COLLECTION AND PROCESSING OF WASTES FROM RUSSIAN NORTHERN FLEET SHIPS

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ABSTRACT

This paper discusses the joint activities between technical experts from Russia, Norway, and the United States regarding the control of Russian Naval ship waste discharges in the Arctic. The initial effort considered the design and construction of a vessel for collecting and processing waste from over 200 Russian Navy ships in the Barents Sea, as part of the Arctic Military Environmental Cooperation (AMEC) Program. The Russian waste-vessel project, officially entitled AMEC Project 2.2-0, focused on identifying waste streams and the amounts generated and the associated discharge requirements, evaluating possible existing technologies for collection and treatment, and developing a conceptual design for the vessel. The types of wastes subject to treatment by the vessel included oily mixtures, sewage (blackwater), domestic water (graywater), and garbage (solid and food waste). All discharges had to adhere to the stringent discharge water quality limits established by Russian Federation regulations. The United States, Russia, and Norway exchanged information on national waste-treatment technologies. These were then evaluated for suitability aboard the vessel. Based on the preferred technologies, a notional concept of the waste-treatment-and-collection vessel was completed. The design and outfitting of a vessel was deferred, but a follow-on effort will be a demonstration of a Russian oily waste-treatment system aboard a Russian Federation vessel in the Northern Fleet.

INTRODUCTION

The Arctic Military Environmental Cooperation Program (AMEC) is a cooperative effort among the U.S. Department of Defense and the Ministries of Defence of Norway and Russia to address critical environmental concerns in the Arctic. While AMEC projects include radioactive waste and non-radioactive waste, this paper discusses two of the non-radioactive waste projects within AMEC (Projects 2.2-0 and 2.2-1). The first deals with collecting and treating waste from Russian Federation (RF) ships in the Barents Sea, and the second is a demonstration and technology validation project to treat bilge oily waste on one Russian naval vessel.

OVERVIEW OF AMEC 2.2-0

Project Description and Background

The purpose of Project 2.2-0 was to design and construct a vessel for collecting and processing ship-generated wastes from Russian naval ships in the Arctic region. The concept for such a vessel was first proposed under AMEC when the United States, Norway, and Russia first began considering projects in 1996.

Project Plan

- Assess the magnitude of waste discharges by Russian Northern Fleet ships.
- Identify and evaluate potential solutions for ship-generated wastes.
- Assess costs to design and implement feasible solutions, and identify the most cost-effective solution.
- Prepare preliminary system designs for the most cost-effective solution.

NATURE OF THE PROBLEM

Number and Types of Ships operating in the Barents Sea

More than 200 seaworthy ships and vessels of the Russian Navy operating in Arctic area are to be serviced by the proposed waste-processing vessel. The ships and vessels use a variety of power plants, ranging from 600 to 200,000 hp (450 to 150,000 kW). Displacement of serviced ships is from 130 to 53,000 tons. The crew size is from 10 to 2,000 persons.

Types and Volumes of Waste Generated by Navy Ships

Oily mixtures, sewage, and garbage are the primary ship-generated wastes subject to collection and subsequent treatment. The daily generation of these wastes on the 200+ ships and vessels is estimated to be the following:

- Oily mixtures 1,000 m^3 (264,000 gal)
- Sewage 1,100 m^3 (290,000 gal)
- Domestic water (graywater) 3,300 m^3 (870,000 gal)
- Garbage 112 m^3 (4,000 ft^3)

The daily generation of waste versus ship size is shown in Table I. Ships with a displacement of 6,800 to 53,000 tons generate the largest share of this waste (about 55 percent).

Table I. Waste Generation by Ships in Russia's Northern Fleet

Types of ship-generated waste	Daily generation (m^3)	Daily generation of waste by ships with displacement, tons							
		53,000–6,800		5,400–2,000		1,600–510		460–40	
		m^3	% of total	m^3	% of total	m^3	% of total	m^3	% of total
Oil mixture	957	526	54.96	189	19.75	200	20.9	42	4.39
Sewage	1129	603	53.41	294	26.04	172	15.23	60	5.31
Domestic water	3336	1809	54.23	858	25.72	492	14.75	177	5.31
Garbage	112	61.8	61.61	29.04	29.46	17.2	16.96	3.9	10.71

The Russian Federation estimates that the ships and vessels generate 40 to 60 percent of their daily waste while they are in port. The main components of the garbage, by weight, are as follows:

- Metal and glass 18%
- Plastics 2%
- Packaging (cardboard, wood, textile, etc.) 35%
- Food waste 45%

Treatment Requirements for Waste-Processing Vessel Operating in the Barents Sea

The ship for collection and treatment of wastes will accumulate significant volumes of treated water that must be discharged in the sea or to receiving shore facilities. Depending upon the location of the waste treatment ship (inner and territorial waters, open sea), requirements for maximum permissible concentrations (MPCs) of harmful substances in discharged treated water will differ.

