwater layup discharge in Table 2 for those constituents that exceeded either Federal or most stringent state water quality criteria (WQC). Table 3 highlights the constituents that exceed WQC. The estimated mass loadings, provided in Table 2, are derived by adding together contributions from both the initial fill volumes and the refill cycle volumes, because the two portions of the effluent have different concentrations.

$$(\text{conc. } \mu g/L)(g/1{,}000{,}000\ \mu g)\ (lbs/453.593\ g)\ (\text{annual volume gal/yr})\ (3.785\ l/gal) = \text{mass loading (lbs/yr)}$$

Based on the sampling data, the total fleet-wide loadings of ammonia, nitrogen, chlorine, copper, nickel, phosphorous, and zinc from this discharge are approximately 41, 55, 1, 7, 36, 8, and 29 pounds per year, respectively.

4.2 Environmental Concentrations

The discharge concentrations presented in Table 3 are compared to Federal and most stringent state WQC.

Copper was present in the fill water from the aft potable water tank, but it is unknown if copper was present in domestic water from the pier connection. The fill water copper concentrations exceeded Federal and the most stringent state. Copper is normally present in the domestic water supply in concentrations that exceed WQC because of the presence of copper-constructed components in drinking water distribution systems. The levels of copper can be partially attributable to the construction of the potable water systems on board the submarine through which the domestic water was routed prior to filling the main seawater condensers. These systems have copper piping and brass valves that can contribute copper to the water.

Table 3 shows the concentrations of the three priority pollutant metals (copper, nickel, and zinc) that exceed Federal and most stringent state WQC. The chlorine concentration from the initial 2-hour layup exceeds the most stringent state criterion. Ammonia, total nitrogen (as nitrate/nitrite, and total kjeldahl nitrogen), and total phosphorous concentrations in the two layup discharges exceed the most stringent state criterion. The presence of phosphorous in the effluent appears to be from the domestic water as the effluent concentrations for total phosphorous shows no increase over the fill water concentrations.

4.3 Potential for Introducing Non-Indigenous Species

There is no movement of the vessel during the layup process and the water used for the layup is chlorinated domestic water from shore facilities. As such, there is no potential for transporting non-indigenous species.

5.0 CONCLUSION

Freshwater layup of seawater cooling systems has a low potential of adverse environmental effects for the following reasons.

1. The mass loadings of chlorine, copper, nickel, and zinc are small although the concentrations exceed Federal and most stringent state WQC. The mass loadings of ammonia, nitrogen, and phosphorous are also small, but concentrations exceed the most stringent state WQC. The total annual mass loadings for ammonia,

nitrogen, chlorine, copper, nickel, phosphorous, and zinc contribute approximately 41, 55, 1, 7, 36, 8, and 29 pounds, respectively. The 89 submarines producing this discharge are geographically dispersed over seven ports.

2. There is no potential for the transfer of non-indigenous species.

6.0 DATA SOURCES AND REFERENCES

Process knowledge and sampling of this discharge were used in preparing this NOD report. Table 4 shows the sources of data used to develop this NOD report. The specific references cited in the report are shown below.

Specific References

1. Kurz, Rich, NAVSEA 92T251. UNDS Equipment Expert Meeting Structured Questions. Main Sea Water System Freshwater Layup. September 5, 1996.

2. Versar Notes, UNDS Freshwater Layup Sampling Meeting. NAVSEA. May 23, 1997.

3. UNDS Phase I Sampling Data Report, Volumes 1 - 13. October 1997.

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General References

USEPA. Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B). 40 CFR Part 131.36.

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

Kurz, Rich, NAVSEA 92T251. Submarine Main Steam Condenser Freshwater Layup E-mail. November 1996. H. Clarkson Meredith, III, Versar, Inc.

Jane's Fighting Ships, Capt. Richard Sharpe, Ed., Jane's Information Group, Sentinel House: Surrey, United Kingdom, 1996.

UNDS Ship Database, August 1, 1997.

Table 1. Summary of Detected Analytes

Constituent	Freshwater Influent	2-Hour Freshwater Effluent	21-Day Freshwater Effluent	Frequency of Detection	Mass Loading
Classicals	(mg/L)	(mg/L)	(mg/L)		(lbs/yr)
Alkalinity	26	27	46	1 of 1	1,616
Ammonia as Nitrogen	0.17	1.3	0.6	1 of 1	41
Chemical Oxygen Demand (COD)	12	BDL	48	1 of 1	1,108
Chloride	20	63	34	1 of 1	2,078
Nitrate/Nitrite	0.62	0.68	0.4	1 of 1	23
Sulfate	21	22.8	17	1 of 1	861
Total Chlorine	1.2	0.028	BDL	1 of 1	0.58
Total Dissolved Solids	140	232	82	1 of 1	6,657
Total Kjeldahl Nitrogen	0.70	0.63	0.81	1 of 1	32
Total Organic Carbon (TOC)	2.70	2.7	25	1 of 1	633
Total Phosphorous	0.22	0.19	0.19	1 of 1	8.3
Total Recoverable Oil and Grease	1.0	BDL	1.0	1 of 1	23
Total Sulfide (Iodometric)	6	3.0	BDL	1 of 1	62
Volatile Residue	76	165	BDL	1 of 1	3,388
Metals	(µg/L)	(µg/L)	(µg/L)		(lbs/yr)
Aluminum					
Dissolved	BDL	57.7	BDL	1 of 1	1.19
Total	109	43.9	BDL	1 of 1	0.90
Arsenic					
Dissolved	BDL	0.8	BDL	1 of 1	0.016
Barium					
Dissolved	35.5	27.5	25.6	1 of 1	1.16
Total	36.2	28.10	26.3	1 of 1	1.19
Beryllium					
Dissolved	BDL	BDL	0.75	1 of 1	0.017
Boron					
Dissolved	BDL	36.8	BDL	1 of 1	0.76
Total	BDL	37.5	BDL	1 of 1	0.77
Calcium					
Dissolved	15700	17050	19800	1 of 1	807
Total	16000	16750	20400	1 of 1	815
Copper					
Dissolved	135	137	107	1 of 1	5.3
Total	136	150	148	1 of 1	6.5
Lead					
Dissolved	BDL	BDL	3.45	1 of 1	0.08
Total	2.3	2.0	4.75	1 of 1	0.15
Magnesium					
Dissolved	2720	6880	5185	1 of 1	261
Total	2860	6890	5495	1 of 1	268
Manganese					
Dissolved	BDL	19.7	276	1 of 1	6.8
Total	6.3	21.8	310	1 of 1	7.6
Nickel					
Dissolved	BDL	409	1175	1 of 1	35.6

