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

Distillation and Reverse Osmosis Brine: Marine Pollution Control Device

April 1999

DISTILLATION AND REVERSE OSMOSIS BRINE
MARINE POLLUTION CONTROL DEVICE (MPCD) ANALYSIS

Several alternatives were investigated to determine if any reasonable and practicable MPCDs exist or could be developed for controlling distillation and reverse osmosis (RO) brine discharges. An MPCD is defined as any equipment or management practice, for installation or use onboard a vessel, designed to receive, retain, treat, control, or eliminate a discharge incidental to the normal operation of a vessel. Phase I of UNDS requires several factors to be considered when determining which discharges should be controlled by MPCDs. These include the practicability, operational impact, and cost of an MPCD. During Phase I of UNDS, an MPCD option was deemed reasonable and practicable even if the analysis showed it was reasonable and practicable only for a limited number of vessels or vessel classes, or only on new construction vessels. Therefore, every possible MPCD alternative was not evaluated. A more detailed evaluation of MPCD alternatives will be conducted during Phase II of UNDS when determining the performance requirements for MPCDs. This Phase II analysis will not be limited to the MPCDs described below and may consider additional MPCD options.

MPCD Options

Distilling and RO plants generate freshwater from seawater for a variety of shipboard applications, including potable water for drinking, hotel services, aircraft and vehicle washdowns, boiler feedwater on steam-powered vessels, and auxiliary boiler feedwater on most vessels. Discharges from distilling and RO plants contain influent seawater, contaminants from system components, and anti-scaling treatment chemicals. Distilling plants boil seawater, and the resulting steam is condensed into distilled water. During the distilling process, seawater constituents form a scale on the heat transfer surfaces. Therefore, anti-scaling compounds are continuously injected into the influent seawater to control the scaling. The remaining seawater concentrate or "brine" that does not boil away is discharged overboard. RO systems separate freshwater from seawater using semi-permeable membranes as a physical barrier, allowing a portion of the influent seawater to pass through the membrane as freshwater, while capturing suspended and dissolved constituents. These captured substances become concentrated in a seawater brine that is subsequently discharged overboard.

Five potential MPCD options were investigated for controlling this discharge within 12 n.m. of shore. The MPCD options were selected based on screenings of alternate materials and equipment, pollution prevention options, and management practices. They are listed below with brief descriptions of each:

Option 1: Restrict operation of water purification plants in port - Eliminate or minimize distilling and RO plant use in port. This would require alternate sources of distilled/demineralized water for boiler feedwater for steam powered vessels.

Option 2: Layup non-essential water purification plants with freshwater when in port - Require the use of shore-supplied freshwater to layup all water purification plants on non-steam powered vessels and the non-essential plants onboard steam powered vessels, to reduce corrosion.

Option 3: Require RO systems on new ships - Specify RO plants instead of distilling plants to meet freshwater requirements (except boiler feedwater production) for new construction ships. RO plant discharges are expected to contain fewer heavy metals.

Option 4: Substitute freshwater for seawater to operate distilling plants onboard steam-powered vessels while in port - Require freshwater from a shore connection, instead of seawater, to provide feedwater for distilling plants on steam-powered vessels. This option would reduce metal mass loadings in the brine discharge by reducing seawater induced corrosion.

Option 5: Change distilling and RO plant construction materials - Specify water purification plants that are constructed of materials that minimize or eliminate discharge of harmful constituents.

MPCD Analysis Results

Table 1 shows the results of the MPCD analysis. It contains information on the elements of practicability, effect on operational and warfighting capabilities, cost, environmental effectiveness, and a final determination for each option. Based on these findings, Option 3 -- requiring RO systems on new construction ships – offers the best combination of these elements and is considered to represent a reasonable and practicable MPCD.

Table 1. MPCD Option Analysis and Determination

MPCD Option	Practicability	Effect on Operational & Warfighting Capabilities	Cost	Environmental Effectiveness	Determination
Option 1. Restrict operation of water purification plants in port	This option primarily affects steam-powered surface ships, which run their distillers in port to produce feedwater for their propulsion boilers. Distilled water would alternatively have to be provided by shore facilities and it is unlikely that the shore facilities could meet the full feedwater requirements of the ships in a port.	The impact of this option on operational capabilities depends on the amount of distilled water that can be obtained from shore for boiler feedwater. Inadequate feedwater supply will adversely affect the ability to get a steam-powered ship underway, and whether or not sufficient reserves are available to quickly go to full power and to sustain that power for as long as needed.	This option would impose additional costs to meet distilled water requirements from an alternate, shoreside source.[1] Costs include shore infrastructure and possible additional shoreside manning. Similar costs would be incurred if shore-supplied steam were used in place of steam from in-port boiler operation. This option would reduce shipboard water purification plant operating and maintenance costs.	This option would be effective in reducing in-port distilling plant brine discharge constituents and any accompanying thermal effects. The effectiveness of this option is proportional to how much the distilling plant operation could be restricted, which would depend on the availability of alternate sources of boiler feedwater and/or steam.	Although this option would reduce the discharge, there is currently no alternate source of boiler feedwater, the option has the possibility to cause an adverse effect on operational capabilities, and this option would impose additional costs to provide an alternate source of boiler feedwater for the operation of propulsion boilers. However, on vessels that are not steam powered, this option warrants further consideration.
Option 2. Layup non-essential water purification plants with fresh-water when in port	Steam powered vessels normally operate just one plant in port to produce the required high purity feedwater for boilers. Therefore, this option addresses all plants on non-steam powered vessels and the non-essential plants onboard steam powered vessels. Freshwater is predicted to be less corrosive than seawater, leading to improved maintenance and reliability. NSTM procedure already allows for freshwater	Freshwater layup of non-essential water purification plants in port is a minor change in management practice, which will not affect the operational availability of the vessel.	The additional cost for the freshwater layup procedure would include shore supplied freshwater for the layup, at approximately $1.00/1000 gallons,[1] and engineering and installation costs for pipings and fittings to provide a pierside freshwater supply. The beneficial effects of reduced corrosion may decrease maintenance costs.	This option would reduce the magnitude of metal mass loadings, however, purification plants still operated in port, may continue to exceed water quality standards.	Implementing a freshwater layup of water purification plants on is: 1) feasible, 2) would not affect ship capabilities, 3) should not impose significant costs, and 4) could reduce metal mass loading. Despite this reduction, metal concentrations could continue to exceed water quality standards.

