UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

This document is part of Appendix A, Catapult Wet Accumulator Discharges: 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)

Appendix A

Catapult Wet Accumulator Discharges: Nature of Discharge

April 1999

NATURE OF DISCHARGE REPORT

Catapult Wet Accumulator Discharges

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 catapult wet accumulator discharges 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

Aircraft are launched from aircraft carriers using a steam driven catapult piston. Steam is supplied to a catapult from a 16,000-gallon pressure vessel known as a catapult wet accumulator. The wet accumulator contains a mixture of steam and saturated water at a high temperature and pressure. As steam is released from the accumulator for a launch, the pressure drops in the accumulator and water flashes to steam producing additional steam. The pressure from the steam against the catapult piston forces the piston to accelerate rapidly, providing sufficient force and velocity to launch the aircraft.[1] Each aircraft carrier has four catapults.

Approximately 8,000 gallons of boiler feedwater are used when initially filling an accumulator on conventionally-powered aircraft carriers. Similarly, 8,000 gallons of steam generator feedwater are used when initially filling an accumulator on nuclear-powered aircraft carriers. Feedwater from boilers and steam generators contain similar constituents. Feedwater is distilled fresh water from the ship's water generating plant. Steam from the ship's main steam plant is used to maintain the water level and to pressurize the accumulator to between 450 and 520 pounds per square inch (psi).[2] The steam is provided to the accumulator through a manifold that distributes the steam below the water level in the accumulator. Figures 1 and 2 show a schematic of a wet accumulator and its associated external and internal piping.

The continuous addition and condensation of steam during flight operations, while standing by for flight operations, or during catapult testing causes the water level in an accumulator to rise. Blowdowns are required to keep water level within operating limits, normally 40 to 50 inches of water.[2] Blowdowns to control water levels release up to 5 inches (750 gallons) of water from the accumulator.[3] The water is blown down through a pipe that is connected to the bottom of the accumulator and discharged overboard approximately 18 to 24 inches below the waterline through a seachest.[1]

Blowdowns also can be performed using a steam blowdown valve that is connected at the top of the accumulator. This valve can also be used to control the water level in the accumulator; however, its primary function is to reduce the pressure in the accumulator to atmospheric pressure prior to emptying the accumulator. Wet accumulators are emptied before major maintenance or if an aircraft carrier will be in port for 72 hours or longer.[2,4] To empty the wet accumulator, multiple blowdowns are performed over an extended period of time (up to 12 hours) to slowly reduce pressure and to minimize noise.

2.2 Releases to the Environment

Aircraft carrier catapult wet accumulators are initially charged with boiler or steam generator feedwater and fed with steam from the steam plant as the catapult is operated. The feedwater is treated with chemicals at specified rates to prevent scaling and corrosion, including oxygen scavengers and chelating agents. Unlike boilers, wet accumulators are unfired pressure vessels and scale and corrosion are not significant problems. Therefore, the treatment chemicals in the initial charge of boiler feedwater are expected to be unreacted and discharged from the wet accumulator during flight operations and blowdowns.[5,6,7,8] With each blowdown, the concentration of feed chemicals is reduced in the accumulator, and the concentration in the accumulator tank approaches that of steam condensate.

Some of the steam supplied to the accumulator is used directly to drive the catapult, while some condenses to distilled water, diluting the initial charge of boiler feedwater in the wet accumulator. The steam supplied to the wet accumulator is pure water with very minor amounts of constituents derived from the materials of construction of the steam generating and handling systems (e.g., copper nickel piping). In addition, there may be small amounts of water treatment chemicals. The constituents are expected to be similar to those found in steam condensate based on process knowledge of similarities in the materials of construction. The amounts of these constituents in steam directed to the wet accumulator are expected to be less than the amounts contained in steam condensate discharge because steam condensate discharge is produced from steam that has longer contact times with piping and equipment of the shore steam system. For the purposes of this NOD report, condensed wet accumulator steam was considered similar to steam condensate. Steam condensate is a separate UNDS discharge and is described in detail in the Steam Condensate NOD report.

2.3 Vessels Producing the Discharge

Only the Navy’s aircraft carriers produce this discharge. There are 12 aircraft carriers in the Navy, one of which is homeported in Japan. All of the remaining 11 aircraft carriers are homeported in the United States.

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

Wet accumulator blowdowns occur as a result of flight operations and catapult testing. Blowdowns resulting from flight operations occur outside 12 nautical miles (n.m.). Blowdowns resulting from catapult tests occur within 12 n.m.

