This document is part of Appendix A, and includes the Submarine Acoustic Countermeasures Launcher Discharge: 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)

Submarine Acoustic Countermeasures Launcher Discharge: Nature of Discharge

April 1999

NATURE OF DISCHARGE REPORT

Submarine Acoustic Countermeasures Launcher Discharge

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 submarine acoustic countermeasures launcher 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

Navy submarines are equipped with acoustic countermeasures devices that, once launched, improve submarine survivability by generating sufficient noise to be observed by hostile torpedoes, sonars, or other monitoring devices. The only acoustic countermeasure systems used by the Navy that result in a discharge are Countermeasures Set Acoustic (CSA) Mk 2 launch systems. Other countermeasures systems do not generate a discharge within 12 nautical miles because their launch tubes are always open to the ocean.[1] Countermeasures devices are launched from the CSA Mk 2 systems for training purposes.

The CSA Mk 2 system encompasses the countermeasure device, a gas generator, an externally-mounted launch tube, and all associated electronic controls for the countermeasure device. Figures 1 and 2 provide the location of the launch tubes on submarine hulls, and the location of components within the launch tube, respectively. Figure 3 shows the mechanism by which gas is captured within the launch tube. A gas generator at the rear of the launch tube provides the propulsive charge for launch of the countermeasure device. When the generator is activated, hot gasses expand, forcing a metal "ram" plate and the countermeasure device out of the launch tube. The ram plate lodges in the end of the launch tube, which forms a watertight end cap after launch. For vessel and crew safety, a check valve and bleed holes in the ram plate are used to allow equalization of internal gasses and liquids with external pressures that vary as the submarine changes depth. The one-way check valve allows seawater to flow into the tube after launch, but does not allow any of the liquids to be released through the opening. The seawater that flows into the tube mixes with the gasses generated by the ammonia perchlorate gas generation propellant, which results in an acidic liquid. The ram plate contains three 3/8-inch diameter bleed holes with plugs that dissolve approximately 3 days after the launch, allowing limited contact between the tube contents and the environment.[2] Each launch assembly, with the exception of the acoustic countermeasure device, is identical on all submarines, regardless of vessel class or hull location.

While the submarine is underway and the launch tubes are underwater, the bleed holes allow some exchange of the launch tube liquid contents with the seawater outside of the launch tube. Actual discharge rates are very difficult to obtain due to the non-homogeneous nature of the liquid mixture, the continuous dilution of the liquid contents through the bleed holes, and variations in seawater flow surrounding the bleed holes due to changes in submarine speed and maneuvers. On some submarines, launch assemblies are located above the waterline when the submarine is traveling on the ocean surface. On these submarines, most of the liquid contents of the launch assemblies drain freely from the bleed holes onto the submarine hull before entering the water. The location of the bleed plug holes prevent the expended launch tube from completely draining; approximately one-quarter to one-half gallon (1 to 2 liters) of the liquids remain, depending on the orientation of the ram plate within the launch tube.[1] On other submarines where the launch assembly is always below the water surface, the liquid drains through the same bleed holes directly into the harbor during the assembly's replacement.

In order to protect workers from exposure to the potentially acidic water that remains in the tube subsequent to launch, the Navy has started adding a one-pound packet of sodium bicarbonate to the system to neutralize pH levels.[3] Also, the Navy is reducing cadmium in the discharge by removing hardware with cadmium-containing coatings from Navy stock.[3] All launchers will be equipped with these changes by the end of March 1999.[4]

2.2 Releases to the Environment

Within three days following the launch of a countermeasure device, bleed hole plugs in the ram plate dissolve, which allows pressure equalization of the launch assembly contents with the external seawater environment. The liquid contents of the launch tube are slowly exchanged with seawater through these bleed holes while the submarine is moving. While the submarine is stationary, little or no exchange with seawater occurs. For the submarines where the launch tubes are located above the waterline, most of the liquid contents of the launch tube freely drain through the bleed holes each time the submarine surfaces. For the submarines with launch tubes located below the waterline, the major discharge occurs when the tubes are replaced pierside while the submarine is stationary. The largest potential volume discharge event would occur when all countermeasure launch tubes have been expended, there has been no discharge through the bleed holes while the submarine was underway, and all launch tube contents are released at one time in port. Therefore, for this analysis, it was assumed that all of the discharge from the CSA Mk 2 system occurs during pierside replacement of the launch assembly.

