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Surface Coating Operations at Shipbuilding and Ship Repair Facilities--Background Information for Proposed Standards

Emission Standards Division

U. S. ENVIRONMENTAL PROTECTION AGENCY

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1.0 SUMMARY

1.1 STATUTORY AUTHORITY

The requirement for development of national emission standards for hazardous air pollutants (NESHAP) is established under Section 112 of the Clean Air Act (42 U.S.C. 7412), as amended in 1990. Emission standards under section 112 apply to new and existing sources of hazardous air pollutants (HAP's) listed in section 112(b). Section 112(c) directs the Administrator to use the HAP list to develop a list of source categories (industries) for which NESHAP will be developed. Surface coating operations within the shipbuilding and ship repair industry have been designated as a source category to be regulated. This background information document supports proposed standards regulating HAP emissions from this source category. As a parallel project, the U. S. Environmental Protection Agency (EPA) is also required to issue control techniques that represent the best available control measures (BACM) to minimize emissions of volatile organic compounds (VOC's) from this source category. This requirement is partly satisfied with publication of an alternative control techniques (ACT) document (EPA Publication No. 453/R-94-032). The document contains information on emissions, controls, control options, and costs. It does not contain the recommended limits which represent BACM. These are represented for comments in the

Since the majority of all volatile HAP's are also VOC's, it was imperative that the NESHAP and identification of BACM be developed concurrently to ensure their compatibility.

1.2 MAXIMUM ACHIEVABLE CONTROL TECHNOLOGY (MACT)

The emission points defined for this source category are indoor and outdoor painting operations. A variety of control options, including add-on control devices and use of coatings with inherently lower emissions of HAP's and VOC's were evaluated. The control option determined to be MACT for surface coating operations in the shipbuilding and ship repair industry was selected primarily because many of the resulting compliant coatings had already survived the Navy's lengthy performance testing program and appear on the Navy "Qualified Product List". To have established more stringent limits for the categories shown in Table 1-1 would have limited the Navy to using coatings that they had not examined in their normal multiple year studies. However, this does not mean that coatings with lower emissions than these listed in Table 1-1

TABLE 1-1. PROPOSED VOLATILE ORGANIC HAP (VOHAP) CONTENT LIMITS FOR MARINE COATING CATEGORIES

	VOHAP limits[a]	
Coating category	Grams per liter (g/L)	Pounds per gallon (lb/gal)[b]
General use	340	2.83
Specialty	--	--
Air flask	340	2.83
Antenna	530	4.42
Antifoulant	400	3.33
Heat resistant	420	3.50
High gloss	420	3.50
High temperature	500	4.17
Inorganic zinc high-build primer	340	2.83
Weld-through (shop) primer	650	5.42
Military exterior	340	2.83
Mist	610	5.08
Navigational aids	550	4.58
Nonskid	340	2.83
Nuclear	420	3.50
Organic zinc	360	3.00
Pre-treatment wash primer	780	6.50
Repair and maintenance of thermoplastic coating of commercial vessels	550	4.58
Sealant coat for thermal spray aluminum	610	5.08
Rubber camouflage	340	2.83
Special marking	490	4.08
Specialty interior	340	2.83
Tack coat	610	5.08
Undersea weapons systems	340	2.83

[a]Volatile organic HAP limits are expressed in units of mass of VOHAP per volume of coating less water.
[b]To convert from g/L to lb/gal, multiply by:
[(3.785 L/gal)(lb/453.6 g)] or (lb-L/120 g-gal).

are not available for certain categories of paint. These materials were not included in this document.

Cost and environmental impacts were developed for MACT using model shipyards to represent the range of facilities found in this industry. The following six models were developed to represent the various types of shipyards that could be subject to the standard. The six models have been distinguished on the basis of relative size of the yard and whether it does new ship construction or repair: (1) large/construction; (2) large/repair; (3) medium/construction; (4) medium/repair; (5) small/construction; and (6) small/repair. Size is based on annual volume of paint and solvent usage. The distinction between sizes is based on annual VOC emission levels (ton/yr), which are critical to the ACT project, so that similar model shipyards can be used for developing emissions and impacts for both the ACT and NESHAP.

Additional data regarding HAP contents of commonly used petroleum distillate solvents such as mineral spirits and naphthas were obtained in the later stages of the project. The new data revealed that earlier estimates of the HAP content of these solvents, which were obtained from their material safety data sheets (MSDS), were far too high. Using the new data emissions from the small "model shipyards" are too low for them to qualify as major sources. Although all six models were retained to describe the industry, only model plants one through four were used for calculating HAP emissions and for developing impacts and cost of the rule.

The MACT determined for this industry was established using VOC as a surrogate for HAP's. The MACT will control coating operations through the use of paints that also meet the VOC limits specified as BACM. When the initial attempt to use data from MSDS and associated information resulted in estimates of HAP emissions that were high, it quickly became clear that developing the requisite information independently was prohibitively expensive. As a result the proposed volatile HAP limits shown in Table 1-1, are expressed in units of volatile organic hazardous air pollutant (VOHAP). The amount of VOHAP in a paint is determined using the Agency's Reference Method 24. A listing and description of each of the marine coating categories and the associated limits is provided in Chapters 3 and 6.

1.3 ENVIRONMENTAL IMPACT

Table 1-2

TABLE 1-2. MACT NATIONWIDE EMISSIONS REDUCTION AND NATIONWIDE AIR, WASTEWATER, SOLID WASTE, AND ENERGY IMPACTS FOR EXISTING MAJOR SOURCES[a]

	Nationwide solvent HAP emission reduction from baseline, percent	Nationwide solvent HAP emission reduction from baseline, Mg/yr (ton/yr)	Secondary air pollutant emissions, Mg/yr (ton/yr)				Incremental annual wastewater production, 10^3 L (10^3 gal)	Incremental annual solid waste production, Mg (ton)	Incremental annual energy consumption, GJ (10^6 Btu)
			PM	SO	NO_x	CO			
	24	272 (300)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

= nitrogen oxides.

summarizes the nationwide environmental impacts of MACT. For the 25 shipyards that are believed to be subject to the rule, compliance with MACT will reduce volatile HAP's by 24 percent from the 1990 ("baseline") level. Included in Table 1-2 are solvent HAP emission reductions and the impacts of compliance with MACT on secondary air pollution, wastewater, solid waste and energy requirements. Since MACT does not include add-on controls, there are no secondary pollutants (particulate matter [PM], SO_x, and NO_x) that would otherwise result from the burning of fuel oil to generate steam for carbon adsorbers or from coal-fired power plants generating electricity to run add-on control equipment. For the same reason, there are no secondary emissions of carbon monoxide (CO), PM, SO_x, and NO_x from incineration of solvent HAP's. As shown in Table 1-1, compliance with MACT will reduce solvent HAP emissions from existing major sources by 272 megagrams per year (Mg/yr) (300 tons per year [ton/yr]).

1.4 COST AND ECONOMIC IMPACTS

The nationwide cost impacts of the MACT rule are summarized in Table 1-3. It should be noted that no new sources are expected in this industry within the next 5 years. The economic analyses indicate that the worst-case maximum industrywide price impact for existing major sources is less than 0.3 percent. Detailed analyses of the costs and the economic impacts are presented in Chapters 8 and 9.

TABLE 1-3. NATIONWIDE MACT COST IMPACTS FOR EXISTING MAJOR SOURCES[a]

Regulatory alternative	Total annual cost, $	Annual emission reduction from baseline, Mg/(ton)	Cost effectiveness, $/Mg ($/ton)
MACT	$1,720,280	272 (300)	6,325 (5,734)

[a]Calculations for 25 major sources.

2.0 INTRODUCTION

2.1 BACKGROUND AND AUTHORITY FOR STANDARDS

According to industry estimates, more than 2.4 billion pounds of toxic pollutants were emitted to the atmosphere in 1988 (Implementation Strategy for the Clean Air Act Amendments of 1990, EPA Office of Air and Radiation, January 15, 1991). These emissions may result in a variety of adverse health effects, including cancer, reproductive effects, birth defects, and respiratory illnesses. Title I (Section 112) of the Clean Air Act provides the tools for controlling emissions of these pollutants.[1] Emissions from both large and small facilities that contribute to air toxics problems in urban and other areas will be regulated. The primary consideration in establishing national industry standards must be demonstrated technology. Before national emission standards for hazardous air pollutants (NESHAP) are proposed as Federal regulations, air pollution prevention and control methods are examined in detail with respect to their feasibility, environmental impacts, and costs. Various control options based on different technologies and degrees of efficiency are examined, and a determination is made regarding whether the various control options apply to each emissions source or if dissimilarities exist between the sources. In most cases, regulatory alternatives are subsequently developed that are then studied by the EPA as a prospective basis for a standard. The alternatives are investigated in terms of their impacts on the environment, the economics and well-being of the industry, the national economy, and energy and other impacts. This document summarizes the information obtained through these studies so that interested persons will be able to evaluate the information considered by the EPA in developing the proposed standards.

National emission standards for hazardous air pollutants for new and existing sources are established under Section 112 of the Clean Air Act as amended in 1990 [42 U.S.C. 7401 et seq., as amended by PL 101-549, November 15, 1990], hereafter referred to as the Act. Section 112 directs the EPA Administrator to promulgate standards that "require the maximum degree of reduction in emissions of the hazardous air pollutants subject to this section (including a prohibition of such emissions, where achievable) that the Administrator, taking into consideration the cost of achieving such emission reductions, and any nonair quality health and environmental impacts and energy requirements, determines is achievable ... ." The Act allows the Administrator to set standards that "distinguish among classes, types, and sizes of sources within a category or subcategory."

The Act differentiates between major sources and area sources. A major source is defined as "any stationary source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit considering controls, in the aggregate, 10 tons per year or more of any hazardous air pollutant or 25 tons per year or more of any combination of hazardous air pollutants." The Administrator, however, may establish a lesser quantity cutoff to distinguish between major and area sources. The level of the cutoff is based stationary source of hazardous air pollutants that is not a major source." For new sources, the amendments state that the "maximum degree of reduction in emissions that is deemed achievable for new sources in a category or subcategory shall not be less stringent than the emission control that is achieved in practice by the best controlled similar source, as determined by the Administrator." Emission standards for existing sources may be less stringent than the standards for new sources in the same category or subcategory but shall not be less stringent, and may be more stringent than--

> (A) the average emission limitation achieved by the best performing 12 percent of the existing sources (for which the Administrator has emissions information), excluding those sources that have, within 18 months before the emission standard is proposed or within 30 months before such standard is promulgated, whichever is later, first achieved a level of emission rate or emission reduction which complies, or would comply if the source is not subject to such standard, with the lowest achievable emission rate (as defined by Section 171) applicable to the source category and prevailing at the time, in the category or subcategory for categories and subcategories with 30 or more sources, or
>
> (B) the average emission limitation achieved by the best performing five sources (for which the Administrator has or could reasonably obtain emissions information) in the category or subcategory for categories or subcategories with fewer than 30 sources.

The Federal standards are also known as "MACT" standards and are based on the maximum achievable control technology previously discussed. The MACT standards apply to both major and area sources, although the existing source standards may be less stringent than the new source standards, within the constraints presented above. The MACT is considered to be the basis for the cases. For example, a stricter standard may help achieve long-term cost savings by avoiding the need for more expensive retrofitting to meet possible future residual risk standards, which may be more stringent (discussed in Section 2.7). A stricter standard may lead to development of new superior technologies and Congress was clearly interested in providing incentives for improving technology. Sometimes it is necessary to adopt a stricter standard to reduce the health and environmental risk of an emissions of one or a group of toxics.

For area sources, the Administrator may "elect to promulgate standards or requirements applicable to sources in such categories or subcategories which provide for the use of generally available control technologies or management practices by such sources to reduce emissions of hazardous air pollutants." These area source standards are also known as "GACT" (generally available control technology) standards, although MACT may be applied at the Administrator's discretion, as alluded to previously.

The standards for hazardous air pollutants (HAP's), like the new source performance standards (NSPS) for criteria pollutants required by Section 111 of the Act (42 U.S.C. 7411), differ from other regulatory programs required by the Act (such as the new source review program and the prevention of significant deterioration program) in that NESHAP and NSPS are national in scope (versus site-specific). Congress intended for the NESHAP and NSPS programs to provide a degree of uniformity to State regulations to avoid situations where some States may attract industries by relaxing standards relative to other States. States are free under Section 116 of the Act to establish standards more stringent than Section 111 or 112 standards.

Although NESHAP are normally structured in terms of source may be impossible or at least impracticable due to technological and economic limitations. Section 112(h) of the Act allows the Administrator to promulgate a design, equipment, work practice, or operational standard, or combination thereof, in those cases where it is not feasible to prescribe or enforce an emissions standard. For example, emissions of volatile organic compounds (many of which may be HAP's, such as benzene) from storage vessels for volatile organic liquids are greatest during tank filling. The nature of the emissions (i.e., high concentrations for short periods during filling and low concentrations for longer periods during storage) and the configuration of storage tanks make direct emission measurement impractical. Therefore, the MACT or GACT standards may be based on equipment specifications.

Under Section 112(h)(3), the Act also allows the use of alternative equivalent technological systems: "If, after notice and opportunity for comment, the owner or operator of any source establishes to the satisfaction of the Administrator that an alternative means of emission limitation" will reduce emissions of any air pollutant at least as much as would be achieved under the design, equipment, work practice, or operational standard, the Administrator shall permit the use of the alternative means.

Efforts to achieve early environmental benefits are encouraged in Section 112. For example, source owners and operators are encouraged to use the Section 112(i)(5) provisions, which allow a 6-year compliance extension of the MACT standard in exchange for the implementation of an early emission reduction program. The owner or operator of an existing source must demonstrate a 90 percent emission reduction of HAP's (or 95 percent if the HAP's are particulates) and meet an alternative emission limitation, established by permit, in lieu of the period of 6 years from the compliance date for the otherwise applicable standard. The 90 (95) percent early emission reduction must be achieved before the otherwise applicable standard is first proposed, although the reduction may be achieved after the standard's proposal (but before January 1, 1994) if the source owner or operator makes an enforceable commitment before the proposal of the standard to achieve the reduction. The source must meet several criteria to qualify for the early reduction standard, and Section 112(i)(5)(A) provides that the State may require additional reductions.

2.2 SELECTION OF POLLUTANTS AND SOURCE CATEGORIES

The Act includes a list of 189 HAP's. Using this list of pollutants, the EPA published a list of source categories (major and area sources) for which emission standards will be developed. Within 2 years of enactment of the amendments (November 1992), the EPA published a schedule establishing dates for promulgating these standards. The schedule for standards for source categories is to be determined according to the following criteria:

(A) The known or anticipated adverse effects of such pollutants on public health and the environment;

(B) The quantity and location of emissions or reasonably anticipated emissions of HAP's for each category or subcategory; and

(C) The efficiency of grouping categories or subcategories according to the pollutants emitted or the processes or technologies used.

After a source category has been chosen, the types of facilities within the source category to which the standard will apply must be determined. A source category may have several facilities that cause air pollution, and emissions from these facilities may vary in magnitude and control cost. Economic standards to the more severe pollution sources. For this reason, and because there is no adequately demonstrated system for controlling emissions from certain facilities, standards often do not apply to all facilities at a source. For the same reasons, the standards may not apply to all air pollutants emitted. Thus, although a source category may be selected to be covered by standards, the standards may not cover all pollutants or facilities within that source category.

2.3 PROCEDURE FOR DEVELOPMENT OF NESHAP

Standards for major and area sources must (1) realistically reflect MACT or GACT; (2) adequately consider the cost, the nonair quality health and environmental impacts, and the energy requirements of such control; (3) apply to new and existing sources; and (4) meet these conditions for all variations of industry operating conditions anywhere in the country.

The objective of the NESHAP program is to develop standards to protect the public health by requiring facilities to control emissions to the level achievable according to the MACT or GACT guidelines. The standard-setting process involves three principal phases of activity: (1) gathering information, (2) analyzing the information, and (3) developing the standards.

During the information-gathering phase, industries are questioned through telephone surveys, letters of inquiry, and plant visits by the EPA representatives. Information is also gathered from other sources, such as a literature search. Based on the information acquired about the industry, the EPA selects certain plants at which emissions tests are conducted to provide reliable data that characterize the HAP's emissions from well-controlled existing facilities.

In the second phase of a project, the information about the industry, the pollutants emitted, and the control options are definitions, national pollutant emissions data, and existing State regulations governing emissions from the source category are then used to establish regulatory alternatives. These regulatory alternatives may be different levels of emissions control or different degrees of applicability or both.

The EPA conducts studies of several regulatory alternatives and selects one as the basis for the NESHAP for the source category under study.

In the third phase of a project, the selected regulatory alternative is translated into a standard. The Federal standard limits emissions to the levels indicated in the selected regulatory alternative.

As early as is practical in each standard-setting project, the EPA representatives discuss the possibilities of a standard and the form it might take with members of the National Air Pollution Control Techniques Advisory Committee, which is composed of representatives from industry, environmental groups, and State and local air pollution control agencies. Other interested parties also participate in these meetings.

The information acquired in the project is summarized in the background information document (BID). Completed portions of the BID and proposed standards, are widely circulated to the industry being considered for control, environmental groups, other government agencies, and offices within the EPA. Through this extensive review process, the points of view of expert reviewers are taken into consideration as changes are made to the documentation.

A "proposal package" is assembled and sent through the offices of the EPA Assistant Administrators for concurrence before the proposed standards are officially endorsed by the EPA Administrator. After being approved by the EPA Administrator, The public is invited to participate in the standard-setting process as part of the Federal Register announcement of the proposed regulation. The EPA invites written comments on the proposal and also holds a public hearing to discuss the proposed standards with interested parties. All public comments are summarized and incorporated into a second volume of the BID. All information reviewed and generated in studies in support of the standards is available to the public in a "docket" on file in Washington, D.C. Comments from the public are evaluated, and the standards may be altered in response to the comments.

The significant comments and the EPA's position on the issues raised are included in the preamble of a promulgation package, which also contains the draft of the final regulation. The regulation is then subjected to another round of internal EPA review and refinement until it is approved by the EPA Administrator. After the Administrator signs the regulation, it is published as a "final rule" in the Federal Register.

2.4 CONSIDERATION OF COSTS

The requirements and guidelines for the economic analysis of proposed NESHAP are prescribed by Presidential Executive Order 12291 (EO 12291) and the Regulatory Flexibility Act (RFA). The EO 12291 requires preparation of a Regulatory Impact Analysis (RIA) for all "major" economic impacts. An economic impact is considered to be major if it satisfies any of the following criteria:

1. An annual effect on the economy of $100 million or more;
2. A major increase in costs or prices for consumers; individual industries; Federal, State, or local government agencies; or geographic regions; or
3. Significant adverse effects on competition, employment, investment, productivity, innovation, or on the ability of

An RIA describes the potential benefits and costs of the proposed regulation and explores alternative regulatory and nonregulatory approaches to achieving the desired objectives. If the analysis identifies less costly alternatives, the RIA includes an explanation of the legal reasons why the less costly alternatives could not be adopted. In addition to requiring an analysis of the potential costs and benefits, EO 12291 specifies that the EPA, to the extent allowed by the ACT and court orders, demonstrate that the benefits of the proposed standards outweigh the costs and that the net benefits are maximized.

The RFA requires Federal agencies to give special consideration to the impact of regulations on small businesses, small organizations, and small governmental units. If the proposed regulation is expected to have a significant impact on a substantial number of small entities, a regulatory flexibility analysis must be prepared. In preparing this analysis, the EPA takes into consideration such factors as the availability of capital for small entities, possible closures among small entities, the increase in production costs due to compliance, and a comparison of the relative compliance costs as a percent of sales for small versus large entities.

The prime objective of the cost analysis is to identify the incremental economic impacts associated with compliance with the standards based on each regulatory alternative compared to baseline. Other environmental regulatory costs may be factored into the analysis wherever appropriate. Air pollutant emissions may cause water pollution problems, and captured potential air pollutants may pose a solid waste disposal problem. The total environmental impact of an emission source must, therefore, be analyzed and the costs determined whenever possible.

A thorough study of the profitability and price-setting made for proposed standards. It is also essential to know the capital requirements for pollution control systems already placed on plants so that the additional capital requirements necessitated by these Federal standards can be placed in proper perspective. Finally, it is necessary to assess the availability of capital to provide the additional control equipment needed to meet the standards.

2.5 CONSIDERATION OF ENVIRONMENTAL IMPACTS

Section 102(2)(C) of the National Environmental Policy Act (NEPA) of l969 requires Federal agencies to prepare detailed environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The objective of NEPA is to build into the decision-making process of Federal agencies a careful consideration of all environmental aspects of proposed actions.

In a number of legal challenges to standards for various industries, the United States Court of Appeals for the District of Columbia Circuit has held that environmental impact statements need not be prepared by the EPA for proposed actions under the Clean Air Act. Essentially, the Court of Appeals has determined that the best system of emissions reduction requires the Administrator to take into account counterproductive environmental effects of proposed standards as well as economic costs to the industry. On this basis, therefore, the Courts established a narrow exemption from NEPA for the EPA determinations.

In addition to these judicial determinations, the Energy Supply and Environmental Coordination Act of 1974 (PL-93-319) specifically exempted proposed actions under the Clean Air Act from NEPA requirements. According to Section 7(c)(1), "No action taken under the Clean Air Act shall be deemed a major Federal

Policy Act of l969" (15 U.S.C. 793(c)(1)).

Nevertheless, the EPA has concluded that preparing environmental impact statements could have beneficial effects on certain regulatory actions. Consequently, although not legally required to do so by Section 102(2)(C) of NEPA, the EPA has adopted a policy requiring that environmental impact statements be prepared for various regulatory actions, including NESHAP developed under Section 112 of the Act. This voluntary preparation of environmental impact statements, however, in no way legally subjects the EPA to NEPA requirements.

To implement this policy, a separate section is included in this document that is devoted solely to an analysis of the potential environmental impacts associated with the proposed standards. Both adverse and beneficial impacts in such areas as air and water pollution, increased solid waste disposal, and increased energy consumption are discussed.

2.6 RESIDUAL RISK STANDARDS

Section 112 of the Act provides that 8 years after MACT standards are established (except for those standards established 2 years after enactment, which have 9 years), standards to protect against the residual health and environmental risks remaining must be promulgated, if necessary. The standards would be triggered if more than one source in a category or subcategory exceeds a maximum individual risk of cancer of 1 in 1 million. These residual risk regulations would be based on the concept of providing an "ample margin of safety to protect public health." The Administrator may also consider whether a more stringent standard is necessary to prevent--considering costs, energy, safety, and other relevant factors--an adverse environmental effect. In the case of area sources controlled under GACT standards, the Administrator is not required to conduct a

3.0 PROCESSES AND POLLUTANT EMISSIONS

3.1 GENERAL

For purposes of this study, the shipbuilding and ship repair industry consists of establishments that build and repair ships with metal hulls. This industry also includes the repainting, conversion, and alteration of ships. Subcontractors engaged in ship painting, blasting, or any other operations within the boundaries of a shipyard are considered to be part of the shipyard, and resulting emissions are considered shipyard emissions. The definition for Standard Industrial Classification (SIC) Code 3731, Shipbuilding and Repairing, generally coincides with the above definition but differs in that SIC Code 3731 includes the manufacture of both offshore oil and gas well drilling and production platforms. Emission limits from coatings used on such platforms are being negotiated as a part of the Federal VOC rule on architectural and industrial maintenance coatings which is still under development.

In order to better define which shipyard facilities will be subject to rulemaking, the following definition of a ship has been adopted:

> any metal hulled marine or fresh-water vessel used for military or commercial operations, including self-propelled vessels and those towed by other craft (barges). This definition includes, but is not limited to, all military vessels, commercial cargo and passenger (cruise) ships, ferries, barges, tankers,

included in the definition and are not typically built or serviced in large-scale shipyards. As would be expected, there is some overlap with the pleasure craft industry. Some of the smaller shipyards work on both ships and pleasure craft.

Approximately 437 facilities (shipyards) of varying capabilities are involved in the construction and repair of ships in the United States.[2] Of the 437 shipyards, 25 are estimated to quantify as major sources based on HAP emissions. A major source is defined as a contiguous facility emitting 10 tons or more of any one HAP or 25 tons or more of all HAP's combined. Of the 437 shipyards, there are eight Naval shipyards and one Coast Guard facility. The shipyards are located along the east, west, and Gulf coasts as well as at some inland locations along the Mississippi River (and its tributaries) and the Great Lakes. Many of the small bargeyards are concentrated in Louisiana and Texas. The majority of these do not qualify as major sources with regard to hazardous air pollutant (HAP) emissions. A more detailed statistical source category profile is presented in Section 9.1. Figure 3-1

Figure 3-1. 437 active U.S. shipbuilding facilities (by State).

shows the geographical location of active U.S. shipyards, and
Table 3-1

TABLE 3-1. U.S. SHIPYARD LOCATIONS

State	No. of shipyards	Estimated No. of major sources
Louisiana	74	5
Texas	53	0
Virginia	34	3
California	33	3
Florida	33	1
Washington	25	1
New York	21	0
Mississippi	17	2
Alabama	15	1
Pennsylvania	12	1
Oregon	10	4
Wisconsin	9	0
Massachusetts	8	0
Maine	7	1
New Jersey	7	0
Ohio	7	0
Indiana	6	1
Illinois	6	0
North Carolina	6	0
South Carolina	6	0
Michigan	6	0
Rhode Island	6	0
Tennessee	6	0
Missouri	5	0
Hawaii	5	0
Georgia	4	0
Maryland	4	1
Puerto Rico	3	0
Alaska	2	0
Arkansas	2	0
Connecticut	2	1
Minnesota	1	0
Oklahoma	1	0
New Hampshire	1	0
TOTAL	437	25

lists individual States, with the number of shipyards and the estimated number of major sources located in each.

