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5.0 OTHER PCB MATERIALS

5.1 TYPES OF OTHER PCB MATERIALS

Reference 8 requires that, ". . . in the event that all of the . . . known sources of non-liquid PCBs . . . have not been removed from a vessel . . . " sampling is to be done to determine whether any materials that remain aboard contain PCBs that must be removed and handled as PCB waste. To simplify sampling, the EPA has lumped all of the listed materials into 10 categories:

1 - Electric cables
2 - Ventilation system gaskets
3 - Rubber gaskets (other than ventilation system gaskets)
4 - Felt gaskets (other than ventilation system gaskets)
5 - Fiberglass, felt, foam, or cork thermal insulation material
6 - Sound deadening felt
7 - Grouting, caulking, rubber isolation mounts, foundation mounts, and adhesives
8 - Tapes
9 - Pipe hangers
10 - Rubber/plastic parts of all sizes and shapes (other than listed above).

In the event that a sample in any category is found to contain PCBs at or above 50 ppm, Reference 8 requires all of the materials in the category to be removed and disposed of as PCB waste. Reference 8 also permits selective removal of materials within a category provided the category is resampled following removal to establish that the category no longer contains materials with PCBs.

While not required to be sampled by Reference 8, all known liquid PCB materials, including oils and greases, must also be removed from the ship; therefore, samples of a few of these materials were taken and assigned category 11.

The sampling data for materials other than cable and ventilation system gaskets were divided into Categories 3 through 11 and recorded in Tables 16, 17, and 18 of Reference 3. Table 9 summarizes all of the data in Reference 3, showing in gray shade the categories where one or more samples in the category contained PCBs at or above 50 ppm. The total number of samples taken in each category is indicated by the number. Note that four categories among the three ships were not sampled for the reasons given in Reference 3.

Some rubber gaskets, those installed in portholes, access port covers and other readily accessible installations, are relatively easy to remove but those in piping systems present particular problems. Removal of seawater system gaskets, for example, entails disassembly of heavy piping systems (some approaching two feet in diameter) and removing flanged fittings and access ports weighing hundreds or thousands of pounds, while providing some means to prevent flooding of the ship as the systems are opened.

The removal of rubber gaskets is a normal practice during the course of domestic recycling. All will be exposed and removed as the ships are cut up, the metals prepared for recycling and the reusables made ready for resale. The added cost to manage the gaskets as PCB materials should be small in this environment because the total weight of gasket material probably doesn't exceed 2000 pounds. However, removing all rubber gaskets from an intact ship does not appear to be practical. Piping systems containing rubber gaskets, including seawater, fresh water, fuel, and waste systems, would have to be disassembled without disturbing the outer hull. This would require many months of work by dozens of workers and might involve restoration of some systems to meet requirements for safe towing. Because of this, no costs are estimated for removal of rubber gaskets.

5.2.2 Category 4, Felt, Other Than Vent Gaskets

Only in the EXPORT CHALLENGER was material found in this category. (Category 4 was not sampled in the WAYNE VICTORY for reasons discussed in Reference 3.) PCB felt was found in a gasket of a decorative closure on a light fixture in the Officer's Mess and PCB-free-felt was found in a heat exhaust fan over the deep fat fryer in the galley. As noted in Section 3.3, there are about 1200 light fixtures in the EXPORT CHALLENGER and all may have PCB felt gaskets. As noted in Section 4.4, felt gaskets leave behind a residue which cannot be easily removed. Therefore, removal of Category 4 felt gaskets requires removal of metal surfaces on either side of the gasket along with the gasket. The estimated cost to remove Category 4 gaskets in the EXPORT CHALLENGER is:

EXPORT CHALLENGER

Labor:	1200 gaskets @ 15/worker-day x $112.50/day	≈ $9000
Disposal:	1200 gaskets @ 1 lb. each x $0.69 per pound	≈ 800
	1200 flange pairs x 5 lbs. each x $0.69 per pound	≈ <u>4,100</u>
	TOTAL	≈$14,000

5.2.3 Category 5, Thermal Insulation

Both the EXPORT CHALLENGER and the WAYNE VICTORY had high PCB levels in samples representing this category. In the EXPORT CHALLENGER, the high PCB sample was foam rubber thermal insulation taken from a ship's air conditioning fan room pipe. In the WAYNE VICTORY, the high-PCB sample was high-temperature thermal insulation from the

3.0 PCBs IN ELECTRIC CABLES AND OTHER ELECTRICAL AND ELECTRONIC EQUIPMENT

3.1 BACKGROUND

In the United States, most electric cables that are removed from old buildings, vehicles, equipment and other retired systems are recycled by shredding the cables to pea-sized or finer particles, separating the nonmetallic insulation materials from the granular copper, selling the copper for remelting and reforming into new products, and disposing of the nonmetallic residues as municipal waste. Some cables are stripped of their insulation by slitting machines that allow workers to physically separate the copper strand from the insulation. Old cables may contain asbestos insulation; therefore, shredding and separating systems are usually equipped with air control systems to ensure containment of asbestos dust.[1]

Because of PCBs in shipboard electric cables, EPA regulations make it difficult and often impossible to recycle the cables in accordance with established methods. One firm[2] has recently acquired the necessary permits to shred and recycle PCB-bearing cables; but, overall, the cable recycling industry has not yet responded to the problem, largely because of uncertain EPA regulations.[3]

Electrical and electronic equipment used in ships may also contain PCBs. Transformers and capacitors contain PCBs, and specific rules for their use and management are contained in EPA regulations. Lubricants, caulks and nonmetallic components used in such equipment may also contain PCBs to the same extent as comparable products used in non-electric services.

3.2 CABLES

The results of the sampling and analysis of electric cables are shown in Tables 9, 10, and 11 of Reference 3.

As can be seen in Table 11 of Reference 3, the WAYNE VICTORY cables contained no PCBs and, therefore, could be recycled for recovery of copper without concern for PCBs. Many WAYNE VICTORY cables also contain lead sheaths which would add to the revenue from recycling. Because of the absence of PCBs, no further efforts were made to explore cable issues in the WAYNE VICTORY.

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[1] From TCI Incorporated, Pell City Alabama.

[2] H.E.L.P.E.R. Inc. of Madison, South Dakota.

[3] In December 1994, EPA proposed many changes to PCB regulations that would help resolve these problems; however, as of November 1996, appropriate rules have not been issued.

Table 9. PCBs Above and Below 50 ppm in Each EPA Item Category*

PCB Item Category	Ship		
	EXPORT CHALLENGER	SHIRLEY LYKES	WAYNE VICTORY
1 - Electric Cables	35	31	24
2 - Vent Gaskets	30	27	23
3 - Rubber Gaskets	9	5	1
4 - Felt, other than Vent Gaskets	2	1	0
5 - Fiberglass, Felt, Foam or Cork Thermal Insulation	3	2	2
6 - Sound Deadening Felt	1	1	0
7 - Grout, Caulk, Rubber Mounts and Adhesives	5	3	5
8 - Tapes	0	2	0
9 - Pipe Hanger Liners	1	1	1
10 - Misc. Rubber and Plastic Parts	3	2	2
11 - Oils and Greases	4	4	2

* Gray shade indicates that one or more samples in the category contained PCBs at or above 50 ppm. The number in each box shows the total number of samples taken in the category.

5.2 REMOVAL OF OTHER PCB MATERIALS

The actions and estimated costs to remove materials in Category 1 (electric cables) and Category 2 (ventilation system gaskets) were discussed in Sections 3 and 4, respectively. Categories 3 through 11 are discussed below.

