SHIPBOARD WASTE DISPOSAL: TAKING OUT THE TRASH UNDER THE NEW RULES

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ABSTRACT

In 1988, the Society of Naval Architects and Marine Engineers Panel M-17, Disposal of Shipboard Wastes, convened two workshops to encourage open discussion of the diverse options available to comply with MARPOL 73/78 Annex V (Garbage). This paper reviews the available engineering, operational, and managerial changes useful in implementing Annex V and outlines the "good marine practice" suggested by the discussions in Panel M-17. Examples of approaches actually adopted by different commercial operators will be offered.

INTRODUCTION

A new marine pollution prevention regime, MARPOL 73/78 Annex V (Garbage), came into force internationally on 31 December 1988 (International Maritime Organization (IMO) 1978; U.S. Congress 1987). Annex V requires ship operators to change the way shipboard garbage is handled and immediately bans discarding plastic materials anywhere in the sea (Whitehead 1988). Disposing of shipboard garbage properly matters more to the company, the sailor, and the national authorities, because Annex V changes the long-accepted maritime practice of tossing garbage into the sea. However, taking out the trash under the new rules means more than stopping sailors from chucking everything over the side. Annex V is no antilitter campaign, but is part of a fundamental shift in the way ship crews and managers operate (Horsman 1982; Vauk and Schrey 1987). Making the transition to a commercial fleet that is able to obey the MARPOL Annex V will take a combination of changing how people have usually done things and providing them with the tools they need to do things differently.

Implementing Annex V has become the job of ship designers, ship operators, and maritime environmental specialists who have the expertise in shipboard systems design and operation. A ship is a small place, of a fixed size, occupied by people, cargo, and a lot of machinery. Rarely is a ship built with spare space or operated with extra people. Under these common constraints, a change in one shipboard activity often has a consequence in another activity. In this paper, the author examines the implementation of the MARPOL Annex V in the merchant fleet from the

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In R. S. Shomura and M. L. Godfrey (editors), Proceedings of the Second International Conference on Marine Debris, 2-7 April 1989, Honolulu, Hawaii. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFSC-154. 1990.

perspective of the marine technical professionals, to convey a sense of the "good marine practice" they need to select, install, and operate solutions to comply with Annex V.

Background: The Role of the Society of Naval Architects and Marine Engineers

The Society of Naval Architects and Marine Engineers (SNAME) is a U.S. organization of ship designers, ship builders, and ship operators. One standing technical panel of the society is Panel M-17 (Disposal of Shipboard Wastes), which is made up of professionals who work in engineering and management to enable ships to meet the legal requirements for environmental protection (SNAME 1982). In 1988, the SNAME Panel on Disposal of Shipboard Wastes convened two shirt-sleeves workshops on "The Shipboard Engineering and Environmental Aspects of Implementing MARPOL 73/78 Annex V (Garbage)" to encourage open discussion of the diverse options available to comply with Annex V. The first panel workshop on 18 July 1988 was hosted by the Office of the Chief Scientist, National Oceanic and Atmospheric Administration (NOAA). By popular demand, a second meeting was held on 12 October 1988, hosted by the Waste Combustion Equipment Council of the National Solid Waste Management Association (NSWMA).

The Panel M-17 workshops have been lively and useful exchanges of information and opinion. More than 80 people attended, including waste disposal firms representatives, port authority representatives, fleet operators, marine engineers and designers, environmental lawyers and regulators, and supply officers, all of whom have work to do to implement Annex V. The meeting participants provided useful information about shipboard and shoreside waste disposal equipment, local port implementation needs, disposal costs, U.S. Coast Guard regulatory proposals, and ways to design a compliance alternative that make sense for individual ships (Martinez 1989).

Enlightened self-interest helped motivate such a free exchange of information. Each fleet had to comply with the new international convention by 31 December 1988, with little lead time to order equipment or change vessel operations. Domestically, the Coast Guard had only a year after Congress passed the new law to draft and issue new rules that apply to all boats, ships, and oil rigs operating in the waters of the United States. No regulations were in place and many in the merchant marine were uncertain what would satisfy the authorities or how to do it. It seemed a good idea to sit down and talk about what we faced.

Background: MARPOL Implementation Philosophies

The MARPOL 73/78 Annex V (Garbage) is the third pollution prevention regime to be imposed on the world merchant fleet. Official shorthand for the International Convention for the Prevention of Pollution from Ships 1973, as amended by the Protocol of 1978, the MARPOL 73/78 contains five annexes that address particular types of ship-source marine pollution. The first annex implemented addressed oil pollution and the second addressed chemical cargo wastes. However, Annex V is philosophically different in

its approach, and maritime professionals need to understand that philosophical difference.