Wet accumulators are emptied before major maintenance or when a ship will be in port for greater than 72 hours. In both cases, aircraft carriers empty the accumulator outside 12 n.m. when returning to port. However, after major maintenance has been performed on a wet accumulator or catapult, the wet accumulator is refilled and the entire catapult system tested in port. If the aircraft carrier will be in port for more than 72 hours after testing is complete, the accumulator will be emptied in port.[4]

3.2 Rate

Before each test, the wet accumulator is filled with approximately 8,000 gallons of boiler or steam generator feedwater. Based on process knowledge, approximately 50 catapult shots are performed during each test. Wet accumulators are emptied before major maintenance of the catapult system or if an aircraft carrier will be in port for 72 hours or longer. After catapult testing, the wet accumulator is blown down or drained of the original 8,000 gallons of feedwater and approximately 1,100 gallons of condensed steam accumulated from the catapult shots. To empty the wet accumulator, multiple blowdowns are performed over an extended period of time (up to 12 hours) to reduce pressure slowly and minimize noise. A blowdown of 5 inches of water, which is equivalent to approximately 750 gallons of water, typically takes about 5 minutes to complete.

Each of the 11 aircraft carriers in the fleet has four wet accumulators, which are tested as described above approximately once every 1.5 years. Thus, fleetwide, approximately 235,000 gallons of water are discharged within 12 n.m. each year from wet accumulators:

Wet Accumulator Annual Blowdown Volume (gallons per year) = (Wet accumulator feedwater capacity) (4 accumulators per carrier) (11 carriers) / (Frequency of test) = (8,000 gallons/accumulator)(4 accumulators/carrier)(11 carriers) / (1.5 years) = 235,000 gallons per year

Similarly, approximately 33,000 gallons of condensed steam are discharged annually:

33,000 gallons/year = (1,125 gallons/accumulator)(4 accumulators/carrier)(11 carriers) / (1.5 years)

3.3 Constituents

The constituents in the feedwater that is used to fill a wet accumulator include disodium phosphate, ethylenediaminetetraacetic acid (EDTA), and hydrazine. None of these constituents are priority pollutants. Based on the analysis of steam condensate samples, the priority pollutants antimony, arsenic, benzidine, bis(2-ethylhexyl) phthalate, cadmium, copper, lead, nickel, selenium, thallium, and zinc can be present in the condensed steam in the wet accumulator. There are no known bioaccumulators in this discharge.

3.4 Concentrations

Table 1 shows the concentrations of the constituents identified in Section 3.3. The table is divided into two sections. The first section shows the concentrations of the pollutants detected in steam condensate. As explained in Section 2.2, the steam supplied to the wet accumulator is expected to contain lower concentrations of these constituents than measured in steam condensate samples. Nevertheless, to be conservative, the concentrations of these constituents in steam condensate were used to estimate the mass loadings from the condensed steam portion of wet accumulator discharge.

The second section of Table 1 shows specified concentrations of boiler feedwater treatment chemicals. As stated in section 2.2 and to be conservative, these chemicals were assumed to be discharged at these concentrations in the boiler feedwater portion of wet accumulator discharge.

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 thermal effect of this discharge is discussed. In Section 4.4, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loading

Table 1 shows the estimated mass loadings of the constituents in wet accumulator discharge that were identified in Section 3.3. Fleet-wide annual mass loadings (in pounds/year) were estimated by multiplying the concentration of the constituents (in micrograms per liter (μg/L)) by the discharge rates from Section 3.2 (converted to liters per year) and the appropriate conversion factors using the following equation:

$$(\text{log-normal mean conc. } \mu g/l)(g/1{,}000{,}000\ \mu g)\ (lbs/453.593\ g)\ (\text{annual volume } l/yr)$$
$$\cong \text{mass loading } (lbs/yr)$$

The annual volume for this discharge is a combination of the volume of steam condensed per year (33,000 gallons) and the volume of feedwater (235,000 gallons) charged into the wet accumulator.

As shown in Table 1, the amounts of priority pollutants discharged annually from the condensed steam portion of wet accumulator discharge are significantly less than one pound. Because the constituent concentrations used to calculate the mass loadings are actually from steam condensate discharge -- thought to overestimate pollutant concentrations in wet accumulator steam -- the actual mass loadings in the condensed steam portion of wet accumulator discharge are probably lower. The annual, fleet-wide mass loadings of the boiler feedwater chemicals in wet accumulator discharge are estimated to be 195, 49, and 49 pounds for disodium phosphate, EDTA, and hydrazine, respectively.