5.2.1 Category 3, Rubber Gaskets Other Than Air Handling System Gaskets

As seen in Table 9, all three ships contain PCBs in this category. Rubber gaskets are used in most electrical and mechanical components and systems. Samples were taken of spare or installed gaskets for hatches, doors, windows, electric distribution boxes, machinery access ports, and piping systems. The ship surveys revealed the presence of rubber gaskets in the main seawater systems, condensate systems, fresh water systems and other piping systems of the EXPORT CHALLENGER and the SHIRLEY LYKES. They are probably used in comparable WAYNE VICTORY systems as well, but the lighting in the vessel was so poor during the resurvey that positive identification could not be made. PCBs were found in more than one half of the samples.

main machinery room. At a minimum, Reference 8 requires removal of the foam rubber pipe insulation in the EXPORT CHALLENGER and the main engine thermal insulation from the WAYNE VICTORY.

References 28 through 31 show that the EXPORT CHALLENGER has approximately 1600 feet of air conditioning and refrigeration system piping, ranging from ¼ inch to 3⅝ inches in diameter, which is insulated with foam rubber insulation of the type found to contain PCBs. The insulated piping traverses several compartments. It is estimated that one worker could remove all the insulation in about five days, generating about 2000 pounds of PCB waste. The cost for removal and disposal of this insulation will therefore be:

EXPORT CHALLENGER

Labor:	1600 ft. @ 1 worker for 5 days @ $112.50/day		≈ $ 600
Disposal:	2000 lbs. @ 0.69/lb.		≈ 1400
		TOTAL	≈$2000

Table 21 of Reference 3 shows that the engine insulation in the WAYNE VICTORY is asbestos. In Section 6.2, the removal of asbestos from the main machinery space of both ships is discussed and cost estimates are provided. No additional costs would be involved in removal of WAYNE VICTORY insulation because of the presence of PCBs.

Following these actions, Reference 8 requires resampling of remaining Category 5 materials such as the thermal insulation in the EXPORT CHALLENGER engine and bulkhead insulation in the WAYNE VICTORY. Should any of the repeat samples reveal PCBs, additional removal would be required; therefore, the cost estimates in Section 6.2 represent the minimum cost for remediating PCB materials in Category 5.

5.2.4 Category 6, Sound Deadening Felt

As shown in Table 9, none of the samples from this category in the two ships where it was sampled showed PCBs; therefore, no remediation of this Category is required.

5.2.5 Category 7, Grout, Caulk, Rubber Mounts and Adhesives

Tables 16, 17, and 18 of Reference 3 show that all three ships had one or more samples in this category that are high in PCBs. Products in this category are widely used in ships. Nearly all electric cable penetrations in switches, junction boxes, power distribution panels and through bulkheads, decks and overheads are caulked. Piping penetrations through bulkheads, decks and overheads are often caulked. Caulk and grout are used to seal cracks in insulation, embed small components, seal portholes, stacks and other openings in topside surfaces, and for many other services. In the SHIRLEY LYKES electric system alone, Reference 12 allows not less than four different types of caulking, sealers and fillers (plastic sealer per MIL-I-3064 or equal, Johns

Manville caulking, Johns Manville sealer and asbestos cloth soaked in red-lead compound). For the EXPORT CHALLENGER, Reference 32 specifies "permanently plastic weatherproof sealant" and "plastic sealing compound" to seal joints between insulation sections on weather deck piping and requires Benjamin Foster 30-36 lagging adhesive (or equal) to glue lagging cloth to insulation, while Reference 36 specifies three different adhesives and bonding agents to be used for installing deck tiles.

Removal of materials in Category 7 presents problems similar to removal of materials in Category 3. The materials are so widely used that removal of all is impractical. From the available drawings, not less than ten different caulking compounds, grouts, and adhesives materials were used in the ships and the true number is probably in the dozens. The objective evidence from Reference 3 shows, however, only high PCBs in caulks and grouts used in piping penetrations in the EXPORT CHALLENGER and WAYNE VICTORY. The drawings showing the number and sizes of caulked pipe penetrations in these ships could not be found, but from visual surveys the number appears to be in the hundreds. For the purpose of estimating a removal cost, it is assumed that there are 500 such penetrations in EXPORT CHALLENGER, the average pipe size is 1 inch, the weight of each penetration, including the piping, is 20 pounds, and one worker can remove four penetrations per day. For WAYNE VICTORY, 250 penetrations are assumed and all other factors are the same.

EXPORT CHALLENGER

Labor:	500 penetrations @ 4/worker/day @ $112.50/day	≈ $14,000
Disposal:	500 penetrations @ 20 lbs. each @ $0.69/lb.	≈ 7,000
	TOTAL	≈ $21,000

WAYNE VICTORY:

Labor:	250 penetrations @ 4/worker/day @ $112.50/day	≈ $7,000
Disposal:	250 penetrations @ 20 lbs. each @ $0.69/lb.	≈ 3,500
	TOTAL	≈ $10,500

In the SHIRLEY LYKES, the only Category 7 material found with PCBs (of three samples taken) was a foam rubber pad. There was only one such pad noted during the ship survey.

Reference 8 requires additional sampling of Category 7 materials after removal of piping penetrations. This sampling may reveal PCBs in other materials, requiring further removal. Therefore, the total cost for removal of Category 7 materials may be higher.

5.2.6 Category 8, Tapes

Only two small pieces of tape were found in the three ships, both in the SHIRLEY LYKES. Less than one worker-hour would be required to remove the tape.

5.2.7 Category 9, Pipe Hanger Liners

No PCBs were found in pipe hanger liners of any of the ships. No action is needed.

5.2.8 Category 10, Miscellaneous Rubber and Plastic Parts

This category intuitively includes a wide variety of products that might contain PCBs. But of the two to three samples taken in each ship, no PCBs were found. Therefore no action is needed.

5.2.9 Category 11, Oils and Greases

Reference 8 requires all ". . . known sources of liquid PCBs . . . " to be removed and defines the term to include ". . . hydraulic equipment; heat transfer fluids; vacuum pump oil; air compressor lubricants; cutting oil; and grease." To determine whether it is likely for such products to contain PCBs, samples were taken and the results reported in Tables 16, 17, and 18 of Reference 3. None of the grease samples were successfully analyzed for PCBs because of interference from impurities; however, hydraulic oil samples from the same machines showed no PCBs. These samples do not cover all of the known sources in the ships, but the results indicate that PCBs are probably not present in hydraulic fluids, lubricants and greases.

6.0 OTHER HAZARDOUS MATERIALS

6.1 INTRODUCTION

Tables 19, 20, and 21 of Reference 3 report the results of sampling of the three ships for potentially hazardous materials other than PCBs. Samples were taken for asbestos in insulation, gaskets, valve packing and electric cables; cadmium plating on metal fasteners; ethylene glycol in diesel cooling systems; chlorofluorocarbons in refrigeration systems; lead in paint chips and organotin in hull paint. With the exception of tin in hull paint (from the use of tributyl tin as an antifoulant), all of the potential hazardous materials were found in all three ships. Therefore, during domestic scrapping, all of the wastes generated that contain these materials will be subject to domestic regulation.

There are other potentially hazardous materials in old ships that were not included in the sampling program. These include sludge in fuel oil and cargo oil tanks, bilge water, and partially used containers of adhesives, paints, solvents and other consumable products left aboard. These materials may be subject to regulation as hazardous wastes when they are removed from ships or no longer have a function in the ship.

Concepts which allow continued use of largely intact scrap ships presents some unique problems. For reefbuilding, current regulations require the removal of materials which may pollute the marine environment. There are no explicit guidelines as to what must be removed and what may remain. Therefore, discussions with regulatory authorities are required.