The MARPOL 73/78 Annex I (Oil) and Annex II (Bulk Chemicals) prescribed the way to comply, including which equipment to use and what procedures to adopt. In addition, it was clear where the responsibility for day-to-day compliance rested. The wastes involved come from cargo tanks, which are the responsibility of the deck officers, or from machinery spaces, which are the responsibility of the engineers. Enforcement and compliance were rigidly defined, and neither the Coast Guard nor ship operators had much leeway from the very start. Finally, not all vessels had to comply by the same date, because internationally agreed upon schedules gave older vessels more time to come into compliance.

The MARPOL 73/78 Annex V (Garbage) is so different that it has taken a while to get used to it. Annex V mandates that overboard disposal must change and that plastic disposal must cease, but implementing Annex V relies on none of the methods which were so central to the previous pollution conventions. Annex V instead:

- applies to ship-generated garbage, regardless of the source, and clearly includes hotel and galley services, which are the responsibility of the stewards;
- does not require specific new equipment in either ships or ports;
- does not tell ship operators or port authorities how to comply; and
- applies to all vessels in all waters immediately, with no delayed implementation schedules for existing vessels.

These are both the strengths and the weaknesses of the entry into force of Annex V. On the positive side, operators are not shackled to a technologically rigid solution and are free to develop their own best way to comply with the new requirements. Also on the positive side, implementing Annex V is not just the engineer's or deck officer's responsibility, but is a shared responsibility across the ship's crew and the shoreside supporting organization. This allows an operator to experiment and make incremental changes that can yield a compliance solution tailored to the way the ship operates (U.S. Department of Commerce 1988). On the negative side, the entire fleet had to comply by 31 December 1988, which meant that few people had the experience in solving the problem aboard ships and few were familiar enough with the annex to protect themselves from the uninformed speculation that was circulating, and everyone wanted equipment or advice at the same time.

TACKLING THE PROBLEM

Table 1, the "MARPOL 73/78 Annex V Summary of Garbage Discharge Restrictions," (U.S. Department of Transportation 1988b, 1988c) sets out

Table 1.--The MARPOL 73/78 Annex V summary of garbage disposal restrictions.

Garbage type	All vessels except offshore platforms and associated vessels		Offshore platforms and associated vessels[b]
	Outside special areas	In special areas[a]	
Plastics--includes synthetic ropes and fishing nets and plastic bags	Disposal prohibited	Disposal prohibited	Disposal prohibited.
Floating dunnage, lining and packing materials	Disposal prohibited 25 nmi from nearest land	Disposal prohibited	Disposal prohibited.
Paper, rags, glass, metal, bottles, crockery, and similar refuse[c]	Disposal prohibited <25 nmi from nearest land	Disposal prohibited	Disposal prohibited.
Food waste not comminuted or ground	Disposal prohibited <12 nmi from nearest land	Disposal prohibited	Disposal prohibited.
Food waste comminuted or ground[c]	Disposal prohibited <3 nmi from nearest land	Disposal prohibited <12 nmi from nearest land	Disposal prohibited <12 nmi from nearest land.
Mixed refuse types	(d)	(d)	(d)

[a]Special areas are the Mediterranean, Baltic, Red and Black Seas, and Persian Gulf areas.

[b]Offshore platforms and associated vessels includes all fixed or floating platforms engaged in exploration or exploitation and associated offshore processing of seabed mineral resources, and all vessels alongside or within 500 m of such platforms.

[c]Comminuted or ground garbage must be able to pass through a screen with a mesh size no larger than 25 mm.

[d]When garbage is mixed with other harmful substances having different disposal or discharge requirements, the more stringent disposal requirements shall apply.

the different classes of wastes that are now regulated and where their disposal is now restricted. As stated previously, the saving grace of Annex V is that no technology is mandated. This injects a little breathing room into the transition and removes any cause for alarm if you cannot retrofit equipment by the entry-into-force date. The open "philosophy" for compliance gives a company more freedom to design its own "right" way, but also compels a designer to consider more alternatives. It means that the role of the marine engineer in implementing Annex V is different. A company cannot delegate the task to an engineer, as was done with Annexes I and II, and expect everything to fall into place neatly. It's not that the engineer cannot deliver a technical solution, it is rather that the solution is not in the hardware.