As reported in the U.S. Industrial Outlook '92--Shipbuilding and Repair dated January 1992:[3]

> The U.S. Active Shipbuilding Base (ASB) is defined as privately owned shipyards that are open, engaged in, or actively seeking construction contracts for naval and commercial ships over 1,000 tons. These full-service yards are the primary sector of the first-tier shipyards, which are facilities capable of constructing, drydocking, or topside-repairing vessels 400 feet in length or more. As of October 1, 1992, there were 16 ASB shipyards. The ASB shipyards continue to employ about three-quarters of the shipbuilding and ship repair industry's total work force of more than 120,000. These figures do not include nine Government-owned shipyards, which do not engage in new construction, but rather in the overhaul and repair of Navy and Coast Guard ships.
>
> Another important sector of the shipbuilding and ship repair industry is one composed of small-size and medium-size facilities, or "second-tier shipyards." These shipyards are primarily engaged in supporting

inland waterway and coastal carriers. Their market is the construction and repair of smaller type vessels, such as tug boats, supply boats, ferries, fishing vessels, barges, and small military and Government-owned vessels.[3]

Shipyard employment varies from 10 employees to 26,000 employees, and subcontractors are frequently used for specific operations like abrasive blasting and painting. Bargeyards typically are relatively smaller operations with a focus on repair activities, while most commercial and military shipyards have more employees and can handle a wide variety of ships and repairs.

All types of vessels are built or repaired in shipyards in the United States. Many of the ships are foreign-owned/operated. Government owned (Navy, Army, and Coast Guard) vessels account for a significant portion of all shipyard work. Steel is the most common material used in the shipbuilding and ship repair industry, but wood, aluminum, and plastic/fiberglass are also used.

The large shipyard organizations that have floating drydocks and/or graving docks generally have extensive waterfront acreage and are capable of all types of ship repair and maintenance. Major shipyards usually combine repair, overhaul, and conversion with shipbuilding capabilities, and employment usually numbers in the thousands. It is difficult to draw a sharp line between yards that build ships and those that repair/maintain ships; many facilities engage in both activities to various degrees. The mix of work varies widely throughout the industry as well as from year to year at a single shipyard.[3,4]

Repair yards perform a wide variety of services and can be categorized into two groups based on the ability to drydock a ship. Those facilities which have no drydock capabilities are known as topside repair yards and can perform the various repairs rendered by these yards may vary from a simple repair job to a major topside overhaul. In general, not much painting is conducted in topside yards so they have low HAP emissions and do not generally qualify as major sources. On the other hand, typical repair yards with the ability to drydock ships do more painting than do construction yards of comparable size. Repainting is an integral part of most repair jobs, and the underwater hull is a significant part of the painted area of a ship.

3.2 SHIPYARDS AND THEIR EMISSIONS

While several shipyard operations use and emit HAP's, the vast majority of HAP emissions come from organic solvents contained in marine paints and solvents used for thinning and cleaning. Other operations that emit small quantities of HAP's, such as welding, metal forming/cutting, abrasive blasting, etc., will be included to determine if a facility qualifies as a major source (i.e., one that emits more than 10 tons of any one HAP or more than 25 tons of all HAP's combined). However, the regulatory focus of this NESHAP (listed under surface coating operations in the source category listing in the Federal Register dated July 16, 1992) is on painting operations and the associated cleaning solvents. This section discusses related details of marine paints, resins, solvents, coating systems, and application equipment.

Some shipyard operations such as part cleaners (degreasers), cooling towers, and asbestos removal are covered by existing or upcoming Federal regulations. In these cases, the existing or upcoming regulations have precedence. This NESHAP is not intended to have any contradictory impact and has not addressed such operations in determining if a facility qualifies as a major source.

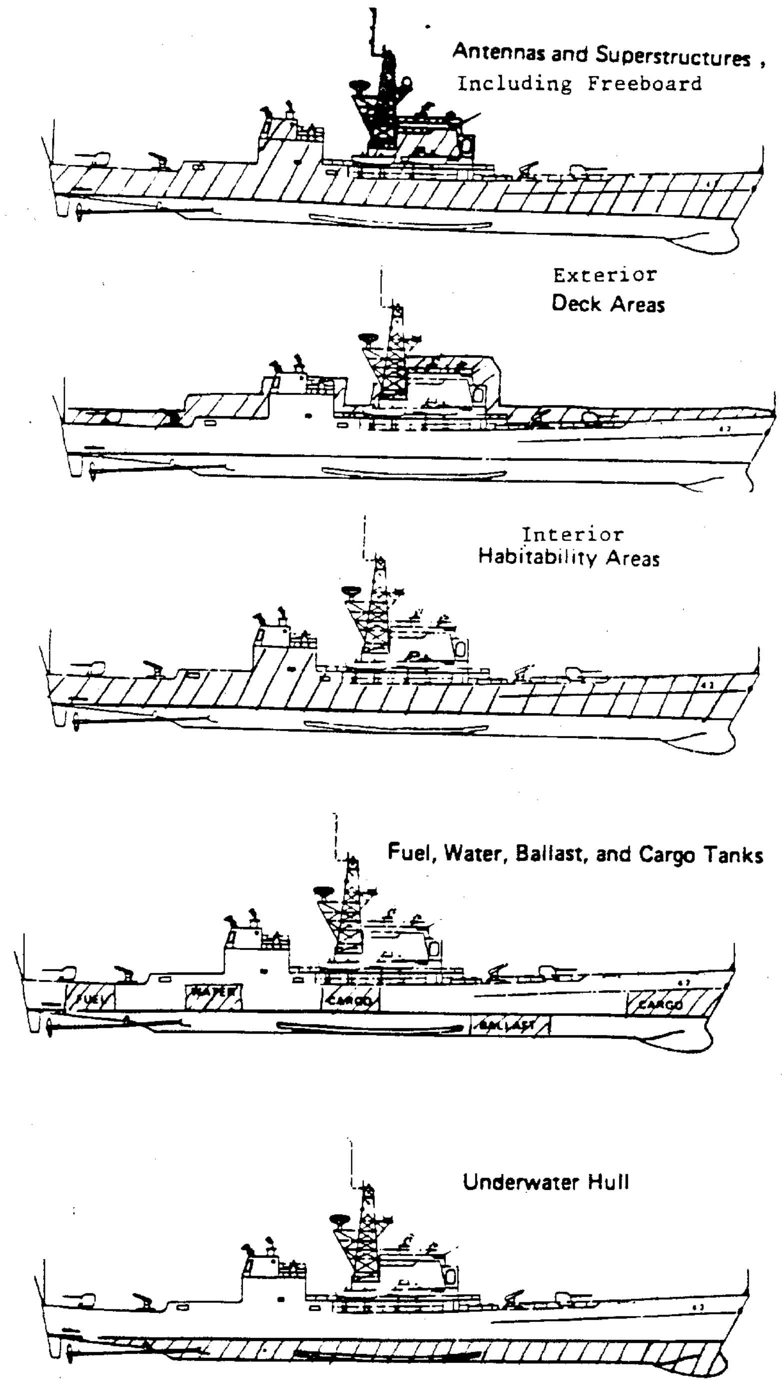
painting and/or repairs are needed below the waterline of a ship, it must be removed from the water using a floating drydock, graving dock, or marine railway. In new construction operations, assembly is usually modular, and painting is done in several stages at various locations throughout the shipyard.

The typical ship construction process begins with steel plate material. The steel is formed into shapes, abrasively cleaned (blasted), and then coated with a preconstruction primer for corrosion protection during the several months it may lay in storage before it is used. This is typically done indoors at the bigger shipyards, and some facilities have automated these steps. Smaller shipyards usually have no indoor facilities, and all work is done at or near the waterfront. Using the preformed plates, small subassemblies are then constructed and again a primer coat is applied. This step is often preceded by removal (blasting) off the preconstruction primer. For instance, Navy specifications require white metal blasting before application of the "paint system" (a succession of compatible coatings applied on top of one another) to provide long term corrosion protection. Larger subassemblies are similarly put together and primed to protect the steel substrate material and provide whatever special properties are needed. At some point in the construction, even those components fabricated indoors are moved outdoors to work areas adjacent to the drydock. Final assembly (and painting) can only be done at the drydock for large ships such as aircraft carriers or cruise ships. At some facilities, smaller ships are completed indoors and then moved to the water using a marine railway and/or cranes. There are five general areas of ship structures that have special coating requirements:

1. Antennas and superstructures (including freeboard);
2. Exterior deck areas;

5. Underwater hull.[4]

Each of these areas is diagrammed in Figure 3-2


Antennas and Superstructures , Including Freeboard
Exterior Deck Areas
Interior Habitability Areas
Fuel, Water, Ballast, and Cargo Tanks
Underwater Hull

to aid with some of the terminology used later in this chapter.[5]

3.2.1 Marine Paints

The basic components in marine paint (coatings) are the vehicle (resin binder), solvent pigment (except for clear coatings), and additives. Resins and solvents are discussed further later on in this section. Paint is used for either protective, functional or decorative (aesthetic) applications or both.[6]

Marine coatings are vital for protecting the ship from corrosive and biotic attacks from the ship's environment. Many marine paints serve specific functions such as corrosion protection, heat/fire resistance, and antifouling (used to prevent the settlement and growth of marine organisms on the ship's underwater hull). A ship's fuel consumption can be increased significantly because of marine fouling, adding to the operational costs. Different paints are used for these purposes, and each may use one or more solvents (or solvent blends) in different concentrations. Specific paint selections are based on the intended use of the ship, ship activity, travel routes, desired time between paintings (service life), the aesthetic desires of the ship owner or commanding officer, and fuel costs. Ship owners and paint suppliers specify the paints and coating thicknesses to be applied at shipyards.

3.2.1.1 Marine Coating (Resin) Types. The general properties of the different chemical types of coatings and their uses in marine applications are discussed in this section. An overall summary of these coating types and applications is provided in Tables 3-2 and 3-3.

TABLE 3-2. AREAS OF APPLICATION FOR MARINE PAINTS (RESIN TYPES)[4]

	Alkyd	Epoxy	Inorganic zinc	Organic zinc	Polyurethane	Vinyl	Chlorinated rubber
	X	X	X	X	X	X	X
	X	X	X	X	X	X	X
	X	X	X		X	X	
	X	X X	X	X	X X	X X	X X
	X	X			X		
	X	X			X		
	X	X	X	X	X		
	X	X					
		X	X	[a]			
		X X	X X		X X	X	

CENTEC Corporation, "VOC Emission Control Technologies for Ship Painting Facilities - Industry Characterization, EPA Document No. EPA-600\2-81-131. July 1981.

TABLE 3-3. MARINE COATING (RESIN) TYPES[4]

Coating type	Resin	Advantages	Disadvantages
	Polyester compounds	Anticorrosive and weather-resistant	Not recommended for immersion
	Natural rubber	Water resistant Fast drying	Softened by heat
	Coal tar pitch	High dielectric strength Inexpensive	Carcinogenic Safety concerns
	Bisphenol-A-type	Anticorrosive Chemical-resistant	Sunlight-sensitive Pot life varies by formulation
	Zinc metal in an inorganic binder	Excellent primer for superstructure Galvanically active	Poor immersion service in solutions of either high or low pH
	Zinc metal in an organic binder	Electrochemically active	Poor immersion service in salt water
	Isocyanate group	Chemical-resistant High gloss	Difficult to recoat
	Molten aluminum or zinc	Low weight Longer service life	Requires topcoat
	Vinyl compounds	Chemical- and water-resistant	Softened by heat Requires wash primer

[4] These marine coatings are usually applied on top of one another. A typical coating system comprises (1) a thin primer coat that provides initial corrosion (oxidation) protection and promotes adhesion of the subsequent coating, (2) one or more intermediate coats that physically protect(s) the primer and may provide additional or special properties, and (3) a topcoat that provides long-term protection for both the substrate and the underlying coatings. The primer is usually a zinc-rich material that will provide galvanic corrosion protection if the overlying paint system is damaged but would quickly be consumed by sacrificial corrosion without a protective topcoat. A good coating system can enhance the beneficial properties of individual coatings. Each coating is

typically a different color to help the applicators ensure that each layer provides complete coverage.

3.2.1.1.1 Alkyds.[7] Alkyd resins are polyester compounds that are formed by reactions between polyhydric alcohols (e.g., ethylene glycol or glycerol) and a polybasic acid (e.g., phthalic anhydride) in the presence of a drying oil (e.g., linseed or soybean oil). The specific oil used determines the curing properties of the resin and its ultimate chemical and physical properties. Alkyds are frequently modified chemically to improve their physical properties or their chemical resistance. Modified alkyds are formed by reacting other chemical compounds (such as vinyl, silicone, and urethane compounds) with the alkyd. Alkyd coatings require chemical catalysts (driers) to cure. Typical catalysts are mixtures of zirconium, cobalt, and manganese salts. Depending on the catalysts and the ambient temperature and humidity, it takes several days to several weeks before the coating is fully cured.

Alkyd coatings are frequently used as anticorrosive primers and topcoats in interior areas and as cosmetic topcoats over high-performance primers in exterior areas. Alkyd coatings are primarily used for habitability spaces, storerooms, and equipment finishes. Fire-retardant alkyd paints are some of the most common interior coatings used on Naval ships. Modified alkyds, particularly silicone alkyds, have excellent weathering properties and are good decorative and marking coatings. However, alkyds are not recommended for saltwater immersion service or for use in areas that are subject to accidental immersion. The alkali generated by the corrosion reactions rapidly attacks the coating and leads to early coating failure. Also, alkyds should not be applied over zinc-rich primers because they are attacked by the alkaline zinc corrosion products.

rubbers by themselves are not suitable for use as coatings and must be blended with other compounds to produce good coatings. Coatings made from chlorinated rubbers that have been blended with highly chlorinated additives provide tough, chemically resistant coatings. These coatings cure by solvent evaporation. These coatings are normally partially dry within 1 hour (hr) and fully dry within 7 days. For this reason, chlorinated rubber coatings are especially useful where fast drying, particularly at low temperatures (0° to 10°C [32° to 50°F]), is required.

Chlorinated rubber coatings are tough, resistant to water, and chemically resistant. However, they are softened by heat and are not suitable for sustained use at temperatures above 66°C (150°F). Chlorinated rubber coatings are suitable for most exterior ship areas that are not continually exposed to excessively high temperatures.

3.2.1.1.3 Coal tar and coal tar epoxy.[7] Coal tar coatings are made from processed coal tar pitch dissolved in suitable petroleum solvents. They form a film by evaporation of the solvent, and the film can be redissolved in solvents. Coal tar films provide very good corrosion protection. However, the dry film is damaged by direct exposure to sunlight, which causes rapid, severe cracking. Coal tars are normally blended with other resins to improve their light stability and to increase their chemical resistance. Common blending resins include vinyl and epoxy materials. Coal tar coatings are widely used in highly corrosive environments such as ship bottoms, where impermeability is important. They are also applied as anticorrosive coatings in ballast tanks and lockers used to store anchor chains.

Coal tar epoxy paints are packaged with the epoxy portion in one container and the curing agent (either amine or polyamide type) in a second container. The coatings must be thoroughly evaporation and continued chemical reaction between the epoxy resin and the curing agent. The "pot life" is different for each unique formulation. Commonly used coatings have pot lives that range from 2 to 8 hr at 25°C (77°F). Coal tar epoxy films have high chemical resistance, easily form thick films, and have a high dielectric strength. The high dielectric strength makes them particularly suitable for use near anodes in cathodic protection systems, where the high current densities can damage other types of coatings. Coal tar epoxy coatings are known to exude low-molecular-weight fractions (ooze solvent), which cause recoating problems. The U.S. Navy limits the use of coal tar and coal tar epoxy coatings to protect workers from the possibility of low levels of carcinogens in the refined coal tar.

Coal tar epoxies are also commonly used on fresh-water barges. Other suitable paints are available, but the coal tars are the least expensive.

3.2.1.1.4 Epoxy.[7] Epoxy coatings for marine applications are typically formed by the chemical reaction of a bisphenol-A-type epoxy resin with a "curing agent" (e.g., amines, amine adducts, or polyamide resins). The coatings are packaged with the epoxy portion in one container and the curing agent in a second container. As with coal tar epoxy systems, the coatings must be used within their pot life. Commonly used epoxy coatings have pot lives that range from 2 to 8 hr at 25°C (77°F). Epoxy coatings typically dry to touch within 3 hr and are fully cured after 7 days at 25°C (77°F). The time to cure depends on the ambient, coating, and surface temperature during the curing period. The curing reaction slows down markedly at temperatures below 10°C (50°F).

Epoxy coating films are strongly resistant to most chemicals and make excellent anticorrosion coatings. They are one of the epoxy coatings chalk when exposed to intense sunlight. For this reason, epoxy coatings are often used with cosmetic topcoats (e.g., silicone alkyds) that are more resistant to sunlight.

3.2.1.1.5 Inorganic zinc.[7] Inorganic zinc coatings consist of powdered zinc metal held together by a binder of inorganic silicate. The binder is formed by the polymerization of sodium silicate, potassium silicate, lithium silicate, or hydrolyzed organic silicates. The liquid coating forms a film by the evaporation of the solvent (water and/or VOC's), followed by the chemical reactions between the silicate materials, zinc dust, and curing agents. Inorganic zinc coatings use water or organic solvents.

A variety of curing mechanisms are used to form the final inorganic zinc coating film. The coatings are frequently packaged as multicomponent paints. All parts must be mixed thoroughly before being applied. After mixing, inorganic zinc coatings have a pot life of 4 to 12 hr. The solvent must evaporate from these coatings before they can form a film. For solvent based, self cure inorganic zincs, some water is needed to allow the binder to cure. Low humidity will retard cure rate.

Because the coatings consist primarily of zinc, they offer extraordinary galvanic corrosion protection. At the same time and for a variety of reasons, they can be corroded by the same environments that damage zinc. Inorganic zinc coatings are often used on weather (exterior) decks and as primers for the ship superstructure.

3.2.1.1.6 Organic zinc.[7] Organic zinc coatings use zinc as a pigment in a variety of organic binders. The primary feature of organic zinc coatings is that the coating film is electrochemically active and reacts to provide cathodic protection to the steel substrate. These coatings are not as compatible with organic topcoats. Generally, these coatings are more tolerant of application variables than are inorganic zinc coatings. The drying and curing properties of this type of coating are determined by the properties of the binder. These coatings are not recommended for immersion service in salt water for the same reason given for inorganic zinc coatings, namely, that they can be corroded by the same environments that damage zinc.

3.2.1.1.7 Polyurethane.[7] Polyurethane marine coatings are made from resins that contain complex monomers that incorporate isocyanate chemistry, which is highly reactive with hydroxyl groups (e.g., water and alcohols), which are commonly used as curing agents. Coating films are formed in two overlapping steps by solvent evaporation followed by a chemical reaction between the polyurethane resin and the curing agents. The most commonly used polyurethane marine coatings are packaged as two- or three-component systems. One component contains the polyurethane resin, and the second component contains an organic polyol. Some systems require the use of a third component containing catalysts (e.g., metallic soaps or amine compounds) to accelerate curing.

Polyurethane coatings form tough, chemically-resistant coatings and make particularly good high-gloss cosmetic finishes. They have good abrasion and impact resistance and are particularly useful in high-wear areas. They have good weather resistance but lose gloss when exposed to intense sunlight. Weathered polyurethane coatings are often difficult to recoat, and subsequent topcoats will not adhere unless special care is taken to prepare the surface before repainting aged or damaged areas. Polyurethane coatings are most commonly used as topcoats, e.g., in a coating system consisting of one coat inorganic zinc, one coat high-build epoxy, and one coat aliphatic polyurethane.

3.2.1.1.8 Spray-metallized coatings.[7] Spray-metallized coatings are formed by melting a metal and spraying it onto the surface to be protected. The metal solidifies in place and forms a tightly adhering barrier to protect against corrosion. Zinc and aluminum are the most commonly used metals for spray-metallizing. Aluminum is generally favored for marine service because of its longer service life and low weight. It is generally necessary to topcoat the sprayed metal coating to improve appearance and protect the metalized coating to gain the maximum possible service life. Vinyl or epoxy coatings are typically used as topcoats for aluminum metal spray coatings.

3.2.1.1.9 Vinyl Coatings.[7] Vinyl resins are formed by the polymerization of vinyl compounds and are used in paints for several applications (categories). The most common resins are based on polyvinyl chloride (PVC) copolymers. These resins form coatings by solvent evaporation. Freshly applied coatings are dry to the touch within 1 hr and are fully dried within 7 days. Vinyl coatings are particularly useful where fast drying, particularly at low temperatures (0° to 10°C [32° to 50°F]), is required.

Coatings based on vinyl polymers perform well in immersion situations and are frequently used to protect submerged structures such as the underwater hull of a ship. These coatings have excellent resistance to many chemicals and are good weather-resistant materials. Vinyl coatings are softened by heat and are not suitable for sustained use above 66°C (150°F). Vinyl paint systems require the use of a thin coat of wash primer (containing acids to etch the surface) as the first coat to ensure good adhesion to steel.[7]

3.2.1.2 Paint Solvents.[8] The solvent component of marine paints is a transient ingredient, but its quality and suitability

Thus, solvents play an important role in film formation and durability even though they are not a permanent component. The solvent in most paints is a mixture of two or more components that impart different properties to the solvent blend.

Two basic performance properties must be considered in selecting the proper solvent for marine coatings: solvency and evaporation rate. Solvency refers to a solvent's ability to dissolve the resin and reduce its viscosity so the paint can be applied. The solubility of the resin and the solvency of the solvent determine initial coating viscosity. Evaporation is subsequently necessary as part of the drying process and in controlling the paint viscosity at various stages of drying (film viscosity increases as the solvent evaporates). The solvent must evaporate relatively quickly during initial drying to prevent excessive flow, but in later stages it must evaporate slowly enough to give sufficient leveling and adhesion. Different solvent components are typically used to achieve such evaporative performance.

Approximately one third of all solvent components used in the ship-building and ship repair industry are HAP's. Table 3-4 lists the most common solvents (both HAP and non-HAP) used at shipyards based on the collected Section 114 information in the data base.[9] The predominant solvents used in marine paints and in their associated cleaning are obtained from petroleum (crude oil). Many of the commonly known solvents are actually petroleum distillation fractions and are composed of a number of compounds. Distillation fractions are typically distinguished as aliphatic or aromatic.

TABLE 3-4. TYPICAL SOLVENTS USED IN MARINE PAINTS AND IN THEIR ASSOCIATED CLEANING[9,10]

HAP solvents	Non-HAP solvents
Toluene	Butyl alcohol
Ethyl benzene	Ethyl alcohol
Methyl ethyl ketone	Methyl amyl ketone
Methyl isobutyl ketone	Acetone
Ethylene glycol ethers	Propylene glycol ethers
Mineral spirits[a]	
High-flash naphtha	
n-Hexane	

[a]Ligroine (light naphtha), VM&P naphtha, Stoddard solvent, and certain paint thinners are also commonly referred to as mineral spirits.

Aliphatic petroleum solvents are distillation products from crude oil and are characterized by relatively low solvent power, relatively low specific gravities, and bland odors. Typical aliphatic petroleum solvents include hexane, mineral spirits, varnish makers' and painters' (VM&P) naphtha, Stoddard solvent, and kerosene.

Aromatic petroleum solvents may be produced from aliphatic compounds as follows. An aliphatic distillate from crude oil is processed through a catalytic reformer, and the resulting naphthenes are then dehydrogenated to form aromatics. There are only four commonly used aromatic solvents in the coatings industry: xylene, toluene, medium-flash naphtha, and high-flash naphtha. Aromatics are stronger solvents than are aliphatics; they dissolve a wider variety of resins.

Using information provided by both the shipbuilding and ship and the various solvents used in marine coatings.[9,10] Many solvents containing significant HAP components such as mineral spirits and high-flash naphtha were not reported as HAP's because the generic solvent name does not appear on the EPA's list of HAP's. This is primarily due to the fact that paint and solvent manufacturers usually list the generic solvent name on the material safety data sheet (MSDS). Recordkeeping and reporting at the shipyards is typically only as detailed (chemical/compound-specific) as the product MSDS's supplied to them.

For the purpose of analyzing data supplied by the industry, all generic petroleum hydrocarbon solvents were split into two groups and specific HAP components and concentrations were assigned based on reference chemical data and the information provided by the paint and solvent manufacturers.[10] Basically, all aliphatic petroleum solvents (except hexane) were assigned a 4 percent (by weight) HAP concentration with the following individual HAP concentrations: xylene - 1.0 percent; toluene - 1.0 percent; ethyl benzene - 1.0 percent; and n-hexane - 1.0 percent. The non-HAP-specific aromatic solvents (medium- and high-flash naphthas), were assigned 10 percent total HAP concentrations with the following individual HAP concentrations: xylene - 8 percent, toluene - 1 percent, and ethyl benzene - 1 percent. Table 3-5

TABLE 3-5. PETROLEUM SOLVENT BLENDS SOLVENTS AND ASSUMED HAP COMPONENTS[10]

Solvent		HAP's	
Type	Name	Name	Concentration (WT%)
Aliphatic	Mineral spirits		
	Ligroine	Xylene	1.0
	VM&P naphtha	Toluene	1.0
	Stoddard solvent	Ethyl benzene	1.0
	140°F solvent	Hexane	1.0
	Paint thinner		4-Total HAP's
	Thinner		
	Hexane	n-Hexane	50
Aromatic	Xylene	Xylene	100
	Toluene	Toluene	100
	Medium-flash naphtha	Xylene	8.0
		Toluene	1.0
	High-flash naphtha	Ethyl Benzene	1.0
			10-Total HAP's

summarizes the above assumptions regarding all major petroleum solvent blends and their HAP concentrations used in marine paints.

3.2.1.3 Coating Systems. In general, the coating systems described in this section are based on those used by the

U.S. Navy and may not be representative of those used by commercial vessels with different service requirements. Coating system selection requires consideration of many different factors, including:

1. Service requirements of the coated surfaces;
2. Materials and application costs;
3. Temperature and humidity during application and drying/curing;
4. Surface preparation requirements;
5. Desired service life;
6. Accessibility of the area for maintenance;[11] and
7. Life-cycle costs.

