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

Appendix A

Dirty Ballast: Nature of Discharge

April 1999

NATURE OF DISCHARGE REPORT

Dirty Ballast

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 dirty ballast 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

Dirty ballast is created when seawater is pumped into fuel tanks for the purpose of improving ship stability. Ballast is weight added to a vessel to move the center of gravity to a position that increases the vessel's stability. Ballast is normally placed low within a vessel's hull to lower the center of gravity. Permanent ballast is usually heavy solid material, such as lead. Temporary ballast is normally seawater, which is pumped in and out of tanks in the vessel.

Dirty ballast systems are different from compensated ballast and clean ballast systems. Compensated ballast systems continuously replace fuel with water in a system of tanks as fuel is consumed. Clean (or segregated) ballast systems have tanks that only carry ballast water; therefore, the ballast water does not mix with fuel. These systems are covered in other NOD reports. In a dirty ballast system, water is added to a fuel tank after most of the fuel is used. Some fuel remaining in the tank mixes with the ballast water, producing "dirty" ballast.

Most classes of Armed Forces vessels use segregated tanks as the primary ballast system and use dirty ballast systems only in extraordinary or emergency situations. Some vessel classes, however, are not provided with clean ballast systems. These vessels regularly use dirty ballast systems and discharge overboard, using oil content monitors (OCM) and oil water separators (OWS) to avoid discharging oil at concentrations greater than regulatory limits.[1] Using fuel tanks for ballast water degrades fuel quality and is therefore avoided whenever possible.

As a vessel consumes fuel, air displaces the fuel in its fuel tanks, thus reducing the vessel’s stability. There is an added detrimental effect to stability when a tank is partially full and the liquid inside can slosh around. The degree to which these factors affect ship stability are dependent on ship design and the sea state. Some classes of ships are more susceptible to stability problems than others and certain locations have historically high wave action. When ship stability is threatened, ballast water can be pumped into a fuel tank to replace the consumed fuel and to regain stability. Ballast water is discharged when it is no longer needed for operational reasons or when preparing for fuel reintroduction.

To maintain safe stability, vessels without clean ballast systems may begin ballasting fuel tanks when remaining ship’s fuel drops to approximately 70-80% of total capacity. These vessels may continue to ballast fuel tanks until approximately 20% of ship’s fuel capacity remains (the minimum percentage allowed by U.S. Coast Guard (USCG) ships).[1] Therefore, by the end of a voyage, as much as 80% of the fuel tanks’ contents could be seawater.

Procedures have been established for both ballasting and deballasting to minimize the concentration of fuel in the dirty ballast. To prepare a fuel tank for ballast, most of the remaining fuel is pumped to another fuel tank. The small quantities of fuel not removed in this first step is transferred to a waste oil tank. When deballasting, most of the dirty ballast is pumped overboard, while being monitored by an OCM, which measures the concentration of oil (fuel) in the water. If the OCM detects oil concentrations in excess of the 15 parts per million (ppm), an alarm sounds and the overboard discharge is stopped. The remaining dirty ballast is then processed through an OWS to reduce the oil concentration to 15 ppm or below, as measured by another OCM. The processed seawater is discharged overboard and the separated oil (fuel) is retained in a waste oil tank for pierside disposal.

2.2 Releases to the Environment

Dirty ballast is water which may contain residual fuel and other constituents as a result of sea water being stored in fuel tanks. Dirty ballast is discharged to the environment after being processed through OCMs and/or OWS systems that ensure the ballast water fuel/oil concentrations are below Federal standards. The discharge is infrequent and occurs just above the waterline of the ship. The possible sources of the constituents of dirty ballast are seawater, fuel remaining in the tank, fuel additives, materials used in the ballast system, and the zinc anodes in the fuel tanks.

2.3 Vessels Producing the Discharge

Three USCG vessel classes use dirty ballast systems. Ships of the WHEC 378 Class (12 ships), WMEC 210 (16 ships), and the WAGB 399 Class icebreakers (2 ships) use their fuel tanks for ballasting in accordance with published Coast Guard directives and as conditions dictate.