Diverse ways are available to comply with Annex V, exercising both managerial and technical prerogative. "Management" changes can greatly reduce the amount of waste generated and reduce the size of the "engineering" solution needed. Some options affect vessel operations that are not the usual jurisdiction of the marine engineers, such as provisioning the accommodations and securing the cargo. A good starting point for evaluating the situation is to read the Marine Environment Protection Committee (MEPC) Guidelines for the Implementation of Annex V (Garbage) (IMO 1988b). This document has been written to introduce the merchant mariner and the maritime designers to the problem-solving method that is best used in handling shipboard wastes. It works well, and the credit goes to the drafters of the document for producing a practical and usable text. The guidelines are well regarded by the designers and operators who have had the opportunity to use them. Better yet, the guidelines are amenable to modifications as operators and authorities gain experience in implementing Annex V.

In the United States, marine engineers and designers have had only partial information available for fulfilling the marine engineering tasks related to Annex V. Each compliance decision has consequences for the way the ship operates, and some apparently simple solutions affect shipboard operations and costs more severely than do some apparently more complex solutions.

Shipboard sanitation and safety must be safeguarded when selecting an installation or retrofit (Signorino 1988). Panel M-17 convened to become familiar with the solid waste management practices in port facilities and with the state of the art of types of equipment used to process or destroy the wastes now addressed in the Annex V (Garbage) requirements. Very few of us, even in the Panel M-17 community of specialists, had previously studied the ship's garbage, Annex V, garbage equipment available for shipboard or shoreside use, or how to safely retrofit garbage equipment on existing ships. Some options use expensive and unfamiliar equipment, such as package incinerators, large capacity compactors, or pulpers. A quick review of the decision and technical options follows.

Estimating the Waste Stream

Before the problem can be solved, some estimate has to be devised of how much garbage will be handled. If possible, detailed inventories can be

done, but many operators are unable to spend the time and money on gathering such information before compliance is required. The discussion in the M-17 meeting reviewed the various ways that people have selected to estimate the ship-generated garbage needing treatment. The following ways have been used with some success:

- The Coast Guard regulatory docket for the implementation of the MARPOL Annex V includes a study that creates a unit called the GBE or "40-gallon garbage bag equivalent" (U.S. Department of Transportation 1988a).

- The U.S. Navy 1988 inventory of shipboard waste yielded numbers of 1.4 kg(3 lb)/person/day of garbage which includes 0.5 kg (1 lb) of food waste and 0.9 kg (0.2 lb) of plastic. This is a twentyfold increase in the average amount of plastic since the 1971 inventory.

- The waste disposal industry categorizes "incinerable waste" according to its heat release by the following classification (Norske Hydro 1988). Note that these categories presume no presorting of waste (Table 2).

Characterizing the Waste Stream

Along the way, the types of shipboard activities that generate the plastic waste will be identified. Each solution to Annex V is simplified if the shipboard waste streams are kept separate, rather than being mixed. Clean plastic can be kept separate from the food-contaminated plastics and both can be collected separately from the other waste that can still be discharged at sea. But making waste separation work requires some cooperation from the crew members or passengers on the ship. It was suggested that SNAME help develop some simple crew and officer training sessions on waste source separation, to motivate and inform people about how it simplified the overall Annex V solution.

The Zero Equipment Option

Having evaluated the amounts, sources, and types of plastic being used and discarded as a result of shipboard operations, the ship operator can implement a few shipboard and shoreside managerial options to comply with Annex V. Those actions require no equipment installations, but affect shoreside company practices and shipboard crew practices.

Change the Purchasing of Ship Supplies

A quick scan of most ships identifies where plastics and other problem materials are used (Cavaliere 1988). In a number of uses, plastic has become the material of choice because it is safer to work with and is unbreakable. Other uses aboard ship, however, are convenience uses, just as are the uses of plastic ashore. It is similar to converting a shoreside business or home away from using the plastics that are so easily available.

Table 2.--Incinerable waste categorized according to its heat release.

Type	Classification of solid combustible waste materials	KJ/kg	Incombustible solids %	Moisture content %	Kg/dm^3
0	TRASH, a mixture of highly combustible waste--paper, cardboard cartons, wood boxes, and combustible floor sweepings from commercial and industrial activities. Contains up to 10% by weight of plastic bags, coated paper, treated corrugated cardboard, oily rags, and plastic or rubber scraps.	20,000	5	10	0.15-0.2
1	RUBBISH, a mixture of combustible waste--paper, cardboard cartons, wood scrap, foliage, and combustible floor sweepings from commercial and industrial activities. Contains up to 20% by weight of restaurant or cafeteria waste, but little or no treated papers, plastic, or rubber wastes.	15,000	10	25	0.15-0.2
2	REFUSE, an approximately even mixture of rubbish and garbage by weight, common to apartment and residential occupancy.	10,000	7	50	0.2-0.3

When a plastic item loses its disposable advantage, it loses most of its purchase appeal. Sometimes, an item that is currently purchased can be done without. A plastic item can be purchased in another material, a disposable item can be eliminated in favor of buying a reusable version that needs to be washed. A formal inventory may not be needed as much as a scavenger hunt for the unnoticed plastics that then become candidates for elimination.