For use overseas, including for scrapping overseas, hazardous materials also present unique problems. As noted in Section 2, materials containing PCBs may not be exported from the United States. Regarding hazardous wastes other than PCBs, 40 CFR 262, Subpart E, specifically prohibits their export unless both the EPA and the Government of the receiving country agree. Reference 4 discusses domestic and international law affecting ship breaking/recycling, noting that the exportation of ships for recycling is not prohibited but that, under the Basel Convention, importing nations may restrict the importation of hazardous materials and wastes.

The restrictions that an importing country will place on a scrap ship cannot be known in advance. However, the following estimates have been developed assuming that no importing country will knowingly permit the importation of large amounts (>1000 pounds) of hazardous wastes or materials that will generate large amounts of hazardous waste. The estimates are derived from the cost of services and waste disposal in the Norfolk, Virginia area (Appendix A). The labor rate is the same as used for the PCB cost estimates, $112.50 per day.

6.2 ASBESTOS

Asbestos is clearly a hazardous material in that it causes cancer, asbestosis, emphysema and other diseases. Because of its unique history, asbestos is heavily regulated in the United States. Asbestos waste is considered a hazardous waste by the Basel Convention, and many countries also regulate it under their own rules. Most thermal insulation in all three ships contains asbestos as seen in Tables 19, 20, and 21 of Reference 3. This is confirmed for the EXPORT CHALLENGER by Reference 32 where a large variety of asbestos products are specified. None of the insulation products in the ships appear to have any reuse potential. All are old, sometimes oil soaked, and fitted to particular systems. They are glued in place and cannot be removed in a manner that would retain any utility. Many scenarios regarding use of old ships may require removal of asbestos thermal insulation, including use of ships in public displays, as storage facilities, or for overseas recycling.

Removal of the many other asbestos products that might be encountered in the ships is not included in the estimate. Marinite wallboard that remains after removal of cables and ventilation gaskets is in excellent condition. Asbestos gaskets and valve packing are also not included as some gasketed machinery and valves, packed with asbestos, may be reusable.

Based on rough estimates from a Norfolk, Virginia area firm having experience in the removal of asbestos from military ships,[1] the cost to remove and properly dispose of asbestos from each of the three MARAD ships is $200,000. A breakdown between labor and disposal cost is not available.

This estimate is approximate. Much of the cost is in safely removing the asbestos from the engineering spaces once it is cut from the components and bagged. In the three MARAD ships, access within the machinery spaces is much better than in compact military ships, and therefore the cost might be lower.

6.3 CADMIUM

The cadmium results reported in Tables 19, 20 and 21 of Reference 3 were obtained by analyzing filings from the surfaces of small metal parts for total cadmium. It is not known whether the cadmium was from plating or from residues of a lubricant or paint (which may contain cadmium), nor were the parts tested to determine whether they fail the Toxic Characteristic Leachate Procedure test of Federal hazardous waste regulations. However, it is known that cadmium-plated metal will fail the test; therefore, it is likely that the parts will also.

The total amount of cadmium-plated parts in any of the three ships is not known. Only one sample was taken from each ship and all three samples showed evidence of cadmium. A brief review of available drawings indicated that cadmium plating was common at the time. Reference

[1] Courtesy of Waco Inc, 118 39A Cannon Blvd, Newport News, Virginia.

20 specifies, for example, cadmium plating of all air diffusers, registers and grills in the ship. From this evidence, it is likely that each of the ships contains hundreds or thousands of cadmium plated parts.

Because the cadmium-plated metal parts are in good condition and may be reusable in many different circumstances, no need to remove these parts is anticipated.

6.4 ETHYLENE GLYCOL

Ethylene glycol (antifreeze solution) was found in cooling systems in the two ships in which it was sampled. Nearly all of the cooling requirements in the ships are provided by seawater. Only specialized cooling needs such as the emergency diesel generator employ antifreeze. Drawings or other information which would allow the amount aboard each ship to be estimated were not available; however, it appears that not more than 200 gallons would be present based on the size of the systems involved. For the reefbuilding scenario, the fluid would probably need to be removed; however, there is so little aboard that the cost to remove it is judged to be insignificant. Because the cooling fluid has corrosion preventive properties, it is considered functional and could be reused in the machines. Therefore, for other scenarios, including export for recycling, the fluid would be left in place.

6.5 CHLOROFLUOROCARBON REFRIGERANTS

Both the EXPORT CHALLENGER and the SHIRLEY LYKES carry domestic air conditioning and cargo refrigeration systems. The systems in both ships are powered by multiple refrigeration compressors using R-12 refrigerant (dichlorodifluoromethane). References 28 and 30 cite a total R-12 charge of 580 pounds for all of the EXPORT CHALLENGER's refrigeration systems. Comparable drawings for the SHIRLEY LYKES could not be located but equivalent systems are anticipated. From physical inspection of the spaces, the WAYNE VICTORY has a minimal air-conditioning system and therefore should contain far less refrigerant. As seen in Tables 19, 20 and 21 of Reference 3, R-12 was confirmed to be present in the refrigeration systems of all ships. The amount left in the systems could not be determined.

Refrigerants such as R-12 are regulated by the international Montreal Protocol on Substances that Deplete the Ozone Layer. Domestic regulations that implement the protocol are in Title 40 of the Code of Federal Regulations, Part 82. These regulations require that the refrigerant in the ships be carefully collected for reuse or disposal by certified technicians if the machines are no longer being used. Venting of the refrigerant to the atmosphere is not permitted.

Whether or not the refrigerant would be removed depends on the ultimate disposition of the ship. For domestic recycling, the recycler may have a market for the refrigeration systems and the refrigerant as well. For reef-building or other uses of the ship that do not require the refrigeration systems to be operable, removal may be appropriate. Because we were unable to measure the amount of freon present in the systems, we could not estimate with any accuracy the cost to remove it.

Regarding export of the ships, the export of any amount of R-12 to any country that has not signed the Montreal Protocol (and its subsequent amendments) is prohibited by EPA regulations. The three nations that have recently imported ships for recycling, Mexico, India and China have signed. Therefore, removal of R-12 would not be required before export, provided the export is made to one of those three nations.

6.6 LOOSE PAINT

Tables 19, 20 and 21 of Reference 3 show that high levels of lead exist in paint aboard all three ships. Although not analyzed, high levels of chromium are also expected because the use of chromium-containing primer paints was common during the time the three ships were built and operated. These paints are specified in paint schedules such as Reference 33. Lead and chromate bearing paints will fail the Toxic Characteristic Leachate Procedure test of Federal hazardous waste rules and will therefore be subject to regulation.

6.6.1 Interior Paint

The interior paints in all ships are in good condition. Paint which is tightly adhering to surfaces prevents corrosion and is therefore serving a function. A requirement to remove adherent paint is not anticipated.

6.6.2 Exterior Paint

Exterior paints on the EXPORT CHALLENGER and WAYNE VICTORY are in poor condition. Severe peeling and bubbling exist on nearly all weather surfaces. The decks of these ships hold large accumulations of paint chips mixed with rust. It is concluded that loose paint and accumulations of paint chips on decks must be removed regardless of the ultimate disposition of the ships.

Measurements of paint chip depth and extent were made on the decks of the WAYNE VICTORY and the EXPORT CHALLENGER. Paint chips cover the weather decks within two feet of the gunwales and all vertical deck-mounted structures on both ships. A sample of paint covering approximately ¼ square foot of such an area was collected and found to weigh about 0.3 lb., giving a paint chip loading of about 1.2 pounds per ft^2. The thickness of peeling paint on weather surfaces was measured at 1/32 inches with a bulk density of about 2 (128 lbs/ft^3). About half of the paint on weather surfaces was estimated to be loose. Estimates of the total weather surface area were made from ships drawings, such as Reference 34, and from all of this information, the amount of loose paint was estimated. The results of these calculations are as follows:

EXPORT CHALLENGER

Total area of paint chips on decks	≈ 6400 ft^2	
Total pounds of loose paint on decks @ 1.2 lbs/ft^2		≈ 8000 lbs.
Total area of peeling paint	≈ 55,000 ft^2	
Fraction easily removable	≈ 1/2	
Volume of peeling paint	≈ 72 ft^3	
Total pounds of peeling paint		≈ 9000 lbs.
	TOTAL	≈ 17,000 lbs.