- **Oily Wastewater.** The permissible content of oil in treated oily wastewater (bilgewater) discharged to the sea is determined by international and RF regulations. According to MARPOL 73/78 and RF regulations, ships can discharge oily water containing less than 100 mg/L of oil at a distance more than 12 nautical miles (nm) from the nearest coast. According to MARPOL 73/78, ships can discharge oily water containing less than 15 mg/L of oil within 12 nm from the nearest coast. RF regulations prohibit Russian Navy ships from discharging any mixtures containing more than 0.05 mg/L of oil in inner or territorial waters (within 12 nm of land). Depending on the chosen set of equipment for oil/water separation and the purification level between 0.05 and 100 mg/L, the waste-processing vessel may discharge the treated water within inner and territorial waters or beyond 12 nm. Specific

MPCs for discharged water would be defined after the evaluation of the selected equipment and a feasibility study.

- **Sewage and Domestic Water.** MARPOL 73/78 and the RF regulations control the level of purification of sewage only. No requirements for the purity of discharged domestic water (graywater) exist in either MARPOL 73/78 or in the Russian Navy Rules for environmental protection. The task of collecting and treating domestic water, therefore, is not placed on the waste-processing vessel. According to MARPOL 73/78 and RF regulations, a ship may discharge pulped and disinfected sewage when more than 4 nm from the nearest coast, or nonpulped and nondisinfected sewage when more than 12 nm from the nearest coast. In both cases, sewage in collection tanks is discharged gradually at a speed of at least 4 knots. In Russia's territorial and inner waters, ships may discharge noncomminuted and disinfected sewage, subject to the following conditions:

  - 5-day Biological Oxygen Demand (BOD): No more than 50 mg/L;
  - Suspended solids: No more than 100 mg/L;
  - Coliform bacteria: No more than 1,000 coliform/L;
  - Residual chlorine: Between 1.5 and 5 mg/L;
  - The ship is moving at a speed no less than 4 knots; and
  - The distance to the nearest coast is no less than 12 nm.

- **Garbage.** Garbage received from ships can be discharged to sea, recycled, or destroyed. MARPOL 73/78 allows ships to discharge food, paper, rags, glass, metal, bottles, crocks, and similar garbage beyond 3 nm from the nearest coast, if it has been comminuted and can pass through a screen with a mesh size of 25 mm. Beyond 12 nm, the garbage can be discharged without treatment. Beyond 25 nm, ships may discharge floatable garbage, such as insulating, lining, and packaging materials. It is banned to discharge to the sea any kinds of plastics, including litter and synthetic ropes and nets. Part of the collected garbage may be discharged to the sea and part may be destroyed. In destroying garbage in incinerators or plasma-arc furnaces, harmful substances may be emitted with off-gases. Concentrations should not exceed maximum permissible levels of harmful substances in National Regulations now in force in the Russian Navy as shown in Table II.

Table II. Maximum Permissible Concentrations (MPCs) of Harmful Substances in Occupational Air and Off-Gases of Equipment for Garbage Disposal

N	Substance	Hazard Class	State of aggregation in air	MPC		
				in occupational air, mg/m^3	in off-gases of equipment for disposal, mg/m^3	
					maximum one-time concentration	daily average
1	Nitrogen oxides (on conversion NO_2)	2	g	5	0.085	0.083
2	Acrolein	2	g	0.2	0.03	0.03
3	Isobutyric aldehyde, butyraldehyde, propinal aldehyde	3	g	5	-	-
4	Crotonaldehyde	2	g	0.5		
5	Aluminum and its alloys (on conversion to Al)	4	a	-	-	-
6	Ammonia	4	g	20	0.2	0.2
7	Arsenic pentoxide	2	a	0.3		0.003
8	Arsenic trioxide	3	g	0.3		0.003
9	Sulfurous arsenic	3	g	10	0.5	0.05
10	Acetone	4	g	200	0.35	0.35
11	Benzene solvent (on conversion to C)	4	g	300	5	1.5
12	Benzene	2	g		1.5	0.8
13	Ethylene oxide	2	g	1	0.3	0.03
14	Beryllium and its compounds (on conversion to Be)	1	a	0.001	-	-
15	Boron fluoride	2	g	11		
16	Bromine	2	g	0.5		
17	Butyl acetate	4	g	200	0.1	0.1
18	Vinyl acetate	3	g	10	0.15	0.15
19	Vinyl chloride	4	g	30		
20	Hexamethylene diamine	2	g	1	0.001	0.001
21	Hexachlorocyclohexane	1	g + a	0.1	0.03	0.03