Establish Who Is Responsible Aboard the Ship

Every cause needs a champion. In the U.S. merchant marine, jobs are commonly defined rigidly as deck, engine, or steward. Tackling Annex V implementation falls in no single department and requires the participation of all personnel or passengers aboard. Each ship should designate a specific person to be responsible for shepherding the entire ship into compliance with Annex V.

Port Reception Facilities

Send It Ashore, But Where?

Each port must provide reception facilities for shipboard garbage. If Annex V creates uncertainties for ship operators, the port operators are just as uncertain about what to do. In the past, it has been difficult and expensive for some ports to provide the reception facilities required by the previous MARPOL annexes, so ports are not thrilled by the obligation to provide "adequate" garbage reception facilities. The task is difficult for the port, which can only guess at (1) the number of ships bringing in foreign "food wastes" that will need Animal and Plant Health Inspection Service (APHIS) certified disposal, and (2) the amount of plastic-contaminated waste that will now be brought ashore to add to the port community's shoreside waste stream.

Many port cities are already straining to deal with their own municipal garbage problems, and adding more ship-generated garbage to the local landfill is not an easy thing to sell. The sentiment of those attending the M-17 meetings seemed to be that most U.S. ports are unprepared to meet the reception facility requirement and the ship operator will still be left "holding the bag."

Some German ports have already imposed a vessel fee, whether the vessel uses the port garbage service or not. At least one U.S. port is considering the same action (Nightingale 1988). Such a fee would be about $150 or more per ship per port call. Such mandatory fees affect the ship operators on those routes, because they may lessen the incentive to install extensive garbage handling equipment on board the ship.

When contracting for disposal services, the usual measurements are tons or cubic yards, because that is how the hauler is charged at the landfill (NSWMA 1988).

Animal and Plant Health Inspection Service Requirements

The port reception facilities must include APHIS waste-handling facilities. The APHIS restrictions are intended to prevent the introduction of foreign plagues, such as foot-and-mouth disease, into the United States (U.S. Department of Agriculture undated). Any organic wastes that have possibly been contaminated by contact with foreign foodstuffs or foreign livestock are subject to quarantine and can be handled only by authorized APHIS contractors or APHIS personnel themselves. The wastes taken off the ship must be totally sterilized, either through autoclaving or by incineration, and the remaining matter must be securely landfilled. The APHIS requirements are not new and are not changed by the Annex V regulations. Much of the plastic wastes coming from ships as a result of the Annex V regime, however, will be food packaging or food serving articles and is subject to the APHIS restrictions. That volume of waste may increase greatly, especially in the interim compliance periods, when vessel operators may prefer to store rather than treat the plastic wastes.

All APHIS wastes must be stored separated from other garbage to avoid contamination, and when off-loaded, it must be delivered to a certified facility for proper sterilization or incineration. All transport must meet strict quarantine requirements. As a result, APHIS waste is expensive to handle. A ship may be billed by the pound of APHIS waste handled per pick up and frequency of pick up, since transport to an APHIS-certified facility is regulated. Ship officers and crew should make all efforts to keep the APHIS waste separated from regular garbage that does not require quarantine. Otherwise, the APHIS inspector, who makes the final decision as to which wastes must be quarantined, may require much larger amounts of ship's garbage to be quarantined, at the expense of the ship operator. The APHIS wastes should be stored on board the ship in leakproof containers until removal. There is no approved container, and it was the opinion of the waste handlers at the meeting that a Rubbermaid Roughneck, such as is used for curbside garbage pickup, was probably sufficient.

There are currently no more than 43 APHIS facilities in the area of U.S. ports. Wastes may not be transported through rural areas, which makes reaching some remote marine terminals almost impossible. Ship operators should contact their local APHIS officers immediately to get the details about any existing or planned APHIS-certified facilities in the vicinity of the ports where they anticipate needing APHIS wastes handled. It was also suggested that operators inquire of their shipping agents or ship management agents what kind of services the agents can provide.