WAYNE VICTORY

Total area of paint chips on decks	≈ 3100 ft^2	
Total pounds of loose paint on decks @ 1.2 lbs/ft^2		≈ 4000 lbs.
Total area of peeling paint	≈ 35,000 ft^2	
Fraction easily removable	≈ 1/2	
Volume of peeling paint	≈ 46 ft^3	
Total pounds of peeling paint		≈ 6000 lbs.
	TOTAL	≈ 10,000 lbs.

Collecting loose paint from decks and scraping the topsides inboard of the gunwales should be straightforward work that could be accomplished by a crew of about 10 workers in five days (50 worker days).

Removing loose paint from the sides of the ships will require draping the ship's sides to prevent paint from falling into the harbor and will be done from scaffolds. This is judged to require double the effort of removing the other topside paint. Thus, the estimate for labor to remove paint chips and loose paint is 150 work days or about $17,000 for each ship. The condition of paint in the SHIRLEY LYKES is considerably better than either of the other two. There are small amounts of loose paint on the decks and most of the paint on the weather surfaces is still adhering. About ¼ of the work estimated for EXPORT CHALLENGER is judged to be needed to collect and dispose of loose paint on SHIRLEY LYKES.

The estimate for removal of paint chips and loose paint from each ship is:

EXPORT CHALLENGER

Labor:		≈$17,000
Disposal: 17,000 lbs. @ $0.58 /lb.		≈ 10,000
	TOTAL	≈$27,000

WAYNE VICTORY

Labor:		≈$17,000
Disposal: 10,000 lbs. @ $0.58 /lb.		≈ 6,000
	TOTAL	≈$23,000

SHIRLEY LYKES

Labor:		≈ $4,000
Disposal:		≈ 3,000
	TOTAL	≈ $7,000

6.7 POLYCYCLIC AROMATIC HYDROCARBONS

Polycyclic aromatic hydrocarbons (PAHs) were analyzed in asphaltic paint used in some wet lockers. PAHs are a family of coal or petroleum-derived hazardous materials often found in coal tar paints that are used where water resistance is imperative. Very small amounts of asphaltic paint were found. All was adherent and still functional; therefore, removal is not required.

6.8 ORGANO-TIN

Tributyl tin (TBT) was once used as the anti-fouling agent in ship bottom paint. Paint with TBT is extremely toxic. During removal, workers must wear protective suits and be provided with filtered breathing air. Removed paint must be handled as a hazardous waste. As the ships were afloat and the sampling plan called only for sampling of the ship's topsides, samples of paint from below the waterline were not taken. However, samples of paint were taken from as far down the side as could be reached. Tin at levels typical of anti-fouling paints (1% or more) was not found in these samples. Sampling of paint from below the ship's waterline is required to determine whether there is an issue with TBT.

6.9 FUEL AND CARGO TANK SLUDGE

Sludges from fuel and cargo tanks are regulated as hazardous wastes in the United States. If the tanks are full or partly full of usable oil, then the tanks contain reusable oils that are not regulated as hazardous wastes. But failing that, cleaning of the tanks to remove the residues will likely be required regardless of the ultimate disposition of the ships. Information on the status of the tanks in all three ships was obtained from the James River Reserve Fleet.[2] Table 10 summarizes this information.

Table 10. Fuel and Oil Tank Status

	EXPORT CHALLENGER	SHIRLEY LYKES	WAYNE VICTORY
Date of last sounding	Nov 14, 1995	Nov 13, 1987	Oct 14, 1982
1 - Number of tanks	22	42	25
2. - Number full or partly full with water or sludge	5	1	2
3 - Number full or partly full with fuel or diesel oil	5	11	15
4 - Number requiring cleaning (row 1 minus row 3)	17	31	10
5 - Oil capacity	3882 tons[3]	3905 tons[4]	2888 tons[5]

Assuming that tanks that are full or partly full of fuel or diesel oil may be left uncleaned, the remaining tanks, shown in row four, require cleaning. The tanks in row two contain a mixture of water and oil sludge or oil sludge alone and must be pumped and then cleaned. Petroleum sludges often contain benzene and other hazardous constituents, or possess hazardous characteristics, as discussed in Reference 5, that cause them to be considered as hazardous wastes.

The cost to clean fuel tanks will be approximately $40 per ton of tank capacity.[6] The complexity and accessibility of the tanks and the amount of oily sludge and water that are encountered all affect the final cost. The capacity of each of the tanks could not be determined. Assuming the number of tanks to be cleaned is directly proportional to the total volume of fuel capacity in each ship, the estimated cost for cleaning the tanks in each ship is:

EXPORT CHALLENGER	17/22 x 3882 tons @ $40/ton = $120,000
SHIRLEY LYKES	31/42 x 3905 tons @ $40/ton = $115,000
WAYNE VICTORY	10/25 x 2888 tons @ $40/ton = $ 46,000

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[2] The most recent Fuel Oil Tank Soundings, James River Reserve Fleet form MA2-58, were provided for each ship.

[3] From the ABS Record and John LaDage, "Principles of Naval Architecture."

[4] From Bethlehem Steel Company Plan Number 4588/S94-0-1, "List of Safety Devices."

[5] From Bruce Engineering Company Drawing VC2-S-AP2.

[6] Courtesy of Boiler Cleaning and Specialty Company, 14428 Columbus Avenue, Portsmouth, Virginia 23704.

A breakdown between labor and waste disposal cost is not available.

The tank sounding information shown in Table 10 may not reflect the current condition of the tanks. Because of restrictions on the discharge of unprocessed bilge water, the James River Reserve Fleet has recently been using onboard tanks to receive bilge water that accumulates in the ships, rather than pump it over the side. The tank soundings for the SHIRLEY LYKES and the WAYNE VICTORY date from many years ago and therefore do not reflect this fluid. The amount is unknown, but it could add substantially to the waste disposal costs.

6.10 BILGE WATER

Large volumes of bilge water in all of the ships were observed in the main machinery spaces, exceeding 1 foot in some areas. Not all bilge areas of the ships were observed. Based on the ship's dimensions and the depth observed, at least 15,000 gallons were present in each machinery space.

Bilge water can come from leakage through hull fittings and internal seawater systems, from condensation of moisture during the cold winter months and from rainwater that passes through openings in the weather decks and bulkheads. Bilge water is often a hazardous waste because of its heavy metal and organic chemical content. In some states, bilge water is listed as a hazardous waste and must be treated as such regardless of its composition.

Assuming the bilge water in the three ships is a hazardous waste and that it must be properly disposed of regardless of the ultimate disposition of the ships, the disposal cost is estimated to be $40,000.

EXPORT CHALLENGER, SHIRLEY LYKES, WAYNE VICTORY

15,000 gal x 8 lbs/gallon x $0.32/lb. ≈ $ 40,000

6.11 EXCESS SHIP'S STORES AND OTHER MATERIALS

In the United States, partly used containers of grease, adhesives, caulks, paints and other such products that have no use and possess hazardous characteristics are regulated as hazardous wastes. Many compartments in all three ships contained partly used containers of such materials that appeared to be for use during maintenance of the ships. Once maintenance ceases and the ships are designated for recycling, the materials have no use, and current regulations require them to be removed and properly disposed of. The amounts of material observed were small, and removing them is estimated to involve very little labor. Therefore, no estimates are provided for removing excess ships' stores.