	(hexachloran)					
22	Hydrazine and derivatives	1	g	0.1	-	-
23	Dimethylamine	2	g	1	0.005	0.005
24	Dioxane	3	g	10		
25	Dichloroethane	2	g	10	3	1
26	Diethylamine	4	g	30	0.05	0.05
27	Kerosene oxidized, technical, power (on conversion to C)	4	g	300	-	-
28	Kerosene sulfonated (on conversion to C)	4	g	300	-	-
29	Sulfuric acid	2	a	1	0.3	0.1
30	Hydrochloric acid	2	g	5	0.2	0.2
31	Acetic acid	3	g	5	0.2	0.06
32	Xylene	3	g	50	0.2	0.2
33	Manganese (on conversion to Mn2+)	2	a	0.3	-	0.01
34	Methyl bromide	1	g	1		
35	Hydrogen arsenide	2	g	0.3		
36	Naphtalene	4	g	20	0.003	0.003
37	Oil polysulfide					
38	Raw oil	3	a	10		
39	Benzene petroleum products	2	g	3	0.008	0.008
40	Ozone	1	g	0.1		
41	Polyvinyl chloride	3	a	6		
42	Polypropylene (unstabilized)	3	a	6	-	-
43	Polyformaldehyde	3	a	5		
44	Polychloropylene	2		0.2	0.005	0.005
45	Low pressure polyethylene	3	a	10	-	-
46	Mercury metallic	1	g	0.01/0.005	-	0.0003
47	Lead and its inorganic compounds	1	a	0.01/0.007	-	0.0007
48	Hydrogen sulfide	2	g	10	0.008	0.008
49	Hydrogen disulfide	2	g	1	0.03	0.005
50	Turpentine (on conversion to C)	4	g	300	-	-
51	Amyl alcohol	3	g	10	0.01	0.01
52	Butyl alcohol	3	g	10	0.1	0.1
53	Methyl alcohol	3	g	5	1	0.5
54	Propyl alcohol	3	g	10	0.3	0.3
55	Ethyl alcohol	4	g	1,000	5	5

56	Styrene	3	g	5	0.003	0.003
57	Tetraethyl lead	1	g	0.005		
58	Toluylene diisocyanate	2	g	0.05	0.05	0.02
59	Toluene	3	g	50	0.6	0.6
60	Tributyl ether of ortophosphoric acid (tributylphosphate)	2	g	0.5	-	-
61	Tricresol	2	g	0.5	0.005	0.005
62	Trinitrotoluene	2	g	1		
63	Trichloroethylene	3	g	10	4	1
64	Triethylamine	3	g	10	0.14	0.14
65	White spirit (on conversion to C)	4	g	300	-	-
66	Hydrocarbons aliphatic saturated C1-C10 (on conversion to C)	4	g	300	-	-
67	Carbon monoxide	4	g	20	3	1
68	Carbon tetrachloride	2	g	20	4	2
69	Phenol	2	g	0.3	0.01	0.01
70	Formaldehyde	2	g	0.5	0.035	0.012
71	Phosgene	2	g	0.5		
72	Freon 12, Freon 22	4	g		100	10
73	Hydrogen fluoride	2	g	0.5	0.02	0.005
74	Hydrogen chloride	2	g	5		
75	Chromates, bichromates (on conversion to CrO_3)	1	a	0.01	0.0015	0.0015
76	Hydrogen cyanide	2	g	0.3		0.01
77	Cyclotrimethylenetrinitroamine (hexogene)	2	g + a	1	-	-
78	Zinc oxide	3	a	6		0.05
79	Caustic alkalis (solutions on conversion to NaOH)	2	a	0.5	-	-
80	Enylchlorhydrine	2	g	1	0.2	0.02

Notes:

1. Hazard classes of substances: 1 = extremely dangerous; 2 = highly dangerous; 3 = moderately dangerous; 4 = not very dangerous.
2. Letters designate the state of aggravation of substances in air: g = gases or vapors; a = aerosols; g + a = mixture of gas and aerosols.

SCENARIOS FOR COLLECTING AND PROCESSING SHIP WASTES

The Russian team identified three alternative scenarios for integrating a subsystem of ships for collection and ships for treatment of ship-generated waste into a single system.

- **Scheme 1.** A system comprising ships of the same type that collect and treat waste (SCTW), whose total required tank capacity equals the daily volume of ship-generated waste.
- **Scheme 2.** A comprising of two types of ships: those that collect (SCW) from ships and transfer it to the SCTW; and the SCTW, which treats waste and also can receive waste from ships, such as the SCW. The total required tank capacity of the SCW equals the daily ship-generated waste less the volume of waste that the SCTW can collect. The total capacity of the whole system's tanks (SCW+SCTW) is less than twice the daily volume of ship-generated waste.
- **Scheme 3.** A system comprising two types of ships: ones that only collect waste (SCW) and ones that only treat waste (STW) received from the SCW. The total required tank capacity of the SCW equals the total tank capacity of the STW, i.e., that of the whole system (SCW+STW) equals twice the daily volume of ship-generated waste. Scheme 2 differs from Scheme 3 in that the SCTWs in Scheme 2 partially undertake the function of collection as well as treatment.