Coating system requirements can be broken down into several generalized categories based upon the ship's structural components. These structural components include the freeboard areas and other exterior surfaces above the waterline (boot top) area; exterior deck areas; interior habitability spaces; fuel, water, ballast, and cargo tanks; and the underwater hull areas. These basic areas of a typical ship are illustrated in Figure 3-2. This figure and the following discussion were taken from a letter from S. D. Rodgers of the Naval Sea Systems Command to A. Bennett of the EPA involving protective coatings for U.S. Naval ships.[5] The remainder of this section provides information on coating systems that have been identified to provide optimum service performance for various ship components.

3.2.1.3.1 <u>Freeboard areas and exterior surfaces above the waterline (boot top) area</u>. The ship's exterior superstructure is subject to acidic fumes, extreme temperatures ranging from those of the tropics to those of the Arctic, intense sunlight, thermal shock when cold rain or sea spray contacts hot surfaces, and attack of wind-driven saltwater and spray. A two- or three-part and/or epoxy-polyamide coatings. Cosmetic color and durability are provided by a silicone-alkyd, acrylic-modified, two-component epoxy, polyurethane, or acrylic topcoat. Typical paint systems use either a two-coat epoxy with a two-coat silicone alkyd or a one-coat, zinc-rich primer with a three-coat epoxy and a two-coat silicone alkyd.

3.2.1.3.2 Exterior deck areas. Decks, in addition to being in contact with seawater, are subject to the wear caused by foot and/or vehicular traffic, mechanical abrasion, fuel and chemical spills, and in the case of landing decks, the landings and take-offs of aircraft. Antislip deck coatings are used to provide a rough surface to help avoid uncontrolled motion of the crew and machinery on wet, slippery decks. Antislip coatings need to be selected for both their mechanical roughness and their resistance to lubricants and cleaning compounds used on the decks. The most durable antislip coatings are based on epoxy coatings that contain coarse aluminum oxide grit. A typical antislip coating system may consist of one coat of epoxy primer and one coat of epoxy nonskid coating.

3.2.1.3.3 Interior habitability spaces. Interior habitability areas suffer from high humidity, abrasion, cooking fumes, soiling, fires, and heat. Nonflaming and intumescent coatings are the two major types of fire safety coatings used. Nonflaming coatings prevent the spread of fire, and intumescent coatings are used to reduce heat damage to surfaces that are exposed to fire. Common nonflaming coatings are based on chlorinated alkyd resins and on water emulsions of chlorinated polymers. Intumescent coatings contain materials that expand (foam) when heated and create a thick insulation film (char) that retards damage to the surface. Typical applications involve the use of alkyd primers under chlorinated alkyd or waterborne

3.2.1.3.4 Tanks. Often cargo spaces and tanks are in a more varied, and in some cases, more aggressively chemically reactive environment than the hull. The cargo/tank coatings must resist seawater, potable (drinking) water, hydrocarbon fuels and lubricants, sanitary wastes, and chemical storage and spills. Coating requirements for potable water tanks are vastly different from those for fuel or ballast tanks. Fuel tank coatings must prevent contamination of the fuel by corrosion products or by materials in the coatings. They must also prevent corrosion damage to the tank and be resistant to aliphatic and aromatic petroleum products. A three-coat epoxy system is satisfactory for this use. Zinc coatings are not used in fuel tanks because zinc dissolved into the fuel, particularly gasoline, can cause serious damage to engines.

Coatings for potable water tanks must prevent contamination of the potable water by corrosion products and must not contribute objectionable smell or taste to the water. The coatings must not react with halogen compounds (e.g., bromine or chlorine) used to disinfect the water. Care must be taken to avoid the use of phenolic compounds in any coating used for potable water tanks. (Phenolic compounds are sometimes added to epoxy coatings to accelerate curing.) Halogenated phenolic compounds in concentrations as low as 1 part per trillion can make drinking water unfit for use.

Ballast tanks are exposed to both total immersion and partial immersion in seawater, but marine fouling is typically not a problem. The upper parts of the tank are constantly exposed to high humidity, condensation, and salt, while the lower portions are constantly immersed. However, the continually immersed areas can be protected by a combination of cathodic protection and barrier coatings. Other portions of the tanks can

3.2.1.3.5 Underwater hull areas. The underwater hull is in constant contact with seawater and must resist the ravages of impact abrasion, galvanic corrosion, and cavitation. Exterior underwater areas also need protection from the attachment of marine organisms, known as fouling. This portion of ships and structures are inaccessible for routine maintenance, and the coatings chosen must give reliable performance for extended periods of time. Corrosion control for underwater areas usually includes cathodic protection using sacrificial anodes (zinc or aluminum) or impressed current cathodic protection systems. Cathodic protection systems generate strongly alkaline environments near the anodes and in areas where damage exposes metal to the water. Both corrosion control and antifouling coatings must be resistant to the environment created by cathodic protection. Three-coat epoxy systems are suitable for use in this area. In the last few years, the use of conventional vinyl antifouling paints has been reduced and self-polishing tin based coatings and ablative copper coatings are more often used.

3.2.1.4 Marine Specialty Coating Categories. A number of marine specialty coating categories were adopted by the California Air Resources Board (CARB) in 1990. All other marine coatings were classified as "general use" coatings and are subject to a single regulation. A description of the specialty coating categories is given in this section because the paint categories used for this project were based on them. Figure 3-3

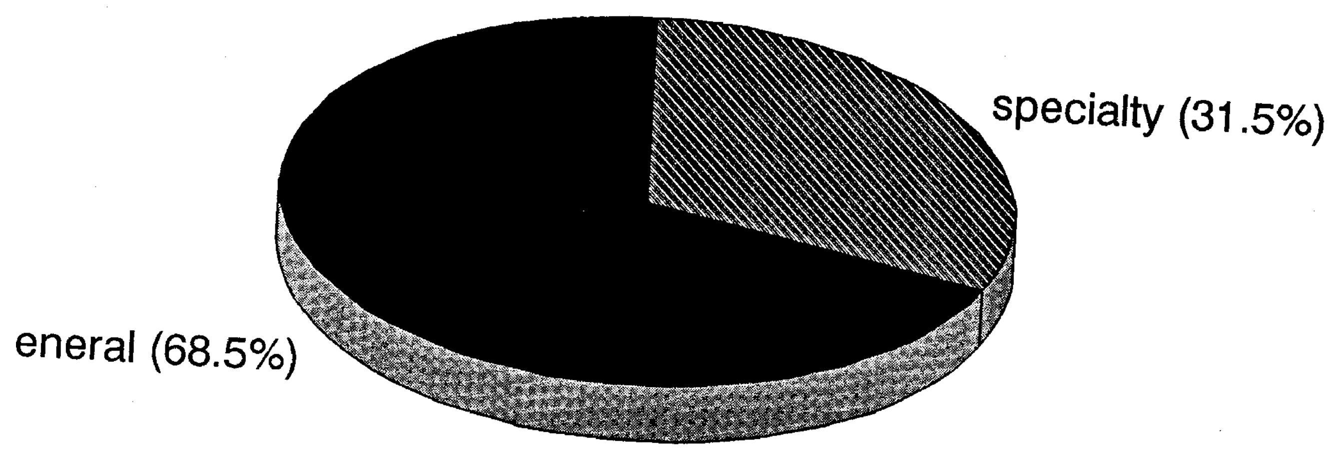


Figure 3-3. Shipyard paint usage (by overall category).[9]

shows that specialty coatings account for 31 percent of total marine coatings used in U.S. shipyards (in the project data base).[9] Specialty categories are based primarily on their functions (e.g., an antifoulant's function is to prevent the hull from fouling). To satisfy these functions, a variety of resins/chemistries may be used. Therefore, the paints in a specialty category may not be easily substituted for one another. The whole paint system may have to be changed to ensure compatibility.

Background. Specific paint categories referred to as specialty were defined by CARB after a number of discussions with industry representatives indicated that a general VOC limit on all marine coating categories was not technologically feasible in meeting the performance requirements for marine vessels.[12,13] Higher VOC limits for these specialty coating categories were adopted by CARB to take into account the performance requirements of each category. A listing of the adopted paint categories is presented in Table 3-6.

TABLE 3-6. ADOPTED MARINE COATING CATEGORIES[12]

SPECIALTY
1. Air flask
2. Antenna
3. Antifoulant
4. Heat-resistant
5. High-gloss
6. High-temperature
7. Inorganic zinc (high build)
8. Weld-through (Shop) primer
9. Military exterior
10. Mist
11. Navigational aids
12. Nonskid
13. Nuclear
14. Organic zinc
15. Pretreatment wash primer
16. Repair and maintenance thermoplastic
17. Rubber camouflage
18. Sealant coat for wire-sprayed aluminum
18. Special marking
20. Specialty (fire-retardant) interior
21. Tack coat
22. Undersea weapons systems
GENERAL USE
23. All nonspecialty coatings

A description of each of the adopted specialty paint categories is given below.

3.2.1.4.1 Air flask coatings. Air flask coatings are special combustion coatings applied to interior surfaces of high pressure breathing air flasks to provide corrosion resistance and which are certified safe for use with breathing air supplies.

3.2.1.4.2 Antenna coatings. Antenna coatings are applied to equipment which is used to receive or transmit electromagnetic signals.

3.2.1.4.3 Antifoulant coatings. Antifoulant coatings are applied to the underwater portion of a vessel to prevent or reduce the attachment of biological organisms. They are required to be registered with the EPA as pesticides.

3.2.1.4.4 Heat resistant coatings. Heat resistant coatings are used on machinery and other substrates that during normal use must withstand high temperatures of at least 204°C (400°F). These coatings are typically silicone alkyd enamels.

3.2.1.4.5 High gloss coatings. High-gloss coatings achieve at least 85 percent reflectance on a 60 degree meter when tested by ASTM Method D-523. These coatings are typically used for marking safety equipment on marine vessels.

3.2.1.4.6 High temperature coating. High temperature coatings are coatings which during normal use must withstand temperatures of at least 426°C (800°F).

3.2.1.4.7 Inorganic zinc (high build) coating. A coating that contains 8 pounds or more elemental zinc incorporated into an inorganic silicate binder that is applied to steel to provide galvanic corrosion resistance. These coatings are typically applied at more than 2 mil dry film thickness.

3.2.1.4.8 Weld-through (shop) preconstruction primer. A coating that provides temporary corrosion protection of steel during inventory, typically applied at less than 1 mil dry film thickness, does not require removal prior to welding, is film building primers including inorganic zinc high-build primers.

3.2.1.4.9 Military exterior coatings. Military exterior coatings are exterior topcoats applied to military vessels (including U.S. Coast Guard) which are subject to specified chemical, biological, and radiological washdown requirements.

3.2.1.4.9 Mist coatings. Mist coatings are thin film epoxy coatings up to 2 mil (0.002 in.) thick (dry) applied to an inorganic or organic zinc primer to promote adhesion of subsequent coatings.

3.2.1.4.10 Navigational aids coatings. Navigational aids coatings are applied to Coast Guard buoys or other Coast Guard waterway markers when they are recoated at their usage site and immediately returned to the water.

3.2.1.4.11 Nonskid coatings. Nonskid coatings are specially formulated for application to the horizontal surfaces aboard a marine vessel, which provide slip resistance for personnel, vehicles, and aircraft.

3.2.1.4.12 Nuclear coatings. These are protective coatings used to seal porous surfaces such as steel (or concrete that would otherwise be subject to intrusion of radioactive materials. These coatings must be resistant to long-term cumulative radiation exposure, relatively easily to contaminate and resistant to various chemicals used to which the coatings are likely to be exposed.

3.2.1.4.13 Organic zinc coatings. Organic zinc coatings are derived from zinc dust incorporated into an organic binder which is used for the express purpose of corrosion protection.

3.2.1.4.14 Pretreatment wash primer coatings. Pretreatment wash primer coatings contain a minimum of 0.5 percent acid by weight and are applied directly to bare metal surfaces to provide

Repair and maintenance thermoplastic coatings have vinyl, chlorinated rubber, or bituminous (coal tar)-based resins and are used for the partial recoating of in-use non-U.S. military vessels, applied over the same type of existing coatings. Coal tar epoxies are not included in this category even though they are bituminous-based; they were determined to better fit the general use (epoxy) category.

3.2.1.4.16 Rubber camouflage coatings. Rubber camouflage coatings are specially formulated epoxy coatings, used as a camouflage topcoat for exterior submarine hulls and sonar domes lined with elastomeric material, which provide resistance to chipping and cracking of the rubber substrate.

3.2.1.4.17 Sealant coat for wire sprayed aluminum. A sealant coat for wire sprayed aluminum is a coating of up to one mil (0.001 inch) in thickness of an epoxy material which is reduced for application with an equal part of an appropriate solvent used on wire-sprayed aluminum surfaces.

3.2.1.4.18 Special marking coatings. Special marking coatings are used on surfaces such as flight decks, ships' numbers, and other safety or identification applications.

3.2.1.4.19 Specialty interior coatings. Specialty interior coatings are extreme-performance coatings with fire-retarding properties that are required in engine rooms and other interior surfaces aboard ships. They are generally single-component alkyd enamels.

3.2.1.4.20 Tack coats. Tack coats are epoxy coats up to two mils thick applied to allow adhesion to a subsequent coating where the existing epoxy coating has dried beyond the time limit specified by the manufacturer for the application of the next coat.

3.2.1.4.21 Undersea weapons systems coatings. Undersea weapons system intended for exposure to a marine environment and intended to be launched or fired undersea.

3.2.1.5 Application Equipment. This section discusses the paint application methods generally used to apply coatings to marine vessels. These methods include:

1. Conventional air-atomized spraying;
2. Airless spraying;
3. Air-assisted airless spraying;
4. High-volume, low-pressure (HVLP) spraying;
5. In-line heaters (hot spraying) in conjunction with other spray equipment;
6. Brushing; and
7. Rolling.

Of these methods, the most popular techniques used at shipyards include brushing, rolling, conventional air-atomized spraying, and airless spraying. Brushing and rolling are primarily used for touchup and recessed surfaces where spraying is not practical. Spraying is primarily used for all other surfaces because of its high application speed.

Spray paint application systems include three basic components: a container that holds the paint, a pressurized propelling system, and a paint gun. A brief summary of the various spray application systems is provided in Table 3-7.[11]

TABLE 3-7. ADVANTAGES AND DISADVANTAGES OF SPRAY PAINT APPLICATION METHODS[11]

Advantages	Disadvantages
Conventional air-atomized spray	
Low equipment and maintenance costs Excellent material atomization Excellent operator control Quick color change capabilities Coating can by applied by syphon or under pressure	Uses high volume of air Does not adapt to high-volume material output Low transfer efficiencies Can cause contamination and worker visibility problems
Airless spray	
Most widely used Low air usage (uses hydraulic pressures) High-volume material output Limited overspray fog Large spray patterns and high application speeds Application of heavy viscous coatings Excellent for large surfaces Good transfer efficiency on large surfaces	Develops excessive spray dust and overspray fog Expensive fluid tips High equipment maintenance Difficult to spray some high viscosity materials Minimum operator control during application System not very flexible Not suitable for high-quality surface appearance Pressurized system can cause injuries to operator if not used with adequate caution
Air-assisted airless spray	
Low coating usage Fair to good operator control on air pressure Few runs and sags in painted surface Good atomization	High equipment maintenance Expensive fluid tips Poor operator control on fluid pressure Not suitable for high-quality surface appearance
High-volume, low-pressure (HVLP) spray	
Low blowback and spray fog Good transfer efficiency Portable (totally self-contained equipment) Easy to clean Overall time and cost savings Can be used for intricate parts Good operator controls on the gun	High initial cost Slower application speed (controversial) Does not finely atomize some high-solids coating materials (controversial) High cost for turbine maintenance Requires more operator training than conventional Still relatively new on the market Some very high solids products not sprayable by HVLP
In-line heaters	
Reduces the need for solvent additions for viscosity reduction Application viscosity is not altered by ambient temperature and weather conditions High film build with fewer coats; smoother surfaces Potential for improved transfer efficiency Several designs available Can be used in conjunction with most types of spray equipment	Additional maintenance and equipment costs Fast solvent flash-off can develop pinhole and solvent entrapment if coating is applied too heavily Requires additional fluid hose to spray gun for recirculating Not recommended for premixed two-component coatings Not intended for water-based coatings
Brushing	
Primarily used for touch-up jobs and in small work areas	Labor-intensive
Rolling	
Manual application used on larger areas where overspray presents cleaning difficulties	May not be appropriate for some primers (does not penetrate surface)

3.2.2 Thinning Solvents

Solvents are frequently added to coatings by the applicator just prior to spraying to adjust viscosity. The volume of HAP emissions from "paint thinning" is second only to that from paint solvents. Thinning is done at most shipyards (regardless of size) even though the paint manufacturers typically state it is usually unnecessary. Weather conditions play a big part in thinning, especially at the northern locations during the winter months when the cold temperatures increase paint viscosity. There are other issues involving thinning where automated paint systems require a quick-drying primer coating. Some high-volume construction shipyards have automated paint operations and use a 50 to 60 percent thinning rate wit preconstruction primers to maintain a just-in-time (JIT) inventory of steel plate to be used in construction work.[9,10]

3.2.3 Cleaning Solvents

Solvents used to clean spray guns and other equipment and to prepare surfaces for painting are referred to as cleaning solvents. These solvents will be addressed by the Industrial Cleanup Solvents Alternative Control Techniques (ACT) document being developed by the EPA. Cleaning solvents must be compatible with solvents in the various marine paints to be effective. A wide range of practices and/or systems are used for equipment cleaning activities. Methods range from spraying solvent through a gun into the air (or a bucket) to using a totally enclosed system in which the spray gun is mounted for cleaning. Several shipyards recycle used solvents in-house, and many others (especially the major yards) are required to dispose of the used solvent as a hazardous material.

Figure 3-4

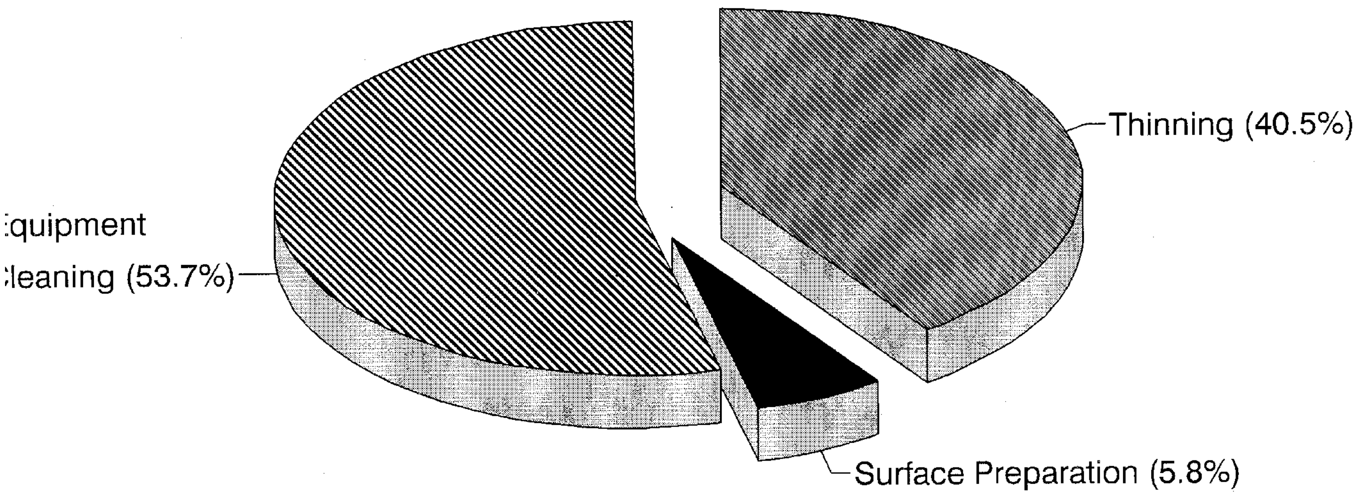


Figure 3-4. Shipyard solvent usage.[9]

and Table 3-8 give the breakdown of solvent usage and the

TABLE 3-8. HAP CONTENT OF SOLVENTS (BASED ON PROJECT DATA BASE)[9,10]

Solvent use description (total volume of solvent)	Average density g/L (lbs/gal)	HAP	Average g/L [a]	Average lbs/gal	Percent of total HAP's
	838.8 (6.99)	Xylene	210	1.75	70
		Toluene	50	0.42	17
		Methyl Ethyl Ketone	28	0.02	9
		Other	12	0.01	4
		Total HAP's	300	2.5	100
[b]	842.4 (7.02)	Xylene	126	1.06	46
		Toluene	62	0.52	23
		Methyl Ethyl Ketone	26	0.22	10
		Other	58	0.48	21
		Total HAP's	272	2.28	100
	846.0 (7.05)	Xylene	216	1.80	70
		Toluene	31	0.26	10
		Methyl Ethyl Ketone	24	0.20	8
		Other	36	0.30	12
		Total HAP's	307	2.55	100
	842.4 (7.02)	Xylene	210	1.75	70
		Toluene	48	0.4	16
		Methyl Ethyl Ketone	25	0.2	8
		Other	18	0.15	6
		Total HAP's	300	2.50	100

average HAP content of each solvent type. Solvents used for surface preparation have been included with cleaning solvents because of the very low usages reported and actual shipyard practices (all solvents are usually stored/collected together). In general, all major solvent uses at shipyards (thinning, equipment cleaning, and surface preparation) are the same in terms of the HAP's used. Approximately 30 percent of all solvents used for thinning are HAP solvents, with xylene accounting for 70 percent, toluene 16 percent, and methyl ethyl ketone 8 percent of the HAP solvents.[9,10]

3.3 BASELINE EMISSIONS

Baseline emissions reflect the level of emission control of HAP's that is achieved in the absence of additional the EPA standards. The baseline emission level is established to facilitate comparison of the economic, energy, and environmental impacts of the regulatory alternatives presented in Chapter 6.

3.3.1 Existing Regulations

No existing regulations limit HAP emissions from major source shipyards. Of the 189 compounds currently on the EPA's HAP list, a handful of chemicals are addressed by various State and local air pollution codes. Some State air toxics regulations limit certain of these pollutants, but these typically are based on modeled ambient concentrations at the fenceline boundary. To date, no shipyards have had to control painting operations to meet state air toxics regulations.

Noting the fact that most HAP solvents are VOC's, existing State marine coating VOC limits for California and Louisiana were examined. These limits are summarized in Table 3-9

Table 3-9 (page 1)

TABLE 3-9 (continued)

and are

broken down by paint category. Additionally, the CTG document Control of Volatile Organic Emissions from Existing Stationary Sources, Volume VI: Surface Coating of Miscellaneous Metal Parts and Products was published in June 1978. This CTG is applied by some States in VOC nonattainment areas. It does not cover outdoor painting of ship's hulls, but some States do apply the CTG to shipyard painting done inside of buildings and on the interior of ships.

The project data base shows a general correlation between HAP's and VOC's in marine paints, but many specific paints' VOC/HAP contents were found to be contrary to the general relationship.[9,10] Any control of HAP's is incidental to VOC control, including higher-solids formulations. Most paint formulations (i.e., military) have specific VOC limits but do not specify which solvent(s) can be used. Therefore, it is possible for paints made to identical generic formulations to have a wide range of HAP contents. Emission control techniques are discussed in more detail in Chapter 4.

3.3.2 Selection of Baseline

In selecting the baseline, no add-on control was considered since none was reported by this industry. Therefore, the current mix of paints and solvents reported by the 33 shipyards that responded to the information collection request (ICR) in the project data base was used to approximate the nationwide mix to establish baseline.

With regard to marine paints, 100 percent of the solvent content was assumed emitted to the air upon application.

Figure 3-5

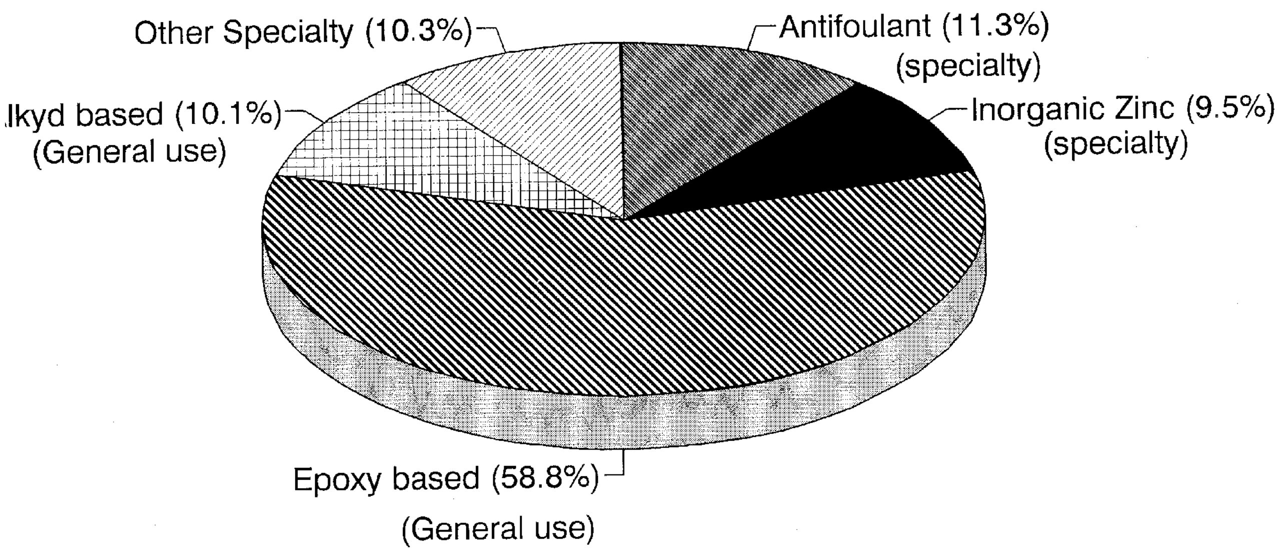


Figure 3-5. Paint category usage.[9]

shows the annual usage breakdown of all marine paints in the data base. The weighted (by volume) average HAP content of paints in each category (g HAP/L of coating less water and less "exempt solvent" [lb HAP/gal of coating less water and less exempt solvent]) was calculated and is presented in Table 3-10. Total HAP emissions from painting operations at a shipyard equals the sum of the annual usage (volume of each paint category used) multiplied by average HAP content.