SHIRLEY LYKES may have a unique problem with fixed ship's ballast. Reference 34 shows the 1375 long tons of "mud ballast" installed with a notation that the ballast is not to be removed without the prior concurrence of the U.S. Coast Guard. The drawing goes on to describe the ballast as "fluid ballast" installed between frames 104 and 108, approximately midships. "Mud ballast" usually refers to drillers mud used in the petroleum drilling industry to lubricate drill bits and remove drilling debris. The mud is treated with lubricants and corrosion inhibitors. Used drilling mud has been used for ship's ballast. Mud ballast may also refer to concrete, rock, water, and other forms of locked-in ballast. There is no information available on the chemical nature of mud ballast in the SHIRLEY LYKES, but it is known that the U.S. Navy has used locked-in fluid ballast treated with sodium chromate to prevent corrosion of the ballast tanks. Sodium chromate is a hazardous material, and, if used in the SHIRLEY LYKES, the ballast could be subject to hazardous waste regulation. If so, the cost to dispose of the ballast could approach $1 million. There is no information available as to whether or not the EXPORT CHALLENGER and the WAYNE VICTORY contain mud ballast.

All three ships are heavily soiled with bird guano and bird carcasses. In some cases, birds have access to interior ships' spaces and have created deposits of guano and bird carcasses that are ankle deep. To the author's knowledge, this situation is not subject to environmental regulation but may be subject to local health standards at the site of recycling.

6.12 NONHAZARDOUS INDUSTRIAL WASTES

The recycling of ships generates large amounts of nonhazardous, solid industrial waste. Bedding, wood products, floor tiles, deck fillers, assorted nonrecyclable metal parts, and debris of many kinds are removed and placed in municipal or industrial waste landfills or processed by local waste management centers. For some scenarios involving use of largely intact ships, such as reefbuilding, loose materials such as bedding must be removed. For most others, no removal prior to ultimate disposition is needed. Because the cost of removing and handling such materials from an otherwise intact ship is judged to be small, we have not attempted to estimate a cost.

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7.0 SUMMARY AND CONCLUSIONS

This report describes the environmental problems attendant to breaking and recycling of small, break-bulk cargo ships of the types and sizes represented by the EXPORT CHALLENGER, SHIRLEY LYKES and WAYNE VICTORY in the United States. The report provides estimated costs for removing hazardous materials from otherwise intact ships so that they might be sold for recycling at a higher price, used for reefbuilding projects, or exported overseas for recycling. The cost estimates are tentative. A ship breaking/recycling firm, experienced in the trade, with trained workers, and with some assurance of repeat work lasting a few years or more, may be able to construct efficient processes for getting the work done for less. Table 11 summarizes the cost estimates developed in the previous sections.

This report, coupled with Reference 3, confirms that the environmental problems faced by recyclers of Navy ships and those who would try to recycle commercial ships are similar. PCBs in electric cables, gaskets, rubber and plastic products of all kinds are found in both groups of ships. Both have asbestos insulation problems, hazardous wastes, lead in old paint, and other comparable problems that touch on nearly every aspect of environmental regulation in the Nation. Some PCB problems appear to be unreconcilable under current regulations, and either regulatory changes or regulatory discretion appears needed to allow ships to be used for reefbuilding or be exported.

Appendix B demonstrates that the sampling guidance of Reference 8 does not appear to provide a clear and complete picture of the situation regarding PCBs in commercial ships. At the time of its preparation, the EPA had none of the data or information in this report or in Reference 3. Therefore, it is not surprising that the sampling guidance is not well suited to commercial ships. Section 6 shows that dealing with other hazardous materials is also difficult and expensive. Guidance is needed for this area, comparable in scope and intent to Reference 8. For all hazardous materials and wastes, a focused approach to sampling, based on reviews of ships' drawings and material lists, supplemented by ships' inspections, and based on the specific regulatory goals in mind, should provide greater precision for less sampling and analysis cost.

Table 11. Summary of Costs for Removal of Hazardous Materials from Ships Prior to Recycling

		EXPORT CHALLENGER		SHIRLEY LYKES		WAYNE VICTORY	
		$ Labor	$ Disposal	$ Labor	$ Disposal	$ Labor	$ Disposal
PCB Materials	Cables	56000	23000	61000	34000	0	0
	Other Electric	14000	14000	14000	14000	14000	14000
	Vent Gaskets	5000	1000	7000	2000	600	400
	Cat. 3, Rubber Gaskets	Note A	Note A	Note A	Note A	Note A	Note A
	Cat. 4, Other Felt Gaskets	9000	5000	0	0	0	0
	Cat. 5, Insulation	0	0	0	0	Note B	Note B
	Cat. 6, Sound Deadening Felt	0	0	0	0	0	0
	Cat. 7, Grout, Caulk, Adhesive	14000 Note C	7000 Note C	0 Note C	0 Note C	7000 Note C	4000 Note C
	Cat. 8, Tapes	0	0	0	0	0	0
	Cat. 9, Pipe Hangers	0	0	0	0	0	0
	Cat. 10, Misc. Rubber, Plastic	0	0	0	0	0	0
	Cat. 11, Oil & Grease	Note D	Note D	Note D	Note D	Note D	Note D
	Surface Cleanup	Note D	Note D	Note D	Note D	Note D	Note D
	PCBs Subtotal	$98000	$50000	$82000	$50000	$22000	$18000
Other Materials	Asbestos	200000		200000		200000	
	Cadmium	0	0	0	0	0	0
	Ethylene Glycol	0 Note E	0 Note E	0 Note E	0 Note E	0 Note E	0 Note E
	Refrigerants	0 Note E	0 Note E	0 Note E	0 Note E	0 Note E	0 Note E
	Loose Paint	17000	10000	4000	3000	17000	6000
	PAH	0	0	0	0	0	0
	Organotin	0	0	0	0	0	0
	Fuel & Oil Sludge	120000		115000		46000	
	Bilge Water	nil	40000	nil	40000	nil	40000
	Waste Ships Stores	0	0	0	0	0	0
	Mud Ballast	n/a	n/a	Note F	Note F	n/a	n/a
	Other Materials Subtotal	$387000		$362000		$309000	
	Grand Total	$535000		$494000		$349000	
	Cost per LSW ton	$77		$57		$78	
AVERAGE COST/LSW ton: $71							

Notes for Table 11.

Note A. The data suggest that removal of rubber gaskets from installed systems will be required to eliminate PCBs from the ships. This is judged to be not practicable in otherwise intact ships.

Note B. The cost for removal of the PCB-contaminated thermal insulation in WAYNE VICTORY is included in the cost of asbestos removal. In the event no asbestos removal is done, separate removal of the insulation to remediate the PCB problem will be required.

Note C. This estimate is based only on removal of caulked and grouted pipe penetrations. Removal of all caulking, grout and adhesive is not practicable.

Note D. Comprehensive sampling for oils and greases and for potential surface contamination problems were not performed. It is therefore not possible to estimate remedial costs.

Note E. There may be small costs for removal of these materials depending on the ultimate disposition of the ships.

Note F. If the mud ballast is found to be a hazardous waste, disposal cost could approach $1 million.

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19. Sun Shipbuilding and Dry Dock Company Drawing 623-779-E, "List of Ventilating Fans, Steam Heating, Coils & Dx Cooling Coils."