4.2 Environmental Concentrations

Wet accumulator discharge is released directly to the environment. The estimated concentrations of the constituents in the discharge are shown in Table 1. The constituent concentrations for the condensed steam portion of the discharge shown in Table 1 are considered to be maximums for the reasons previously cited.

Based upon a comparison of the concentrations of all constituents in Table 1 to Federal and most stringent state water quality criteria (WQC), the concentrations of nitrogen (as ammonia, nitrate/nitrite, and total nitrogen), phosphorous, benzidine, bis(2-ethylhexyl) phthalate, copper, and nickel shown in Table 1 are discharged in excess of Federal and/or the most stringent state WQC. Table 2 shows the comparison of concentrations of those constituents that exceed WQC to their WQC.

The discharge will not significantly increase concentrations of pollutants near the ship. To empty the wet accumulator, multiple blowdowns are performed over an extended period of time (up to 12 hours) to reduce pressure slowly and minimize noise, so concentrations near the ship will be lower because the incremental discharges allow concentrations to dissipate.

4.3 Thermal Effects

The potential for catapult wet accumulator discharge to cause thermal environmental effects was evaluated by modeling the thermal plume using mixing conditions that would produce the largest plume and then comparing the thermal plume to state thermal discharge requirements. Thermal effects of catapult wet accumulator discharge were modeled using thermodynamic equations to estimate the plume size and temperature gradients in the receiving water body.[9] The model was run under conditions that would estimate the maximum plume size (e.g., minimal wind, slack water) for a wet accumulator on an aircraft carrier. The plume characteristics were compared to thermal mixing zone criteria for Virginia and Washington State.[9] Of the five states that have a substantial presence of Armed Forces vessels, only Virginia and Washington have established thermal mixing zone dimensions. Other coastal states require that thermal mixing zones be established on a case-by-case basis. Based upon this analysis, the discharge of a wet accumulator pierside does not cause thermal effects that exceed any known state criteria.[9]

4.4 Potential for Introducing Non-Indigenous Species

Given that the water in wet accumulators is condensed steam at a temperature of 460^{o}F, and the charging feedwater to the wet accumulators is distilled fresh water from the ship’s water generating plant, there is no potential for the transport of non-indigenous species.

5.0 CONCLUSION

Catapult wet accumulator discharge has a low potential to cause an adverse environmental effect because:

- Mass loadings of benzidine, bis(2-ethylhexyl) phthalate, nitrogen, phosphorous, copper, and nickel within 12 n.m. are small, less than a pound per year combined fleetwide, discharged at concentrations near WQC;
- The discharge contains small quantities of water treatment chemicals;
- Resulting contributions to environmental concentrations from the discharge are expected to be insignificant because the discharge event is spread out over multiple blowdowns that allow concentrations to dissipate; and
- The discharge of a wet accumulator pierside does not cause thermal effects that exceed known state thermal mixing zone criteria.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources were obtained. Process information and assumptions were used to estimate the rate of discharge. Based on this estimate and on concentration requirements of boiler feedwater chemistry, the concentrations of feedwater chemistry constituents resulting from this discharge were then estimated. Table 3 shows the sources of data used to develop this NOD report.

Specific References

1. UNDS Equipment Expert Meeting Minutes - Catapult Wet Accumulator Discharges, Round Two Meeting. March 14, 1997.

2. UNDS Equipment Expert Meeting Minutes - Catapult Wet Accumulator Steam Blowdown. August 20, 1996.

3. Joe Hungerbuhler, NSWCCD-SSES 9223. Information on Catapult Wet Accumulator Blowdown. November 1, 1996. Clarkson Meredith, Versar, Inc.

4. Commander, Naval Air Force, U.S. Atlantic Fleet. Responses to TYCOM Questionnaire. M. Rosenblatt and Son, Inc. May 20, 1997.

5. Naval Ship Systems Engineering Station, Memorandum - Boiler Blowdown Discharges. August 23, 1991.

6. UNDS Equipment Expert Meeting Structured Questions - Nuclear Steam Generator Blowdown/Safety Valve Testing Effluents. NAVSEA 08U, August 16, 1996.

7. NSWC, Carderock Division, Memorandum - Chelant Boiler Feedwater Treatment Implementation. March 18, 1995.

8. Naval Ships' Technical Manual (NSTM), Chapter 220, Volume 2, Revision 7, Sections 21 and 22. Boiler Water/Feed Water Test & Treatment. December 1995.