2.3 Vessels Producing the Discharge

The CSA Mk II system is installed on 24 Navy submarines of two different classes: four vessels of the Ohio (SSBN 726) Class, and 20 vessels of the Los Angeles (SSN 688) Class. Launch assemblies on Ohio Class vessels are located above the waterline when the submarine is surfaced; assemblies on Los Angeles Class vessels are located below the waterline. In addition, the number of launch assemblies differs by vessel class. Ohio Class vessels have 16 launch assemblies while Los Angeles Class vessels have 14 assemblies.[2] Neither the Army, Air Force, U.S. Coast Guard, nor Military Sealift Command own or operate submarines.

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

Submarine countermeasures operations during training exercises typically occur outside of 12 n.m. in the open ocean. Discharges from launch tubes located above the waterline may occur within and beyond 12 n.m. while the submarine is underway on the surface as the effluent drains from the bleed holes. Some additional leakage from these launch tubes could occur pierside while the launch tubes are removed from the submarine. Discharges from launch tubes located below the waterline could also occur pierside when the launch tubes are offloaded. A small amount of exchange between all submerged launch tubes and the surrounding waters could occur continuously within and beyond 12 n.m.

3.2 Rate

The volume of the launch tube is approximately 17 gallons (65 liters). Approximately 60 expended launch tubes are removed annually fleetwide.[2] Therefore, approximately 1020 gallons of effluent is generated per year. For the purposes of this report, the discharge event volume was assumed to be 17 gallons, although in the cases where launch assemblies are above the waterline, some of the launch tube effluent would be discharged prior to a launch assembly replacement operation, and under normal circumstances even those tubes located below the waterline do not discharge their entire contents.

When a submarine is traveling on the ocean surface, liquid contents of the launch assemblies that are located above the waterline were estimated to discharge at a rate of one gallon per minute through bleed holes. During a discharge event in port, the liquid contents are released through the same bleed holes while being transported from the submarine to the pier, and therefore also discharge at a rate one gallon per minute. For the purposes of this report, it was assumed that all liquids in the launch assembly are discharged into surrounding waters before the assembly is placed on the pier.

3.3 Constituents

Table 1 summarizes the analytical data from sampling of an actual gas generator and launch tube assembly, with a sodium bicarbonate packet in place and no cadmium-containing coatings.[5] The constituents detected in sampling, i.e., lead, copper, cadmium, and silver, were expected based upon the known components of the gas generator (e.g., ammonia perchlorate propellant), hardware coating components, and solder within the system electronics.[1] In addition to analyzed concentrations, based upon knowledge of the components of the gas generator, exhaust gas products that may become a part of the discharge can include hydrochloric acid, carbon dioxide, water vapor, carbon monoxide, nitrogen, alumina, iron (II) chloride, titanium dioxide, hydrogen, and iron (II) oxide.[6] Table 2 provides a complete listing of the types and quantities of gas generator exhaust gas products. Of the discharge constituents, lead, copper, cadmium, and silver are priority pollutants. There are no bioaccumulators that have been identified in this discharge.