Recently, APHIS administrators have brought up a new concern about handling compacted wastes. The APHIS regulations for steam sterilizing foreign garbage are based on experience with handling fresh, uncompacted wastes such as are off-loaded from an international airline flight. The autoclaving procedures depend on killing temperatures penetrating the core of the mass of garbage, and a half hour has generally proved effective with a margin of safety. However, well-compacted wastes are, by definition, more dense, and the APHIS has no confidence that a half hour of steam exposure will penetrate the core of the garbage mass. Practically, this means

that a ship operator should now be cautious about compacting APHIS wastes as well, because the savings in storage may be offset by a higher cost for APHIS disposal. The APHIS is likely to have to recalibrate the autoclaving time to compensate for the degree of compaction of the wastes (i.e., 10 to 1, 20 to 1, 40 to 1) in order to ensure that the steam penetrates to the core and kills. Any longer interval of autoclaving is certainly going to increase the operating costs of the autoclave and the price of APHIS disposal for the compacted wastes.

The APHIS-quarantined wastes are not the same as "infectious" wastes. It is important not to confuse the two, because it is much more expensive to dispose of infectious wastes (i.e., hospital wastes). Plus, there is so much public outcry over the recent well-publicized incidents of hospital waste washing ashore on eastern U.S. beaches that no ship operator should invite trouble by using the term "infectious waste" when he means APHIS-quarantined waste.

The Shipboard Equipment Option

Though Annex V requires no equipment to be installed on a ship, many operators will choose to add garbage handling equipment such as compactors, comminuters, or incinerators. Each piece of equipment installed, whether new or retrofit, needs to operate safely and effectively and not create any disease hazards for the shipboard personnel. In all cases, the tradeoffs need to be identified before expensive decisions are made. In the MEPC Guidelines, Section 5, "Shipboard Equipment for Processing Garbage" requests ". . .information on the development and use of shipboard. . ." comminuters, compactors, and marine garbage incinerators. This is a genuine request for a technical exchange and is another of the provisions unique to Annex V implementation.

Comminuters: Specifications and Installation Needs

Comminuters are a type of heavy-duty garbage grinder. Though not required by Annex V, comminuters are mentioned in both Annex V and in the proposed U.S. regulations. They are useful primarily for handling galley and scullery wastes that can be discharged in the zone between 3 and 12 nmi offshore (or anywhere within a special area). Comminuters must reduce the wastes to pass through a screen 25-mm (1-in) square. Such equipment is available for galley installation and works well.

Storage tanks for comminuted food wastes were discussed briefly. Such a tank allows a ship's steward to continue comminuting food wastes while within 3 nmi, but avoid discharging it into restricted waters. If used, the tanks must be installed so as to be easily flushed clean. Tank materials must be able to withstand potential corrosion from rotting food slurries and must be adequately vented to prevent anaerobic conditions in the tank.

Comminuted food wastes should never be flushed to black water (sewage) holding tanks or to marine sanitation devices (shipboard sewage treatment plants). Food wastes cannot be adequately degraded by the microorganisms

in the systems and can overload the aerobic capacity of the tanks and make the whole system go septic. Such a ghastly mess must be avoided at all costs.

Pulpers

The SOMAT Corporation makes a pulper for use on U.S. Navy ships that works like a comminuter, but further processes the slurried waste to press out the water and dry the waste material enough to make it easier to burn or store. One unit can separate out plastics because the plastics float in the pulping chamber while the other wastes pass through. These devices are about the size of a washing machine.

Compactors: Specifications and Installation Needs

Garbage compactors, used on some ships, have had mixed success. Many of the original units were never intended to be installed on a rolling, heaving ship or be used in the salt-laden sea atmosphere. Purpose-built units for marine installation are now readily available, however, and they fare better. The principal reason for using a compactor is clear: garbage storage takes less room. However, the stored compacted garbage, especially food-contaminated plastics, can "ripen" to a stinky mess if not properly isolated and disinfected. The M-17 discussion raised the following points:

- Hygiene for stored wastes needs to be guaranteed, since the accumulated wastes will otherwise rot and attract vermin. The U.S. Public Health Service (PHS) has standards for shipboard sanitation that must not be compromised. To prevent rotting, food wastes may need to be frozen or at least refrigerated in the 40°F cold room until disposal ashore. This may cut into the steward's storage space.

- Though compactors are usually not large, using them requires organizing the garbage collection and installing them requires identifying enough space for storing the compacted garbage as well. Both the compactor space and the storage space should have adequate space drains and hose washdown fixtures. The discharge of the "compactor juice" created is not regulated, as far as anyone present knew.

- Compactors may be used with unsorted garbage or with separated waste streams. It may be worthwhile for a ship to install more than one compactor, if one is used principally for the APHIS wastes generated from the galley and the other is used for all other plastic-containing wastes generated on board the ship that do not need quarantine. One fleet operator suggested that compactors were also useful for baling dry wastes to be recycled.