9. NAVSEA. Thermal Effects Screening of Discharges from Vessels of the Armed Services. Versar, Inc. July 3, 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.

USEPA. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants. 57 FR 60848. December 22, 1992.

USEPA. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California, Proposed Rule under 40 CFR Part 131, Federal Register, Vol. 62, Number 150. August 5, 1997.

Connecticut. Department of Environmental Protection. Water Quality Standards. Surface Water Quality Standards Effective April 8, 1997.

Florida. Department of Environmental Protection. Surface Water Quality Standards, Chapter 62-302. Effective December 26, 1996.

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Hawaii. Hawaiian Water Quality Standards. Section 11, Chapter 54 of the State Code.

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The Bureau of National Affairs, Inc., 1996.

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Virginia. Water Quality Standards. Chapter 260, Virginia Administrative Code (VAC) , 9 VAC 25-260.

Washington. Water Quality Standards for Surface Waters of the State of Washington. Chapter 173-201A, Washington Administrative Code (WAC).

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UNDS Equipment Expert Meeting Minutes - Aircraft Launch Equipment and Recovery Equipment Discharge Meeting. August 22, 1996.

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

Patty's Industrial Hygiene and Toxicology, 3rd Edition, George D. and Florence E. Clayton, Ed. John Wiley & Sons: New York, 1981.

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.