The minimum required number of collector ships for a given number of serviced ships is based on the maximum number of ships that collector ships can service in a day. The number of collector ships can be provided by any combination of SCW and SCTW (Scheme 2) or only SCW (Schemes 1 and 3).

In all three schemes, to ensure that the daily volume of waste generated can be treated in less than 24 hours, the total tank capacity and the combined waste-processing rates on the treatment ships (STW or SCTW) must be equal or to or greater than the daily volume of waste generated by the serviced vessels.

Minimum Number of Ships for Treating Ship-Generated Waste

Because the AMEC 2.2-0 goal was to design a single or a few STW(s) (or SCTW(s)), not a system of ships to collect and treat waste, the team scrutinized Schemes 2 and 3, in which there must be very few STWs, or at least fewer than in Scheme 1. The SCWs collect and transfer the prescribed daily amount of ship-generated waste.

The actual cycle of ship operations affects the minimum number of STWs required. Because of the need for maintenance time, potential temporary disablement of the ship, and long-term uninterrupted and cyclic waste treatment, at least two ships are required. A single STW is insufficient, even if its tank capacity and treatment-units output can receive and treat the whole daily volume of accumulated waste. This need for two STWs also agrees with the minimum number of SCTWs that can receive wastes from the required 10–15 SCWs (explained below) per day, assuming a 3-day waste generation on serviced ships and vessels. Furthermore, each STW will need dock repairs about every 3 years. The eventual minimum number of STWs should, therefore, be 2+1, and the third hull should be in service when the first one goes into dry-dock.

When one STW is in dry-dock, only two ships can work concurrently. It is, therefore, appropriate to take the capacity of STW tanks and corresponding output as the half of the volume of overall daily waste generation by serviced ships with a certain safety margin (10–20 percent), for a possible non-uniform filling in transferring waste to the SCTW. To ensure smooth operation of the STWs, it is essential to organize the collection and transfer of ship-generated waste. If in a day, each SCW can realistically service four to six ships and Navy ships can hold 3 days of waste, it will take no fewer than 10 to 15 SCWs, with overall capacity equal to the daily generation of ship waste. If ships can only hold waste for 1 day, it would take 30 to 40 SCWs. Operating so many SCWs for the Northern Fleet not only is unlikely from the economic and technical point of view but would make waste transfer to a limited number of STWs impossible. In this case, each of two STWs would receive wastes from 15 to 20 SCWs a day, which is obviously impracticable. To service 10 to 15 SCWs is quite feasible for two STWs, especially if the two can transfer wastes concurrently. The number of SCWs in the subsystem of two STWs working concurrently must, therefore, not exceed 10 to 15.

If the number of STWs is 1+1, each of them needs the capacity to receive and treat the daily volume of generated waste, because when one STW is under repair, the second must meet the full demand on waste treatment for serviced ships and vessels.

Model System for Collecting and Treating Ship-Generated Waste

The main goals of Project 2.2-0 are to collect, treat, and dispose of oily mixtures, sewage, and garbage from the following:

- Navy ships and vessels at moorings or piers.
- Oil and garbage-disposal ships.
- Ships that collect and store liquid and solid (garbage) marine (ship) waste.
- In some cases, waste delivered from shore.

The RF also would like the vessel to be equipped to clean up accidental oil spills from the water surface independently or as a part of an oil spill response clean-up team.

Additional goals include the following:

- Collect and dispose of sludge from onboard treatment plants for oil mixtures and sewage.
- Collect and deliver to coastal facilities spent lubricating oil, ash, and solid waste not intended for treatment in disposal units.
- Clean, wash, and disinfect ship transport containers for garbage.
- Wash and clean (including ship parts) waste-holding tanks of other vessels with subsequent receipt and treatment of products of tank cleaning.

- **Regions and Features of Ship Use.** The ship for collecting and treating ship waste is for use in the areas of Northern Fleet bases in the Barents Sea during non-ice-field periods. The ship can also act as first response in emergency situations connected with oil spills in coastal areas.
- **Schemes for Ship Operation.**
  - Scheme 3 of the collecting and processing scenarios is the preferred basic scheme of operation. Collector ships (SCW) deliver the waste to a treatment plant (SRW) located pier-side or in another specially assigned location. A stationary SRW would be designed for a maximum treatment rate unconstrained by the space, weight and other requirements imposed on the collection and treatment ships (SCTW).
  - The SCTW would only transport, process, and discharge the treated products in permissible discharge areas. In case of an insufficient number of collector ships, SCTW operates according to Scheme 2. In this scheme SCTW participates in a 3-day cycle of collection of ship-generated waste from the largest ships and vessels, and if necessary, receives waste from nearby collector ships concurrently. If the selected set of equipment on the SCTW fails to achieve the required level of purification to discharge in inner and territorial waters, provision would be made to accumulate and transport waste in floating tanks for discharge in a permissible area.

Table III shows the main characteristics of the subsystem of waste treatment subsystem.