Total	BDL	433	1175	1 of 1	36.1
Selenium					
Dissolved	BDL	BDL	2.45	1 of 1	0.057
Total	BDL	BDL	1.60	1 of 1	0.037
Sodium					
Dissolved	10500	39200	17800	1 of 1	1,216
Total	10500	37550	21400	1 of 1	1,265
Thallium					
Dissolved	BDL	0.75	BDL	1 of 1	0.015
Total	1.3	BDL	BDL	1 of 1	(a)
Tin					
Dissolved	5.1	BDL	BDL	1 of 1	(a)
Total	4.2	BDL	2.75	1 of 1	0.06
Zinc					
Dissolved	137	463	784	1 of 1	27.7
Total	127	451	851	1 of 1	29
Organics	(µg/L)	(µg/L)	(µg/L)		(lbs/yr)
Bis(2-ethylhexyl) phthalate	137	BDL	BDL	1 of 1	(a)

BDL - Denotes the below the detection for the method and instrument.
(a) No mass loadings are calculated for constituents that were not detected in either the 2-hour or 21-day freshwater layup discharge.

Log normal means were calculated using measured analyte concentrations. When a sample set contained one or more samples with the analyte below detection levels (i.e., "non-detect" samples), estimated analyte concentrations equivalent to one-half of the detection levels were used to calculate the mean. For example, if a "non-detect" sample was analyzed using a technique with a detection level of 20 mg/L, 10 mg/L was used in the log normal mean calculation.

Table 2: Estimated Annual Mass Loadings for Freshwater Layup Discharge

Analyte	2-hr Layup Conc. (μg/L)	Estimated Mass Loadings (lbs/yr)	21-day Layup Conc. (μg/L)	Frequency of Detection	Estimated Mass Loadings (lbs/yr)	Total Estimated Loadings, Freshwater Layup (lbs/yr) Fleetwide
Annual Volume (gal/yr):		2,466,000			2,772,000	
Copper						
Dissolved	137	2.8	107	1 of 1	2.5	5.3
Total	150	3.1	148	1 of 1	3.4	6.5
Nickel						
Dissolved	409	8.4	1175	1 of 1	27.2	35
Total	433	8.9	1175	1 of 1	27.2	36
Zinc						
Dissolved	463	9.5	784	1 of 1	18.7	27
Total	451	9.3	851	1 of 1	19.7	29
Ammonia as Nitrogen	1300	27	600	1 of 1	14	41
Nitrate/Nitrite	680	14	400	1 of 1	9	23
Total Kjeldahl Nitrogen	630	14	810	1 of 1	18	32
Total Nitrogen[A]	1310	28	1210		27	55
Total Chlorine	28	0.58	-	1 of 1	-	0.58
Total Phosphorous	190	3.9	190	1 of 1	4.4	8.3

A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 3: Mean Concentrations of Constituents Exceeding Water Quality Criteria

Constituent	2-Hour Layup Concentration	21-Day Layup Concentration	Federal Acute WQC	Most Stringent State Acute WQC
Metals (μg/L)				
Copper				
Dissolved	137	107	2.4	2.4 (CT, MS)
Total	150	148	2.9	2.5 (WA)
Nickel				
Dissolved	409	1175	74	74 (CA, CT)
Total	433	1175	74.6	8.3 (FL, GA)
Zinc				
Dissolved	463	784	90	90 (CA, CT, MS)
Total	451	851	95.1	84.6 (WA)
Classicals (mg/L)				
Ammonia as Nitrogen	1.3	0.6	None	0.006 (HI)[A]
Nitrate/Nitrite	0.68	0.4	None	0.008 (HI)[A]
Total Kjeldahl Nitrogen	0.63	0.81	None	-
Total Nitrogen[B]	1.31	1.21	None	0.2 (HI)[A]
Total Chlorine	0.028	-	None	0.010 (FL)
Total Phosphorous	0.19	0.19	None	0.025 (HI)[A]

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)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CA = California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 4. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and 3Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate				X
3.3 Constituents		X		X
3.4 Concentrations		X		
4.1 Mass Loadings		X		
4.2 Environmental Concentrations	X			
4.3 Potential for Introducing Non-Indigenous Species				X