In an emergency, all vessels of the Armed Forces with fuel tanks have the capability to generate emergency dirty ballast. Generation of emergency dirty ballast on Navy, MSC, Army, Air Force, Marine Corps, and the remainder of the USCG vessels occurs only when the vessels' clean or compensated ballast systems are insufficient to maintain proper stability during extraordinary or emergency circumstances. Emergency dirty ballast is not considered a discharge under UNDS, and is not addressed in this report.

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

Two of the three USCG ship classes (WHEC 378 and WAGB 399) that use dirty ballast systems operate beyond 12 nautical miles (n.m.) of land and only transit through 12 n.m. of land entering and leaving port. These ships may deballast within 12 n.m. of land using their OCM and OWS systems however this is rarely done. The third class of ship that uses a dirty ballast system is the USCG's WMEC 210. These ships are located in several ports on the East, Gulf and West Coasts. They may conduct normal operations within 12 n.m. of land on these Coasts, and therefore may ballast and deballast within 12 n.m. of land. These vessels also deballast using their OCM and OWS systems.

The policy for MSC and Navy vessels, and the practice of USCG vessels, is to discharge dirty ballast beyond 12 n.m. of shore, or to hold the dirty ballast until it can be transferred to a shore facility or containment barge.[2,3]

3.2 Rate

A survey found that few cutters routinely use dirty ballast within 12 n.m. even though USCG policy permits discharge within this area if using an OWS and OCM.[4] The limited number of ballasting operations were insufficient to estimate the annual volume of dirty ballast discharged. Therefore, for cutter class vessels, fuel capacities, and the maximum percentage of these fuel tank capacities that are allowed by USCG policy for dirty ballasting, were used to estimate the annual volume of dirty ballast discharged. This resulted in an overestimate of dirty ballast discharge volumes for USCG vessels. Table 1 lists USCG vessel fuel capacities.

Using 80% of fuel capacities listed in Table 1 to estimate the deballasting discharge for each deballasting event, WMEC 210 Class vessels could discharge approximately 41,800 gallons of dirty ballast [(0.8)(52,236 gallons)]. The WAGB 399 Class ships could generate up to 1,080,000 gallons of dirty ballast and WHEC 378 Class ships could generate up to 166,400 gallons per deballasting event. The estimated maximum total annual discharge of dirty ballast for the three classes of USCG ships is 21.6 million gallons, using the number of deballast events per year from Table 2 and the following calculations. All of this discharge is assumed to occur within 12 n.m. of shore and the results are believed by the USCG to be a gross overestimate of the actual discharge. Of this 21.6 million gallons, two-thirds is from one class (WHEC 378) which operates principally beyond 12 n.m.

Total (gal/yr) = sum of [(0.8)(capacity)(# vessels)(# deballasting events)]

where,

Total = estimated maximum dirty ballast total annual discharge

0.8 = maximum percentage of fuel tank capacity allowed by USCG policy for dirty ballast

capacity = fuel capacity in gallons

vessels = number of vessels per class

deballasting events = number of deballasting events per year

The estimated maximum dirty ballast total annual discharge for WHEC 378 Class ships is:

(0.80) (208,000 gallons of fuel) (12 vessels in the class) (7 deballasting events per year) = approximately 14 million gallons per year.

The duration of USCG vessels' dirty ballast discharge is estimated by considering deballasting procedures and equipment characteristics. Based on operational experience, approximately 75% of the dirty ballast can be discharged directly overboard while being monitored through an OCM at an estimated flow rate of 250 gallons per minute (gpm).[2] The remaining 25% of ballast is required to be processed through an OWS, at a flow rate of 25 gpm. Using a dirty ballast volume of 80% of vessel fuel capacity, an estimated flow rate of 250 gpm for direct ballast overboard discharge, and 25 gpm through the OWS, the discharge duration is summarized in Table 3. For example, the maximum time to deballast for WHEC 378 Class ships is approximately 36 hours.