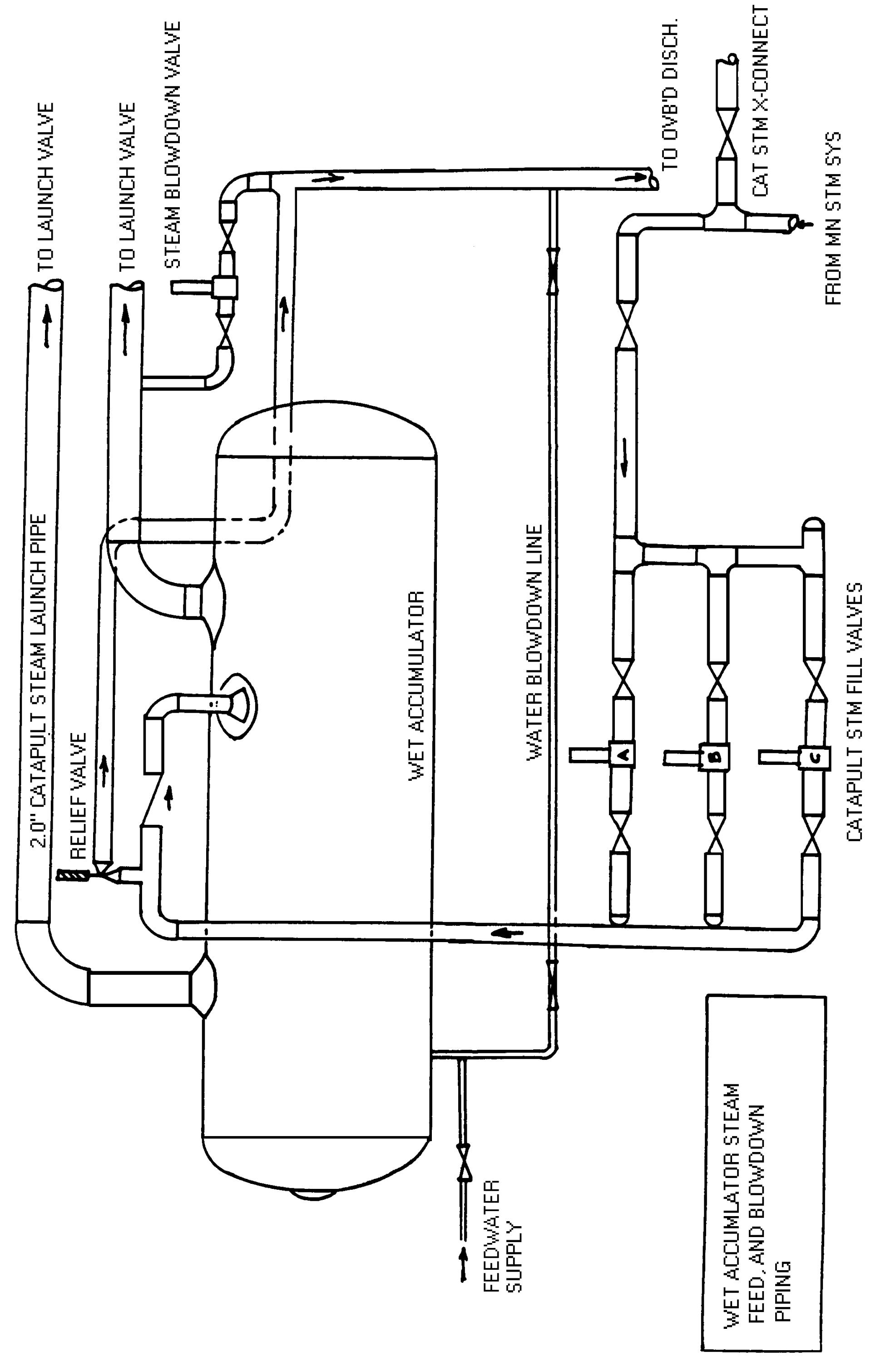

Figure 1. Wet Accumulator Steam, Feed, and Blowdown Piping

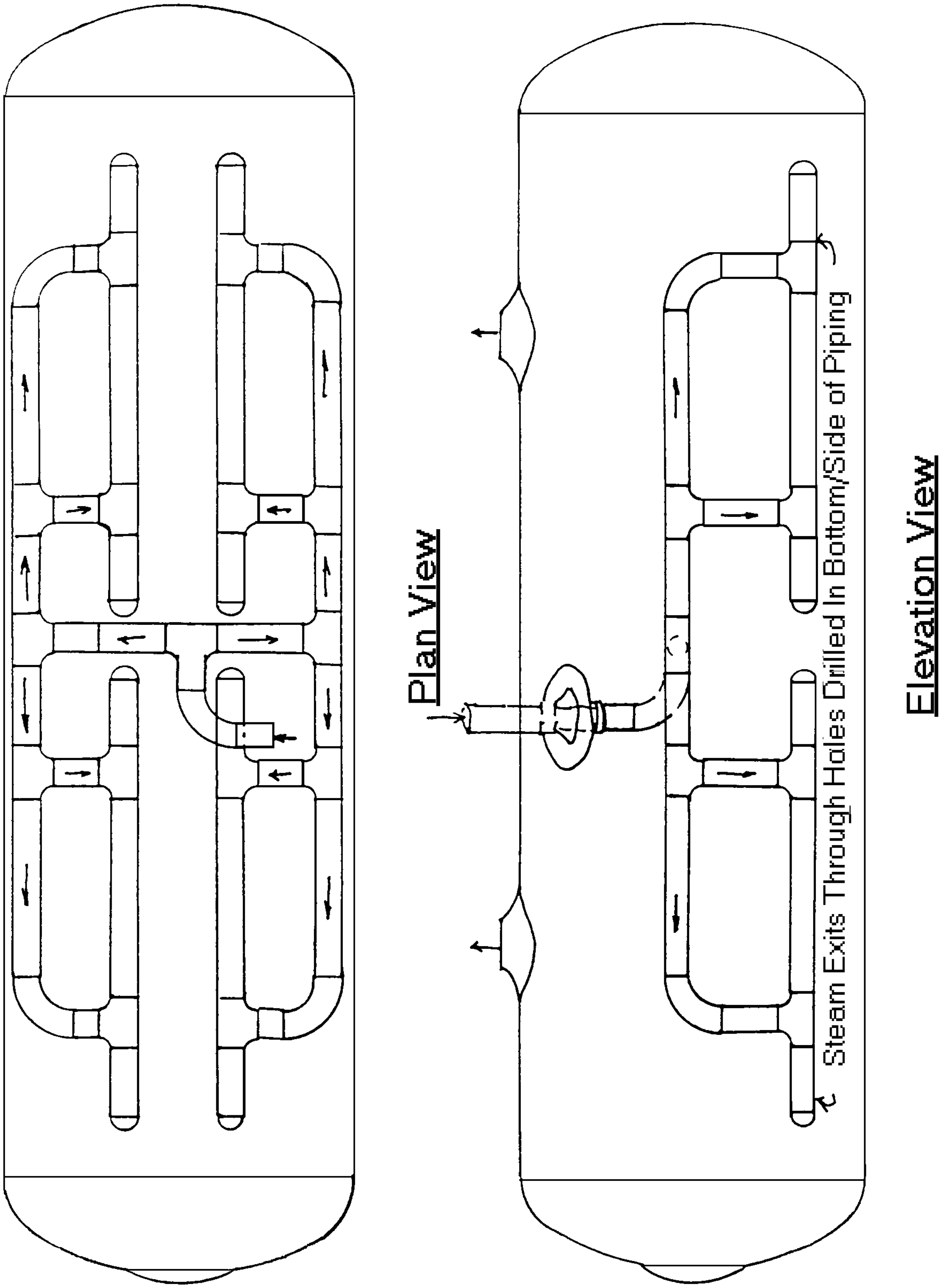

Figure 2. Wet Accumulator Internal Steam Charging Manifold

Table 1. Estimated Catapult Wet Accumulator Discharge Constituents, Concentrations, and Mass Loadings Based Upon Steam Condensate Sampling Data

Constituents	Concentrations (µg/l)		Rate of Wet Accumulator Discharge (l/yr)[3]	Fleet-Wide Mass Loading (pounds/yr)
From Steam Condensate[1]	**Log Normal Mean[2]**	**Concentration Range**		
Antimony				
Total	7.13	BDL - 26.8	125,000	2.0×10^{-3}
Arsenic				
Total	0.74	BDL - 2.3	125,000	2.0×10^{-4}
Cadmium				
Total	2.86	BDL - 6.1	125,000	7.9×10^{-4}
Copper				
Dissolved	13.4	BDL - 49.0	125,000	3.7×10^{-3}
Total	20.1	BDL - 91.0	125,000	5.5×10^{-3}
Lead				
Dissolved	3.58	BDL - 12.7	125,000	9.9×10^{-4}
Total	4.38	BDL - 18.9	125,000	1.2×10^{-3}
Nickel				
Dissolved	10.3	BDL - 22	125,000	2.8×10^{-3}
Total	11.6	BDL - 34.7	125,000	3.2×10^{-3}
Selenium				
Total	2.87	BDL - 3.5	125,000	7.9×10^{-4}
Thallium				
Dissolved	1.18	BDL - 13.3	125,000	3.3×10^{-4}
Zinc				
Dissolved	13.94	7.15 - 21.9	125,000	3.8×10^{-3}
Total	11.35	BDL - 23.0	125,000	3.1×10^{-3}
Ammonia as Nitrogen	180	120 - 370	125,000	4.9×10^{-2}
Nitrate/Nitrite	440	300 - 810	125,000	1.2×10^{-1}
Total Nitrogen	1240	NA	125,000	3.4×10^{-1}
Total Phosphorous	90	BDL - 270	125,000	2.5×10^{-2}
Benzidine	32.8	BDL - 73.5	125,000	9.0×10^{-3}
Bis(2-ethylhexyl) phthalate	19.4	BDL - 112	125,000	5.3×10^{-3}
From Boiler Feedwater Treatment Chemicals[4]				
Disodium phosphate	100,000	NA	888,000	196
Ethylenediaminetetraacetic acid (EDTA)	25,000	NA	888,000	49