3.4 Concentrations

Table 1 provides a summary of the analytical results obtained from sampling of the launch tube water immediately following a launch, and sampling five days after launch.[5] Of the two data sets, the analytical data from sampling five days after launch is more representative of the actual pierside discharge because typical submarine operational schedules do not allow for immediate replacement of the launched countermeasures devices. In reality, submarines usually continue for months until a scheduled maintenance port call results in a launch tube change out and discharge of launch tube water. For the data shown in Table 1, where a concentration value was found to be below the detection limit, the mean concentration value was calculated using one-half of the detection limit. The pH of the launch tube water five days after launch was 7.2, which is similar to the pH of seawater (~8).

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

The total annual discharge volumes provided in Section 3.2 were used to estimate potential constituent mass loadings as follows:

$$\text{Mass Loading (lbs/yr)} = \text{(avg. concentrations in } \mu\text{g/L) (discharge in gal/yr) (3.785 L/gal) (2.205 lb/kg) (}10^{-9}\text{ kg/}\mu\text{g)}$$

Analytical data from sampling five days after launch was used to calculate mass loadings because that data set is more representative of the actual pierside discharge than data from sampling immediately following launch. Even this overstates the potential mass loading, as most submarines will continue to operate for months after the launch, before changing the launch tubes. For example, the mass loading for copper was estimated as:

$(80\ \mu g/L)(1020\ gal/yr)(3.785)(2.205)(10^{-9}) \approx 7 \times 10^{-4}$ lbs/yr, or approximately 2 ten-thousandths of an ounce per discharge event

Table 3 provides annual fleet-wide mass loadings and discharge event mass loadings for the metallic constituents listed in Table 1.

4.2 Environmental Concentrations

Table 4 compares the concentrations of the Mk 2 system discharge to Federal and the most stringent state water quality criteria (WQC). Copper, cadmium, and silver concentrations are above both the Federal and most stringent state WQC. Lead was detected in only one of the ten samples; lead in this sample exceeded the most stringent state WQC.

4.3 Potential For Introducing Non-Indigenous Species

There is a low potential for this discharge to transport non-indigenous species because:

1) the 17-gallon launch tube is capped immediately following the launch of a countermeasure device, with the only means of seawater entry being a one-way check valve and three 3/8-inch diameter bleed holes. Therefore, there is limited opportunity for organisms to ever enter the launch tube;
2) because launches of countermeasure devices are estimated to take place 60 times a year fleetwide and typically take place in the open ocean;
3) any deep ocean water organism would be unlikely to survive in near-shore waters.[7]
4) the total volume of the discharge per year is small.

5.0 CONCLUSION

Submarine acoustic countermeasures launcher discharge has a low potential to cause an adverse environmental effect from constituents and the introduction of non-indigenous species because:

1) The constituent mass loading is low. For example, the mass loading of copper into receiving waters during one of the 60 discharge events per year would be two ten-thousandths of an ounce.

2) The small volume of the discharge, combined with the low likelihood that the organisms taken on could survive in port, make it unlikely that the discharge could transport viable non-indigenous species.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Equipment expert information was used to estimate the rate of discharge. The constituents and concentrations in this discharge were obtained from process knowledge and analytical data. Table 5 shows the sources of the data used to develop this NOD report.

Specific References

1. UNDS Equipment Expert Meeting - Submarine Acoustic Countermeasures Launcher Discharge, 12 June, 1998.

2. UNDS Data Call Response, Countermeasure Set, Acoustic (CSA) Mk 2, PMS415D5, Naval Sea Systems Command, 20 February 1998.

3. Engineering Change Proposal (ECP) CR-GG77-E0002, Naval Surface Warfare Center (NSWC) Crane Division, 5 April 1997.

4. Personal Communication between Ken Burt, PMS415, Naval Sea Systems Command, and Gordon Smith, SEA 03L, Naval Sea System Command, 23 February 1998.

5. Analysis of Products from Expended Propellant Billet Gas Generators, Naval Surface Warfare Center, Crane, Code 4052, Ser 4052/7073, 13 May 1997.