TABLE 3-10. AVERAGE HAP CONTENT OF "AS SUPPLIED" MARINE PAINTS[9]

Paint category	Total reported usage, L (gal)	Weighted average total HAP content	
		g/L	(lb/gal)
General Use--Alkyd	604,765 (159,658)	355	(2.98)
General Use--Epoxy	3,515,080 (927,981)	56	(0.47)
Antifoulant	674,466 (178,059)	268	(2.25)
Repair and maintenance thermoplastics	122,886 (32,442)	271	(2.28)
Fire Retardant	297,432 (78,522)	120	(1.00)
Heat Resistant/High Temperature	22,360 (5,903)	60	(0.50)
High Gloss	65,174 (17,206)	94	(0.79)
Inorganic Zinc	570,064 (150,497)	274	(2.30)
Nuclear	35,026 (9,247)	146	(1.23)
Organic Zinc	28,114 (7,422)	240	(2.00)
Pretreatment Wash Primer	8,235 (2,174)	18	(0.15)
Special Marking	38,473 (10,157)	23	(0.19)

Thinning solvents are also assumed to be 100 percent emitted to the air upon application of the thinned paint. The HAP content of all solvents was calculated to be 2.1 lb HAP/gal of solvent based on the reported breakdown of solvent uses and chemical reference data.[9,10] Thinning solvent emissions from a shipyard equal annual usage multiplied by the HAP content.

Cleaning solvents were not included in emission estimate calculations. Industry reported that most cleaning solvents used are collected and disposed of as hazardous waste.

In Chapter 6, baseline emissions are calculated for a range of model plants using information from the data base and the previously mentioned assumptions involving HAP emissions from paints and solvents. The baseline is used to estimate nationwide emissions from all major source facilities. It will also be used in the cost analysis of regulatory alternatives, as well as in the evaluation of environmental and economic impacts.

3.4 REFERENCES FOR CHAPTER 3

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TABLE 3-9. EXISTING STATE MARINE COATING VOC LIMITS
(Expressed in units of g/L and lb/gal of
coating as applied--minus water and exempt solvent)

Coating category	California VOC limits				Louisiana VOC limits	
	g/L		lb/gal		g/L	lb/gal
	Sept. '91	Sept. '94	Sept. '91	Sept. '94	July '91	
General limits	340	340	2.8	2.8	420	3.5
Antenna	530	340	4.4	2.8	490	4.1
Antifoulant	400	400	3.3	3.3	440	3.7
Heat resistant	420	420	3.5	3.5	420	3.5
High gloss	420	420	3.5	3.5	420	3.5
High temperature	500	500	4.2	4.2	650	5.4
Inorganic zinc	650	340	5.4	2.8	650	5.4
Nuclear (Low-activation interior)	420	420	3.5	3.5	490	4.1
Military exterior	340	340	2.8	2.8	420	3.5
Navigational aids	550	340	4.6	2.8	420	3.5
Pre-treatment wash primer	780	420	6.5	3.5	780	6.5
Rpr and Mnt thermoplastics	550	340	4.6	2.8	650	5.4
Wire spray sealant	610	610	5.1	5.1	648	5.4
Specialty interior	340	340	2.8	2.8	420	3.5
Special marking	490	420	4.1	3.5	490	4.1
Tack coat	610	610	5.1	5.1	610	5.1
Undersea weapons systems	340	340	2.8	2.8	--	--
Extreme high gloss	N/A	N/A	N/A	N/A	490	4.1
Metallic heat resistant	N/A	N/A	N/A	N/A	530	4.4
Anchor chain asphalt (TT-V-51)	N/A	N/A	N/A	N/A	620	5.2
Wood spar varnish (TT-V-119)	N/A	N/A	N/A	N/A	492	4.1
Dull black finish (DOD-P-15146)	N/A	N/A	N/A	N/A	444	3.7

TABLE 3-9 (continued)

Coating category	California VOC limits				Louisiana VOC limits	
	g/L		lb/gal		g/L	lb/gal
	Sept. '91	Sept. '94	Sept. '91	Sept. '94	July '91	
Potable water tank coating (DOD-P-23236)	N/A	N/A	N/A	N/A	444	3.7
Flight deck markings (DOD-C-24667)	N/A	N/A	N/A	N/A	504	4.2
Vinyl acrylic top coats	N/A	N/A	N/A	N/A	648	5.4
Antifoulants on aluminum hulls	N/A	N/A	N/A	N/A	550	4.5
Elastomeric adhesives (with 15 wt % rubber)	N/A	N/A	N/A	N/A	730	6.1

4.0 EMISSION CONTROL TECHNIQUES

4.1 INTRODUCTION

Emissions of HAP's from shipbuilding and ship repair facilities result primarily from painting operations and the associated cleaning solvents. Emissions from these sources are several orders of magnitude greater than those from any other source within this industry (e.g., heavy metals found in welding or metal-cutting fumes). Therefore, the regulatory focus of this NESHAP is the shipyard painting operations and the associated cleaning activities. This chapter discusses control techniques that are demonstrated and those for which technology transfer is strongly indicated to control HAP emissions from painting and cleaning at shipyards. Section 4.2 discusses the control options available to reduce emissions from painting operations, and Section 4.3 discusses options that apply to cleaning.

4.2 PAINTING OPERATIONS

Emissions of HAP's from painting operations result from three components: (1) organic solvent in the paint as supplied by the paint manufacturer (i.e., paint "as supplied"), (2) organic solvent in the thinner, which is added to the paint prior to application and becomes part of the paint "as applied" and (3) any additional volatile organics released during cure. All the organic solvents from both components, including the HAP solvents, are emitted as the applied paint dries/cures.

4.2.1 Paints As Supplied

Traditionally, the paint manufacturer's selection of constituents for any coating was relatively simple. Concerns centered around the physical properties of the resin, the technical support offered by the resin supplier, and the solvency and cost of various solvents. Beginning in the late 1970's, manufacturers began to react to programs for reducing tropospheric ozone, and many manufacturers altered coating formulations to reduce the amount of VOC's contained in the coatings.

The 1990 Clean Air Act Amendments not only extend concern for the emissions of solvents from paints used in the shipbuilding industry, but also introduce a completely new area of concern, emissions of HAP's. The coating manufacturers are trying to reduce both total VOC's and individual HAP's in the coatings, which leaves the paint manufacturers with fewer alternatives in formulating coatings using present resin systems.

The only alternative to reformulation for reducing HAP emissions from applying coatings is to contain and destroy the solvent vapors released during painting operations. This is a common approach with shop-applied coatings but presents a challenge when painting substrates as large as ships (usually done outdoors).

Traditional paint formulations are a consequence of many influences that vary by manufacturer. Lower-HAP formulations are available because either a manufacturer reduced total VOC's and as a consequence, reduced the HAP content as well or, serendipitously, the manufacturer selected solvents for the formulation that are not on the list of HAP's. Of the solvents used in marine paints used by the shipyards surveyed, most are VOC's, and approximately 36 percent of the VOC's are HAP's.[1]

formulations. These paints have lower VOC-to-solids ratios than solventborne paints, and the HAP-to-solids ratio is also generally lower than in solventborne materials. A second avenue is decreasing the solvent-to-solids (nonvolatiles) ratio. These "higher solids" coatings reduce solvent emissions per surface area painted. Both reformulation strategies are useful for reducing HAP emissions as well. Still a third avenue is available to control HAP's: substituting a non-HAP solvent (e.g., methyl n-amyl ketone [MAK]) for a HAP solvent (e.g., glycol ether). Several coating manufacturers have marine paints with little or no HAP solvents. Although these (re)formulated coatings contain little or no HAP's compared to the equivalent HAP-based paints, they may have the same VOC content because the organic solvent content usually remains the same. In fact, in some solvent substitutions it could be possible for the VOC content to increase even though the HAP content decreases.

To identify lower-HAP paint formulations, information (1990-1991) was compiled from a survey of paint use at shipyards.[1] Lower-HAP coatings were examined for 3 of the 23 paint categories described in Chapter 3: antifoulant and inorganic zinc specialty coatings and general-use (epoxy and alkyd) coatings. The other 19 categories will be included under "other specialty coatings" and will be addressed by individual limits to maintain existing HAP/VOC contents. The four categories previously mentioned were closely examined because they make up more than 90 percent of the total volume of paint used at the shipyards surveyed - hence 90 percent of project "data base."

4.2.2 Paints As Applied

Controlling the amount of HAP's emitted from paints as applied may include (1) using lower-HAP paints, (2) selecting thinners that contain less HAP's (or reducing the overall amount of thinners needed), or (3) preventing the HAP solvents from the paint and thinner from being emitted to the atmosphere. Lower-HAP formulations are discussed in Section 4.2.1. The options to reduce or eliminate HAP's from thinners are (1) changing the thinners to those with less HAP's and (2) reducing the amount of thinner needed by heating the paint to reduce viscosity immediately prior to spraying. Add-on control devices also are used to control HAP emissions from both paints and thinners during painting operations in other industries. The following sections describe the applicability and limitations of each of these control options.

4.2.2.1 Lower-HAP Thinners. Lower-HAP thinners may be used in conjunction with some lower-HAP paint formulations. Paints formulated with non-HAP solvents can be thinned with the same non-HAP solvents. Other paints with less forgiving formulations may not tolerate some of the lower-HAP thinners. The thinning solvent must be able to dissolve the resin and reduce its viscosity so the paint can be applied, so care must be taken when making these substitutions.

4.2.2.2 Paint Heaters. Paint heaters can be used in conjunction with or in place of paint solvents (i.e., thinners, reducers, etc.) to reduce paint viscosity by heating the paint prior to application using an in-line heating element located just upstream of the spray gun. Paint heaters are used at least two shipyards and many have also been used in a variety of industrial and automotive paint applications.[1] These heaters appear adaptable to any paint spray system but are most often on the paint flow rate; the lower the flowrate, the greater the temperature increase. One manufacturer indicates that an in-line heater can increase paint temperatures by 38°C (100°F) at 0.76 liters per minute (L/min) (0.2 gallon per minute [gal/min]), 22°C (72°F) at 1.51 L/min (0.4 gal/min), and 6°C (43°F) at 3.0 L/min (0.8 gal/min).[2] The effect of heating on the viscosity of the paint varies somewhat between coatings and depends on the physical properties of the paint.

Paint heaters reportedly are not a panacea for viscosity problems. Representatives of shipyards in colder climates have complained that applying heated paint to cold surfaces in winter months results in poor paint surface characteristics (i.e., cracking) because of the rapid cooling of the hot paint after it is applied to the cold surface.[1]

4.2.2.3 Add-On Controls. Add-on pollution control devices are used by many industries to control VOC emissions from coating operations. Although none are known to be used in this industry, these devices have potential applications for controlling HAP emissions (which are in many cases also VOC's) from painting shops. The efficiency of the control system depends on the capture efficiency of the enclosure used to contain the painting emissions as well as the removal/destruction efficiency of the add-on control device.

Emissions from outdoor painting operations are presently difficult to control since there is no commercially available technology for enclosing the painting area and capturing the emissions. Only one outdoor painting process, painting (storage) tanks, was evaluated for add-on controls because the tank itself is a natural enclosure when the inside is painted. At least one innovative enclosure design has been patented that may be effective during hull blasting operations and may also be useful this reason, add-on controls have not been evaluated for hull painting.[3] Emissions from indoor painting operations are more easily contained; it is technically feasible to capture emissions from indoor painting operations and route the emissions to a control device.

For control of indoor painting (such as within tanks) emissions, the add-on devices evaluated are thermal and catalytic incinerators and carbon adsorption systems. Incinerators are control devices that destroy VOC contaminants using combustion, converting them primarily to carbon dioxide (CO_2) and water. Carbon adsorbers are recovery devices that collect VOC's on an activated carbon bed. The VOC's are recovered when the carbon bed is regenerated using steam or hot air. The steam or hot air also reactivates the carbon bed. The recovered VOC's are then destroyed or disposed of. Summaries of these add-on control devices, their associated costs, and their performance characteristics can be found in Table 4-1 and in References 4, 5, and 6, respectively.

TABLE 4-1. SUMMARY OF VOC (HAP SOLVENT) ADD-ON CONTROLS EVALUATED

Add-on control[a]	Advantages	Disadvantages
Thermal incinerator	>98% destruction efficiency	- High operating cost for low-concentration streams
Catalytic incinerator	>98% destruction efficiency; uses lower temperature than thermal incinerator	- Heavy metals can foul/poison catalyst - Requires constant flow and concentration
Carbon adsorption	Concentrates low-VOC streams; removal efficiency >95%	- Cannot recover individual components
Carbon adsorption/ incineration	>97% removal/destruction efficiency; smaller incinerator can be used	- Capital cost high

[a]Note: An enclosure, such as a building or traveling sealed work area, would be

4.3 SOLVENT CLEANING

Equipment used for painting operations at shipyards usually includes paint spray guns, lines, pumps, and containers (pots) used to hold the paint. All of this equipment, except the pots, is usually cleaned by purging solvent through the spray system (i.e., the spray gun with the paint line and pump still attached) into a bucket. The bucket is then emptied into a 55-gallon drum. Paint pots are also cleaned with solvent. A brush is often used to remove any dried paint remaining in the pot. In some cases, solvents are also used to clean surfaces before paint is applied.

Two primary control options are available to reduce HAP emissions from cleaning: (1) work practices to reduce amount of solvent used and the amount allowed to evaporate and (2) the use of solvents with lower HAP contents.

The Alternative Control Techniques document for Industrial Cleaning Solvents published by the EPA suggested a two step program for reducing the emissions from solvents. The first consists of a solvent accounting program tracking the use, fate, and costs of all cleaning solvents. The second element consists of actions management may take to reduce or control emissions based on knowledge of cleaning solvent use, fate, and costs. The solvent management system may include techniques that reduce emissions at the source. These techniques would include using special solvent dispensers when wiping a surface with rags and disposing of the rags in a covered container to help reduce solvent evaporation.[7]

4.3.1 Work Practices

Many yards are changing their work practices to save used solvent for reuse and to reduce solvent disposal costs (used solvent typically must be disposed of as hazardous waste). Certain work practices minimize the amount of solvent used and displaced as more solvent is added. The extent of evaporation is affected by movement of air across the opening. When left uncovered, solvent will evaporate constantly. Emissions also occur when solvent is poured from one container into another. Losses from containers that are in use can be reduced by minimizing the area that is open during use. A variety of devices have been developed that minimize evaporative emissions. For instance, self-closing funnels on 55-gallon waste solvent barrels. These screw into the bung hole on the barrel and minimize evaporative emissions from the barrel because the barrel is normally closed when solvent is not being added. They also reduce spillage and evaporative losses from spillage.

Other work practice changes can be made related to spray equipment. Emptying the spray gun of paint prior to cleaning (i.e., spraying the equipment dry) and cleaning equipment promptly after use (not allowing the paint to dry in/on equipment) are major improvements. Evaporative emissions can be reduced by improved handling practices involving cleaning paint systems, solvent transfer, and solvent storage.

Work practices that reduce evaporative emissions during cleaning of spray equipment include (1) drawing solvent from a closed supply solvent container and discharging into a closed container with an opening only large enough to accommodate the tip of a spray gun and (2) lowering the gun pressure (decreasing air and paint pressure) to minimize atomization of the solvent during cleaning.

4.3.2 Substitute Solvents in Cleaning Materials

Several cleaning products are available that contain non-HAP solvents or use HAP solvents with lower vapor pressures (which thereby evaporate more slowly at ambient temperatures). Emissions are reduced because less solvent evaporates over a reformulated solvents.

Some new cleaners have been substituted for many of the traditional solventborne products. The performance characteristics required of substitute products vary depending on the application.

In some industries, limonene is used as a non-HAP substitute solvent for such HAP solvents as methyl ethyl ketone (MEK). Limonene is a terpene hydrocarbon made up of essential oils derived from lemons.

Additional non-HAP solvents could be used in place of HAP-based cleaning solvents. Solvency of the paint in the cleaner is necessary to some degree, but it is not as critical as for thinning. Therefore, waterborne materials or non-HAP solvents may be satisfactory cleaners.

4.4 REFERENCES FOR CHAPTER 4

1. Memorandum from deOlloqui, V., Midwest Research Institute (MRI), to Project File, List of Shipyards Included in the Shipbuilding and Ship Repair Database. November 11, 1992.

2. Telecon. deOlloqui, V., MRI, with Olsen, G., Graco, Inc. Discussion concerning paint heaters. October 9, 1992.

3. Telecon. Harris, V., MRI, with McConnell, F., Metro Machine Corporation, Norfolk, Virginia. April 28, 1992.

4. Memorandum and attachments from Farmer, J. R., EPA/ESD, to Distribution. August 22, 1980. Thermal Incinerator Performance for NSPS. 29 pp.

5. Seiwert, J. J. Regenerative Thermal Oxidation for VOC Control. Smith Engineering Company, Duarte, CA. Presented at Wood Finishing Seminar--Improving Quality and Meeting Compliance Regulations. Sponsored Key Wood and Wood Products and Michigan State University. Grand Rapids. March 5, 1991. 27 pp.

6. Radian Corporation. Catalytic Incineration for Control of VOC Emissions. Park Ridge, NJ, Noyes Publications. 1985. pp. 4-5

Cleaning Solvents. EPA-453/R-94-015 U. S. Environmental
Protection Agency, Research Triangle Park, NC.
February 1994.

5.0 MODIFICATION AND RECONSTRUCTION

National emission standards for hazardous air pollutants (NESHAP) apply to both new and existing major source facilities. The degree of emission reduction required for new sources (those sources for which construction commenced after the date of proposal of this standard) shall not be less than the maximum achievable control technology (MACT) demonstrated by the best controlled similar source. The MACT standards for existing sources may be equal to or less stringent than the MACT standards for new sources but cannot be less stringent than the average level of control achieved by the best performing 12 percent of existing sources.

A major source that undergoes a modification that is not offset by reductions in emissions of HAP's at that source must meet the MACT emission limitation for existing sources. A major source that undergoes a reconstruction, however, must meet the MACT emission limitation for new sources. Modification and reconstruction are further defined in Section 5.1, and their applicability to the shipbuilding and ship repair industry is discussed in Section 5.2.

5.1 PROVISIONS FOR MODIFICATION AND RECONSTRUCTION

5.1.1 <u>Modification</u>

Section 112(g)(1) of the Clean Air Act defines modification

> [A] physical change in, or change in the method of operation of, a major source which increases the actual emissions of any hazardous air pollutant emitted by such source by more than a de minimis amount or which results in the emissions of any hazardous air pollutant not previously emitted by more than a de minimis amount.

The EPA has not yet issued regulations to implement the amended section 112 provisions related to modifications. Based on the precedent set for similar Section 111 provisions, it is expected that changes such as routine maintenance, repair, replacement of worn parts, or an increase in the hours of operation will not be considered modifications.

Certain changes, even though they result in an increase in HAP emissions greater than a de minimis amount, are not considered modifications. Section 112(g)(1) of the Act establishes an offset provision such that a physical change in, or change in the method of operation of, a major source is not considered a modification if the change also results in an equal or greater decrease in the quantity of emissions of another HAP (or HAP's) deemed by the EPA to be more hazardous. The owner or operator of the source shall submit documentation to the EPA (or the State) showing the increase in emissions and the corresponding decrease of the more hazardous pollutant.

Modifications that are not subject to the offset provision must meet the MACT emission limitation for existing sources. However, existing major sources are subject to the NESHAP in any case. As a result, the modification will not bring about any change in the standards to which the source is subject unless the increase in emissions causes an area source to become a major source. No modification may be made to a major source until such modification is approved by the EPA (or the State, if an approved permit program is in effect).

modification is whether actual emissions from the changed emission point or points, process, product line, or entire facility have increased as a result of the modification. Changes in the emission rate may be determined by emission factors as specified in the latest issue of Compilation of Air Pollution Emission Factors, otherwise known as AP-42, or other emission factors determined by the EPA to be superior to AP-42 emission factors.[1] In cases where using these emission factors does not clearly demonstrate that emissions increase or decrease, other methods such as material balances, continuous monitoring data, or manual emission tests may be used to determine changes in emission rates.

5.1.2 Reconstruction

The EPA has set aside 40 CFR, part 63 to codify NESHAP for source categories covered under section 112 of the Act. On August 11, 1993, the EPA proposed the general provisions that will apply to these NESHAP (58 FR 42760). The discussion that follows is based on the proposed general provisions.

Reconstruction is defined in 40 CFR 63.2 as:

> [T]he replacement of components of an affected source to such an extent that:
>
> 1. The fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable new source; and
>
> 2. It is technologically and economically feasible for the reconstructed source to meet the promulgated emission standard(s) established by the Administrator pursuant to section 112 of the Act.
>
> Upon reconstruction, an affected source is subject to relevant standards for new sources, including compliance dates, irrespective of any change in emissions of

For this definition, "fixed capital cost" means the capital needed to provide all the depreciable components of an existing source.

If the owner or operator of a major source is planning to replace components within that source, and the fixed capital cost of the new components exceeds 50 percent of the fixed capital cost of a comparable new source, the owner or operator must apply to the Administrator (or, if an approved permit program is in effect, to the permitting authority in the State) for approval of the reconstruction. This application must be made at least 180 days before the reconstruction is planned to commence and must include the information specified in 40 CFR 63.5(d)(1)(ii) and 40 CFR 63.5(d)(3).

There is no offset provision for reconstruction as there is for modification. Therefore, any reconstruction must meet the MACT emission limitation for new sources.

5.2 APPLICATION TO SHIPBUILDING AND SHIP REPAIR FACILITIES

As discussed previously, both existing and new major sources are subject to the NESHAP for a source category. For some source categories, the standard that applies to new sources is more stringent than that for existing sources. This is not the case for the shipbuilding and ship repair industry; the standards that apply to new and existing surface coating operations are expected to be identical. The standards will also apply to modifications or reconstructions at a major source. However, if an area source (which is not subject to the NESHAP) becomes a major source by virtue of increased emissions associated with a modification or reconstruction, the newly created major source becomes subject to the standards.

Shipbuilding and ship repair coating operations typically occur at locations throughout the shipyard, and changes in any of

40 CFR 63.2. As such, a description of the modification and reconstruction that may occur for each process is beyond the scope of this section. However, some general changes that may occur at shipbuilding and ship repair facilities (shipyards) are presented below.

5.2.1 Addition of Spray Booths

Adding uncontrolled spray booths for applying coatings generally increases emissions due to an increase in coating production capacity, even though the shipyard production capacity has not changed. For example, a shipyard that is near operational capacity may be taxing the coating capacity of the existing spray booths. The facility then adds new spray booths to relieve this production bottleneck. The emissions then increase on a mass-per-time basis (kg/hr) because more coating can be accomplished per hour with the additional spray booths than before the modification.

5.2.2 Addition of a New Operation

A shipyard may add an operation not previously performed at that facility, resulting in an increase in emissions. The operation may be added to satisfy the requirements of a new material/coating or to bring in-house an operation previously performed by a subcontractor. An example of such an operation is the shaping and in-house application of preconstruction primers to steel plates that are later used in fabricating ships.

5.2.3 Addition of a New Product Line

Adding a new product line generally involves extensive changes throughout an existing facility. In addition to modifications described in Sections 5.2.1 and 5.2.2, the layout of all or part of the shipyard may need to be changed. This may involve relocating or constructing raw material storage, process operations, offices, and utilities.

added to the existing product lines already in existence at the facility. This usually involves the most extensive physical changes to the facility and would most likely increase emissions. Depending on the extent of the changes that are made to the existing product lines, adding a new line may qualify as reconstruction. The second scenario involves replacing an old product line with a new product line. In this case, the physical changes to the shipyard may be minor because manufacturing floor space and process capacity are available from eliminating the old product line.

5.3 REFERENCE FOR CHAPTER 5

1. U. S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors (AP-42). Fourth edition and Supplements A-E. September 1985.

6.0 MODEL SHIPYARDS AND REGULATORY ALTERNATIVES

6.1 GENERAL

Model shipyards were developed to characterize shipyards in the shipbuilding and ship repair industry. Due to the nature of this industry and its sporadic painting operations, an individual shipyard can fall in and out of a given model yard description. The model yards are meant to represent variations in the industry as a whole; they do not represent every existing shipyard. This chapter describes the model shipyards, identifies the emission points associated with each model shipyard, and presents the baseline emissions from the model shipyard emission points. Model shipyards will also be used to estimate nationwide emissions from the use of marine paints in major sources. A major source is not limited to shipyards with the potential to emit 9.1 megagrams per year (Mg/yr) (10 tons per year [tons/yr]), of any one HAP or 22.7 Mg/yr (25 tons/yr) of all HAP's combined. The rule will also be applicable to marine related operations/activities in major sources.

In addition to describing model shipyards and their baseline emissions, this chapter also presents the regulatory alternatives for new and existing facilities and the impact of these alternatives on reducing HAP emissions. The regulatory alternatives represent various courses of action that the EPA

Regulatory alternatives are limited to those control methods that meet or exceed the maximum achievable control technology (MACT) floor. The environmental, energy, cost, and economic impacts associated with applying the alternatives to each of the model shipyards and the estimated nationwide impacts are presented in subsequent chapters.