Table III. Main Characteristics of the Waste Treatment Subsystem

Types of waste	Oily water	Sewage	Garbage
Daily generation of waste by serviced ships and vessels	1,000 m^3 (260,000 gal)	1,100 m^3 (290,000 gal)	112 m^3 (4,000 ft^3)
Daily generation of ship-generated (with safety margin) at bases	800 m^3 (200,000 gal)	900 m^3 (240,000 gal)	90 m^3 (3,200 ft^3)
Minimum number of SCTWs without regard for one SCTW under dock repair	2 or 1	2 or 1	2 or 1
Minimum required capacity of tanks of each SCTW provided that ships work concurrently	400 or 800 m^3 (100,000 or 200,000 gal)	450 or 900 m^3 (120,000 or 240,000 gal)	45 or 90 m^3 (1,6000 or 3,200 ft^3)
Required volume of tanks of treatment ships with consideration for a possible non-uniform distribution of received waste among them (20% for $N_{SCTW} > 1$)	480 m^3 (130,000 gal)	540 m^3 (140,000 gal)	55 m^3 (1,900 ft^3)
Range of capacity of tanks of SCTW (min-max) taken in refined specifications	500–800 m^3 (130,000 to 200,000 gal)	550–900 m^3 (150,000 to 240,000 gal)	55–90 m^3 (1,900 to 3,200 $ft^{3)}$)
Volume of treated waste by one SCTW in % of overall daily generation of waste at bases, according to Scheme 3	60–100%*	60–100%*	60–100%*
Number of ships with waste treated by one SCTW in 24 hours, according to Scheme 3	40–60–100	40–60–100	40–100–160
Volume of waste treated by one SCTW in % of overall diurnal generation of waste at bases, according to Scheme 1	up to 15%**	up to 20%**	up to 35%**
Number of ships with waste treated by one SCTW in 24 hours, according to Scheme 1	4–6	4–6	4–6

Notes:

* Under delivery of waste by means of SCW to STW (SCTW) with treatment plant operating at full power: Scheme 3.

** Under collection of waste provided by one SCTW: Scheme 1.

EQUIPMENT INVESTIGATED

As part of Project 2.2-0, the Russian team reviewed technologies from Norway and the United States for consideration on the Russian waste-processing ship. AMEC representatives from each country provided several systems or technologies as potential candidates. Norway offered several systems from Norwegian industry, as did Russia, while the United States focused on new technologies that had been or were being developed by the Naval Sea Systems Command at Carderock for the U.S. Navy.

The presentation of U.S. Navy-developed equipment included:

Now in production -

- The solid waste pulper;
- The shredder for metal and glass; and
- The plastics waste processor.

Under development -

- The membrane technology based bilge oily waste treatment system;
- Blackwater/graywater treatment system;
- The in-tank oil/water separator;
- Vortex incinerator; and
- Plasma-arc waste destruction system.

The following ship waste-treatment methods, developed by Norwegian firms, were discussed or demonstrated to Russian experts:

- Plants for cleaning different types of oily wastewater;
- Plasma-arc furnace for treating all wastes;
- Incinerators for solid wastes and oil sludge; and
- Equipment for wastewater treatment.

The Russian team presented the following Russian-manufactured equipment that could meet some of the very stringent Russian environmental requirements:

- Oily wastewater treatment plants that operate at 10 m^3/hr and produce an effluent containing less than 5 mg/L oil in water;
- Wastewater treatment plant that can meet sewage discharge requirements at a rate of 5 m^3/hr; and
- Plasma-arc-based incinerator that processes solid waste and sludge at 750 kg/hr and can meet Russian maximum permissible concentrations (MPCs) of harmful substances in its emissions.

SPECIFICATIONS FOR THE VESSEL

The preliminary specifications for the proposed vessel that the Russian team prepared are based on their requirements for collecting and treating ship wastes in the Barents Sea and their assessment of the waste-processing technologies and equipment observed in the United States and Norway. The Russian team described a vessel that would meet the specifications summarized in Table IV.

Table IV. Specifications of the Waste Collection and Treatment Vessel

Requirement	Details
Class of the Vessel	Ship must meet RF requirements for oil skimmers, be self-propelled with ice-breaking force to navigate in the Arctic in open pack ice or ice cakes during the summer, and be operated from the bridge without the need for constant staff in the engine rooms.
Performance	• Collect (receive) from ships (vessels) oil mixtures in tanks and subsequently separate (filtrate) with onboard machinery, and, if necessary, transfer oily water and processed products to the shore. • Collect from ships wastewater in tanks for acceptance and storage, and possibly transfer to specialized treatment facilities, including land-based facilities. • Collect garbage from ships into purpose-built compartments (special holds or bins) and possibly transfer to the sorter and to specialized storage and disposal facilities (land-based ones, if necessary). • Collect oil mixtures, effluent, and garbage from skimmers, barges, and piers into specially intended tanks (reservoirs, special holds, or bins), and treat them on board. • Separate (filtrate) oil mixtures, bilgewater, and contaminated waters; clear and decontaminate sewage to a level permitting discharge in any sea area, including "special areas," and Russia's interior and territorial waters. • Store (dispose) and transfer to land (transport ship) separated oil and other treated products. • Collect accidental oil spills into the specially intended ship tank and transfer to the pier or another vessel. • Treat liquid and solid waste (separate, treat, and dispose) with onboard equipment between ship bases at sea state 4 or below. • Transfer (to land or other vessels) oil mixtures, effluent waters, spent oil, and slime from onboard treatment units through receiving ports via hose lines and cranes. • Measure oil content with an oil-content monitor that automatically recirculates unacceptable discharge.