20. Sun Shipbuilding and Dry Dock Company Drawing 623-779-H, "Ventilation and Air Conditioning Terminal List."

21. Sun Shipbuilding and Dry Dock Company Drawing 623-915-4, "Machinery Space Ventilation Arrg't. Material List."

22. Bethlehem Steel Company Plan Number 4588/S38-1-8, "Ventilation Induction Unit List."

23. Bethlehem Steel Company Plan Number 4588/S38-1-9, "Ventilation Terminal List."

24. Bethlehem Steel Company Plan Number 4588/S38-1-5, "Ventilation Diagram - Machinery Space."

25. Bethlehem Steel Company Plan Number 4588/S38-1-3, "Ventilation Diagram, Main & Upper Tween Dks."

26. Bethlehem Steel Company Plan Number 4588/S38-1-2, "Ventilation Diagram - Forecastle Dk, Upper Dk & Above."

27. Bethlehem Steel Company Plan Number 4588/S38-1-4, "Ventilation Diagram - Lower Tween Dk & Hold."

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APPENDIX A

COST FOR ENVIRONMENTAL SERVICES AND WASTE DISPOSAL IN THE NORFORK, VIRGINIA AREA

July 1997

APPENDIX A
COST FOR ENVIRONMENTAL SERVICES AND WASTE DISPOSAL IN THE NORFOLK, VIRGINIA AREA

The costs for waste disposal services at the Norfolk Naval Shipyard are provided below. The costs represent those charged to a large industrial facility that deals with large amounts of waste. The costs are based on the waste production rates estimated by the shipyard and vary with the concentration of PCBs and the anticipated volumes of materials in each concentration range. The cost for waste disposal services at other facilities may vary from these.

A.1 PCB WASTE

A.1.1 PCB Solid Waste

- Less than 50 ppm — $0.41 per pound
- 50 to 499 ppm — $0.93 per pound
- 500 to 4999 ppm — $0.44 per pound

The report uses an average cost of $0.69 per pound for disposal of PCB solids, assuming that half falls within each range.

A.1.2 PCB Liquid Waste

- Less than 50 ppm — $0.43 per pound
- 50 to 499 ppm — $0.65 per pound
- 500 to 4999 ppm — $0.42 per pound

A.1.3 PCB Liquid and Solid Mixtures

- up to 499 ppm — $0.70 per pound
- 500 ppm or greater — $3.00 per pound

A.2 HAZARDOUS WASTE LIQUIDS

A.2.1	Ignitable	$0.49 per pound
A.2.2	Corrosive	$0.51 per pound
A.2.3	Reactive	$2.33 per pound
A.2.4	TCLP	$0.72 per pound, in quantities up to 1000 gallons
A.2.5	TCLP	$0.32 per pound, in quantities >1000 gallons
A.2.6	Excess toxic chemicals	$0.46 per pound

A.3 HAZARDOUS WASTE SOLIDS

A.3.1 Ignitable	$0.81 per pound
A.3.2 Corrosive	$0.79 per pound
A.3.3 Reactive	$1.41 per pound
A.3.4 TCLP	$0.58 per pound
A.3.5 Excess toxic chemicals	$0.82 per pound

The report uses the cost for TCLP (Toxic Characteristic Leachate Procedure) wastes, assuming that most of the wastes generated by recycling will be of this kind.

A.4 INDUSTRIAL SOLID WASTE, NONHAZARDOUS

A.4.1 Solid Waste	$48.20 per ton

APPENDIX B

EVALUATION OF EPA GUIDANCE FOR SAMPLING ABOARD SHIPS

APPENDIX B
EVALUATION OF EPA GUIDANCE FOR SAMPLING ABOARD SHIPS

B.1 INTRODUCTION

The sampling for PCBs aboard the EXPORT CHALLENGER, SHIRLEY LYKES and WAYNE VICTORY was performed, to the extent practicable, in accordance with the EPA guidance of Reference 8. Reference 8 states that the guidance is ". . . an interim method of determining whether polychlorinated biphenyls (PCBs) have been removed from ships . . . " destined for recycling. The guidance provides two basic options:

- remove all known sources of liquid and non liquid PCBs, or
- sample the ship to determine whether any known sources are aboard, remove those that are found, and resample to confirm that none remain.

The EPA defines "known sources" broadly. Electric cables, gaskets, caulks, rubber products, plastic products and nearly all other nonmetallic materials fall under the definitions. The guidance includes a sampling scheme that groups materials into 10 categories, specifies minimum numbers of samples to be taken in each category and allows a category to be dismissed from further consideration if no PCBs are found at or above 50 parts per million.

The guidance specifies that the total number of samples taken will be equal in number to the square root of the weight of the ship as sold for recycling. Typical MARAD ships destined for recycling weigh from 4,000 to 10,000 tons, leading to 63 to 100 samples. Two categories of materials, electric cables and ventilation system gaskets, are given special emphasis. Forty percent of all samples must be cables and 40% ventilation system gaskets. The remaining 20% are split among the remaining eight categories.

The guidance specifies in detail how the samples are to be selected. Ship's compartments are selected at random. Several sampling criteria are specified, such as the number of samples in each category, the minimum number of samples on each deck of the ship and so forth. Within the limits of the criteria, samples are taken at random. Other than the arrangement of ship's compartments, no prior knowledge of the ship's materials or methods of construction is required nor is the application of such knowledge permitted.

An effective sampling protocol should measure PCBs in the ships with a high degree of precision such that, after removals, there is a good chance that no more will be found. If significant amounts are missed during the first round of sampling, a recycler could be caught in repetitive cycles of removing materials and resampling, affecting the profitability of the project. This Appendix compares construction details from ship's drawings and from inspections of the ships with the sampling results to determine, qualitatively, whether or not the sampling resulted in a precise measurement of PCBs and whether there are any categories of PCBs that are not covered.

B.2. SAMPLING FOR PCBs IN ELECTRIC CABLES

B.2.1 Introduction

PCBs were found in the cables of the EXPORT CHALLENGER and SHIRLEY LYKES. To determine whether the samples represent a fair cross section of all the cables in each ship, available ship's drawings were reviewed to determine the number and type of the cables actually installed in each ship, and the samples were then compared to the drawing information.

B.2.2 Cables in the EXPORT CHALLENGER and SHIRLEY LYKES

Section 3 discusses the drawings that were reviewed to establish, as best as practicable, the cable used in each ship and summarizes the information in Tables 1 and 2. None of the samples were marked with cable type. Cable tracing would allow cable samples to be associated with specific circuits and therefore specific cable types, but this is tedious and beyond the scope of the project. Instead, each two-, three-, and four-conductor cable sample was assigned an assumed type from the measured diameter and observed number of conductors (recorded in Appendix A of Reference 3). Because no cable diameter drawings were available for EXPORT CHALLENGER, the SHIRLEY LYKES data was used for both ships. Cable diameters were sometimes severely distorted by installation and years of service; therefore, the measurements may not be precise. Samples with one or five or more conductors are ignored.

Figures B-1 and B-2 present the results graphically. The Y axis of each table is the length, in feet, and weight, in pounds, of each type of cable as determined in Section 3 and shown in Tables 1 and 2. Each cable type is recorded on the X axis in abbreviated format. T4 indicates, for example, TAVIB4. The boxed numbers in the figures show the number of samples taken of the types intersected by the box. For example, the box in Figure B-1 that contains the number 18 indicates that 18 samples of cables having two, three, or four conductors and diameters equal to those of T4, D4 or F4 cables (0.477 to 0.563 inch) were taken.

Figure B-1 illustrates that in the EXPORT CHALLENGER, samples of cable types T16, T20 through T33, T52 through T106 and T212 through T400 were not taken. These represent approximately 35% of the cables by length and 66% of the cables by weight of all those shown in Table 1 of Reference 3. Similar omissions are shown in Figure B-2 for the SHIRLEY LYKES; samples of cable types D10 through T83 and D168 through T550 were not taken; representing approximately 33% of the cables by length and 72% of the cables by weight of all those shown in Table 2 of Reference 3.