MPCD Option	Practicability	Effect on Operational & Warfighting Capabilities	Cost	Environmental Effectiveness	Determination
	layups. A freshwater source and the means to feed it to the plant are required for this option.				
Option 3. Require RO systems on new ships	Steam-powered-vessel propulsion boilers require quantities of high purity feedwater not currently achievable by shipboard RO systems, so these vessels would require a combination of RO and distilling plants. RO units are smaller, requiring less space and equipment interface than distilling plants.	RO membranes are damaged by oil and other contaminants prevalent in littoral waters.[2,3] This option would reduce acoustic and thermal signatures since RO plants have fewer motors and pumps, and do not require or produce heat.	Overall, RO systems cost significantly less than distilling plants with respect to life cycle costs, including acquisition, engineering and installation, logistics support, operation, and maintenance. RO units do not require chemical feed and cleaning agents, so chemical and cleaning costs would not incur.	This option would reduce the brine discharge volume and is predicted to reduce the concentrations of constituents in the discharge. Compared to distillers, RO plants contain fewer heavy metal sources, do not use heat in the water purification process-eliminating thermal effects, and do not use anti-scaling chemical additives.	Requiring the installation of RO plants on all new ships would: 1) be feasible if installed along with distilling plants on steam-powered vessels, 2) have minimal operational impacts, 3) cost significantly less than distilling plants, and 4) reduce brine discharge constituent concentrations.
Option 4. Substitute freshwater for seawater to operate distilling plants onboard steam-powered vessels while in port	Influent water for the distillers would require a pierside freshwater supply, however, shore facilities may not be equipped to provide a sufficient volume of freshwater. Considerable shore infrastructure upgrades would be required to implement this option.	Since this option is confined to in-port operation of distilling plants, it will not impact operational and warfighting capabilities.	This option would impose cost increases due to: 1) shore supplied freshwater at $1.00/1000 gallons[1] and 2) engineering and installation costs for shore infrastructure upgrades. The beneficial effects of reduced corrosion could reduce maintenance costs, therefore compensating for and increase from cleaning and de-scaling.	This option would reduce, but not eliminate the discharge of heavy metals, such as copper and nickel, originating from distilling plant components.	Implementing the use of freshwater for water purification plant operation on steam powered vessels in port is: 1) feasible with shore infrastructure upgrades, 2) would not affect ship capabilities, and 3) would reduce metal mass loading. Despite this reduction, metal concentrations could continue to exceed water quality standards.
Option 5. Change distilling and RO plant construction materials	This option would primarily apply to distilling plants because RO plants do not employ heating coils which introduce metals into the	This option would not impact ship operations, provided that system reliability is maintainted. Thermal signature is not	This option would impose research, development, and material costs. The alternative materials (i.e. stainless steel, titanium, or	Alternate materials would reduce the concentration and volume of brine discharge constituents. The level of constituent	Changing plant piping and fitting materials will reduce heavy metal and scaling treatment constituent concentrations and loadings

MPCD Option	Practicability	Effect on Operational & Warfighting Capabilities	Cost	Environmental Effectiveness	Determination
	discharge stream. In order for this option to be practicable, the new materials could not increase the maintenance requirements, size, or weight of the water purification plant. If materials are simply substituted, space requirements would remain the same and weight would be expected to decrease, making this a practicable option.	expected to change.	nickel alloys) would range in cost from $0.10/lb to $100/lb.[4,5,6] Shore infrastructure and manning costs would increase if material changes required special maintenance and repair capabilities.	reduction would be proportional to the extent to which materials contributing to heavy metals in the discharge are replaced or removed from the system.	from brine discharge. Using alternate materials for the actual water purification equipment is less practicable, may entail higher life cycle cost, and Navy grade water purification plants made of alternate materials are not readily available.

REFERENCES

[1] Memorandum from Mr. R. Bernstein (M. Rosenblatt & Son, Inc.), Subj: Estimate for Freshwater Supply to Vessels While Inport, November 13, 1997.

[2] Naval Ship's Technical Manual, Chapter 531 - Desalination, Volume 1 - Low-Pressure Distilling Plants, S9086-SC-STM-010/CH-531V1, First Revision, March 21, 1996.

[3] Naval Ship's Technical Manual, Chapter 533 - Potable Water Systems, S9086-SC-STM-010/CH-533, Third Revision, March 15, 1995.

[4] Titanium Prices, e-mail from Mr. Sam Fisher, Principal Metals, Inc., November 13, 1997.

[5] Titanium Prices, personal communication with Mr. Bob Marsh, Titanium Industries, Inc., November 24, 1997.

[6] Metals Prices, MetalWorld, Inc., http://www.metalworld.com, August 29, 1997.