Hydrazine	25,000	NA	888,000	49

The constituents listed above are those expected to be found in the wet accumulator discharge. BDL denotes below detection limit.

1. Constituents listed are the priority pollutants detected in steam condensate samples.
2. Highest of the dissolved and total log average values.
3. This value is the product of the annual wet accumulator discharge cited in section 3.2 and the conversion factor of 3.785 liters per gallon.
4. These concentrations are based on the specified rates of application of these constituents to boiler feedwater to inhibit scaling and corrosion.

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 also used to calculate the log-normal 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. Mean Concentrations of Constituents that Exceed Water Quality Criteria Catapult Wet Accumulator Discharge

Constituent	Log-Normal Mean Concentration (µg/L)	Federal Acute WQC (µg/L)	Most Stringent State Acute WQC (µg/L)
Ammonia as Nitrogen	180	None	6 (HI)[A]
Nitrate/Nitrite	440	None	8 (HI)[A]
Total Nitrogen	1240	None	200 (HI)[A]
Total Phosphorous	90	None	25 (HI)[A]
Benzidine	32.8	None	0.000535 (GA)
Bis(2-Ethylhexyl) Phthalate	19.4	None	5.92 (GA)
Copper [1]			
Dissolved	13.4	2.4	2.4 (CT, MS)
Total	20.1	2.9	2.5 (WA)
Nickel [1]			
Total	11.6	74.6	8.3 (FL, GA)

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.

[1] Assumes the constituents and their concentrations in this discharge are similar in concentration to the constituents found in steam condensate that originates from shore facilities.

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

Table 3. Data Sources

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