Incinerators: Specification, Selection, and Use

Using an incinerator for plastic wastes enables the ship crew to destroy the troublesome wastes rather than hold them and rely exclusively

on port reception facilities or shoreside waste haulers. Ship operators consider incinerators in a tradeoff study against other compliance options in the implementation of the MARPOL Annex V. The Annex V rules require only compliance, and the ship operator will want to know as much as possible about the consequences of installing an incinerator before making the decision.

Incinerators available for shipboard use differ significantly from each other and cannot be considered all the same. They differ in number of combustion chambers, rate of waste feed, form of waste feed, auxiliary fuel required, pretreatment or waste separation needed, amount of operator training needed, auxiliary equipment or ventilation needed, retrofit installation difficulties, and other ship-specific parameters.

Before installing an incinerator, a ship operator must know what needs to be incinerated and in what amounts. Some wastes require shredding or similar pretreatment before incineration. Other wastes require more fuel to destroy than makes sense, so those wastes (e.g., metal scraps) should be separated ahead of time. Some wastes (e.g., glass) cannot be incinerated in some incinerators, but are handled by others. No single size vessel "needs" an incinerator. Ship owners are going to make this type of decision based more on how many people are on the ship and how the ship operates.

There are no technical standards for shipboard incinerators under Annex V. Neither the IMO nor the U.S. Environmental Protection Agency have set effluent or emission standards for the ashes, residues, or stack gases. The American Society for Testing and Materials (ASTM) Committee D-34 Waste Disposal is the proper group to develop performance and effluent standards, but there is no activity in D-34 to develop standards for incinerators of any size. The last attempt to develop such a standard failed due to a lack of agreement on what was acceptable.

In the United States, the operation of incinerators of a size suitable for shipboard use is not regulated by the Federal Government. At the state and port level, the regulation of small incinerators in communities ashore varies greatly. A shipboard incinerator might be subject to local incinerator restrictions if the incinerator is used while the ship is in port, just as ships operating in some California ports have to burn different fuels in order to meet the local air quality restrictions.

There are no IMO, United States, or Coast Guard residence time or minimum temperature standards for the combustion chamber used in shipboard incinerators. The Waste Combustion Equipment Council is working on an "industry standard" for incinerator performance. The classification society Germanischer Lloyd has developed regulations (Germanischer Lloyd 1987) and the Norwegian ship classification society Det Norske Veritas also has regulations for the equipment Det Norske Veritas (1980). In the United States, a shipboard incinerator construction standard and a selection guide are being developed under ASTM Committee F-25 Shipbuilding. When that is completed and accepted by ASTM, the Coast Guard may accept it as a technical standard. Until then, the Coast Guard is constrained to regulate

incinerators according to its existing marine engineering regulations on auxiliary boilers: control systems, flameout protections, space ventilation, enough room around the installation, and fire protection.

I am skeptical about using garbage incinerators for destroying shipboard plastics. The Canadian experience with municipal incinerators seems to have fallen short of what incineration might promise, because operating the plants perfectly is so crucial to the environmental effectiveness of the technology (Mohr 1988). Shipboard incinerators, unless carefully tested and tended, may only make the plastics prohibition another shell game by dumping dangerous substances into the sea via the air and the ash.

Integrated Waste Collection, Treatment, and Disposal

Some firms have developed totally integrated ship waste handling systems, and these have been installed on a number of passenger vessels. Successfully operating these systems requires that the crew learn how the system operates and uses the parts of the system to their best advantage. Unfortunately, some have proved too easy to ruin when silverware is thrown into the incinerator or the shredder is fed a full dose of bed linens.

EXAMPLES FROM THE FLEET

How have ship operators actually responded? Many organizations are still trying to make cost-effective decisions about how to comply with the new Annex V requirements. Some examples can be given, but the identities of the fleets have been removed because this information is largely anecdotal and companies may still decide to change their approach as they develop permanent compliance. The compliance approaches presented are eliminating shipboard plastics, installing compactors, installing fuel-fired incinerators for select waste streams, and installing an incinerator for all shipboard wastes.