6. Excerpts from Naval Surface Warfare Center (NSWC) Crane Division Preliminary Report for the Saltwater Immersion and Pressure Testing of the ADC Mk 3 Mod 0 with Lithium Battery, EDD 95-068, NSWC Crane Division, May 1995.

7. "Stemming the Tide," Controlling Introductions of Nonindigenous Species by Ships' Ballast Water, Committee on Ships' Ballast Operations, National Academy Press, Washington D.C., 1996, p. 36.

<u>General References</u>

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.

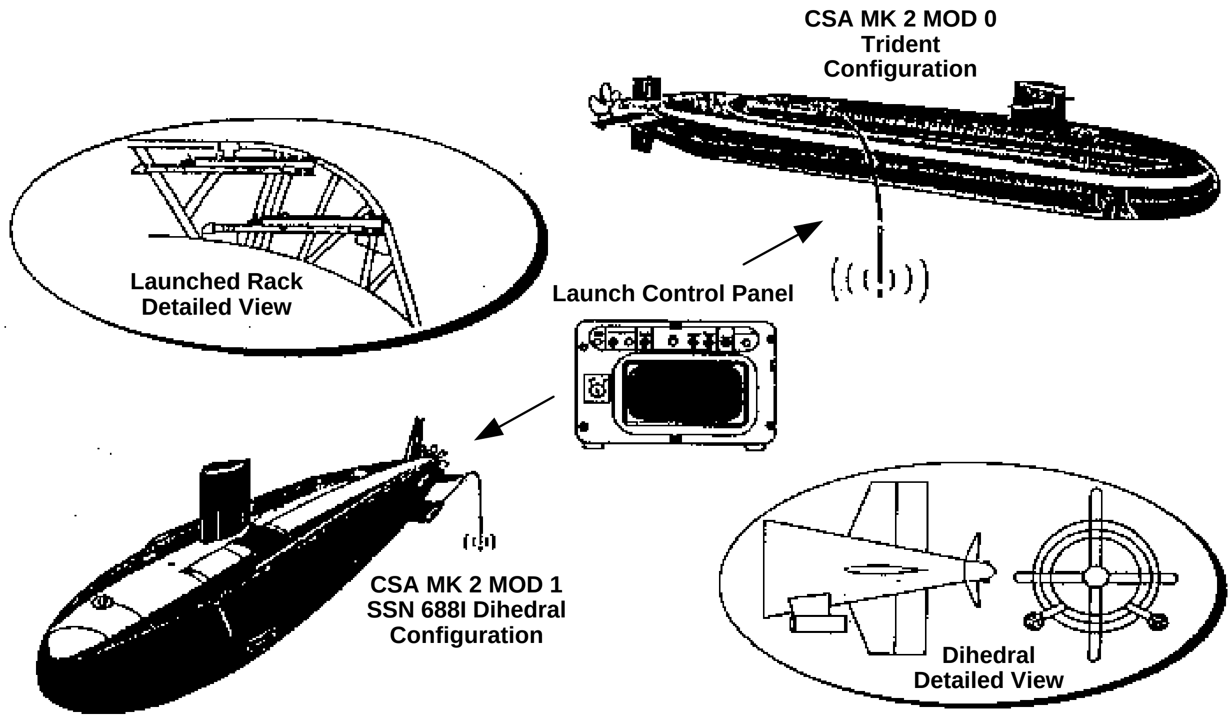

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Figure 1. Configuration of CSA Mk 2 Launchers
on SSBN 726 and SSN 688 Class Vessels

