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

## Refrigeration/AC Condensate: Nature of Discharge

April 1999

# NATURE OF DISCHARGE REPORT

***Refrigeration/AC Condensate***

## 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 condensation discharge that is produced from air conditioner (AC) units, refrigerated spaces, and stand-alone refrigeration units 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

AC units provide cooling for ship spaces. When warm, moist air passes over the refrigeration coils of an AC unit, condensation forms that drips from the coils. This condensation is produced continuously while the AC unit is operating. In addition to AC units, vessels have refrigerated spaces for food and other perishable materials. These spaces are designed for both frozen and chilled cargo and commonly range in temperature from below 0 °F to 35 °F.[1] Condensation also forms from the normal operation of these refrigerated spaces when moist air is cooled below the dew point on the cold evaporator coils of the refrigeration system. The condensate is collected in drains in these refrigerated spaces.

Two types of refrigerated space systems are used: gravity-coil units and forced-air units. Gravity-coil units are typically used in older ships. They employ tinned-copper refrigerant piping which runs back and forth along one or more bulkheads in the refrigerated space.[1] Aluminum fins are attached to the piping to provide a large surface area for the exchange of heat. As the air cools, it becomes more dense and sinks below the comparatively warmer air, creating circulation without the need for a fan. One disadvantage to this type of cooling unit is that the tubing is bulky, so the use of gravity-coil units has been discontinued on newer Navy ships. Forced-air refrigeration units are more compact, self-contained, and use a fan to blow air across the coils. The forced-air units can be used not only in cold storage spaces, but also in other ship spaces.

On most surface ships, gravity coil refrigerant piping is made of tinned-copper.[1,2,3] The forced-air units have brazed-copper piping. Submarine refrigerated space refrigerant piping and evaporator coils are made of copper.[1]

Drip troughs (galvanized steel or tinned-copper) are installed under gravity-type cooling coils to collect condensate or water during defrosting.[1] The piping from these troughs is as short as practicable and leads to compartment drain piping. The forced-air units have drip pans made of galvanized steel or tinned-copper which are placed under the units to collect the condensate. Valved deck drains are also installed in refrigerated spaces that have operating temperatures above 32°F. Deck drains are installed in refrigerated spaces with operating temperatures below 32°F. At least one deck drain is installed in the passage or compartment outside the refrigerated food storage spaces.[1]

The condensate drainage is similar for vessels of all the Armed Forces: condensate produced above the waterline is directed overboard; condensate produced below the waterline is retained on board temporarily before it is pumped overboard. On most Navy ships, condensate is routed directly overboard or combined in a common condensate drain and discharged overboard if the space is above the waterline or to a condensate drain tank if the space is below the water line.[2] Some condensate may also be directed to the machinery space wastewater drain system, the wastewater receiving tank, the sewage collection, holding, and transfer (CHT) tank, or the bilge. On Army watercraft, condensate from refrigeration and air conditioning systems is not collected. Any condensate which forms is typically removed by natural evaporation; if a significant amount of condensate accumulates, it may be removed by mopping or wiping. On vessels of the other Armed Forces, the condensate is discharged to the bilge from spaces below the waterline.

On submarines, drains are installed in chilled stores space decks to remove water from condensation and defrosting. The drains are provided with an isolation valve and lead to a bilge collecting tank or sanitary tank.

### 2.2 Releases to the Environment

Refrigeration/AC condensate is generally released to the environment by direct gravity drainage overboard, or in some cases from a condensate drain tank or other collection points below the waterline. In addition to continuous condensate drainage, intermittent discharges from refrigerated spaces include water and mild detergents used for cleaning (generally weekly), and water from melting ice that is created when the spaces are defrosted (for gravity-coil units, weekly or when the thickness of the frost on the refrigeration coils exceeds 3/16 inch).[4] The water from cleaning and defrosting is discharged into the space drains or the deck drains.

Organic materials can be an infrequent part of the discharge from residual spilled food items that wash into the drainage. Although spilled food can be washed to drains occasionally, spills would normally be cleaned and disposed of as solid waste or into graywater drains.

Navy supply ships that carry refrigerated cargo for at-sea replenishment of Navy combatants use hot seawater spray to defrost the cargo spaces. This seawater, as well as the freshwater used to flush out any residual seawater after defrosting, is discharged through the refrigeration condensate drainage piping. The seawater is provided by the firemain and is heated to 100 °F by a dedicated heater prior to being sprayed at a maximum rate of 100 gallons per minute on the refrigeration coils. The vessel classes that employ heated seawater spray for defrosting are the AFS, AOE, AO, and AOR classes.[5]

Refrigeration condensate could contain trace amounts of metal from the refrigerant coils and drainage piping, but these concentrations are expected to be comparatively low (see Section 3.4).

### 2.3 Vessels Producing the Discharge

Navy and MSC vessels produce refrigeration and AC condensate; this includes 254 Navy surface ships, 94 Navy submarines, and 70 MSC ships.[2] In addition, an estimated 228 Coast Guard vessels and 4 Air Force vessels produce this discharge.