These values result in the maximum expected time to deballast since the calculations assume the largest dirty ballast volume (the maximum allowed is 80% of the ship's fuel capacity) and ignore any processing of ballast through the OWS performed concurrently with the ballast being discharged directly overboard. Also, it is unlikely that the entire duration of deballasting is within 12 n.m. of shore, so the calculations overestimate the amount of dirty ballast discharged within 12 n.m.

3.3 Constituents

Because process information and data on compensated fuel ballast, a similar discharge, were sufficient to characterize this discharge, no sampling was performed on dirty ballast. The constituent sources of dirty ballast are almost identical to the constituent sources in compensated fuel ballast systems. Therefore, sampling performed for compensated fuel ballast discharge can be used to predict the constituents in dirty ballast.

Soluble components of the fuel remaining in the tank mix with the seawater ballast during extended contact while in the compensated fuel or dirty ballast tanks. The fuels will normally be either Naval Distillate Fuel (NATO F-76) or Aviation Turbine Fuel (JP-5). In addition, the USCG uses biocide fuel additives in their fuel tanks to control bacterial growth in the fuel-water interface.[5,6] All these sources can contribute to the concentrations reported as total petroleum hydrocarbons and oil and grease. Specific fuel-based constituents can include benzene, toluene, ethylbenzene, xylene, cresols, phenols, and polycyclic aromatic hydrocarbons.[7]

Materials used in fuel and ballast systems on the ships, which include copper, nickel, iron and zinc, and the fuel or additives in the fuel such as biocides, can contribute to metal concentrations in the discharge. Based on compensated ballast sampling, the metals in the discharge can include copper, nickel, silver and zinc. The biocides used can contain naphtha and dioxaborinane compounds.

The potential priority pollutants in dirty ballast discharge are 2-propenal, benzene, toluene, ethylbenzene, phenol, copper, nickel, silver, thallium, and zinc. The only bioaccumulator found in compensated ballast screening was mercury.

3.4 Concentrations

Knowledge of dirty ballasting systems and practices and use of compensated fuel ballast screening enables the characterization of dirty ballast discharge concentrations.

In support of the Compensated Ballast NOD report, a sampling effort was conducted during a refueling evolution. The results of the sampling effort are applicable to this NOD report because the same fuels are used in both compensated ballast and dirty ballast. Constituent concentrations are based on compensated ballast with the exception of oil concentrations, which are limited to 15 ppm by USCG practices and the use of OCMs and OWSs. The concentrations of detected priority pollutants, oil and grease, and a bioaccumulator are shown in Table 4.

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

An estimate of the maximum oil loading from dirty ballast for the three USCG vessel classes was calculated by first estimating the greatest potential discharge volume and assuming that the discharge contains the maximum allowable concentration of oil (15 ppm). In reality, the concentration is expected to be somewhat lower than this, due to the preballasting and deballasting procedures used by the USCG vessels, as described in Section 2.1. Using these values with existing information on vessel operating profiles, an annual oil mass loading value for each of the three USCG vessel classes was calculated.

The estimated maximum oil mass loading generated for each deballast event was calculated using the equation:

Estimated Maximum Oil Loading Generated by Deballasting Event in Pounds (lbs) =
[80% fuel capacity (gal)] (3.785 L/gal)(15 mg/L)(10^{-6} kg/mg)(2.205 lb/kg)

Using this equation, the estimated maximum oil loading generated in each deballasting event for WHEC 378 Class ships is:

(0.80)(208,000 gal)(3.785 L/gal)(15 mg/L)(10^{-6} kg/mg)(2.205 lb/kg) = approximately 21 lbs

Similarly, the WMEC 210 Class and the WAGB 399 Class would generate approximately

5 and 135 pounds of fuel for each deballasting event, respectively.