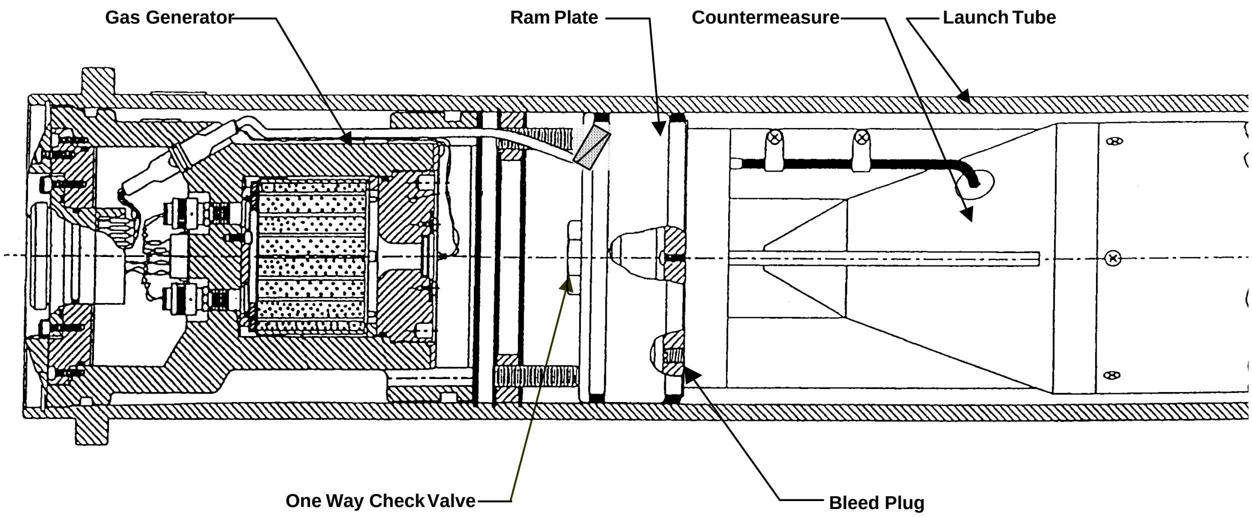

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Figure 2. Location of Countermeasures Launcher Components Within a Launch Tube