Model shipyards are described in Section 6.2 with a discussion of overall shipyard categories, shipyard sizes, and paint and solvent usages. Emission points and operating parameters are defined in Section 6.3, and baseline emission estimates are described in Section 6.4. The MACT for this industry is presented in Section 6.5, along with estimated HAP emission reductions. More detailed information regarding model shipyard development is provided in a memorandum from MRI to the EPA entitled "Final Model Plants Memorandum," which will be included in the project docket.[1]

Actual HAP emissions were estimated using information supplied by shipyards and manufacturers of marine paints. There are some unresolved issues with the HAP/paint data base and it was believed that the data was not accurate enough to be used as the basis for determining MACT. It is believed, however, that the (weighted) average HAP content of paints in each category are fairly accurate and that the HAP content of paints in the data base that meet the VOC limits are representative of the HAP's in the paints that will be used when the NESHAP becomes effective. Baseline HAP emissions from model shipyards are presented in Chapter 6, Table 6-9.

6.2 MODEL SHIPYARDS

The model shipyards are based primarily on information from four sources: responses to Section 114 information requests (surveys) sent to marine coating manufacturers, responses to

Information for both the BACM and the NESHAP were gathered during the site visits. Rather than issue a separate draft CTG, the EPA is using the NESHAP to request public comment on a draft recommended BACM. The draft recommended BACM is the proposed MACT for coatings and solvents.

The model shipyard descriptions are presented in Table 6-1. These model shipyards were defined based primarily on two parameters: (1) the type of work performed (construction versus repair) and (2) the relative size of the shipyard (small, medium, or large) in terms of annual paint and solvent usage. Market segments involving military versus commercial work were also evaluated and determined not to be significant in terms of HAP emission differences. The rationale for selecting these primary parameters is presented below.

TABLE 6-1. MODEL SHIPYARD DESCRIPTIONS

Model shipyard No.	1	2	3	4	5	6
Yard type	Construction	Repair	Construction	Repair	Construction	Repair
Size[a]	Large	Large	Medium	Medium	Small	Small
Total coating usage, L/yr (gal/yr)[b]	510,560 (134,876)	453,718 (119,860)	158,726 (41,931)	131,228 (34,667)	70,988 (18,753)	70,511 (18,627)
Total solvent usage, L/yr (gal/yr)	162,132 (42,831)	23,091 (6,100)	43,532 (11,500)	20,562 (5,432)	10,845 (2,865)	1,893 (500)

[a]Cutoffs are based on levels of total VOC emissions adopted for the CTG Project.
[b]Coating usage volumes are less water.

6.2.1 New Construction vs. Repair

The type of work performed at the shipyards was first selected as a defining parameter for model shipyards because a larger portion of painting and surface preparation was believed to be performed indoors at construction yards than at repair yards. It was later determined that this is only true for large fabricated starting with the smallest components. Early construction work frequently takes place in fabrication shops. Most, if not all, of those shops are subject to State rules developed pursuant to guidance contained in the CTG document, Control of Volatile Organic Emissions from Existing Stationary Sources, Volume VI: Surface Coating of Miscellaneous Metal Parts and Products, published in 1977. In many of the shops, painting and blasting areas are specially contained and vented to protect the workers. These conditions and existing enclosures lend themselves more readily to the application of add-on control devices than do outdoor coating and blasting activities. (At repair facilities, nearly all the work is performed in place on the ship; relatively little painting and blasting occurs inside buildings.) In addition, the scope of activities at a typical construction yard is broader than at a repair yard. A smaller proportion of the revenue at a construction yard is derived from painting and surface preparation activities than at a repair yard. As a result, a NESHAP that affects painting and surface preparation costs may have different economic impacts at construction yards than it does at repair yards. Model shipyards representing these two types of operations are expected to prove useful when the economic impact analysis is performed.

Some yards perform both construction and repair, but one business area typically predominates. For purposes of the model shipyards, a construction yard is presumed to derive at least 70 percent of its revenue from construction, while a repair yard derives at least 70 percent from repair.

6.2.2 Shipyard Size

Size is an important model plant parameter because cost and economic impacts of control are often more severe for smaller operations. At the same time, the em ission reductions

Shipyard size can often be correlated to the number and type (size/class) of ships a shipyard can service annually. There is a direct correlation of shipyard size with the size of ships, and an inverse correlation with the number of ships built and/or repaired. This is particularly true for some small bargeyards where several hundred barges requiring minimal repairs can be serviced each year. Bigger shipyards usually service fewer (but larger) ships and provide a wider range of services. Three sizes (small, medium, and large) have been defined to reflect the makeup of the industry, where there are a few very large shipyards and more numerous medium and small shipyards.

The sizes are defined based on the annual volume of paint and solvent usage. The cutoff between sizes is based on annual VOC emission levels (tons/yr), which are critical to the CTG project, so that similar model shipyards can be used for the CTG and NESHAP. The differentiation between large and medium shipyards generally coincides with a natural break observed in the data base. There was, however, no similarly obvious break to help define medium and small shipyards. Based on an analysis of the survey data, paint usage at the various model shipyards ranges from 70,511 to 510,560 liters per year (L/yr) (18,627 to 134,876 gallons per year [gal/yr]). Solvent usage ranges from 1,893 to 162,132 L/yr (500 to 42,831 gal/yr) for thinning and cleaning. (All volume units are presented in terms of less water.)

6.3 MODEL SHIPYARD PARAMETERS

The model shipyards were defined based on the two primary parameters discussed above. In order to develop the impact analyses, additional critical parameters were developed for each model shipyard.

The paint and solvent information from the surveys was solvent use profiles for the model shipyards are presented in Table 6-2

TABLE 6-2. MODEL SHIPYARD PAINT/SOLVENT USE PROFILE
(Percent of total gallons)

Paint/solvent category	Model shipyard No. 1	2	3	4	5	6
SPECIALTY PAINTS (as supplied)						
Antifoulant	4	22	4	22	4	22
Inorganic zinc	15	1	15	1	15	1
All others (combined)	10	12	10	12	10	12
GENERAL USE PAINTS (as supplied)						
Epoxy based	55	63	55	63	55	63
Alkyd based	17	2	17	2	17	2
TOTAL PAINTS[a]	100	100	100	100	100	100
SOLVENTS						
Thinning	50	20	20	20	40	3
Cleaning[b]	50	80	80	80	60	97
TOTAL	100	100	100	100	100	100

[a]Sums may not add to 100 due to rounding.
[b]Includes cleaning of equipment, parts, and surfaces.

. This table shows that construction and repair shipyards differ in the relative usage of the various paints used. It also presents the split between solvent used for thinning and that used for equipment cleaning.

6.3.1 HAP Content of Paints and Solvents

Data on the HAP content of paints in each paint category from the shipyard surveys were gathered to determine a weighted average HAP content for each category. To simplify this analysis, the average was calculated from the high-use paints of each category (those that make up 80 percent or more of the total paint used in each category). A similar calculation was made to obtain the weighted average VOC content. The weighted average HAP and VOC contents of the paint categories are presented in

Table 6-3. The VOC contents are included for comparison/

TABLE 6-3. WEIGHTED AVERAGE VOC AND HAP CONTENT OF PAINTS AND SOLVENTS AS SUPPLIED[a]

Category	Average VOC content[b]		Average HAP content[b]	
	g/L	lb/gal	g/L	lb/gal
SPECIALTY PAINTS				
Antifoulant	388	3.23	268	2.25
Repair and Maintenance Thermoplastics	493	4.11	271	2.28
Fire retardant	360	3.00	120	1.00
Heat resistant/high temperature	466	3.88	60	0.50
High gloss	492	4.10	94	0.79
Inorganic zinc	545	4.54	274	2.30
Nuclear (Low activation interior)	401	3.34	146	1.23
Pretreatment wash primer	712	5.93	18	0.15
Organic zinc	548	4.57	240	2.00
Special marking	446	3.72	23	0.19
GENERAL USE PAINTS				
Alkyd based	474	3.95	355	2.98
Epoxy based	350	2.92	56	0.47
SOLVENTS				
Thinning	840	7.0	300	2.5
Cleaning	840	7.0	300	2.5

[a]Weighted by reported usage (volume, gal) of each paint in a given category. Reference 3.
[b]Less water and exempt solvents.

TABLE 6-4. EXAMPLE CALCULATION FOR DETERMINING THE WEIGHTED AVERAGE HAP CONTENT FOR ALL MARINE PAINTS[a]

	A		B	A x (B/100)	
	Avg HAP content[b]		Percent of total usage, %	Contribution to weighted average HAP content[b]	
Paint category	g/L	lb/gal		g/L	lb/gal
Specialty--Antifoulant	268	2.25	11.2	30.2	0.252
Specialty--Inorganic zinc	274	2.30	10.0	27.4	0.230
Specialty--All others (combined)	144	1.20	10.3	14.8	0.124
General Use--Alkyd based	355	2.98	10.1	35.9	0.300
General Use--Epoxy based	56	0.47	58.4	32.7	0.274
Total	--	--	100	141.0	1.18

[a]Weighted by reported usage (volume, gal) of each paint in a given category. Reference 3.
[b]Less water and exempt solvents.

correlation purposes and to show the relationship between average VOC contents and existing State (California and Louisiana) marine coating VOC limits (shown in Table 3-9).

The weighted average HAP content for all marine paints is 141.0 g/L (less water) (1.18 lb/gal [less water]). This value was used for the HAP emissions calculations involving spray booths (indoor painting operations), which represent one of the emission points described in the next section. Table 6-4 shows how the weighted average HAP content was determined and illustrates the general method for calculating averages weighted by paint usage (volume). Weighted averages were also used in calculating emissions based on various approaches for determining MACT.[2]

The average HAP contents of solvents used for both thinning and cleaning were determined similarly. Survey responses were used to derive the average HAP content of all solvents in each of these categories. These average HAP contents also are presented in Table 6-3. There is no significant difference in the HAP content of the solvents used for thinning and cleaning. Approximately 36 percent of all solvents are HAP's. Based on composition data for solvents, xylene was assumed to represent 70 percent of the HAP solvent portion, toluene 16 percent, methyl ethyl ketone 8 percent, and all others 6 percent. The average solvent density used for thinning and cleaning was assumed to be 840 g/L (7.0 lb/gal).[3,4]

6.3.2 Application Point Profile

Information from the surveys was further analyzed to determine for each model shipyard the approximate percentage of paint and solvent that is applied at the two primary locations within the shipyard: (1) at outdoor work areas on ship exteriors and interiors and (2) at indoor spray booths. Based on the construction shipyards (model shipyard No. 1) and 10 percent at all other shipyards (model shipyard Nos. 2 through 6) (see

Table 6-5).[3] Based on comments from some of the paint manufacturer representatives, the paint used in spray booth applications at shipyards is usually some type of inorganic zinc (preconstruction) primer, alkyd, or pretreatment primer.[3] However, very little data were provided on paint usage by category at indoor and outdoor application points. Therefore, the overall mix (weighted average) of all paints in the data base was used for further analysis of indoor painting operations.

TABLE 6-5. MODEL SHIPYARD PAINT OPERATIONS

Location	Model shipyard No.					
	1	2	3	4	5	6
PERCENT OF TOTAL USAGE						
Outdoor (ship exteriors + ship interiors)	70	90	90	90	90	90
Indoor spray booths	30	10	10	10	10	10
TOTAL	100	100	100	100	100	100
PAINT USAGE, L (gal)						
Outdoor (ship interiors + ship exteriors)	357,391 (94,413)	408,346 (107,874)	142,853 (37,738)	118,104 (31,200)	63,890 (16,878)	63,458 (16,764)
Indoor spray booths	153,169 (40,463)	45,372 (11,986)	15,872 (4,193)	13,124 (3,467)	7,098 (1,875)	7052 (1,863)
TOTAL	510,560 (134,876)	453,718 (119,860)	158,726 (41,931)	131,228 (34,667)	70,988 (18,753)	70,510 (18,627)

6.4 BASELINE EMISSIONS

Two primary emission points were determined for all model shipyards. Baseline emissions were calculated for each emission point as a reference point for subsequent analysis of the various control options and associated emission reductions. The primary emission points involve painting and relate to the location of the painting operation as described in Section 6.3.2.

Emission point No. 1 was defined as all outdoor painting (ship exteriors and interiors), and emission point No. 2 was as part of the "as applied" formulation of the various marine coatings and are therefore included in the emissions. Each of the two emission points was considered to have two components: (1) paint "as supplied" (1A and 2A) and (2) solvent added for paint thinning (1B and 2B). This subdivision was similarly used to evaluate the control options.

The average HAP contents of the various paints and solvents used to develop Table 6-3 were used to calculate annual HAP emissions from the two emission points at each of the model shipyards based on the paint/solvent use profiles presented in Tables 6-1 and 6-2. Tables 6-6

TABLE 6-6. ANNUAL HAP EMISSIONS FROM EMISSION POINT 1A: AS-SUPPLIED COATINGS USED AT OUTDOOR PAINTING OPERATIONS Mg/yr (tons/yr)

Coating category	Model shipyard No.					
	1	2	3	4	5	6
SPECIALTY PAINTS						
Antifoulant	3.8 (4.2)	23.7 (26.7)	1.5 (1.7)	6.9 (7.7)	0.6 (0.8)	3.7 (4.1)
Inorganic zinc	14.2 (17.4)	1.0 (1.2)	5.6 (6.9)	0.3 (0.4)	2.5 (4.0)	0.2 (0.5)
All others (combined)	5.2 (5.7)	7.1 (7.8)	2.1 (2.3)	2.0 (2.2)	0.9 (1.0)	1.1 (1.2)
GENERAL USE PAINTS						
Alkyd based	20.4 (22.5)	2.9 (3.2)	8.2 (9.0)	0.8 (0.9)	3.6 (4.0)	0.5 (0.5)
Epoxy based	10.9 (12.0)	14.5 (16.0)	4.4 (4.8)	4.2 (4.6)	1.9 (2.1)	2.6 (2.5)
TOTAL	56.1 (61.8)	49.8 (54.9)	22.4 (24.7)	14.4 (15.9)	10.0 (11.0)	7.7 (8.5)

TABLE 6-7. ANNUAL HAP EMISSIONS FROM EMISSION POINT 1B: THINNING SOLVENT USED AT OUTDOOR PAINTING OPERATIONS Mg/yr (tons/yr)

HAP (percent)	Model shipyard No.					
	1	2	3	4	5	6
Xylene (70)	11.9 (13.1)	0.9 (1.0)	1.7 (1.8)	0.8 (0.8)	0.8 (0.9)	< 0.1 (< 0.1)
Toluene (16)	2.7 (3.0)	0.2 (0.2)	0.4 (0.4)	0.2 (0.2)	0.2 (0.2)	< 0.1 (< 0.1)
Methyl ethyl ketone (8)	1.4 (1.5)	0.1 (0.1)	0.2 (0.2)	0.1 (0.1)	0.1 (0.1)	< 0.1 (< 0.1)
Other (6)	1.0 (1.1)	< 0.1 (< 0.1)	0.1 (0.1)	< 0.1 (< 0.1)	< 0.1 (< 0.1)	< 0.1 (< 0.1)
TOTAL (100)	17.0 (18.7)	1.3 (1.4)	2.4 (2.6)	1.1 (1.2)	1.2 (1.3)	< 0.1 (< 0.1)

through 6-8 present the resulting HAP emissions from each of

TABLE 6-8. ANNUAL HAP EMISSIONS FROM EMISSION POINTS 2A AND 2B: INDOOR PAINTING OPERATIONS
Mg/yr (tons/yr)

Emission point	Model shipyard No.					
	1	2	3	4	5	6
2A (Paints)[a]	21.7 (23.9)	6.5 (7.1)	2.3 (2.5)	1.8 (2.0)	1.0 (1.1)	1.0 (1.1)
2B (Thinning solvents)	7.3 (8.0)	0.2 (0.2)	0.3 (0.3)	0.2 (0.1)	0.1 (0.1)	< 0.1 (< 0.1)
TOTAL	21.8 (31.9)	6.6 (7.2)	2.5 (2.8)	2.0 (2.2)	1.2 (1.3)	(1.1)

[a]Using an overall weighted average HAP content of 141.0 g/L (1.18 lb/gal) less water.

TABLE 6-9. TOTAL HAP EMISSIONS FROM MODEL SHIPYARDS[a]
Mg/yr (tons/yr)

Emission point	Model shipyard No.					
	1	2	3	4	5	6
1-OUTDOOR PAINTING						
1A (Paints)	56.1 (61.8)	49.8 (54.9)	22.4 (24.7)	14.4 (15.9)	10.0 (11.0)	7.7 (8.5)
1B (Thinning solvents)	17.0 (18.7)	1.3 (1.4)	2.4 (2.6)	1.1 (1.2)	1.2 (1.3)	< 0.1 (< 0.1)
2-INDOOR PAINTING						
2A (Paints)	21.7 (23.9)	6.4 (7.1)	2.3 (2.5)	1.8 (2.0)	1.0 (1.1)	1.0 (1.1)
2B (Thinning solvents)	7.3 (8.0)	0.2 (0.2)	0.3 (0.3)	0.1 (0.1)	0.1 (0.1)	< 0.1 (0.1)
TOTAL	102.1 (112.4)	57.7 (63.5)	27.2 (30.0)	17.5 (19.3)	12.3 (13.6)	8.7 (9.6)
No. of major sources	6	4	5	10	0	0
Total nationwide emissions[a]	612.5 (674.6)	230.6 (254.0)	136.4 (150.2)	175.1 (192.8)	0 (0)	0 (0)

[a]Baseline (combined) HAP emissions from 25 major sources = 1,155 Mg/yr (1,272 tons/yr).

the primary emission points.

The following assumptions were used in calculations involving HAP emissions from paints and solvents: (1) all solvents in the coating, including those used for thinning, are emitted to the air once the paint is sprayed and (2) emissions of HAP solids from paint overspray are not now amenable to control. Many of the shipyards indicated the presence of secondary emission points as part of the shipbuilding and ship repair industry. Operations activities such as equipment cleaning, welding, gas freeing (purging residual gas vapor from tankers and barges), metal fabrication, fuel combustion, flame cutting, asbestos removal, chromium plating, and metal part cleaning (degreasers) emit varying quantities of VOC's and HAP's. Such emissions should be aggregated in determining if a facility is a major source. However, they were not considered primary in determining emission points for this study and were not evaluated.

Table 6-9 provides a summary of total HAP emissions by emission point for each model shipyard. Baseline HAP emissions from the six model yards range from 8.7 to 102.1 Mg/yr (9.6 to 112.4 tons/yr). These data indicate, not surprisingly, that the types and amounts of paint and solvent used at repair and construction yards are the most important factors in determining HAP emissions. Differences between model shipyard type (construction versus repair) HAP emissions can also be directly correlated to the differences in paint and solvent use. The calculated average HAP contents of all marine paints is 141.0 g/L

(less water) (1.18 lb/gal [less water]) and ranges from 56 to 355 g/L (less water) (0.47 to 2.98 lb/gal [less water]) for the major use categories. The HAP contents do not correlate with VOC contents, as can be seen in Table 6-3. This causes difficulties in reformulation control options (for both NESHAP and CTG projects) and is discussed further in the next section.

Thinning solvent accounts for approximately 25 percent of the HAP emissions from large construction shipyards (model No. 1) and 2 percent of large repair yard (model No. 2) HAP emissions. Data from the other model shipyards indicate that thinning solvent accounts for 7 to 10 percent of HAP emissions.

6.5 MAXIMUM ACHIEVABLE CONTROL TECHNOLOGY (MACT)

The shipbuilding and ship repair industry is basically uncontrolled in terms of HAP's. No add-on control devices were used by any of the shipyards surveyed.[3] Reformulating paints to lower-VOC coatings, which has been underway for some time, could indirectly reduce HAP's as well because almost all HAP solvents are also VOC's. Some of the HAP's are stronger solvents, thus pressures to reduce VOC content, could, without other constraints, result in an increase in HAP's to offset the total reduction mandated by VOC limits. Add-on controls (i.e., incinerators and adsorbers) to reduce HAPs from work done on the exterior of a ship were not considered (in light of the size of ships and available technology). Such controls were, however, evaluated for spray booths. Because of the limited data certain assumptions regarding the total air flow were made. Considering the sporadic nature of painting operations, an overestimation of the air flow may have contributed to the very high costs per ton of HAP's calculated. Cost details are provided in Chapter 8 for spray booth add-on controls and paint heaters.

to reduce HAP's. Some marine paints have a lower HAP content than others. The MACT floor is based on these paints with relatively low HAP contents. It is presumed that once the level is established, other manufacturers will reformulate to comply. Reformulation can take any of several avenues: solvent-substituted coatings (as defined in Chapter 4), higher-solids (nonvolatiles) coatings, and waterborne coatings. Use of thinners that have low- or no-HAP solvents is also considered a type of solvent substitution.

The HAP content of various paints cannot be viewed in a vacuum. The issue of HAP's versus VOC's is important to consider in all reformulation scenarios. Approximately one third of the VOC's used as solvents in marine paints are also HAP's, as described in Chapter 3. The data show, however, that reducing VOC's does not necessarily mean that HAP's will be reduced in a specific paint. Many of the paints have multiple solvent components, and if the paint manufacturer chooses to reduce or eliminate the non-HAP solvent(s), the HAP content would not change (or may increase). Similarly, reductions in HAP's via substitution need not reduce VOC's, either (i.e., lower-HAP coatings are not necessarily lower-VOC). Indeed, concerns have been raised that VOC limits currently imposed by some States (and the proposed BACM) will drive industry to use stronger solvents, many of which are HAP's.[5] While there is no direct correlation between reducing HAP's and VOC's in each specific paint, it is believed that reducing VOC's overall, will result in HAP emission reductions as well.

The approach for determining the MACT floor being considered for this industry involves setting HAP limits for marine paints numerically equal to the VOC limits adopted in the CTG. Baseline emissions from the 25 major-source shipyards is estimated to be

(300 tons/yr). Because there are no process, equipment, or facility size considerations that subdivide the industry technically, the following chapters involving an analysis of environmental impacts, costs, and economic impacts are fairly straightforward. Any HAP limits on marine paints will also affect VOC emissions from shipyards located in VOC attainment areas. The impact(s) of combined HAP and VOC limits must be considered in all analyses to ensure compatibility with the CTG.

6.6 REFERENCES FOR CHAPTER 6

1. Memorandum from Reeves, D., Midwest Research Institute (MRI), to Driver, L., EPA/CPB. October 1, 1992. Final Model Plants Memorandum.

2. Memorandum from Reeves, D., MRI, to Project File. September 29, 1993. HAP emission estimates using Navy QPL data.

3. Memorandum from deOlloqui, V., MRI, to Project File. November 11, 1992. Facilities in the Shipbuilding and Ship Repair Data Base.

4. Memorandum from deOlloqui, V., MRI, to Project File. November 16, 1992. List of Coating Manufacturers Surveyed.

5. Memorandum from Williamson, M., MRI, to Project File. March 18, 1993. List of Shipyard Site Visits.

7.0 ENVIRONMENTAL IMPACT

The environmental and energy impacts of maximum achievable control technology (MACT) as applied to existing major sources are presented in this chapter.

Since MACT for this industry involves reformulation or selection of lower-VOC paints, environmental and energy impacts for each of the emission points are greatly simplified.

A description of MACT identified in Chapter 6, Model Plants and Regulatory Alternatives, is summarized in Table 7-1.

TABLE 7-1. MAXIMUM ACHIEVABLE CONTROL TECHNOLOGY (MACT) FOR HAP EMISSIONS POINTS

	HAP emission points
	Painting
Baseline	No control
MACT	Measure VOC as a surrogate for HAP and base the HAP limit on BACM

The air and water pollution impacts are discussed in Sections 7.1 and 7.2, respectively.

7.1 AIR POLLUTION IMPACTS

Some paints and solvents used by this industry contain limit the maximum allowable HAP emissions for each category of paint. The primary and secondary air pollution impacts are described below.

7.1.1 Primary Air Pollution Impacts

Primary impact will be the HAP and VOC emission reductions that result from using paints and solvents that contain less of these pollutants. In this industry, more than one-third of all organic HAP's are VOC's. Use of coatings with different solvents or selection of lower-VOC paints will not necessarily reduce VOC's and HAP's in the same proportion. Overall reductions in both HAP and VOC emissions, however, will result with the use of lower-VOC paints. Because solventborne coatings with lower-VOC equate to a higher volume of solids per volume of coating, emission reductions are obtained because there is less solvent in the paint and, of course, less paint is needed to provide enough film forming material to coat a given area of substrate.

The annual HAP solvent emission level (including any contained in thinning solvents) that would result from implementation of VOC limits on "as applied" basis is presented in Table 7-2. The HAP emission reduction from baseline was calculated for each model shipyard. It ranged from 1.4 to 27.6 Mg/yr (1.5 to 30.4 tons/yr). The estimated emissions reduction resulting from implementation of MACT ranged from around 10 to nearly 32 percent by mass for the range of Model shipyards (Nos. 1 to 4).

TABLE 7-2. ENVIRONMENTAL IMPACT OF MACT ON MODEL SHIPYARDS[a]

	Model shipyard no.					
	1	2	3	4	5	6[b]
	102.1 (112.4)	57.7 (63.5)	27.2 (30.0)	17.5 (19.3)	12.3 (13.6)	8.7 (9.6)
	74.5 (82.0)	48.5 (53.4)	18.7 (20.6)	14.8 (16.3)	8.4 (9.3)	7.4 (8.1)
	27.6 (30.4)	9.2 (10.1)	8.5 (9.4)	2.7 (3.0)	3.9 (4.3)	1.4 (1.5)
	27.0	15.9	10.4	15.5	31.6	15.6

TABLE 7-3. NATIONWIDE IMPACT OF MACT ON EXISTING MAJOR SOURCES[a]

Regulatory approach[b]	Emissions, Mg/yr (tons/yr)	HAP emission reduction from baseline, Mg/yr (tons/yr)	Percent reduction in solvent HAP emissions
Baseline	1,155 (1,272)	N/A	N/A
MACT	883 (972)	272 (300)	24

Nationwide impacts on the 25 existing major sources in the fifth year after proposal of the NESHAP are estimated in Table 7-3. Annual baseline HAP emissions were estimated to be 1,155 Mg/yr (1,272 tons/yr). The impact of implementing MACT was estimated to be a net reduction of 272 Mg/yr (300 tons/yr) or 24 percent. Because no new sources are projected, the estimated impacts for the existing sources represents the total impact in the fifth year after the standards are proposed.