The annual maximum oil mass loading per class was calculated using the equation:

Estimated Maximum Oil Loading Generated by Deballasting (lbs/yr) = (discharge amt. per event (lbs))(# vessels)(# deballasts/year)
where,
discharge amt. = pounds of oil per deballasting event
vessels = number of vessels in class
deballasts/year = number of deballasting events per year

Using this equation, the estimated maximum oil loading generated by deballasting per year for WHEC 378 Class ships is:

(21 lbs per deballast) (12 vessels in class) (7 deballasting events per year) = 1,764 lbs/yr

Given the assumed maximum concentration of 15 ppm, the maximum total mass loading for oil for all Coast Guard vessels is 2,704 pounds per year as shown in Table 2.

In a similar manner, the concentrations of each of the constituents shown in Table 4 (which are based on compensated ballast data for constituent concentrations) were used to calculate the mass loadings shown in Table 5.

4.2 Environmental Concentrations

Dirty ballast water discharged from armed forces vessels is expected to be similar to the compensated ballast discharge. In compensated ballast samples, copper, nickel, silver, and zinc exceeded Federal and the most stringent state WQC, and ammonia, benzene, phosphorous, thallium, total nitrogen, O&G, and 2-propenal concentrations exceeded the most stringent state WQC.[7] Table 4 is a summary of compensated ballast sample concentrations and applicable WQC.

4.3 Potential for Introducing Non-Indigenous Species

There is no significant potential for introducing, transporting, or releasing non-indigenous species with dirty ballast discharge. Navy and MSC policy requires that all dirty ballast be discharged beyond 50 n.m., and those USCG vessels with a combination of clean and dirty ballast systems also follow that practice.[2,3] The potential is mitigated by the fact that the three classes of USCG vessels with exclusively dirty ballast systems do not take on ballast while in port and normally ballast and deballast beyond 12 n.m., where they are less likely to take on non-indigenous species. In addition, the USCG has a policy that states if a cutter does ballast within 12 n.m. of land, a full-tank ballast exchange should be conducted twice while in open waters beyond 12 n.m., otherwise, hold the ballast and discharge it on the next voyage beyond 12 n.m.

Dirty ballast could also be discharged to a shore facility for processing. Most USCG vessels deballast prior to returning to port, at greater than 12 n.m. from shore.

5.0 CONCLUSIONS

Uncontrolled, dirty ballast has the potential to cause an adverse environmental effect because:

1) oil can be discharged in significant amounts above water quality criteria, and

2) oil in the discharge can also create a sheen that diminishes the appearance on surface waters.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Table 6 lists data sources for this NOD report.

Specific References

1. LT. Aivalotis, Joyce, USCG, April 15, 1997, to File.

2. UNDS Equipment Expert Meeting Minutes, Dirty Ballast, August 2, 1996.

3. Department of the Navy. Environmental and Natural Resources Programs Manual, OPNAVINST 5090.1B, Chapter 19-10, November 1994.

4. Department of the Navy. Carderock Division, Naval Surface Warfare Center. Summary of Dirty Ballast Questionnaire Responses for the Uniform National Discharge Standards (UNDS) Program. NSWCCD-TM-63-98/48. March 1998.

5. Military Specification MIL-S-53021A, Stabilizer Additive, Diesel Fuel, August 15, 1988.

6. LT Aivalotis, Joyce, USCG, Dirty Ballast Reply, 20 May, 1997.

7. UNDS Phase 1 Sampling Data Report, Volumes 1-13, October 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.

Georgia Final Regulations. Chapter 391-3-6, Water Quality Control, as provided by The Bureau of National Affairs, Inc., 1996.

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

Mississippi. Water Quality Criteria for Intrastate, Interstate and Coastal Waters. Mississippi Department of Environmental Quality, Office of Pollution Control. Adopted November 16, 1995.

New Jersey Final Regulations. Surface Water Quality Standards, Section 7:9B-1, as provided by The Bureau of National Affairs, Inc., 1996.