The primary difference between ship classes is the amount of condensate that is generated, which depends on ambient temperature, relative humidity, and the size and number of units per ship. USCG vessels also produce refrigeration and AC condensate, and use specifications similar to the Navy for refrigeration and AC units. Army watercraft have no collection or discharge of condensate from refrigeration or air conditioning systems.

## 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

Flows from refrigeration units and AC units can be discharged at any time, both within and beyond 12 nautical miles (n.m.) from shore. Operation of the refrigerated spaces and AC units in port or in transit is not significantly different from operation beyond 12 n.m. from shore.

### 3.2 Rate

No measurements are available to fully characterize the flow for refrigeration/AC condensate for all ship classes. The range of flow rates volumes will depend on the temperature and humidity of the air and the capacity of the cooling units.

Amphibious ships and aircraft carriers of the Navy tend to have the most air conditioning capacity because of their large contingent of personnel, and therefore, represent worst-case flow rates for AC condensate discharge. An estimate of AC condensate volume was developed for an amphibious ship and an aircraft carrier. The estimate was derived for typical ship operating conditions. The worst-case scenario assumes an unlimited supply of humid air (above 60°F) to the AC system. In reality, after the air has been dehumidified, the exchange rates with new air are much lower and will limit available moisture for condensate to about half the worst case amount. The estimate also assumed that condensate is generated when the outside air is 60°F dry bulb or higher.[6]

Based on the above conditions, an amphibious ship will generate no more than 3,840 gallons of condensate per day, and an aircraft carrier no more than 6,795 gallons per day. Vessels of the other Armed Forces tend be smaller and have fewer personnel, and therefore, will produce less AC condensate discharge.

### 3.3 Constituents

Refrigeration condensate could contain metals from the refrigerant coils and condensate drainage piping, and mild detergents from the occasional cleaning of the refrigerated spaces. AC condensate could contain small amounts of metal from the AC coils or the drain piping. These materials can include aluminum, bronze, copper, iron, lead, nickel, silver, tin, and zinc.

Food particles washed into the condensate drainage system from occasional food spills would increase the Biochemical Oxygen Demand (BOD) in the discharged water. Seawater used to defrost cargo spaces on Navy supply ships, and the freshwater used to flush residual seawater from the cargo spaces are also intermittent constituents of this discharge.

The priority pollutants of this discharge are copper, lead, nickel, silver, and zinc. None of the constituents of this discharge is a bioaccumulator.

### 3.4 Concentrations

Refrigeration/AC condensate can contain small amounts of metals from contact with refrigerant coils and condensate drainage piping. These concentrations are expected to be low for the following reasons:

1) Condensate is essentially pure water and is not a corrosive medium such as seawater;
2) Drainage lines are only fractionally full of condensate which indicates qualitatively low flow and low residence time;
3) Condensate drainage flow velocities and turbulence are extremely low. Therefore, erosion of metals in drainage is not a factor as it could be in pressurized seawater systems;
4) The residence time of condensate in drainage systems is low. The negligible increase in the residence time because of the slower flow does not increase the chance of entrainment of metals;
5) Copper drainage piping forms a protective corrosion-inhibiting film of cuprous oxide on surfaces in contact with water;[7] and
6) The low temperature of this discharge, both on refrigeration coils and in the condensate drainage piping, would tend to inhibit the corrosion process.

Food spills which could contribute some organic matter to the discharge are intermittent and limited to small amounts. Therefore, they are expected to contribute very little BOD to the discharge. Seawater is also a component of refrigeration condensate discharge of vessels with cargo refrigeration spaces.

## 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. Mass loadings are discussed in Section 4.1 and the concentrations of discharge constituents after release to the environment are discussed in Section 4.2. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

### 4.1 Mass Loadings

Mass loadings were not calculated for this discharge.

### 4.2 Environmental Concentrations

Refrigeration/AC condensate is essentially atmospheric moisture which condenses on refrigeration coils. For reasons stated in Section 3.4, concentrations of any of the potential constituents in this discharge are expected to be low. Therefore, the probability that this discharge results in any measurable effect on environmental concentrations is low.

### 4.3 Potential for Introducing Non-Indigenous Species

Because this discharge consists of atmospheric moisture, the potential for introducing non-indigenous species is not significant.

## 5.0 CONCLUSION

Mass loadings and environmental concentrations cannot be calculated with existing information; however, process information is sufficient to characterize the concentrations and loadings of constituents of this discharge.

Refrigeration/AC condensate has a low potential for adverse environmental effect because:

1) the liquid discharge is moisture condensed from the air;
2) concentrations of metals are expected to be low due to the non-erosive and non-corrosive nature of this discharge, and its low temperature; and
3) the contribution from detergents and from food residues is expected to be small and intermittent in nature.

## 6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Table 1 shows the sources of data used to develop this NOD report.

**<u>Specific References</u>**

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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.

**Table 1. 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 |
| 2.3 Vessels Producing the Discharge | UNDS Database | | | X |
| 3.1 Locality | | | | X |
| 3.2 Rate | | | X | X |
| 3.3 Constituents | MSDS | | | X |
| 3.4 Concentrations | | | | X |
| 4.1 Mass Loadings | | | | X |
| 4.2 Environmental Concentrations | | | | X |
| 4.3 Potential for Introducing Non-Indigenous Species | | | | X |