7.1.2 Secondary Air Pollution Impacts

Secondary emissions of air pollutants result from generation of the energy needed to comply with the standard. Since reformulation/selection of lower-VOC paints does not involve any type of control device or equipment, the shipyards will produce no secondary air pollution. Some shipyards, however, may need to use paint heaters to reduce paint viscosity to avoid use of solvents because they would increase emissions and violate the standard. To the extent paint heaters are used, some additional energy would be required with associated secondary air impacts at the power plant. These impacts will be insignificant and far outweighed by the beneficial reductions in HAP and VOC emissions if thinner had been used.

7.2 WATER POLLUTION IMPACTS

There are no direct impacts to water pollution resulting from reformulation or selection of lower-VOC paints. When higher-solids coatings are utilized, less paint is used and the total amount of associated overspray would also be expected to be reduced since the same total volume of paint solids will be applied. Since spray painting usually occurs at the dock or near the shoreline, some overspray is carried to the water; reduced overspray would be expected to reduce the water pollution impact of spray painting operations at shipyards. There are no data available with which to estimate current water pollution impacts from overspray or the reduction in water pollution that would result from implementation of MACT.

7.3 SOLID WASTE DISPOSAL IMPACTS

No additional or new types of solid or hazardous waste will be generated by implementation of MACT. The lower-VOC (higher-solids) products will result in fewer paint cans being used to apply the same solids volume. Fewer paint cans will then have to be disposed of as solid waste. Hazardous waste disposal will also be reduced to the extent that the empty paint cans are handled as hazardous waste.

7.4 ENERGY IMPACTS

As mentioned previously in Section 7.2, there is a chance that some shipyards may choose to use additional paint heaters in those located in cold climates. The energy impact from any additional heaters being used as a result of implementing MACT cannot be quantified with certainty, but since each paint heater uses only 2.3 kilowatts on average, their total energy consumption is minuscule.[1,2]

7.5 OTHER ENVIRONMENTAL IMPACTS

No increase in noise levels will result from implementing MACT. Pumps and compressors used to move paint and air are responsible for the majority of the noise in the existing operations. These delivery systems are not expected to require change.

7.6 OTHER ENVIRONMENTAL CONCERNS

7.6.1 Irreversible and Irretrievable Commitment of Resources

Implementing MACT will not result in an irreversible or irretrievable commitment of natural resources. Because energy use will not increase, there will be no significant increase in the use of coal, oil, gas, or uranium.

7.6.2 Environmental Impact of Delayed Standard

Because there are no significant water pollution, solid waste, or energy impacts, there is no significant benefit to be obtained from delaying proposal of the standard. Furthermore, no emerging emission control technology was identified that achieves greater or cheaper HAP reductions equal to those represented by the approach considered. Consequently, there are no advantages to delaying proposal of the standard. Any delay would, however, forego the HAP emission reductions for the period of the delay.

7.7 REFERENCES FOR CHAPTER 7

1. Telecon. Caldwell, M. J., Midwest Research Institute, with J. Czajak, Binks Manufacturing. October 14, 1992. In-line paint heaters.

2. Telecon. deOlloquoi, V., Midwest Research Institute, with G. Olson, Graco, Inc. October 9, 1992. In-line paint

8.0 COSTS OF CONTROLS

This chapter presents the costs associated with maximum achievable control technology (MACT). As discussed in previous chapters, MACT for the shipbuilding and ship repair industry will require use of lower-VOC paints for each of the 23 paint categories identified in Table 1-1. The cost analysis for MACT is essentially the same as for the alternative techniques document (ACT) but uses hazardous air pollutants (HAP's) instead of volatile organic compounds (VOC's) for the benefit cost ratio. Details of the cost analysis are provided in Appendix E.

Most, if not all, existing "major source" shipyards are located in ozone nonattainment areas and will have to control VOC emissions in addition to HAP's.

The proposed best available control measures (BACM) as alluded to in the Preamble require the use of paints that also meet MACT. Thus, at shipyards already subject to limits similar to the BACM presumptive norm (i.e., those located in California), the additional cost of the NESHAP will be limited to the cost of more frequent reporting required by the NESHAP program. The actual industrywide (25 major sources) total costs of the NESHAP are presented in Section 8.6.

No new major source shipyards are expected to be built in the next 5 years; therefore, no costs were developed for new facilities. The standards that will apply to existing surface unlikely case that one should be created. This seems unlikely considering that this industry has for several years been in a general state of decline due to the downsizing of military forces.

8.1 MACT LIMITS

Three categories of coatings constitute more than 90 percent of the industry's reported paint usage in the data base. These were used to estimate the cost of the MACT limits. The low usage paints were not included because of some questions and inconsistencies with the associated paint categories in the data base. The NESHAP will limit HAP contents to levels that correspond to the VOC limits established by the "California limits." These are the 1992 VOC limits contained in South Coast Air Quality Management District (SCAQMD) Rule 1106, Marine Coating Operations and San Diego Air Pollution Control District (SDAPCD) Rule 67.18.[1,2] The HAP usage, and hence emissions, were derived from material safety data sheets (MSDSs), while the cost estimates were supplied by shipyards and supplemented by coating manufacturers. Most facilities provided data on coatings used in 1990; a few provided data from 1991.

All of the above MACT and VOC limits are presented as maximum or never-to-be-exceeded limits for the "as applied" coatings. ("As applied" includes any solvent thinning of the coating before it is applied to the substrate.) Most shipyards indicated that some thinning is done routinely, particularly in cold weather.[3] Some manufacturers provided the maximum thinning levels allowed for cold weather application. The information obtained in the surveys from shipyards and coating manufacturers pertained to "as received" coatings, i.e., before thinning. In evaluating the coatings in the data base against the "as applied" limits presented in Chapter 6, all coatings at or below the indicated

8.2 ASSUMPTIONS

Hazardous air pollutant emissions from shipyard coating operations result from HAP's contained in the coatings and solvents used to thin the coatings. Based on information contained in the shipyard survey responses, the net cost associated with switching to lower-VOC coatings was assumed to be the sum of the additional cost of the coatings, the savings associated with higher solids content, the savings associated with decreased thinner usage, the costs of additional recordkeeping and reporting requirements, and the cost of implementing new work practices. The same assumptions documented in Chapter 7 to estimate/calculate HAP emissions were used in the cost analysis.

Costs were developed for "baseline" (all coatings in the three primary categories) and for those coatings considered compliant with MACT limits. The parameters for coatings used in the cost analysis for baseline and MACT are based on information in the data base developed from the shipyard and coating supplier survey responses.[3,4] These coating parameters are summarized in Table 8-1. Baseline parameters correspond to coatings in use today as indicated by the project data base. Under MACT, the average HAP and VOC contents are lower than the average baseline

TABLE 8-1. COATING PARAMETERS[a]

Coating category	HAP limit, g/L-water (lb/gal-water)	Weighted average price, $/L ($/gal)	Weighted average VOC content, g/L-water (lb/gal-water)	Weighted average HAP content, g/L-water (lb/gal-water)	Average weighted solids content, % vol
Antifoulant					
Baseline	None		387 (3.23)(34)	270 (2.25)	54
Compliant with MACT limit	400 (3.33)		344 (2.87)(34)	268 (2.25)	59
Inorganic zinc					
Baseline	None		544 (4.54)(12)	274 (2.30)	51
Compliant with MACT limit	650 (5.40)		541 (4.51)(12)	274 (2.30)	51
General use					
Baseline	None		368 (3.07)(16)	70 (0.58)	57
Compliant with MACT limit	340 (2.83)		275 (2.29)(20)	37 (0.31)	65
Solvent	None		840 (7)(1) (4)	300 (2.5)	N/A[b]

[a]These coating parameters are based on the shipyard and coating supplier survey responses. Volatile organic compound and HAP content given in grams of VOC or HAP per liter of coating minus water and minus "exempt" solvents (pounds of VOC or HAP per gallon of coating minus water and minus "exempt solvents"), as applied. Numbers in this table are independently rounded.
[b]Not applicable.

levels.

8.2.1 Solids (Nonvolatiles)

For the impact analysis, it was assumed that the total build of the lower-VOC coating (the dry film thickness) would equal that of the conventional counterpart, i.e., the total amount of solids (nonvolatiles) applied would remain constant.[5] Because lower-VOC solventborne coatings contain more solids, the total volume of paint needed to coat a given area is less than for the conventional, lower-solids coatings at constant transfer efficiency.

The solids content of the majority of the coatings was reasonable approximation for solventborne coatings, it is not valid for coatings that contain more than trace quantities of water or significant organic reaction by-products. Because the equation produced unreasonably high solids contents in some instances, caps were established for each of the three main coating categories, based on information provided by coating suppliers.[6,7] The maximum solids content for antifoulants and inorganic zinc coatings was assumed to be 65 percent by volume and that of general use coatings was assumed to be 70 percent.

Solids data (provided on product data sheets) were used for some inorganic zinc and alkyd coatings (part of the general use category). When available, actual solids data were used rather than the solids content calculated by the equation described in Appendix E.

8.2.2 Thinning

In evaluating the use of lower-VOC solventborne coatings, additional assumptions involving thinning were made to estimate cost impacts. One such assumption was that lower-VOC ("as-supplied") coatings require the same amount of thinning solvent, gallon for gallon, as conventional coatings. Because fewer gallons of lower-VOC coatings would be used to apply the same volume of film forming material, thinner use would decrease. A decreased thinner use results in HAP emission reductions and a cost savings.

8.2.3 Equipment and Work Practices

Some yards that had tested lower-VOC, higher-solids coatings indicated that they had to change the type of spray guns they used because higher pressures were needed to atomize the new coatings. One yard indicated that higher solids coatings tended to clog the lines, requiring more purging and more cleaning time. Some yards indicated that it takes longer for the lower-VOC different spray guns, additional purging, or increased cure times.[8-11] Because such costs or benefits could not be quantified, they were not included in the cost analysis.

8.3 RESULTS OF THE ANALYSIS

The incremental coatings and thinner costs associated with MACT are presented in Table 8-2.

TABLE 8-2. ANNUAL COATING AND THINNER COSTS FOR IMPLEMENTING MACT, $/yr[a]

	Model yard					
	Construction			Repair		
	Small	Medium	Large	Small	Medium	Large
	70,988 (18,753)	158,726 (41,931)	510,560 (134,876)	70,511 (18,627)	131,228 (34,667)	453,718 (119,860)
	10,845 (2,865)	43,532 (11,500)	162,132 (42,831)	1,893 (500)	20,562 (5,432)	23,091 (6,100)
	40	20	50	3	20	20
	(2,161) 0 20,484 (374)	(4,833) 0 45,802 (752)	(15,545) 0 147,326 (6,998)	(11,808) 0 18,627 (5)	(21,975) 0 34,667 (386)	(75,979) 0 119,860 (433)
	17,948	40,217	124,783	6,814	12,306	43,448

cludes the use of lower-VOC coatings with thinner usage equal to a constant percentage of total coating

Since lower-VOC approximates to higher-solids, fewer gallons of lower-VOC coatings are required. The lower-VOC coatings, however, are more expensive on a dollar-per-gallon basis. The savings associated with the decreased volume requirements is more than offset by the higher price of the lower-VOC general use coatings. The inorganic zinc coating category was broken up into two categories: weld-through (shop) primer with a VOC limit of 650 g/L and air inorganic zinc (high build) primer with a limit of 340 g/L, identical to the limit for the general use category. Therefore, for these coatings, it has been assumed there is no cost impact because many of the baseline coatings will comply with the MACT limits. Note in Table 8.2, however, for antifoulants there is a savings in coating costs.

The costs for using coatings compliant with MACT limits include both the costs (or savings) of using the lower-VOC coatings and the savings from the need for less thinner. (Thinner usage is assumed proportional to the volume of total coating use).

The annual net cost of coating and thinner, calculated for each model shipyard, ranged from $6,800 for a small repair yard to $125,000 for a large construction yard. Since the type of work done at a shipyard determines the relative mix of paints applied, it also directly impacts the costs associated with MACT. The cost for repair yards, where relatively more antifoulant is used, was less than 40 percent of that for similar-sized construction yards.

8.4 RECORDKEEPING AND REPORTING REQUIREMENTS

To gather information on existing recordkeeping and reporting (R&R) by this industry, current regulations were reviewed and a limited number of shipyards were contacted.[12-19] They revealed that R&R practices are established by permit conditions, and in some instances, the requirements of Section 313 of the Superfund Amendments and Reauthorization Act of 1986 (SARA 313). For that reason, the cost of recordkeeping to comply with permit and SARA 313 requirements are considered as the baseline from which to measure the incremental cost of this rule.

This regulation will place maximum allowable limits on the HAP content of marine coatings. Complying with MACT limits will require more involved recordkeeping practices than those necessary at the baseline. This section discusses the recordkeeping and reporting requirements and the associated costs developed for baseline and MACT limits. Section 8.4.1 discusses the assumptions and various inputs used to develop the recordkeeping and reporting requirements, and Section 8.4.2 provides and elaborates on the associated costs. Additional detail on recordkeeping and reporting costs is presented in Appendix E.

8.4.1 Assumptions and Inputs

Information gathered from shipyards indicates R&R practices in construction and repair yards are similar.[15-19] Therefore, model yard R&R requirements presented in this section are distinguished based only on size.

Recordkeeping and reporting costs are a function of the probably be used. Labor requirements include training, data recording and analysis and report preparation.

8.4.1.1 <u>Baseline</u>. Most large and medium shipyards already maintain records to comply with State or local permits as well as SARA 313 requirements. It has been assumed that the operations at these facilities are complex enough and the facilities sophisticated enough that they already use a computerized system for R&R. In contrast, small yards, which we now believe will not be subject to the NESHAP, are too small to be subject to SARA 313 requirements or significant permit conditions. As a result, small model yards typically have not invested in a computerized system for maintaining these records.

The current reporting requirements for large and medium yards (at baseline) are assumed to consist of an annual SARA 313 report and an annual report of VOC emissions. To prepare these reports, it is assumed that the facilities have adapted their central inventory tracking system to record the quantity of each paint and thinner used at the yard. It is also assumed that this information is coupled with a data base in which the HAP and VOC contents of each paint and thinner are stored. The total technical labor devoted to recordkeeping and reporting for large and medium yards prior to promulgation of the NESHAP is estimated to be 159 hours per year (hr/yr). Additional detail on this estimate is presented in Appendix E. Because small shipyards are not typically subject to SARA 313 or other reporting requirements, they have no labor cost under baseline conditions.

8.4.1.2 <u>MACT Compliance</u>. To comply with MACT limits, it is assumed that no additional equipment is required for any model facility. Large and medium yards do not need to purchase new equipment because the equipment required at baseline is adequate for this purpose. Small yards do not need additional equipment

Significant R&R labor will be required to demonstrate compliance with the MACT units. For this analysis, it was assumed that records must be kept on a monthly basis and compiled quarterly. A requirement to submit quarterly reports the first year and semiannual reports in subsequent years was assumed, as was the need for initial and refresher training sessions for the employees involved in recordkeeping. Estimates of the total technical labor for R&R range from 270 hr/yr for small yards up to 1,053 hr/yr for large yards. (See Appendix E for additional information.)

8.4.2 Costs of Recordkeeping and Reporting

Table 8-3

TABLE 8-3. RECORDKEEPING AND REPORTING COSTS (INCREMENTAL COSTS ABOVE BASELINE), $/yr[a]

	Model yard					
	Construction			Repair		
	Small	Medium	Large	Small	Medium	Large
Baseline						
Labor	0	5,875	5,875	0	5,875	5,875
Equipment	0	1,400	1,400	0	1,400	1,400
Total	0	7,275	7,275	0	7,275	7,275
MACT (Maximum limits)						
Labor	9,964	16,098	38,896	9,964	16,098	38,896
Equipment	0	1,400	1,400	0	1,400	1,400
Total	9,964 (9,964)	17,498 (10,233)	40,296 (33,021)	9,964 (9,964)	17,498 (10,223)	40,296 (33,021)

[a]The costs in parentheses represent the incremental costs for recordkeeping and reporting above the costs of these activities incurred under baseline requirements.

TABLE 8-4. HOUR AND LABOR RATES FOR RECORDKEEPING AND REPORTING

Type of labor	Hour rate	Labor rate
Technical	(A)	$33/hr
Management	0.05 (A)	$49/hr
Clerical	0.10 (A)	$15/hr

shows costs developed for R&R for both baseline and MACT compliance. The final R&R costs were based on hour and labor rates from the Emission Standards Division (ESD) Regulatory Procedures Manual.[20] These rates are summarized in Table 8-4. Additional information and example cost calculations are presented in Appendix E.

8.5 COST EFFECTIVENESS OF MACT

The cost effectiveness (cost per mass of HAP controlled) of implementing MACT is presented in Table 8-5

TABLE 8-5. COST EFFECTIVENESS FOR MACT[a]

	Model yard					
	Construction			Repair		
	Small	Medium	Large	Small	Medium	Large
	3.9 (4.4)	8.8 (9.7)	29.6 (32.6)	1.2 (1.4)	2.4 (2.6)	8.1 (8.9)
	17,948 9,964	40,217 10,223	124,783 33,021	6,814 9,964	12,306 10,223	43,448 33,021
	27,912	50,440	157,804	16,778	22,529	76,469
	7,157 (6,344)	5,732 (5,200)	5,331 (4,841)	13,982 (11,984)	9,387 (8,665)	9,441 (8,592)

for each model shipyard. These values are the incremental costs relative to the baseline assumptions. The emission reductions expected as a result of this rule are presented in Chapter 7 and summarized as part of Table 8-5. The incremental cost is the sum of the coating-related costs (Table 8-2) and the R&R incremental costs (Table 8-3). The total incremental cost was divided by the anticipated emission reduction to obtain the cost effectiveness.

Cost effectiveness for the model construction shipyards ranged from $5,000 to $7,000/Mg ($4,600 to $6,100/ton) and model repair yards ranged from $9,000 to $14,000/Mg ($8,300 to $12,700/ton). This difference is due to the higher usage of general use coatings at construction yards. The mix of coatings significantly impacts the amount of HAP emissions from the model yards. Even though costs associated with repair yards are lower than those for construction yards, so are the HAP emission reductions. Therefore, the net cost effectiveness is higher for all repair yards.

8.6 TOTAL INDUSTRY COST FOR MACT

Estimates of the nationwide cost impacts on the 25 existing major sources in the fifth year after proposal of the NESHAP are presented in Table 8-6.

TABLE 8-6. NATIONWIDE COST IMPACT ON EXISTING MAJOR SOURCES[a]
(In the Fifth Year After NESHAP Proposal)

	Model yard					
	Construction			Repair		
	Small[b]	Medium	Large	Small	Medium	Large
	27,912	50,440	157,804	16,778	22,529	76,469
	0	5	6	0	10	4
	0	252,200	946,824	0	225,290	305,876
Total industry costs = $1,730,190						

b

as major sources based on the updated HAP/paint

Total industry annual costs resulting from implementing the NESHAP were estimated to be about

$1.7 million. The environmental impact of implementing MACT was estimated in Chapter 7 to be a net HAP reduction of 272 Mg/yr (300 tons/yr). Overall cost effectiveness in the fifth year after proposal of the NESHAP would be $6,360/Mg ($5,767/ton).

These estimates presume that all incremental environmental costs are imposed as a consequence of implementing MACT. In fact, as discussed in the introduction of this chapter, those shipyards located in nonattainment areas (which is thought to include all 25) will likely be required to meet State requirements for limiting VOC emissions as the States impose rules based on the EPA's recommendations on best available control measures (BACM) for control of VOC's. For that reason, there will be little or no cost to the industry to meet the NESHAP but costs could be up to $1.7 million/yr, if one chooses to ascribe all of the cost to this rule.

8.7 REFERENCES FOR CHAPTER 8

1. South Coast Air Quality Management District Rule 1106. November 4, 1988. Amended June 2, 1989.

2. San Diego Air Pollution Control District Rule 67.18. July 3, 1990.

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9.0 INDUSTRY PROFILE AND ECONOMIC IMPACT ANALYSIS

9.1 PROFILE OF THE U.S. SHIPBUILDING AND REPAIR INDUSTRY

9.1.1 Introduction

This industry profile details the various market characteristics of the domestic shipbuilding and repair industry. The EPA, under Section 112(d) of the 1990 Clean Air Act, is developing a national emission standard for hazardous air pollutant (NESHAP) concerning those hazardous air pollutant (HAP) emissions associated with marine coating operations. This NESHAP will directly impact the shipbuilding and repair industry, which is classified under SIC 3731.[1] All major-source establishments within SIC 3731 will be required to comply with the NESHAP except offshore drilling and production platforms. Not included in SIC 3731 are nine Government-owned shipyards, which do not engage in new construction, but rather in the overhaul and repair of Navy and Coast Guard ships.[2] These shipyards will be regulated by this NESHAP if they qualify as major sources. While the lion's share of marine coating operations takes place under the auspices of shipyard owners, some of the work is contracted out to ship painting contractors. This work, which is performed on shipyard premises, is classified under SIC 1721, Painting and Paper Hanging, and will be affected by this NESHAP.[3]

The shipbuilding and repair industry is organized into two tiers. Tier one is the collection of shipyards that have the capability to construct, dry-dock, and/or topside repair vessels depth in the channel to the facility is at least 12 feet.[4] Tier one shipyards supply ships primarily for the domestic military market--mostly large naval vessels--with a small percentage of its output geared for commercial use. These predominantly large shipyards, while small in number, account for the lion's share of revenue and employment in the industry, producing mainly very large ships.

Tier two shipyards build and repair ships of less than 400 feet in length. These shipyards manufacture for the military market as well, but emphasize commercial production. Tier two shipyards are larger in number and manufacture more units than first-tier producers, but tend to be much smaller in size.

The distinction between the first and second tier is important for several reasons. First, tier one shipyards tend to be much larger than tier two shipyards, and are likely to respond differently to regulatory cost-increases. Second, tier one shipyards depend heavily on U.S. military contracts, and so demand determinants differ considerably from the second tier, which relies on commercial production. Finally, the tiers produce for different markets, and do not compete with each other. Thus, tier one and tier two shipyards can be thought of as distinct market segments.

The profile is organized as follows. Section 9.1.2 presents information on the structure of the industry as a whole. This includes general information on the industry characteristics, end-use markets, world trade and foreign competition. Section 9.1.3 discusses the industry structure of tier one shipyards in detail. Section 9.1.4 considers tier two shipyards. The two latter sections are comprised of nine sections each: an overview of tier activities; production; ship repairs; consumption; vertical integration; market concentration; demand;

9.1.2 Industry Structure

9.1.2.1 General Characteristics Table 9-1

TABLE 9-1. NUMBER OF ESTABLISHMENTS, VALUE OF SHIPMENTS AND EMPLOYMENT FOR THE SHIPBUILDING AND REPAIRING INDUSTRY, 1980 - 1991

Year	No. of establishments[a]	Value of shipments, 10^6 \$[b]	Employment, 10^3
1991[c]	N.A.	$10,242.0	120.0
1990	N.A.	$10,855.1	121.2
1989	N.A.	$9,640.2	119.3
1988	N.A.	$8,793.0	120.1
1987	590	$8,504.4	120.2
1986	N.A.	$8,839.9	120.6
1985	N.A.	$9,357.7	130.3
1984	N.A.	$9,643.6	132.7
1983	N.A.	$9,487.1	141.0
1982	698	$10,967.2	166.7
1981	N.A.	$11,001.3	178.9
1980	N.A.	$9,268.5	177.3

[a]Number of establishments available only for census years 1987 and 1982.
[b]Current dollars.
[c]Estimate.

Sources: U.S. Department of Commerce, Bureau of the Census. 1987 Survey of Manufacturers, 1988-1990 Annual Survey of Manufacturers; U.S. Department of Commerce, International Trade Administration. <u>U.S. Industrial Outlook</u>, Washington, D.C., p. 22-1.

presents the number of establishments, value of shipments in current dollars, and employment for the shipbuilding and repair industry for the years 1980-1991..

Data on number of establishments is available only in the census years 1982 and 1987. The census definition of establishments corresponds to what can be considered individual plants or facilities. As can be seen, the number of establishments declined considerably from 1982 to 1987. This reduction is attributable primarily to a contraction in the number of small and medium size shipyards, which began closing due to considerable overcapacity problems.

Value of shipments data is presented in current dollar terms. As shown, value of shipments declined in tandem with the number of establishments through 1987. From 1987 to the present, value of shipments increased slowly, as small and medium shipyards rebounded from their mid-decade woes.

Employment data is presented for the years 1980 to 1990, and estimated for 1991. The level of employment showed a steady decline from 1980, when the industry employed 177.3 thousand workers, to 1986, with a workforce of 120.6 thousand. Since 1986, employment has remained fairly steady.

Table 9-2

TABLE 9-2. DISTRIBUTION OF ESTABLISHMENTS, REVENUE, AND EMPLOYMENT BY EMPLOYMENT-SIZE CLASS FOR THE SHIPBUILDING AND REPAIRING INDUSTRY, 1987

		Distribution by employment--size class (No. of employees)			Percent of Total		
	Total	1-99	100 - 999	1,000 +	1-19	20-99	100 +
	590	487	89	14	82.5	15.1	2.4
[6] $	8,504.4	764.9	2,128.7	5,610.8	9.0	25.0	66.0
[3]	120.2	11.5	26.7	81.8	9.6	22.2	67.5

presents the distribution of establishments, value of shipments, and employment by employment-size class for the shipbuilding and repair industry in 1987. Data in this form is not available in noncensus years.