Eliminating Plastics

Company A operates chemical carriers in the domestic trade of the United States. Most of the voyages are between refineries in the Gulf of Mexico and tank farms along the eastern seaboard. A separate portion of the fleet services the west coast of the United States. The crews make short voyages with frequent port stops, but no foreign trips. For this firm, APHIS restrictions pose no problem. However, because the Gulf of Mexico is part of a trade route, the company has to think now about what might be needed to comply with a special area designation in the Gulf of Mexico. Company A began changing its supply procurement practices in 1987 to eliminate plastics and disposable goods wherever possible. Polystyrene coffee cups were banned and heavyweight paper cups were purchased instead. Crew support for eliminating plastics has been strong, because the trash problem in the Gulf of Mexico is apparent as they sail her waters. Further material substitutions will be made, such as asking suppliers to deliver maintenance supplies in metal cans rather than plastic containers. The company has no clear idea how much plastic waste they can eliminate from the ships' garbage, but they want to do as much as they can with replacing

materials before locking themselves into an engineering solution. Equipment may be limited to galley comminuters and compactors, which fit more easily into the vessels' operations than do incinerators.

Compactors

Company B operates tankers with few people aboard along trade routes that bring the vessels into U.S. ports frequently. Company B chose to install compactors, after having previously considered installing incinerators on each vessel. The compactors are intended to be an interim compliance solution and Company B has not ruled out installing incinerators. First, however, the company wants to see what the wastes are on the ships, how they can be changed to nonplastic materials, and what standards for incinerator performance are developed by ASTM or IMO.

Incinerators for Selected Wastes

Company C ships carry general cargo and have a relatively small number of people working on board any vessel. They operate an irregular trade route around the Pacific with no guarantee of port facilities in some of the less frequently visited ports. Company C chose to install purpose-built diesel-fired incinerators to handle their waste while at sea and free them from relying on the uncertainties of the foreign port facilities. The managers and operators of the vessels appear satisfied with the units, which are regularly used.

Incinerator Installed for All Shipboard Wastes

Company D has tankers, so the ships have relatively few crew members, no passengers, and a steady load of maintenance activities with the probability of small oil leaks around machinery and deck piping fixtures. They service relatively remote terminals where it would be difficult to arrange for APHIS waste disposal. This firm elected to retrofit a large incinerator, so that the crew could destroy all the shipboard wastes without relying on port facilities for any garbage disposal. The experience of the fleet operators has been that the system works well so long as a high temperature is attained in the combustion chamber. One unanticipated limiting factor has been the disposal of dirty oil sorbent pads. The material of the pad itself burns nicely, but it also melts if the combustion chamber is not hot enough, and the melting pad material can pool and leak out the air inlets of the incinerator. The temperature of the chamber must be high enough when the pads enter the chamber to take the waste directly to combustion.

FUTURE MARPOL ANNEX V DEVELOPMENTS: SPECIAL AREAS

The term "special area" means an area where no dumping of garbage is allowed (U.S. Department of Transportation 1988a). An important point is that the requirements of each special area do not go into effect until all the national authorities bordering on the proposed special area officially notify the IMO that adequate reception facilities are available. Only then

does IMO send out a global notice of the special area designation, and 1 year later the designation goes into effect. At this point, only the Baltic Sea has met that requirement. The Baltic Sea will be a special area as of October 1989. The North Sea has also been proposed and the border countries are filing notices with IMO. The formal designation of the North Sea as a special areas under Annex V will occur in the fall of 1989. The Gulf of Mexico, bordered by Mexico, the United States, and Cuba, has been suggested as a special area under the MARPOL Annex V (IMO 1988a). However, neither Cuba nor Mexico are signatories to the MARPOL convention and it is not possible for IMO to designate a special area without the advance consent of all nations surrounding the proposed area. The problems that face those who favor designating the Gulf of Mexico as a special area point up the limitations of MARPOL Annex V, even after its entry into force.

SUGGESTIONS FOR FUTURE DEVELOPMENT

Educating Passengers and Tourists

Passenger ships have been the source of a lot of garbage tossed into the sea (Smock 1988). Citizen outreach should include a campaign to tell potential passenger ship customers about MARPOL Annex V and their role in ensuring its success. Environmental professionals interested in eliminating marine debris should target the travel industry and the vacationing public with information emphasizing the benefits of the changes in shipboard handling of plastic materials. Passenger ship operators will be affected by this pollution prevention annex far more than they have been affected by any previous MARPOL annex. As "hotels" in a highly competitive travel and leisure market, passenger ship operators must have some assurance that complying with Annex V can be accomplished with a minimum of disruption to the carefree atmosphere that they try to provide to the vacationing passengers. Recent practice on many short cruises and "party boats" operating out of U.S. ports has been to use disposable materials, principally plastics, for many food and drink services. On longer voyages, passengers bring a variety of personal products for their own use. In North America at least, travellers can buy shampoos, razors, and deodorants in convenient unbreakable small plastic packages that are expected to be discarded when empty. Till now, there was no reason for a ship passenger to think twice about bringing aboard plastic containers. This may be the first time a person realizes the toothpaste tube is plastic. The MARPOL Annex V changes all that, and the travelling public should be encouraged via the travel magazines and other literature to learn to leave the plastic disposables ashore or to expect to keep them until returning to shore. The travelling public is increasingly sophisticated and will probably be glad to make such small changes, if it protects the pristine open sea that they desire.