Onboard purification plants for oil mixtures, with necessary devices and auxiliary equipment to receive and deliver these waters and tanks for mixture storage	Separation/filtering units should meet the requirements to the extent of water-purification output for oil content (must not exceed 0.05 mg/L, irrespective of oil content in water at the inlet). The volume of receiving tanks for oil mixtures from serviced vessels should total 500 to 800 m^3. The daily output of onboard separation/filtering units should ensure treatment of the entire amount of oil mixtures received on board and stored in vessel tanks. Options include the following: • U.S. unit, rated at 11.4 m^3/hr, with collection efficiency ≤ 5 mg/L. • Russian unit, rated at 10 m^3/hr, with collection efficiency ≤ 5 mg/L. • Norwegian unit, rated at 6–15 m^3/hr, with collection efficiency ≤ 15 mg/L. • Norwegian unit, rated at 6–40 m^3/hr, with collection efficiency ≤ 15 mg/L. The volumes of tanks for receiving oil mixtures should correspond to plant capacity, i.e., 500 and 800 m^3 accordingly. Oil mixtures are purified first by plants to 5–15 mg/L, and further by special secondary filters to 0.05 mg/L. The complete life-service of the separation/filtering units should total no fewer than 30,000 hours.
Wastewater-treatment and disinfection units with the necessary devices and auxiliary equipment, including machinery to receive and deliver these waters	The volume of the ship tanks for receiving sewage from the vessels should total 550–900 m^3. The daily output of onboard wastewater-treatment and disinfection units should ensure treatment of the complete store of these waters in the tanks of the vessel. In developing the technical proposal for a ship, the alternatives of treatment and disinfection units with a capacity of 900 m^3/day should be examined; no fewer than two single-type plants of identical capacity in each alternative should be identified. The volumes of wastewater holding tanks should correspond to capacities of 550 and 900 m^3, accordingly. Options include Russian devices rated at 5.0 m^3/hour, an American unit rated at 30 m^3/hour, and a Norwegian unit.

Garbage-treatment units (incinerator and plasma-arc furnace) with necessary devices and supplementary equipment	Should be environmentally safe: gases discharged must contain no mineral or organic aerosols or toxic components exceeding the maximum admissible levels determined by the 1990 RF regulations. The volume of the ship reservoirs for garbage (holds and bins), received from other vessels, should total 55–90 m^3. The daily output of onboard treatment units should ensure the treatment of the entire amount of garbage stored in the onboard garbage tanks (holds and bins). The equipment should include the following: • Cargo crane(s), rated at 3 to 4 tons with a boom radius of 15 m to the left and right sides of the ship for the loading/reloading of garbage from serviced vessels; • Compartment equipped for sorting garbage; • Crusher of glass, ceramics and metal; • Compactor of various metal, plastic and other types of waste; • Dewatering unit for sewage sludge; • Unit for treating food waste into food additives for livestock with a subsequent delivery to the land in a packaged form; and • Compartment for interim storage of treatment products (briquettes of compressed metal, packages of crushed glass, ceramics, and ash). On large-displacement vessels, the equipment of the serviced vessel, such as a plasma-arc furnace, a plastic-waste processor, a glass/metal/ceramics crusher, or an incinerator (for oily rags, plastics, cans, food, dirty fuel, and packing materials), can receive waste.
Device for collecting accidental oil spills at low speed and while stationary	• Bow device for collecting oil while moving at 1.0 to 1.5 knots. • Device for placing an extended floating barrier to contain and collect oil spills with the total area of about 0.2 km^2. • Independent oil-catching device. • Boat for placing a floating barrier compliant with fire-safety requirements. • Flexible tugged tanks with equipment and hoses (four units—two on board and two stored at the base), 1,000 m^3 each.
Accumulative tanks	• For slime, resulting from on-board wastewater treatment units and received from vessels equipped with wastewater treatment units, totaling no less than 30 m^3. • For spent lubricating oil received from the serviced vessels and subject to recovery on the land totaling 30–40 m^3.