This distribution is particularly interesting in that it points out the large number of relatively small establishments, and the small number of very large establishments. Four hundred and eighty-seven establishments have less than 100 employees. These establishments make up 82.5 percent of the total number of establishments in the industry, but employ only 9.6 percent of total industry employment, and account for 9.0 percent of industry value of shipments. Conversely, 14 establishments--only 2.4 percent of the industry total--have 1,000 or more employees, employ 67.5 percent of total industry employment, and account for 66.0 percent of industry value of shipments.

9.1.2.2 End-Use Markets End-use markets in the shipbuilding and repair industry can be divided into two broadly defined market segments: military and nonmilitary. The market segments refer to the end-use markets where the ships are delivered or repaired. In general, shipyards have the capability

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to produce both types of vessels, although many shipyards specialize in one or the other. Table 9-3

TABLE 9-3. PRODUCT CLASSES IN THE SHIPBUILDING AND REPAIRING INDUSTRY

Market segment	Product class
Military	Aegis Combat System Gas Turbine Powered Cruisers and Destroyers
	Advanced Design Corvettes
	Air Cushion Vehicle Amphibious Craft
	AO Diesel Powered Fleet Oilers
	AOE 6 Class Gas Turbine Powered Fast Combat Supply Ships
	Fast Missile Frigates for International Navies
	Gas Turbine and Pressure Fired Boiler Steam Powered Guided Missile Frigates
	Guided Missile Nuclear Cruisers
	Hydrofoil Missile Boats
	Iowa Class Battleships
	LHA and LHD Amphibious Assault Ships
	LSD Diesel Powered Landing Ship Dock Amphibious Ships
	Mine Warfare Ships
	Nimitz Class Nuclear Carriers
	Patrol and Missile Boats
	SSN 21 and SSN 688 Class Nuclear Attack Submarines
	Triton Ballistic Missile Nuclear Submarines
	Smaller Military Vessels, including naval vessels, Coast Guard drug interdiction patrol craft, and small army vessels
Nonmilitary	Cable Ships
	Containerships
	Double Hull Product Carriers
	Double Hull, Very Large Crude Carriers and Shuttle Ships
	Fast Catamaran and Hydrofoil Ferries
	Heavy Lift Ships
	Hospital Ships
	Integrated Tug-Barge Combinations
	Large Barge Carrying Ships
	Liquified Natural and Propane Gas Carriers
	Off Shore Supply Boats
	Ore/Bulk/Oil Combination and other Dry-Bulk Carriers
	Roll-On/Roll-Off Ships
	Small Coastal and Swath Cruise Ships/Mega Cruise Liners
	Surface Effect Passenger Ships
	Trailing Arm, Split-Hull Hopper and other dredges
	Other small nonmilitary vessels, including towboats, tugboats, ferries, casino boats, research vessels, and fireboats
Combined[a]	Barges, including Covered Dry Cargo Barges, Open Hopper Barges, Deck Barges, and Liquid Cargo (Tank) Barges

lists the products that are classified as military, nonmilitary, or combined (both military and nonmilitary applications). Of interest is the fact that ships have extensive and highly specialized end-uses.

Table 9-4

	No. of establishments		Value of shipments		Employment	
	Number	% of Total	10^6 \$[a]	% of Total	10^3	% of Total
[b]	261	100	8,186.5	100	114.1	100
	77	**29.5**	**6,914.2**	**84.5**	**95.8**	**84.0**
	17	6.5	5,324.1	65.0	75.9	66.5
	60	23	1,590.1	19.4	19.9	17.4
	164	**62.8**	**1,144.0**	**14.0**	**16.0**	**14.0**
	58	22.2	562.8	6.9	7.0	6.1
	106	40.6	581.2	7.1	9.0	7.9
[c]	**20**	**7.7**	**128.3**	**1.6**	**2.3**	**2.0**

U.S. Department of Commerce, Bureau of the Census. 1987 Survey of Manufacturers.

lists the number of establishments, value of shipments and employment for the military and nonmilitary market segments of the U.S. shipbuilding and repair industry. It is clear from the table that the military market segment dominates the industry. Seventy-seven establishments specialize in military construction and repair, accounting for 84.5 percent of value of shipments, 84.0 percent of employment. Military establishments comprise only 29.5 percent of the total reporting establishments, suggesting that these plants are on average considerably larger in terms of value of shipments and employment than nonmilitary establishments.

9.1.2.3 World Trade and Foreign Competition United States import and export data for 1989 and 1990 are listed in Table 9-5

TABLE 9-5. VALUE OF IMPORTS, VALUE OF EXPORTS, AND PERCENTAGE OF TOTAL REVENUE THE SHIPBUILDING AND REPAIRING INDUSTRY, 1989 AND 1990, 10^6 $

Year	Value of imports	Percentage of total value	Value of exports	Percentage of total value
1990[b]	18.1	0.18	455	4.4
1989	149	1.5	321	3.3

Source: U.S. Department of Commerce, International Trade Administration. U.S. Industrial Outlook, Washington, D.C., p. 22-1.

TABLE 9-6. GROSS TONNAGE AND PERCENTAGE OF WORLD ORDERS PLACED IN THE SHIPBUILDING AND REPAIRING INDUSTRY, 1991

Country/Region	Gross tonnage ordered	Percentage of world orders
Japan	7,282,756	40.5%
South Korea	3,496,693	25.6%
European Community	2,888,190	14.5%
Rest of the World	3,864,479	19.4%

Source: "World Order Book Hits 13-Year High at 43 million GT," Maritime Reporter and Engineering News: 1992 World Yearbook, June 1992, pp.25-26.

. As shown, both imports and exports make up a very small percentage of U.S. production. Imports and exports are minimal in both the military and commercial markets. Domestic military shipbuilding and repair is required by U.S. law to be performed in U.S. shipyards. Commercial vessels used in domestic trade are required, by the Jones Act, to be built and repaired in the U.S., thus minimizing commercial imports..

On the export-side, the U.S. has not established itself as a major global competitor, and therefore is not situated firmly in the export market. Table 9-6 presents the major shipbuilding countries and regions in terms of gross tons ordered in 1991. As shown, Japan and South Korea are far and above the world leaders in shipbuilding and repair, combining to account for 66.1 percent of gross tonnage ordered in 1991. The U.S., which falls in the "rest of the world" category, ranked 27th in the world in 1991, with less than 1 percent of world gross tonnage.[5] Germany was the number one producer in the European Community, ranking third in the world with 4.8 percent of 1991 gross tonnage.[6]

9.1.3 First-Tier Shipyards

9.1.3.1 Overview There are currently 108 first-tier shipyards operating in the United States.[7] The majority of these shipyards have the capability to produce very large naval ships, including carriers, battleships, submarines, and barges, as well as commercial ships such as large cruise liners and liquified natural gas carriers. Even though the building and repair of the smaller ships is concentrated in the second tier, many first-tier shipyards build and repair ships less than 400 feet in length..

Table 9-7

TABLE 9-7. MAJOR U.S. PRIVATELY-OWNED FIRST TIER SHIPBUILDING FACILITIES

Company	Location	Employment
Avondale Industries, Inc. - Avondale Shipyards Division	New Orleans, LA	7,211
Bath Iron Works Corporation	Bath, ME	9,504
General Dynamics Corp. - Electric Boat Division	Groton, CT	18,000
Ingalls Shipbuilding, Inc.	Pascagoula, MS	17,200
National Steel and Shipbuilding Company (NASSCO)	San Diego, CA	3,931
Newport News Shipbuilding	Newport News, VA	26,000
Norshipco - Norfolk Division	Norfolk, VA	2,879
Portland Ship Repair Yard	Portland, OR	2,000
Southwest Marine	San Diego, CA	1,273
Tampa Shipyards, Inc.	Tampa, FL	1,142
Todd Pacific Shipyards Corporation - Seattle Division	Seattle, WA	1,278

Source: "U.S. Maritime Directory Listings," Marine Log, June 1992, pp.49-59.

lists the 11 largest privately-owned facilities, in terms of number of employees, in the first tier of shipbuilding and repair. As reported in June, 1992, these facilities had a collective labor force of 90,418.[8] Figure 9-1

displays the geographic location of these 11 facilities. As shown, production is concentrated in three broadly defined regions: the Atlantic Coast, the Pacific Coast, and the Gulf Coast.

Although all first-tier facilities have the capability to manufacture very large ships, they do not necessarily employ large numbers of production workers, nor do they always generate revenues in excess of tier-two shipyards. For example, the Ingalls Shipbuilding, Inc. first-tier yard, in Pascagoula, Mississippi, employs a labor force of 15,531, while the Fraser first-tier shipyard on Howards Bay in Superior, Wisconsin, has a labor force of only 160 people.[9]

9.1.3.2 Ship Repairs In 1991, forty-one of the 108 first-tier shipyards were capable of conducting repairs on ships over 400 feet in length.[10] It is difficult to draw a sharp distinction between a shipbuilding and ship repair yard, as many shipyards engage in both types of work.[11].

9.1.3.3 Consumption Consumption in the first tier is divided into two broadly defined market segments: military and commercial. In the military market segment, the U.S. Navy and the U.S. Maritime Administration has identified the U.S. Active Shipbuilding Base (ASB), which is defined as those privately-owned shipyards that are open and currently engaged in or seeking

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contracts for the construction of major oceangoing or Great Lakes ships 1,000 gross tons or over.[12] At the end of 1991, 16 shipyards operated in the ASB. Approximately 82.4 thousand employees, or 68 percent of total shipbuilding and repairing employment, are employed by the ASB.[13]

Ninety-four percent of the production workers at ASB facilities are engaged in Navy or Coast Guard ship construction and repair work.[14] Thus, consumption in the ASB, and therefore in the first-tier, is highly reliant on military contracts.

In 1991, U.S. shipyards had 82 new naval ships on order or under construction, and three commercial ships under construction (zero commercial ships were ordered in 1991).[15] Therefore, consumption in the commercial market segment is negligible.

9.1.3.4 Vertical Integration First-tier shipyards are completely vertically integrated, with steel fabrication, metal cleaning and coating, carpentry, welding and painting, and many other functions generally located at the same site. Figure 9-2

Figure 9-2. Example of vertical integration in first-tier shipyards.

displays the previously mentioned Ingalls Shipbuilding yard.[16] The wide variety of on-site activities presented here is typical of the shipbuilding and repair industry. Even small and medium shipyards, employing a relatively small number of employees, are vertically integrated in this manner..

9.1.3.5 Market Concentration The first tier of the shipbuilding and repair industry is highly concentrated. While market-share data is not available, 1987 census data indicates that the 14 establishments with employment in excess of 1,000 workers at this time account for 66.0 percent of industry value of shipments. It is likely that this level of concentration will continue to prevail in 1992..

9.1.3.6 Demand Demand for first-tier ships is divided between the military and commercial sector of the economy. Since military end-uses are driven by the need for national security, demand is thought is be highly inelastic in this sector. Determinants of demand for commercial end-uses are much less easy to pin down, since the end-uses are so diverse. End-use demands are derived from the demand for cruise vacations, petroleum .

shipping, and dry-bulk shipping, to cite a few examples. At this point, demand elasticities for the commercial segment of first-tier shipbuilding have not been estimated.

9.1.3.7 Foreign Competition The military segment in first-tier shipyards is protected from foreign competition since all vessel production and repair activities must be performed in domestic shipyards..

In contrast, the commercial sector of first-tier shipyards is subject to intense competition. Table 9-8 displays the U.S. share of 1989 and 1990 world shipbuilding orders, in numbers of ships and deadweight tons. As shown, the U.S. received zero commercial orders in 1989, and only three orders in 1990. Moreover, those three orders were for use in domestic trade, and were therefore protected from foreign competition. No new orders for commercial ships were placed in 1991.

TABLE 9-8. ORDERBOOKS FOR COMMERCIAL SHIPS: THE U.S. FIRST-TIER SHIPYARDS AS A PERCENTAGE OF WORLD ORDERS

	1989	1990
U.S.		
No. of ships	0	3
Percent of world orders	0.0	0.2
Dead-weight tons	0	42,107
Percent of world orders	0	0.1
World		
No. of ships	1,433	1,909
Dead-weight tons	56,598,587	71,749,810

Source: "World Order Book Hits 13-Year high at 43 million GT," Maritime Reporter and Engineering News: 1992 World Yearbook, June 1992, pp.25-26.

9.1.3.8 Future Prospects Shipbuilding and repair for the military market segment will continue to be the primary source of employment will decline substantially after 1992 due to a reduction in Navy shipbuilding.[18].

Accompanying this decline will be attempts to expand commercial production. Global competition in this area is vigorous, and so demand is likely to grow slowly. Increased demand for double-hull tankers, stemming from the Oil Pollution Act of 1990, could provide an opportunity for U.S. shipbuilders.[19]

Near-term needs for tanker overhaul could also provide a market for ship repairs. The world tanker fleet is aging, and more than 45 percent of the fleet is over 25 years old.[20]

It is clear that global demand for tier-one commercial vessels will increase substantially by the year 2000.   However, since the U.S. shipbuilding and repair industry has not demonstrated global competitiveness, it is not clear what share of this growing market they will garner. Demand in the near term is forecasted to decline by about 1.6 percent based on a reduction in military consumption.[21]

9.1.4 Second-Tier Shipyards

9.1.4.1 Overview There are approximately 300 second-tier shipyards operating in the United States. These shipyards build and repair three general classes of ships: **power driven vessels**, including tugboats, towboats, offshore supply boats and crew boats, fishing vessels, ferries and passenger vessels, and military vessels; **river barges**, including hoppers, tank barges, deck barges, and machinery barges; and **offshore barges**, including dry cargo hopper and deck barges, tank barges, and machinery barges..

Second-tier shipyards are diverse in terms of employment levels. In mid-1992, individual facilities ranged in employment from less than twenty employees to over 1,000.[22] Total

9.1.4.2 Production New construction activity from 1982 to 1991 is presented in Table 9-9

TABLE 9-9. NEW CONSTRUCTION ACTIVITY IN TIER-TWO SHIPYARDS, 1982 - 1991 (Number of Vessels)[a]

Year	Power-driven vessels	River barges	Offshore barges
1991	122	604	4
1990	90	521	12
1989	196	571	29
1988	237	278	6
1987	348	145	9
1986	239	166	5
1985	300	277	8
1984	350	221	10
1983	240	483	17
1982	665	808	108

[a]These number are based on a sample of tier-two shipyards. Thus, the total number od vessels produced is likely to be understated. However, it is estimated that the sample represents eighty percent of tier-two employment. Therefore, trends in production are considered representative of tier-two shipyards.

Source: American Waterways Shipyard Conference. 1991 Annual Shipyard Survey, Arlington, VA., p. 7

. As shown, production is considerably lower in 1991 than in 1982. In the late 1970s and early 1980s, production in the second-tier peaked due to expectations of increased demand for second-tier ships. These expectations stemmed from the perception of growing demand for ships used for grain and coal exports.[24] In addition, tax .

incentives built into the 1981 tax reform law, including accelerated depreciation and the investment tax credit, also served as an incentive to step up output efforts.[25] When export markets failed to absorb the second-tier's growing output, overcapacity became the norm, depressing prices and leading to industry contraction of second-tier shipbuilding.[26]

9.1.4.3 Ship Repairs Repair activity in the second tier is presented in Table 9-10

TABLE 9-10 . REPAIR ACTIVITY IN TIER-TWO SHIPYARDS, 1982 - 1991 (Number of Vessels)[a]

Year	Power-driven vessels	River barges	Offshore barges
1991	7,721	23,386	407
1990	5,982	15,825	752
1989	5,974	13,810	356
1988	8,613	11,071	397
1987	7,886	11,345	333
1986	7,341	9,399	317
1985	6,606	7,079	531
1984	6,085	9,631	484
1983	5,422	8,958	531
1982	4,652	7,399	377

[a]These number are based on a sample of tier-two shipyards. Thus, the total number of vessels repaired is likely to be understated. However, it is estimated that the sample represents about eighty percent of tier-two employment. Therefore, trends in production are considered representative of tier-two shipyards.

Source: American Waterways Shipyard Conference. 1991 Annual Shipyard Survey, Arlington, VA., p. 11

. In contrast to new construction, repair activity has increased substantially throughout the decade. Shipowners have shown a marked preference for upgrading and overhauling older ships rather than investing in new ships. This is due to the market uncertainty that has characterized second-tier shipbuilding in the 1980s..

9.1.4.4 Consumption Consumption in the second tier is divided between two broadly defined market sectors: commercial and military. Unlike first-tier shipyards, the second tier relies on commercial orders for the bulk of its production and repair activities. Military consumption is concentrated in the market for power-driven vessels. These vessels are small ships primarily supplied to the Navy, Army and Coast Guard. Table 9-11

TABLE 9-11. NEW CONSTRUCTION AND REPAIR ACTIVITY IN TIER-TWO SHIPYARDS; THE MILITARY SECTOR, 1982 - 1991 (Number of Vessels)[a]

Year	Number of military power driven-vessels constructed	Percent of total	Number of military power driven-vessels repaired	Percent of total
1991	52	42.6	416	5.4
1990	27	30.0	495	8.4
1989	39	19.9	456	7.6
1988	119	50.2	450	5.2
1987	122	35.1	432	5.5
1986	90	37.7	375	5.1
1985	120	40.0	547	8.3
1984	120	34.3	387	6.4
1983	35	14.6	327	6.0
1982	18	2.7	387	6.2

[a]These number are based on a sample of tier-two shipyards. Thus, the total number of vessels repaired is likely to be understated. However, it is estimated that the sample represents about eighty percent of tier-two employment. Therefore, trends in production are considered representative of tier-two shipyards.

Source: American Waterways Shipyard Conference. 1991 Annual Shipyard Survey, Arlington, VA., pp. 8 and 12 lists the number of military power-driven vessels constructed and repaired from 1982 to 1991, as well as the percent of the total power-driven vessel market they make up. As shown, military consumption of newly-constructed ships varied greatly throughout the decade. Military repair work was more steady, ranging from 5.1 percent to 8.4 percent of total repairs of power-driven vessels..

New construction and repair of river barges and offshore barges, as reported earlier in Tables 9-9 and 9-10, is devoted to the consumption of the commercial market.

9.1.4.5 Vertical Integration As with first-tier shipyards, second-tier shipyards are completely vertically integrated. All phases of production, from design to launch, are performed on the same site.[27] Steel fabrication, structural assembly, engine and propeller assembly, communications and navigation equipment installation, and coatings application are .

done at the shipyard.[28] Thus, second-tier shipyards employ marine engineers, pipefitters, welders, electricians, carpenters, painters, and other skilled craftsman.[29]

9.1.4.6 Market Concentration Data relating specifically to market concentration is not available for second-tier shipyards. Revenue data is particularly difficult to secure. However, a sense of the extent of market concentration in the second tier can be gleaned from industry employment data. Total employment in the second tier during 1991, mentioned above in Section 9.4.1, was estimated to be 33,715. Employment varies widely from facility to facility. Only one facility in the second tier is thought to have greater than 1,000 employees, and many have less than 20. Assuming employment levels are closely correlated with production levels, it is concluded here that the second tier is not very highly concentrated..

9.1.4.7 Demand Demand for ships in the second tier is tied closely to conditions in the general economy. Thus, cyclical fluctuations at the macro-level are mirrored by the second-tier shipyards..

The determinants of demand for second-tier shipyards varies greatly, as do end-use markets. Production for the military market is marked by highly inelastic demand, derived from the demand for national security. Demand on the commercial side derives from diverse end uses, including riverboat gambling, fishing and grains processing. At this point no demand elasticities have been estimated for the commercial side of second-tier shipbuilding.

9.1.4.8 Foreign Competition Competition from overseas manufacture and repair of commercial ships in the second tier is minimized by the Jones Act. This law requires that vessels used in the domestic trade be built and repaired in the United war.[31] Thus, second-tier commercial shipbuilding and repair is protected from competition from abroad..

Military production in the second tier is also protected from global competition, as military vessels are built and repaired in the U.S. for national security reasons.

9.1.4.9 Future Prospects The lion's share of second-tier production is protected from foreign competition by the Jones Act. Thus, unlike in the first tier, production of commercial vessels is an assured market throughout the 1990s. One area of increased demand is likely to come from construction of riverboat casinos since gambling on riverboats has been legalized in Missouri, Iowa, and Louisiana. Growth in demand for second-tier commercial vessels is likely to mirror GNP growth, in the range of 2 to 3 percent through the mid-1990s. .

9.2 ECONOMIC IMPACT ANALYSIS

9.2.1 Introduction

Economic impacts are estimated for markets as well as facilities that are affected by the NESHAP. Market-level impacts will take the form of price and output adjustments stemming from the shifting market-supply curve, while facility-level impacts are analyzed as they alter the cost structure of individual manufacturers.

The NESHAP will influence the behavior of those facilities operating in the shipbuilding and ship repair industry (SIC 3731). This industry does not fit neatly into one well-defined market. Rather, several market segments must be delineated because the industry's goods and services account for several distinct end-uses.

Specifically, the shipbuilding and repair industry can be characterized by three features that distinguish market segments. First, facilities produce for military and commercial end-uses.

"tiers" of manufacture -- the first tier and the second tier -- which for the most part do not compete with each other in the marketplace.** These market segments were discussed in the industry profile.

Twenty-five shipyards have been identified as major HAP sources that are impacted by the NESHAP. In order to gauge the nature and magnitude of market-level impacts, we must identify the market segments in which the major-source shipyards operate. These market segments are characterized in terms of employment, value of shipments, and number of establishments. Data on these characteristics are derived from five sources: (1) the U.S. Department of Commerce, Bureau of the Census' 1987 Survey of Manufactures; (2) the American Waterways Shipyard Conference 1991 Annual Shipyard Survey; (3) The "U.S. Maritime Directory Listings," from Marine Log, June 1993; (4) the U.S. Department of Transportation, Maritime Administration's Report on Survey of U.S. Shipbuilding and Repair Facilities, 1992; and (5) Clean Air Act Section 114 survey responses.

Since the impacted shipyards are known, the approach for estimating NESHAP impacts involves constructing economic representations of each shipyard. The names of the impacted shipyards will not be identified when discussing specific impacts.

9.2.2 Quantifying The Industry

The number of establishments operating in SIC 3731 is estimated by the 1987 Census of Manufactures to be 590.[32] Establishments are stand-alone operations, but in some cases, more than one establishment is operated by the same company. We use this same estimate to represent the number of establishments existing in the base year of analysis, 1991. While it is

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possible that the number of establishments has changed since 1987, there is some evidence that the changes have not been wholesale. First, value of shipments in real terms has varied only slightly, increasing by only 2.2 percent between 1987 and 1991.[33] In addition, employment in SIC 3731 has declined slightly, from 120,200 in 1987 to 120,000 in 1991.[34] Furthermore, there is no discussion in the industry literature of **significant** consolidation, entrants to, or exits from the market.

Other sources of data on the number of establishments differ from the census figure, but they tend to be incomplete. The "U.S. Maritime Directory Listings," from Marine Log, June 1993, presents results of a survey to which 428 shipbuilding and repair facilities responded.[35] This listing is admirable for its level of detail, but is likely to be an understatement since it is a survey. Additional data sources report only on selected portions of the industry.

Along with the 1987 census figure of 590 establishments, 1991 totals for the value of shipments and employment are $8.694 billion and 120 thousand, respectively.

Producers of drilling and production platforms are exempt from this NESHAP. Bureau of Census figures show that in 1987, nine facilities engaged in the production of these vessels. Value of shipments and employment for these facilities is estimated at $20 million and 271, respectively. Thus, the industry data we use for estimating impacts is as follows:

1. number of establishments = 581
2. value of shipments = $8.674 billion
3. employment = 119,729

The Bureau of Census reports only on privately owned firms, but the U.S. Government's Department of the Navy also owns and operates shipyards. The Office of the Navy Comptroller's Budget survey responses include data on eight of these facilities. The total number of employees at these facilities is reported as 49,604. Revenue, excluding one facility, totals $3,942.9 billion in 1991. These are all first-tier facilities engaged in military repair activities. All new military construction contracts are awarded to commercial shipyards. Impacts on government-owned facilities are estimated separately from those on privately-owned facilities.

9.2.3 Defining Market Segments

With the industry as a whole quantified, we must also define the specific market segments. The tasks are to separate total industry data into the first and second tier, military and civilian end-uses, and construction and repair facilities.

Data on the first and second tiers are readily available from two sources: The U.S. Department of Transportation, Maritime Administration's Report on Survey of U.S. Shipbuilding and Repair Facilities, 1992, and the American Waterways Shipyard Conference 1992 Annual Shipyard Survey. These surveys cover the first and second tier, respectively. The former survey is conducted by the Maritime Administration to determine if national defense needs and national emergencies can be responded to adequately.[36] This report is comprehensive and lists 108 first tier facilities.[37] These are the largest facilities in the industry, and they account for the lion's share of employment and value of shipments. Total employment in the first tier for 1987 is estimated to be approximately 90,000. This estimate represents about 75 percent of industry employment. Bureau of Census data reveals that while value of shipments increase with establishment size, value of shipments per employee is fairly constant. Using this correlation, we estimate total value of shipments for the first tier to be 75 percent of industry value

The second tier accounts for the remainder of the industry, so second-tier data is derived simply by subtracting first-tier data from the industry totals. This calculation gives an estimate of 482 facilities in the second-tier, with a total value of shipments of $2.169 billion and employment of 30,000.

Bureau of Census data indicate that facilities producing for military end-uses account for 84.5 percent of industry value of shipments, 84 percent of industry employment, and 29.5 percent of total industry establishments. Unfortunately, no data is available for the actual percentage of production accounted for in the military market segment in the first tier. Nevertheless, we know that first tier establishments are highly dependent on military consumption. Since all facilities are dependent to a large extent on demand from the military sector, we assume, for purposes of assessing impacts, that the entire first tier is comprised of military establishments. Of the three commercial contracts awarded to first-tier shipbuilders in 1991, all were awarded to facilities which rely on military contracts for the majority of their production.