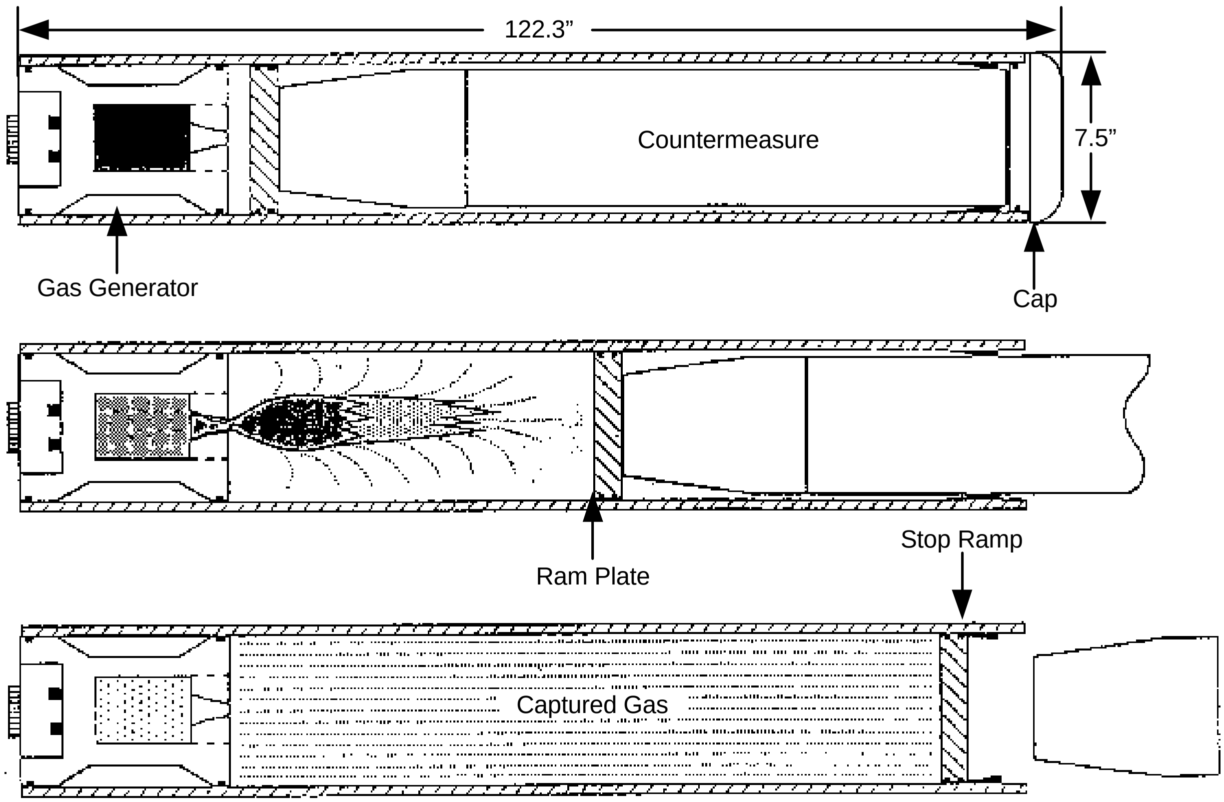

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Figure 3. Countermeasure Launch Process

Table 1. Constituent Concentration Data Immediately and Five Days Following Launch [5]

Constituent	Dissolved Concentrations Immediately Following Launch							Mean value	Dissolved Concentrations Five Days Following Launch							Mean value
Metals	µg/L															
Barium	BDL[a]	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL[a]	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Lead	BDL[b]	BDL	BDL	BDL	BDL	BDL	200	110	BDL[b]	BDL	BDL	BDL	BDL	BDL	BDL	100
Copper	100	160	290	800	180	860	260	380	70	40	70	90	60	170	80	80
Cadmium	70	630	60	740	120	290	440	340	40	150	100	20	20	90	30	60
Chromium	BDL[c]	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL[c]	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Silver	BDL[d]	20	BDL	20	BDL	40	20	20	20	BDL[d]	BDL	BDL	BDL	30	BDL	10
Other																
pH	7.2	6.0	6.0	5.7	6.3	5.3	5.9	5.8*	7.5	7.1	6.9	7.0	7.4	7.2	7.5	7.2*

[a] BDL = below detection limit; detection limit for barium is 1000 µg/L
[b] Detection limit for lead is 200 µg/L
[c] Detection limit for chromium is 80 µg/L
[d] Detection limit for silver is 20 µg/L

* Mean pH calculated using arithmetic average of [H+] values

Table 2. Gas Generator Exhaust Gas Products [6]

Exhaust Gas Product	Mass per Gas Generator (g)
HCl	23.036
CO_2	21.860
H_2O	16.846
CO	14.096
N_2	9.345
Al_2O_3	2.832
$FeCl_2$	2.068
TiO_2	1.998
H_2	1.803
FeO	1.523
P_2	0.002
PN	0.054
CH_4	0.004
NH_3	0.001
$FeCl_3$	0.001
PO_2	0.001
PO	<0.001
PH_3	<0.001

Table 3. Estimated Annual Mass Loadings

Constituent	Loading (lbs/yr)	Loading per Discharge Event* (ounce/event)
Cadmium	0.0005	0.0001
Copper	0.0007	0.0002
Lead	0.0009	0.0002
Silver	0.00009	0.00002

* based upon 60 maximum-volume discharge events per year

Table 4. Comparison of Discharge Constituents with Water Quality Criteria (μg/L)

Constituent	Mean Concentration or Value	Federal Acute WQC	Most Stringent State Acute WQC
Cadmium	60	42	9.3 (FL, GA)
Copper	80	2.4	2.4 (CT, MS)
Lead	100	210	5.6 (FL, GA)
Silver	10	1.9	1.2 (WA)

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

Table 5. Data Sources

	Data Source			
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
3.2 Rate			X	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