Compartments and facilities of treatment tanks and reservoirs	Devices for cleaning, washing, and disinfecting ship-transport conveyers for garbage, and devices and machinery for steam-curing, washing, and cleaning of tanks for oil mixtures and effluent water of other vessels, with subsequent reception and treatment of cleaning products.
Instrumentation, systems, and devices for receiving and delivering oil mixtures and effluent water	Equipment should comprise stationary pumps rated at 100 m^3/hr and portable pumps rated at 50 m^3/hr, pipelines, hoses, and storage space for this portable equipment after disinfection (cleaning).
Equipment automation	Equipment for treating oil mixtures and garbage and treating and decontaminating sewage should have remote and local control.
Number and types of special onboard equipment	Number and types of separation/filtering units for oil mixtures and wastewater treating and decontamination, garbage treatment; devices for collecting accidental oil spills; and other special machinery (hose drums, secondary filters, conveyers, compactors) are to be determined after a comparative technical and economical assessment of the different equipment is made.
Placement of equipment	Production and ship-service areas should be structurally separated. The production area should include areas for 1) equipment for controlling the operation of waste-treatment equipment; and 2) indicators for decontaminating recycled oil mixtures, bilgewater, contaminated and effluent water, and exhaust gases of waste disposal devices.
Environmental safety requirements	• Waste-treatment technology placed in a sealed loop isolated from ship's service area. • Sanitary-hygienic compartments, including rooms for providing medical aid to members of crew and treatment plant personnel. • Environmental control at all stages of the waste-treatment process. • Passage to the production area through a special decontamination center. • Laboratory equipped with necessary instruments for conducting physiochemical and bacteriological analyses of wastewater, and for checking oil concentration in treated water, concentration of aerosols, and toxic components of exhaust gases from waste-disposal units.

Shipbuilding Elements	• Vessel autonomy of 10–15 days. • Flank speed of 10–12 knots, at full-load displacement of the vessel and rated power of the main propulsion machinery plant in regular mile test. • Fuel tank capacity that allows 10 days of operation at 10 knots for ≥1,000 miles. • Maneuverability of the ship that allows the ship to: - Collect oil from the sea surface at speeds up to 5 knots, using the main propulsion machinery plant (MPMP) and the bow auxiliary thrust device; - Deploy a floating oil-spill boom while alongside the serviced vessel, at sea state 4 and wind speed up to 5 knots; and - Run at more than 5 knots in reverse, using the MPMP. • Ship’s body, stability, subdivision, damaged stability, sitting, sea-keeping capabilities, systems, devices, and fire-and-explosive safety measures* • Rolling characteristics that do not restrict the use of special facilities, devices, and systems when operating under full load and at sea state 4.
Completion and habitability	• Requirements for recruiting the personnel (civilians) must account for two labor shifts (duties) at common ship’s stations and positions, while sailing between bases and three labor shifts at waste-treatment units. • Ship’s habitability should comply with the “Sanitary Regulations for Sea-Going Vessels of USSR,” 1984 edition, with allowance for Russian Navy requirements.

<table>
<tr>
<td>Power plant</td>
<td>The MPMP should be diesel electric and meet the following requirements:

• Major diesel generators that provide the rated power supply of all users on board, wherever possible, and two stationary steerable propellers (SP); and
• Ability to receive waste from the serviced vessel, while alongside it during long-term, slow movement (0 to 5 knots) in combination with auxiliary thrust devices, and while operating under full load and at sea state 4.

The ship's electrical power system (EPS)* should have alternate 3-phase current, 50 Hz, 380 V, centralized control system, ensure power supply from land, and incorporate:

• The main diesel generators of the MPMP;
• Emergency and standby diesel generators, with amount and power sufficient for users working simultaneously in different operation modes, including emergency situations;
• A station for receiving electrical power supply from land, ensuring crew life support and operation of all systems, devices, and equipment necessary for regulated use of the vessel;
• Two automated auxiliary water-tube boilers (one standby) and one supplementary waste-heat boiler (to supply the vessel and production processes with vapor while cleaning and washing the tanks and reservoirs (p.4.2.3 and 4.2.7)); and
• Power plant that is controlled from the pilothouse and the area of energetics and damage tolerance.</td>
</tr>
</table>

Shipboard equipment	• Maneuverability at low speed, with an auxiliary thrust device (bow thruster). • For freight handling operations, an onboard electric hydraulic crane (1–2 pcs.), rated at 3–4 tons, with a boom radius of 15 m to the left and right sides of the ship. • Onboard anchor gear, mooring and tow equipment, device for closing the openings in the body, deckhouses, and superstructures. * • Life-rescue equipment. * • Supplies and salvaging property outfitted according to Russian Navy requirements.
Ship's service systems	• Fire-prevention and bilge systems and the domestic-water facilities and compressed air systems. * • An onboard system to collect its own bilgewater, contaminated and effluent water, with subsequent withdrawal into tanks for receiving similar water from serviced ships. • Year-round air conditioning in living, public, medical, and service areas. • To maintain necessary temperature range during the cold season, a heating system with supplying machinery in auxiliary, public health, and service rooms. • To maintain necessary temperature range in marine cold rooms, the refrigerating machines and air coolers, with one as a standby.
Automation	• Overall system of control, together with control systems, delivered with units and equipment. • Vessel automation, power plant, waste-treatment technical equipment, common ship systems, and devices. * • Protection of information against the unauthorized access, performed in accordance with the State Technical Commission's guides, under the administration of the RF President.
Navigation and communication equipment	To ensure onboard navigation safety, a radar station should be installed, along with other equipment. *

Note:
* Must comply with the Rules of the Marine Register of Russia, allowing for Russian Navy requirements.