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

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).

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.

Table 1. USCG Vessel Fuel Capacity and Consumption Data [8]

Vessel Class	WMEC 210	WHEC 378	WAGB 399
Fuel Capacity (100%) (gal):			
F-76 (diesel)	52,236	208,000	1,349,920

Table 2. Maximum Annual Oil Mass Loading Estimate for USCG Vessels

Vessel Class	No. of Vessels	Oil per Deballast Event (lb)	Deballast Events per Year	Maximum Oil Discharged (lbs/yr)[A]
WMEC 210	16	5	5	400
WHEC 378	12	21	7	1764
WAGB 399	2	135	2	540
				Total: 2,704 lbs/yr

Notes:

A - based on maximum allowable OWS system discharge concentration limit (15 ppm),

Table 3. USCG Vessel Dirty Ballast Discharge Duration

Vessel Class	WMEC 210	WHEC 378	WAGB 399
Amount to Deballast (gal)[A]	41,800	166,400	1,080,000
Direct Discharge (gal)	31,400	124,800	810,000
Direct Discharge (gpm)	250	250	250
Direct Discharge (hours)	2.1	8.3	54
OWS Processing (gal)	10,500	41,600	270,000
OWS Processing (gpm)	25	25	25
OWS Processing (hours)	7.0	27.7	180
Total Ballast Discharge Time (hours)[B]	9.1	36	234

Notes:

A - Amount to deballast is 80% of F-76 fuel capacity.

B - Time estimates are maximum values per deballast event, based on maximum ballast volumes and moderate direct discharge flow rates.

Table 4. Estimated Dirty Ballast Constituent Concentrations that Exceed Federal and/or Most Stringent State Water Quality Criteria Based on Compensated Ballast Sampling Measurements

Constituent	Maximum Dirty Ballast Concentration (µg/L)	Federal Acute WQC (µg/L)	Most Stringent State Acute WQC (µg/L)
Ammonia as Nitrogen	300	none	6 (HI)[A]
Benzene	153	none	71.28 (FL)
2-Propenal	203	none	18 (HI)
Total Nitrogen	580	none	200 (HI)[A]
Total Phosphorous	340	none	25 (HI)[A]
Copper	86	2.4	2.4 (CT, MS)
Mercury[B]	0.00083	1.8	0.025 (FL, GA)
Nickel	267	74	8.3 (FL, GA)
Silver	5.7	1.9	1.9 (CA, MS)
Thallium	10.8	none	6.3 (FL)
Zinc	4845	90	84.6 (WA)
Oil & Grease	15000	visible sheen[C] /15,000[D]	5000 (FL)

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 - Mercury was not found in excess of WQC; concentration is shown only because it is a bioaccumulator.
C - Discharge of Oil. 40 CFR 110, defines a prohibited discharge of oil as any discharge sufficient to cause a sheen on receiving waters.
D - International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). MARPOL 73/78 as implemented by the Act to Prevent Pollution from Ships (APPS).

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

Table 5. Estimated Maximum Annual Mass Loadings for Dirty Ballast Constituents that Exceed Water Quality Criteria

Constituent	Annual Mass Loading (lb/yr)
Ammonia[A]	54.2
Benzene[A]	27.6
Phosphorous[A]	61.4
Total Nitrogen	105
2-Propenal	36.6
Copper[A]	15.5
Nickel[A]	48.1
Silver[A]	1.0
Thallium	1.95
Zinc[A]	872.1
Mercury[A,B]	0.00015
Oil & Grease[C]	2704

Notes:

A - Based on constituent concentrations found in compensated ballast water

B - Mercury was not found in excess of WQC; mass loading is shown only because it is a bioaccumulator.

C - Oil and Grease mass loading based on maximum allowable OWS system discharge concentration limit (15 ppm), not on compensated ballast sampling results.

80% of the ship's fuel capacity is always used for ballast anytime a ship takes on ballast water.

Table 6. Data Sources

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