Figure B1

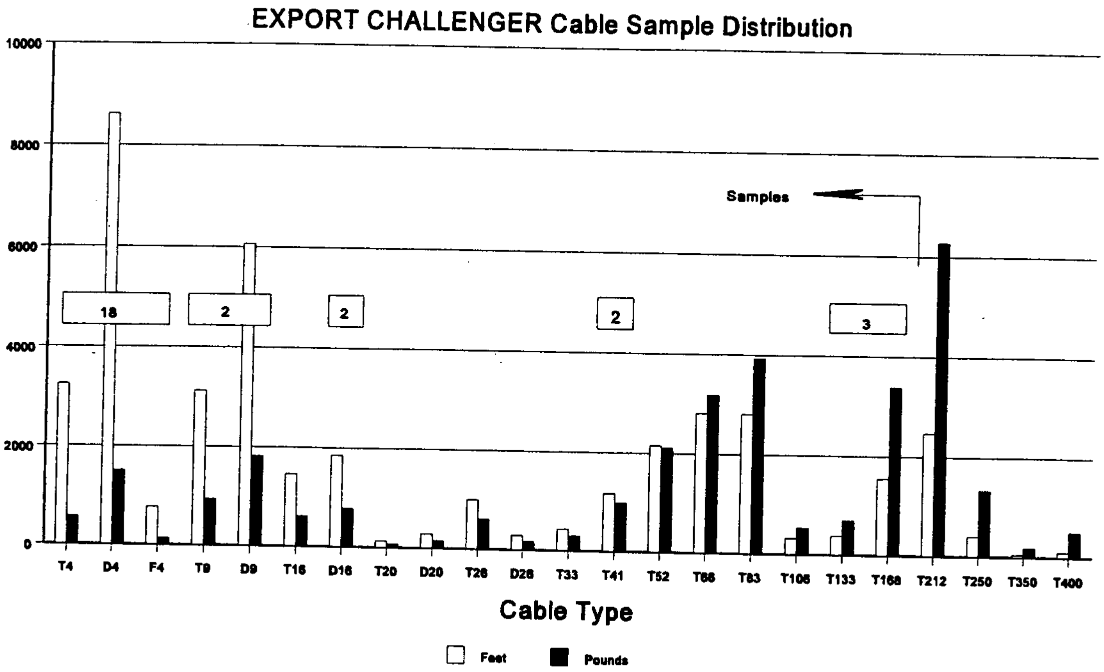
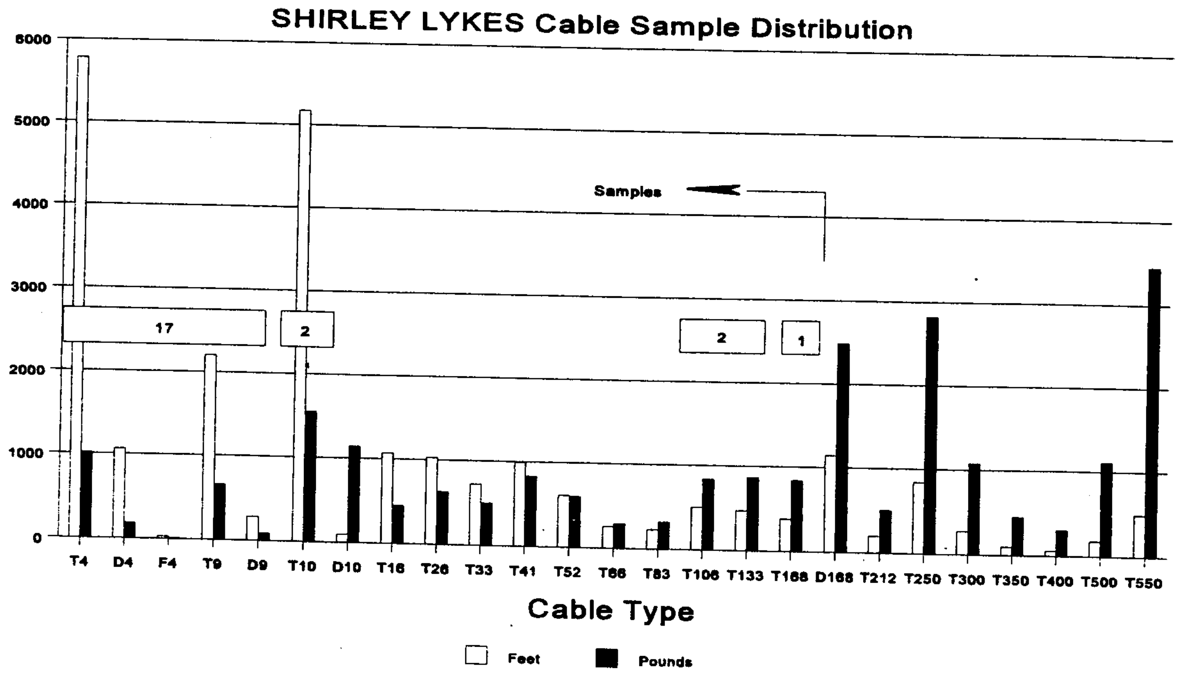


Figure B2



Reference 12 lists 95 different kinds of electric cables that are installed in the SHIRLEY LYKES. Many small diameter phone cables (¼ inches and less) and a variety of multiconductor interior communications cables are included on this list in addition to those covered in Tables 1 and 2 in Section 3. At best, the sampling plan would have called for 31 of the 95 types to be sampled, because no more than 31 samples were required. In fact, after identifying samples as to cable types as discussed above, it is likely that no more than nine different types of two, three and four conductor cables were sampled along with six other types of one conductor and greater-than-four conductor cables, for a total of 15 different types.

B.2.3 Conclusions

The EPA sampling guidance, as implemented in the EXPORT CHALLENGER and SHIRLEY LYKES, revealed the presence of PCBs in cables but may not provide enough information to guide cost-effective remediation. Many of the larger cables and dozens of speciality cables in both ships were not sampled, and it qualitatively appears that the sampling approach did not provide a truly random set of samples. Therefore, it is unlikely that removal of only the cable types shown as high in PCBs will be effective at removing PCB cables. Resampling, as required by Reference 8, is likely to reveal more problems. It can be speculated that in the WAYNE VICTORY, where some similar sampling biases exist (most samples are two- and three-conductor small diameter cables), the absence of PCBs is only a fluke of the sampling approach.

Sampling of the EXPORT CHALLENGER, SHIRLEY LYKES and WAYNE VICTORY using the guidance of Reference 8 is among the first applications of the guidance to commercial ships, and the experience suggests that alternate approaches may provide better data with fewer samples, and therefore less cost to the recycler. A sampling scheme based on random selection of cable samples from among those cables shown in drawings and other available information sources is one approach that may provide superior results with fewer samples. Alternately, if it can be established that a recycler will shred cables for copper recovery, or dispose of cables in an appropriate landfill, and not reuse them individually, a single analysis of a composite sample may provide sufficient information to regulate proper disposal and further reduce compliance cost.

B.3 SAMPLING PCBs IN VENTILATION SYSTEM GASKETS

Tables 13, 14 and 15 of Reference 3 present the results of ventilation gasket samples. As required by Reference 8, special emphasis was placed on sampling ventilation gaskets. Thirty-two to 40 percent of all samples were taken in this category. The sampling revealed a limited number of different gasket materials, ranging from one in WAYNE VICTORY to seven in EXPORT CHALLENGER, and multiple samples of apparently identical materials were taken. In accordance with Reference 8, the gasket samples were taken at random without reference to ship's drawings.

It appears that the number of samples exceeds that needed to identify PCBs in ventilation gaskets. It is understood that the emphasis afforded ventilation gaskets by Reference 8 is because of the frequent use of PCB-bearing felt in U.S. Navy ships. Felt is not necessarily used in all ships. Ventilation system materials of construction are often shown on material lists or system drawings. For example, Reference 22 for the EXPORT CHALLENGER specifies rubber gaskets and cork with synthetic rubber that is adhesive coated, and shows where the materials are installed. Sampling schemes based on such information may yield results in significantly fewer samples without sacrificing precision.