In March 2000, Russian and U.S. Project Officers met in St. Petersburg, Russia to review progress on Project 2.2-0 and plan the way ahead. Phase I of the project - to define the requirements, assess RF, NO, and US technologies, and propose a notional design for a waste treatment vessel - had been completed successfully. However, it was decided to defer Phase II - final detailed design and vessel construction - and instead, select one of the waste streams for a shipboard technology demonstration. The waste stream selected was bilge oily waste. Follow-on Project 2.2-1 was formulated with the goal of demonstrating a Russian system for bilge oily waste treatment on a Russian Federation northern Fleet naval ship or vessel.

PROJECT 2.2-1: DEMONSTRATION OF A RUSSIAN OILY WASTE-TREATMENT SYSTEM ONBOARD A RUSSIAN FEDERATION SHIP OR VESSEL

Description of the Project

The purpose of this project is to fabricate, install, and demonstrate a Russian oily wastewater (bilgewater) treatment system on board a Russian Navy Ship in the Northern Fleet.

The project is structured into 4 tasks:

- **Task 1** is the review of available Russian oily bilgewater treatment technology and selection of a system and a Russian navy ship for the installation and demonstration.
- **Task 2** is the fabrication of the bilgewater treatment system.
- **Task 3** is the installation of the system on board the ship.
- **Task 4** is the onboard operation and demonstration of the system and training of the ship's crew.

Project 2.2-1 Technical Experts from Russia and the U.S. looked at two different types of Russian oil/water separators that could be suitable for shipboard installation. The first was a system developed by Rubin Central Design Bureau for Marine Engineering, St. Petersburg, Russia. It is pictured below in Figure 1. Southern Shipping Company, St. Petersburg, Russia, offered the second system called ECOMARINE. It is pictured in Figure 2.

Fig. 1. The Rubin
Oil/Water Separator

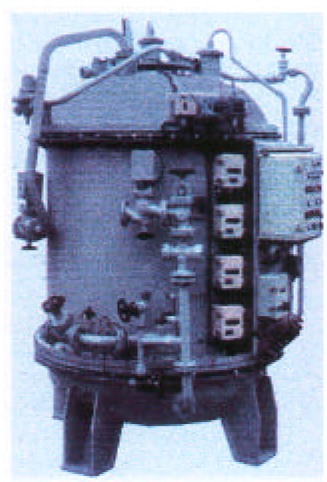

Fig. 2. The ECOMARINE
Oil/Water Separator

Norwegian and United States Technical Experts will review specifications compiled by the Russian side and the Technical Experts from all three nations will consider these and other competing commercial systems to select the best for the shipboard demonstration in the RF Navy Northern Fleet.

AMEC PROJECT OFFICERS

The AMEC 2.2-0 Project Officers for the U.S. Department of Defense were Joel Krinsky, Naval Sea Systems Command (until he retired from Government service in 2000), and then Mr. Craig Alig, Naval Sea Systems Command Carderock Division of the Naval Surface Warfare Center. Dr. William Bailey of Geo-Centers, Inc., provided technical expertise and contractor support on this project. The Norwegian Project Officer was Captain Tor Gunnar Eide, Norwegian Navy. Det Norske Veritas AS provided technical expertise and contractor support to the Norwegian team. The Russian Project Officer was Captain Alexander Zharikoff, Russian Navy. Other members of the Russian team included Dr. Adam Gonopolsky and Captain Mikael Malishev. ICC Nuclide provided contractor support for the Russian team.

AMEC Project 2.2-1 Project Officer for the U.S. Department of Defense is Mr. Craig Alig. Dr. William Bailey continues to provide technical expertise. Mr. Christian Karanski, Technology Management Company provides contractor support for this project. The Norwegian Project Officer is Commander Stein Ivar Alsaker, Royal Norwegian Navy Material Command, Bergen, Norway. Mr. Kjell Karlstad of the same organization provides technical expertise for the Norwegian team. The Russian Project Officer is Commander Anton Sobolevsky of the Shipbuilding Department of the RF Navy Ministry of Defense.

REFERENCES

1. C. ALIG and W. A. BAILEY, "Project 2.2: Design and Construction of a Waste Collection and Processing Vessel for Naval Ship Waste: Summary Report" NSWCCD-63-TR-2000/243, Arctic Military Environmental Cooperation Program, U.S. Department of Defense, March 2000.

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