Switching to nonplastic items will be a bigger adjustment on these vessels, because it will affect how service is delivered to the fare-paying passengers. First, fare-paying passengers cannot be compelled to sort their garbage, as crew members can, so the ship operator must devise a shipboard system that either handles all the collected waste without sorting, or depends on the crew members to separate the trash after it is

picked up from throughout the ship. Second, replacing plastics in some instances will increase costs directly. For example, paper cups cost two or three times as much as expanded polystyrene cups cost. A passenger ship operator should be rewarded, not penalized, for moving away from the disposable plastics that are cheaper to use. Passengers and environmental organizations should praise the successful ship operators and challenge the others to do as well.

Develop Plastic Melters for Port Facilities or for Ships

This promising technology is already available for shoreside use, though it has not been widely used in the United States. The process reduces the volume of the typical plastic trash by a factor of 40, creating extruded blocks of plastic that are also likely to meet the hygiene and vermin-killing standards of the APHIS and PHS for shipboard sanitation. Plastic treated by a "melter" does not have to be sorted by material types. On the other hand, the plastic handled this way is not being recycled as such; it is simply being reduced in volume and must still be returned to shore for disposal.

Burning plastics may not be necessary, if a manageable melter for plastic wastes can be devised. A small unit might be useful for a passenger vessel or a small terminal, and a larger unit might be very useful for a remotely located terminal that has no easy way to handle the plastic wastes that are delivered by ships. The U.S. Navy is researching the development of a shipboard piece of equipment for use aboard its larger vessels, but that work is not expected to produce a prototype for several years.

Repackage With Selective Plastics

All plastics are not equal (Society of the Plastics Industry 1988). Incineration creates different combustion products, for example. Polyvinyl chloride polymer contains chlorine atoms, so that incinerating these materials is guaranteed to release hydrochloric acid. Other plastics, such as polyethylene or polypropylene, burn with less hazardous combustion products. In addition, plastics melt at different temperatures and react differently in waste treatment processes. So, the operators may gain some advantage in waste handling by changing from one kind of plastic to another. By investigating the types of plastic used in the products brought aboard ship, the ship operator can retain the advantages of using plastic in some products, but the disposal problems can be simplified, both at the ship and in the ports (Council on Plastics and Packaging in the Environment 1988).

In some senses, repackaging means rethinking away from disposable items to items that have a longer life span. Some shoreside restaurants have replaced plastic plates with plastic or wicker baskets that are lined with paper napkins for each serving. Yes, more paper napkins get used, but the waste bin has much less plastic debris in it.

Switch to Degradable Plastic

Some new plastic resins are being marketed as degradable, either because they photodegrade in ambient light or because they biodegrade when microbes decompose certain starches or celluloses used in their manufacture. These resins and any products made from them are considered plastic under Annex V and the Coast Guard regulations.

Refining Waste Handling to Large-Scale System

Now the APHIS system is set up to handle daily operations at airports, but it is much less prepared to handle daily operations at seaports. The APHIS organization must make the transition to be able to handle a larger volume of wastes, without the extraordinary arrangements that ship operators are having to deal with today. That may require more APHIS inspectors and will certainly require more APHIS-certified facilities accessible to arriving ships throughout the country.

Long-Range Prospects--Ten Years Down the Road

Ten years from 31 December 1988 should find the MARPOL 73/78 Annex V (Garbage) transition complete. At some time between now and then, ports and ships will learn how to manage shipboard garbage in a way that satisfies the annex, safeguards the sanitation and hygiene of the ship, safeguards the port country from animal or plant pestilence, and compensates the disposal firms without bankrupting the ship operators. After all, the shift in shipboard garbage disposal is not happening in isolation. Concurrently, shoreside communities and industries are recognizing that the present disposal practices for municipal garbage must change and that the popular use of "disposable" products leaves a permanent legacy ashore, just as it does at sea. The changes that the annex demands of the ship operators may soon be mirrored ashore. As more people confront the same garbage handling problems in their businesses and homes, engineers and designers will have more incentive to develop efficient products and processes, which may then offer a better alternative to the ship operators than those that exist now. Ten years from now, taking out the garbage will be very different, whether you are at sea or on land.

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