B.4 SAMPLING FOR OTHER PCB MATERIALS

Reference 8 requires that, "... in the event that all of the [...] known sources of non-liquid PCBs ... have not been removed from a vessel" sampling is to be done to determine whether any that remain aboard contain PCBs and must be removed before export. To simplify sampling, the EPA has combined all materials other than cables and ventilation system gaskets into eight categories:

- Rubber gaskets (other than ventilation system gaskets),
- Felt gaskets (other than ventilation system gaskets),
- Fiberglass, felt, foam, or cork thermal insulation material,
- Sound deadening felt,
- Grouting, caulking, rubber isolation mounts, foundation mounts, and adhesives,
- Tapes,
- Pipe hangers, and
- Rubber/plastic parts of all sizes and shapes (other than listed above).

Reference 8 requires no more than 20% of all the PCB samples in the ship to be from these eight categories. For the three MARAD ships, this amounts to no more than one or two samples from each category. The results of the sampling of the eight categories are shown in Tables 16, 17 and 18 of Reference 3.

The sampling results show that the categories do not necessarily reflect the methods of construction of commercial ships and do not necessarily provide for effective remediation.

- Identical products are often used in two or more of the same EPA categories. For example, processed cork/rubber material was found in the ventilation systems (Category 2) and machinery closure panels (Category 10) of the EXPORT CHALLENGER; and felt was found in the ventilation systems, an electrical controller closure (Category 4) and a pipe hanger liner (Category 9) of the SHIRLEY LYKES.

- It is often difficult to assign a product to a particular category. The rubber part in the foot of the ladder in the EXPORT CHALLENGER steering gear room could be described as a "rubber gasket" (Category 3), a "rubber isolation mount" (Category 7, where it was assigned) or a miscellaneous rubber part (Category 10). Assignment of a sample to an EPA category can be a very important decision. Had this part been found to contain PCBs (it did not), the entire category to which it was assigned to would require remediation and resampling.

- Some of the categories contain apparently unrelated products. There are no known similarities between rubber mounts and caulks, adhesives and grout (all in Category 7) that would warrant removal and resampling of these types of materials if one showed high PCBs.

- So few samples were taken of "Other PCB Materials" that many potential PCB materials were doubtlessly overlooked. Paint, for example, was intentionally not sampled (as directed by Reference 8), because paint on surfaces that are to be remelted need not be controlled. But paint is a well-known potential PCB material that is applied to many surfaces, such as thermal insulation that will never be remelted.

- The categories do not reflect a consistent approach to sampling. Some categories are specific materials (tape, for example), while others are services (pipe hanger liners, for example) that can be met by many different materials at the discretion of the ship's designer.

These problems can be resolved by a sampling scheme that focuses on materials rather than services and relies on reviews of ship's drawings, material lists, insulation schedules, paint schedules, etc., to select the materials and locations to be sampled. For example, a specific gasket material that is used in many services can be sampled in a few specific services, from known locations, to determine whether that material, in all of its applications, requires remediation. Such an approach is likely to provide a more comprehensive view of the PCB situation in a ship and a more thorough remediation in preparation for alternative use or export.

For domestic recycling, it may not be necessary to sample for "Other PCB Materials" prior to recycling. The results of the Toxicity Characteristic Leachate Procedure test for the nonmetallic parts of electric cables, reported in Tables 9, 10, and 11 of Reference 3, show that the PCBs do not leach even at levels as high as 3,900 ppm in the nonmetallic parts. Additional sampling of other types of PCB-bearing materials will likely show the same. Therefore, it appears that the materials can be safely handled in a recycling environment without prior knowledge of the PCB content. With very few exceptions, nonmetallic materials in the "Other PCB Materials" categories are not recycled. A regulatory scheme that allows them to be accumulated and tested for PCBs only when disposal (or reuse) is being arranged may significantly reduce analysis cost and improve overall environmental protection.

B.5 SAMPLING FOR PCB LIQUIDS

Reference 8 requires all "... known sources of liquid PCBs ... " to be removed but does not specify any sampling for PCBs in liquids. Navy experience[1] shows that about 3% of the liquid samples taken have PCBs at or above 50 ppm. Therefore, a sampling program may have a high probability of finding no PCBs. EPA guidance should provide the sampling option for potential liquid sources of PCBs to the same extent as for solid nonmetallic materials. As with solid materials, review of ship's drawings may reveal the types of fluids used in the various affected systems and minimize the required number of samples.

B.6 SAMPLING FOR PCB SURFACE CONTAMINATION

Reference 8 specifies that

> "Impervious solid surfaces [. . .] which are contaminated with liquid PCBs, shall be cleaned to less than 100 micrograms per 100 centimeters square (<100 $\mu g/100\ cm^2$) PCBs if the material beneath the surface is to be smelted in a smelter { . . . }. If the material beneath the surface is not going to be smelted, then the surface shall be cleaned to $\leq 10\ \mu g/100\ cm^2$."

It further specifies that

> "Non-impervious solid surfaces { . . . } which are contaminated with liquid PCBs, shall not be evaluated for PCB removal by a surface sampling test, but cleaned to <50 ppm, [. . .] if the solid beneath the surface will be recycled by smelting [. . .]. If the solid beneath the surface will be recycled but not smelted { . . . }, the PCB cleanup level is <2 ppm as measured by a core or scrape sample."

None of the sampling guidance in Reference 8 covers sampling for these situations. The most common nonimpervious surface that may be contaminated with PCBs is insulation in engineering spaces. This material can contain PCBs from paint, particularly heat-resisting aluminum paint that is widely used in the three ships, or from spills. There is no simple way of distinguishing whether PCBs detected in such materials come from spills or from the original materials. With regard to impervious surfaces, Navy data[2] show that 24% of the surfaces that have been wipe-tested exceed 10 $\mu g/100\ cm^2$ and 6% exceed 100 $\mu g/100\ cm^2$. While the Navy data cover only Navy ships, many of the ships sampled are comparable to commercial ships (oil cargo ships, tugboats, yard craft), and therefore it is likely that comparable problems exist in commercial ships.

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[1] Naval Sea Systems Command Document, *Inact Ship PCB Survey Results*, November 30, 1995.

[2] Ibid.

Existing EPA guidance for wipe sampling of surfaces, such as Reference 35, is not necessarily applicable, because it applies to sampling following spills. Shipboard PCB surface residues, if any are present, are most likely the result of years of accumulations of oils, some from inadvertent spills and some from intentional design features of nearby equipment.

PCB surface contamination, unlike PCBs in solid materials, creates risk of exposure to the workers. Therefore, sampling and remediation of surface contamination are needed, whether or not a ship is to be exported for recycling or domestically recycled.

B.7 SAMPLING FOR OTHER HAZARDOUS MATERIALS

There is no EPA guidance for sampling or removal of hazardous materials, other than PCBs, in ships destined for alternative uses. As discussed in Chapter 6, there are many non-PCB potentially hazardous wastes that might require removal. The removal of some of these materials may be more costly than dealing with PCBs; therefore, regulatory guidance is needed. As with PCBs, a sampling plan based on review of available drawings or other ship's information will provide the best basis for developing the least costly and most effective sampling program.

B.8 CONCLUSIONS

The sampling of EXPORT CHALLENGER, SHIRLEY LYKES and WAYNE VICTORY for PCBs in accordance with the EPA guidance of Reference 8 identified PCBs in the three ships but may not have revealed the most significant sources or provided the information a recycler needs to perform effective removal of the PCBs. The information in this report provides the basis for developing an improved sampling strategy that overcomes these problems.