The breakdown of new construction and repair facilities in the first tier is based on Bureau of Census data. For military facilities, the 1987 Census of Manufactures indicates that 77 percent of value of shipments, 79 percent of employment, and 22 percent of the number of establishments are devoted to new construction. The remaining facilities are engaged in ship repairing.

In the second tier, the bulk of production is delivered to commercial markets. Of the total number of vessels **constructed** in the second tier in 1991, only 7.0 percent were for military end-uses. Of the total number of vessels **repaired** in the second tier in 1991, only 1.3 percent were for military end-uses. No

Thus, we assume that the proportion of vessels constructed and repaired is equivalent to the proportion of revenue generated by military production in the second tier. Employment for second-tier military facilities is based on industry averages of revenue per employee. The industry average of $72,450 per employee applies fairly well across facility size as reported in the Census of Manufactures. We estimate the number of establishments for second-tier construction and repair facilities based on the second-tier average employment per company.

Table 9-12

TABLE 9-12. MARKET SEGMENTS IN THE SHIPBUILDING AND REPAIRING INDUSTRY: PRIVATELY OWNED SHIPYARDS

Market segment	No. of establishments	Real value of shipments, 1991 $ mil	Employment
First Tier Facilities			
Military construction	24	5,009.47	70,939
Military repair	84	1,496.33	18,857
Second Tier Facilities			
Military construction	33	151.8	2,086
Military repair	9	43.37	597
Commercial construction	190	966.98	11,989
Commercial repair	241	1,006.45	15,260
Industry totals	581	8,674.4	119,729

TABLE 9-13. MARKET SEGMENTS IN THE SHIPBUILDING AND REPAIRING INDUSTRY: GOVERNMENT OWNED SHIPYARDS[a]

Market segment	No. of establishments	Real value of shipments, 1991 $ mil	Employment
Military repair, first tier only	9	4,435.8	55,805

[a]Estimates of value of shipments and employment are extrapolated linearly for nine establishments from the Section 114 survey data on eight establishments.

presents the market-segment allocation for privately owned shipyards that results from the above allocation procedure, and Table 9-13 presents the allocation for government-owned shipyards.

9.2.4 <u>Model Plants</u>

Model plants were developed for potentially affected shipyards for the purpose of estimating the costs and environmental impacts of control requirements. The model plants are based on the type of work performed (construction vs. repair) and the relative size of the shipyard (small, medium, or large) in terms of annual paint and solvent usage. The distinctions between military and commercial, and first and second tier facilities are not considered a major factor in determining control costs or environmental impacts. For a detailed description of model plants, refer to BID Chapter 8. For the 25 major source shipyards affected by this NESHAP, the model plant allocation is as follows: six large construction yards, five medium construction yards, four large repair yards, and ten medium repair yards. No model plant distinctions were made based on military and commercial market segments, or on the tier of operation.

The identity of each of the 25 major-source shipyards is known. However, some of the economic data pertaining to each yard is confidential business information (CBI) obtained from the Section 114 survey responses. Thus, economic profiles will not be presented in the EIA for each yard. Data will be aggregated and summarized wherever presented to avoid potential disclosure of CBI.

The shipyard-level data used in the analysis includes annual total revenue and employment. Annual total revenue and employment are taken from the Census of Manufactures and Section 114 survey responses.

Annual total revenue data is not available from Section 114 survey responses for 10 of the 25 affected facilities. When developing model plants, revenue data for these facilities is

The next step in the methodology is to assign the affected shipyards to market segments. As mentioned, the model plant assignment already provides a breakdown of affected shipyards by construction and repair. Each of the affected shipyards must be assigned to the tier within which it operates, and distinctions are made as to their end-use market, i.e. military or commercial.

The tier assignments are based on data from the U.S. Department of Transportation, Maritime Administration's Report on Survey of U.S. Shipbuilding and Repair Facilities, 1992, and from Marine Log, July 1993. The military/commercial distinctions are also based on these sources, and on Section 114 survey responses.

9.2.5 Control Costs

Total annual control costs are estimated for each model plant (see BID Chapter 8). Costs are identified for only one control option. Table 9-14 shows the control costs for each model plant. Annual costs are associated with recordkeeping and reporting requirements and the cost of switching to lower-VOC coatings.

TABLE 9-14. MODEL PLANT CONTROL COSTS

	Annual reporting and recordkeeping cost	Annual compliance costs	Total annual costs
Large construction	32,627	124,783	157,410
Large repair	32,627	43,448	76,075
Medium construction	9,825	40,217	50,042
Medium repair	9,825	12,306	22,131
Small construction	9,478	17,948	27,426
Small repair	9,478	6,814	16,292

Using the control costs in Table 9-14 and the model plant and market segment assignments as described in Section 9.2.4, it is now possible to apportion the control costs on a market apportionment of these costs will enable us to estimate the economic impacts for each market segment later in this analysis.

TABLE 9-15. COST IMPACTS BY MARKET SEGMENT

Market segment	No. of major sources	Total annual cost, 1991 $ mil
-------------------First Tier Facilities------------------		
Military construction	8	0.937
Military repair (private)	10	0.383
Military repair (public)	2	0.098
-------------------Second Tier Facilities----------------		
Military construction	2	0.100
Military repair	0	0.000
Commercial construction	2	0.207
Commercial repair	1	0.022
Totals	25	1.650

9.2.6 Market Segment Impacts

9.2.6.1 Maximum Price Increase A market price increase for each market segment is estimated assuming full-cost pass-through. This calculation involves comparing the total annual control costs (TAC) to total revenue (TR) for each market segment. Market segment annual control costs are simply the sum of the model plant control costs in each market segment. Two methods are used in this analysis to determine the maximum price increase..

In theory, if all facilities in a perfectly competitive market experience identical percent increase in the average cost of production due to regulation, the industry supply curve would shift by that amount. Therefore, for this method, a proxy for the supply shift is the average market-segment TAC-to-TR calculation.

Using the average industry response methodology described above, a maximum price increase for each market segment is then calculated. The results are presented in Table 9-16. As can be seen, this methodology estimates that only the second tier military construction market segment is expected to experience any price impacts. Under this scenario, this market segment would experience a maximum price increase of 0.1 percent.

TABLE 9-16. MAXIMUM PRICE INCREASE BY MARKET SEGMENT

Market segment	Average TAC-to-TR method	Marginal facility TAC-to-TR method
-------------------First Tier Facilities------------------		
Military construction	0.0%	0.1%
Military repair (private)	0.0%	0.1%
Military repair (public)	0.0%	0.0%
--------------------Second Tier Facilities----------------		
Military construction	0.1%	0.2%
Military repair	0.0%	0.0%
Commercial construction	0.0%	0.3%
Commercial repair	0.0%	0.0%

If facilities are differentially impacted, which is more often the case, the supply curve will shift by the amount dictated by the "marginal" facilities. Marginal facilities are those that are on average the least efficient, from a cost standpoint, at producing each unit of output. Since we are not able to identify the marginal facility either before or after the imposition of regulatory costs, the first method for estimating the maximum price increase is appealing. However, for the purpose of providing a conservative[***] assessment, in the second method of estimating the maximum price increase due to the NESHAP we assume that the facility with the highest TAC-to-TR ratio in each market segment is the marginal facility.

The results of the "marginal' facility approach are also presented in Table 9-16. As expected, the results show that a more significant price impact should be expected compared to the first method. For the first tier facilities, application of this scenario yields a 0.1 percent maximum price increase for the military construction and military private repair market segments. Expected price impacts for the second tier facilities include a 0.2 percent maximum price increase for the military construction market segment and a 0.3 percent maximum price increase for the commercial market segment.

The conclusion of these calculations is that the additional cost of the NESHAP is estimated to have relatively small impacts on the final price of a repaired or newly constructed ship. The price impact of the NESHAP on any market segment is estimated to be 0.3 percent or less and some market segments show negligible price increases.

9.2.6.2 Foreign Competition While the full-cost pass-through scenario identifies the maximum price adjustment, the competitive position of overseas shipbuilders and repairers could constrain the pricing discretion of domestic firms. However, most major commercial and all military construction and repair are protected from foreign involvement by the Jones Act, which requires that vessels used in domestic trade be built and repaired in the United States due to national security concerns..

9.2.6.3 Price Elasticities of Demand Estimates of price elasticities of demand are used to gauge the magnitude of the market quantity response to changes in market prices. No sources of elasticities for this industry have been identified. Thus,

<u>elasticity: (1) the nature of the good; (2) the availability of close substitutes; and (3) the share of expenditures in the consumers budget accounted for by the purchase of this good.</u>.

The market for military construction and repair is driven by the need for national security and the national defense budget, and there are no substitutes. Therefore, the demand for military goods and services is assumed to be extremely inelastic (i.e. the quantity purchased varies only slightly with price). A price elasticity estimate of 0.01 is sufficient to characterize this degree of inelasticity.

The market for commercial construction and repair is driven by the health of the overall economy, because most commercial vessels provide a portion of the U.S.'s commodity transportation infrastructure. Other commercial vessels include cruise ships and casino boats, which provide entertainment services, and dredges, which provide construction and reclamation services. Demand for all of these uses is subject to business cycle fluctuations. Limited substitutes for most commercial uses are available due to the nature of the goods being transported or special water-related uses. Typically, transportation is necessary for consumption of the good and is not a large portion of the price of the delivered good. Entertainment services can be considered nonnecessary, and thus sensitive to price. Taking into consideration all of these factors, we assume that the demand for commercial construction and repair is slightly elastic, suggesting an elasticity ranging from 0.25 to 0.75. However, to be conservative[****], we assume an elasticity of 1.00.

9.2.6.4 <u>Output, Revenue, and Employment Impacts From the price adjustments and demand elasticities, additional impacts including output, revenue, and employment adjustments are</u>

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calculated. An exponential demand equation is used for estimating output adjustments. .

These adjustments are calculated by solving the demand equation for the percentage change in quantity (%)Q), in the following way:

$$Q = aP^{e} \quad (1)$$

$$Q_0 = aP_0^{e} \quad (1A)$$

$$Q_1 = aP_1^{e} \quad (1B)$$

$$\%)P = \frac{P_1 - P_0}{P_0}$$

$$\%)Q = \frac{Q_1 - Q_0}{Q_0}$$

$$= \frac{aP_1^{e} - aP_0^{e}}{aP_0^{e}}$$

$$= \frac{P_1^{e} - P_0^{e}}{P_0^{e}}$$

$$= \frac{[P_0(1 + \%)P)]^{e} - P_0^{e}}{P_0^{e}}$$

$$= \frac{P_0^{e}(1 + \%)P)^{e} - P_0^{e}}{P_0^{e}}$$

$$= (1 + \%)P)^{e} - 1 \quad (2)$$

Where

Q = Quantity

a = Constant

^{e} = Price Elasticity

P = Price

Subscript = Time Period

Substituting %)P and e into the equation yields %)Q.

$$\%)TR=[(\%)P+\%)Q)+(\%)P\times\%)Q)] \qquad (3)$$

To calculate employment changes, we assume that a 1 percent change in output is equivalent to a 1 percent change in employment. This assumption implies a constant worker-to-output ratio for the industry, which may not be valid over the entire range of possible production levels at a given facility, but is reasonable for small changes from the baseline level.

The above assumptions and the price adjustments presented in Section 9.2.6.2 can now be used to estimate the impact of the NESHAP on the shipbuilding and repair industry's total output, employment, and revenue. Tables 9-17

TABLE 9-17. QUANTITY AND EMPLOYMENT IMPACTS BY MARKET SEGMENT: AVERAGE TAC-to-TR PRICE INCREASE METHOD

Market segment	Percent change in quantity produced	Percent change in employment	Employment change
-------------------First Tier Facilities------------------			
Military construction	0.0%	0.0%	0
Military repair (private)	0.0%	0.0%	0
Military repair (public)	0.0%	0.0%	0
-------------------Second Tier Facilities----------------			
Military construction	0.0%	0.0%	0
Military repair	0.0%	0.0%	0
Commercial construction	0.0%	0.0%	-3
Commercial repair	0.0%	0.0%	0

TABLE 9-18. TOTAL REVENUE IMPACTS BY MARKET SEGMENT

Market segment	Average TAC-to-TR method	Marginal facility TAC-to-TR method
-------------------First Tier Facilities------------------		
Military construction	0.0%	0.1%
Military repair (private)	0.0%	0.1%
Military repair (public)	0.0%	0.1%
--------------------Second Tier Facilities----------------		
Military construction	0.1%	0.2%
Military repair	0.0%	0.0%
Commercial construction	0.0%	0.0%
Commercial repair	0.0%	0.0%

and 9-18 present the results of these calculations. These results indicate that the costs of the NESHAP are expected to have a negligible impact on the industry's total output and employment.

However, Table 9-18 shows that the NESHAP may have a slight impact on the industry's revenue. Using the average industry response methodology, the military construction segment of the second tier is expected to experience a decrease in revenue of 0.1 percent. The "marginal" facility methodology yields a slightly greater impact estimate: all market segments in the first tier are expected to experience a 0.1 percent decrease in revenue while the military construction market segment in the second tier is expected to experience a 0.2 percent reduction in revenue. The other market segments in the second tier are not expected to be impacted.

9.2.7 Facility-Level Impacts

9.2.7.1 Ability of Facilities to Recoup Control Costs The ability of shipyards to recoup control costs through price increases is based on a comparison of facility-level costs with market-segment costs. The price increase necessary for a regulated facility to fully recoup annualized control costs may not be achievable if it is higher than the market-segment price increase. For the purposes of this analysis, a regulated facility's price increase will be considered significant if it is greater than 1 percent and deviates considerably from its market segment price increase. The 1 percent value will be referred to as the screening value..

This methodology of comparing a regulated facility's price increase to its market segment price increase is only possible if the market-segment average TAC-to-TR method of computing the maximum price increase is considered. The inability to recoup control costs has implications for shipyard profitability and capital availability.

Table 9-19 presents the results of the maximum price increase calculations for each facility. The facilities are identified by an assigned number rather than by the actual facility names. This method allows a discussion of the facility-level impacts to take place without the danger of disclosing potential confidential business information. This method of presenting data also prevents an identification of the market segment to which each facility belongs due to the interest of preserving each facility's anonymity.

TABLE 9-19. MAXIMUM PRICE INCREASE BY FACILITY

Facility	Maximum price increase	Facility	Maximum price increase
1	0.0%	14	0.0%
2	0.1%	15	0.0%
3	0.0%	16	0.0%
4	0.1%	17	0.2%
5	0.0%	18	0.0%
6	0.0%	19	0.0%
7	0.0%	20	0.1%
8	0.0%	21	0.3%
9	0.0%	22	0.0%
10	0.1%	23	0.1%
11	0.0%	24	0.0%
12	0.0%	25	0.1%
13	0.0%		

An examination of the data reveals that none of the facilities are expected to experience price increases greater than the screening value of 1 percent. In particular, with the exception of one facility expected to experience a price increase of 0.3 percent and another facility expected to experience a price increase of 0.2 percent, all other facilities show price increases of 0.1 percent of less. In addition, a comparison of each facility's maximum price increase to its corresponding market segment price increase reveals that the results of facility-level analysis are not significantly different from the results of the market segment analysis. Therefore, the conclusion of this analysis is that implementation of the NESHAP is not expected to significantly impact the twenty-five major-

9.2.8 Small Business Impacts

The Regulatory Flexibility Act requires Federal agencies to give special consideration to the impact of regulation on small businesses. The 1982 *Guidelines for Implementing The Regulatory Act* specify that a regulatory flexibility analysis (RFA) must be prepared if a proposed regulation will have (1) a significant economic impact on (2) a substantial number of small entities. Regulatory impacts are considered significant if:

i. Annual compliance costs increase total costs of production by more than 5 percent

ii. Annual compliance costs as a percent of sales are at least 20 percent (percentage points) higher for small entities

iii. Capital cost of compliance represent a significant portion of capital available to small entities

iv. The requirements of the regulation are likely to result in closures of small entities

A 1992 revision to the guidelines states that an RFA must be performed if there is any impact on any number of small businesses.

Small businesses in SIC 3731 are defined by the U.S. Small Business Administration as independently owned and operated firms with 1,000 or fewer employees. Eight of the 25 facilities affected by the NESHAP are considered small entities. To assess the potential for disparate impacts we examine the difference between the average TAC-to-TR ratio for large and small facilities in the same market segment.

The results of this comparison are presented in Table 9-20. An examination of the data reveals that small entities in the shipbuilding and repair industry are not expected to experience significantly greater economic impacts compared to the rest of small entities and the rest of the industry occurs in the first tier military construction market segment. Small entities in this market segment are expected to experience a slightly higher price impact than the remainder of the facilities in the same market segment. However, the difference in impacts is small and is not expected to put the small facilities at a competitive disadvantage compared to the other facilities in its market segment.

TABLE 9-20. SMALL BUSINESS IMPACTS BY MARKET SEGMENT

Market segment	No. of affected small businesses	Average small business TAC-to-TR	Average large business TAC-to-TR
-------------------First Tier Facilities------------------			
Military construction	2	0.1%	0.0%
Military repair (private)	5	0.0%	0.0%
Military repair (public)	0	N/A	0.0%
-------------------Second Tier Facilities----------------			
Military construction	0	N/A	0.1%
Military repair	0	N/A	N/A
Commercial construction	0	N/A	0.3%
Commercial repair	1	0.0%	N/A

N/A = not applicable.

The conclusion of this analysis is that a regulatory flexibility analysis is not required since the NESHAP is not expected to significantly impact a substantial number of small entities in the shipbuilding and repair industry.

9.3 REFERENCES FOR CHAPTER 9

1. Executive Office of the President, Office of Management and Budget. Standard Industrial Classification Manual, 1987, p. 238.

2. U.S. Department of Commerce, International Trade Administration. U.S. Industrial Outlook 1992, Washington, D.C., p. 22-2.

3. Reference 1, p. 62.

4. U.S. Department of Transportation, Maritime Administration. Report on Survey of U.S. Shipbuilding and Repair Facilities, 1991.

5. Reference 2, p.22-2.

6. Reference 2, p.22-2.

7. Reference 4, p. 3.

8. "U.S. Maritime Directory Listings," Marine Log, June 1992, calculated internally from employment figures, pp. 49 to 59.

9. Reference 4, pp. 14 and 18.

10. Reference 4, p.40

11. Reference 4, p.40.

12. Reference 4, p. 41.

13. Reference 2, p. 22-2.

14. Reference 5.

15. Reference 4, p.50.

16. Reference 4, p.19.

17. Reference 2, p. 22-5.

18. Reference 2, p. 22-5.

19. Reference 2, p. 22-6.

21. Reference 2, p. 23.

22. Reference 8.

23. American Waterways Shipyard Conference. 1991 Annual Shipyard Survey, Arlington, VA., p. 1, calculated based on available data and phone conversation with Laurie Sweningson.

24. Reference 2, p. 22-4.

25. U.S. Department of Commerce, International Trade Administration. U.S. Industrial Outlook 1987, Washington, D.C., p. 38-4.

26. Reference 2, p. 22-4.

27. The American Waterways Operators, Some Facts About the Nation's Tug and Barge Industry, not dated.

28. Reference 27.

29. Reference 27.

30. Reference 25, p. 38-4.

31. Reference 27.

32. The U.S. Department of Commerce, Bureau of the Census. 1987 Survey of Manufacturers.

33. Reference 1. Percentage change computed internally.

34. Reference 1.

35. The "U.S. Maritime Directory Listings," Marine Log, June 1992, p. 3.

36. The U.S. Department of Transportation, Maritime Administration. Report on Survey of U.S. Shipbuilding and Repair Facilities, 1991, p. 1.

37. Reference 5, p. 4.

APPENDIX A.

EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT

APPENDIX A.

EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT

The purpose of this study was to provide data to support the development of the proposed national emission standard for hazardous air pollutants (NESHAP) for surface coating operations within the shipbuilding and ship repair industry. To accomplish the objectives of this program, technical data were gathered on the following aspects of the industry: (1) surface coating operations and the associated solvent used for thinning, (2) the release and controllability of hazardous air pollutants (HAP's) emitted into the atmosphere from the above emission points, and (3) the types and costs of demonstrated emission control technologies. The bulk of the information was gathered from the following sources:

1. Technical literature;

2. Plant visits;

3. Questionnaires sent to industry;

4. Industry representatives;

5. State and regional air pollution control agencies; and

6. Equipment vendors.

Significant events relating to the evolution of the background information document are itemized in Table A-1.

TABLE A-1. EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT

Date	Company, consultant, or agency/location	Nature of action
08/27/91	Ameron Protective Coatings, Brea, CA Chugoku Marine Paints, Belle Chase, LA Devoe Coatings, Louisville, KY Hempel Coatings, Houston, TX International Paint Company, Houston, TX Proline Paint Company, San Diego, CA Seaguard Inc., Portsmouth, VA Sigma Coatings, Inc., Harvey, LA Valspar Corp., Minneapolis, MN	Section 114 information request sent by the U. S. EPA (as part of the CTG project)
01/21/92	Newport News Shipbuilding (NNS), Newport News, VA	Plant (shipyard) visit
01/22/92	Norfolk Shipbuilding and Drydock Corporation (NORSHIPCO), Norfolk, VA	Plant (shipyard) visit
01/23/92	Metro Machine Corporation, Norfolk, VA	Plant (shipyard) visit
01/23/92	General Dynamics Corporation (Electric Boat Division), Groton, CT Ingalls Shipbuilding, Pascagoula, MS National Steel and Shipbuilding Company (NASSCO), San Diego, CA Newport News Shipbuilding (NNS), Newport News, VA Norfolk Shipbuilding and Drydock Corporation (NORSHIPCO), Norfolk, VA Southwest Marine, Inc., San Diego, CA	Section 114 information request sent by the U. S. EPA (as part of the CTG project)
02/19/92	Department of the Navy, Secretary of Navy, Washington, DC	Request from U. S. EPA for assistance in the regulation of the shipbuilding and ship repair industry
03/12/92	Trinity Marine Group, New Orleans, LA Atlantic Marine, Jacksonville, FL Jeffboat, Jeffersonville, IN Bath Iron Works, Bath, ME MARCO Shipyard, Seattle, WA Portland Ship Repair, Portland, OR Todd Pacific Shipyard Corporation, Seattle, WA Campbell Industries, San Diego, CA Eastern Shipyards, Panama City, FL	Section 114 information request sent by the U.S. EPA
03/30/92	Department of the Navy, Naval Sea Systems Command (NAVSEA), Arlington, VA Portsmouth Naval Shipyard, Portsmouth, NH Norfolk Naval Shipyard, Norfolk, VA Philadelphia Naval Shipyard, Philadelphia, PA Charleston Naval Shipyard, Charleston, SC Pugent Sound Naval Shipyard, Bremerton, WA Pearl Harbor Naval Shipyard, Pearl Harbor, HI Long Beach Naval Shipyard, Long Beach, CA Mare Island Naval Shipyard, Valejo, CA	Section 114 information request sent by the U. S. EPA
04/01/92	Hall-Buck Marine, Inc. (HBM), Baton Rouge, LA	Plant (shipyard) visit

TABLE A-1. (continued)

Date	Company, consultant, or agency/location	Nature of action
04/02/92	Acadian Shipyard, Inc., Bourg, LA	Plant (shipyard) visit
04/02/92	Bourg Dry Dock and Service Company, Houma, LA	Plant (shipyard) visit
04/02/92	Detyens Shipyards, Inc., Mt. Pleasant, SC Texas Drydock, Inc., Orange, TX Southern Oregon Marine, Coos Bay, OR Fraser Shipyards, Superior, WI Al Larsen Boat Shop, Terminal Island, CA Dorchester Industries, Inc., Dorchester, NJ Duwamish Shipyard, Inc., Seattle, WA International Ship Repair, Tampa, FL Marine Industries NW, Inc., Tacoma, WA	Section 114 information request sent by the U.S. EPA
04/03/92	Bollinger Machine Shop and Shipyard, Inc., Lockport, LA	Plant (shipyard) visit
04/17/92	U. S. Environmental Protection Agency and Naval Sea Systems Command (NAVSEA) representatives	Meeting to discuss the shipbuilding and ship repair project and VOC rules
02/22/93	U. S. Environmental Protection Agency, Naval Sea Systems Command (NAVSEA), and Industry (shipyards and marine coating manufacturers) representatives, Norfolk, VA	Industry meeting
06/07/93	Mailed to industry members, selected vendors and trade associations	Letter requesting comment and additional information on lower-HAP coatings
06/29/93	Mailed to industry members and selected vendors	Request from U. S. EPA for comment on draft BID Chapters 3 through 6
09/01/93	U. S. Environmental Protection Agency, Naval Sea Systems Command (NAVSEA), and Industry (shipyards and marine coating manufacturers) representatives, Durham, NC	Industry meeting
09/16/93	Department of the Navy, Naval Sea Systems Command (NAVSEA), Arlington, VA	Information from NAVSEA on VOC compliant paints
09/28/93	Mailed to members of the Work Group	Work Group mailout
09/29/93	Department of the Navy, Naval Sea Systems Command (NAVSEA), Arlington, VA	Information from NAVSEA on military specifications and paint data base
10/01/93	Baker and Daniels, Indianapolis, IN representing Jeffboat, Jeffersonville, IN	Information on recommended thinning allowances for coating operations
10/07/93	Bath Iron Works, Bath, ME	Information on cold weather usage of solvents for coating reduction (thinning)
10/26/93	Norfolk Shipbuilding and Drydock, Corp. (NORSHIPCO), Norfolk, VA	Information sent from plant regarding recordkeeping and reporting

TABLE A-1. (continued)

Date	Company, consultant, or agency/location	Nature of action
11/08/93	Newport News Shipbuilding (NNS), Newport News, VA	Information sent from plant regarding recordkeeping and reporting
01/07/94	Mailed to Industry Members, Selected Vendors, and Trade Associations	Letter requesting comment on Inorganic Coatings, Inc. response paper

APPENDIX B.

INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

APPENDIX B.

INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

This appendix consists of a reference system which is cross-linked with the October 21, 1974, Federal Register (39 FR 37419) containing the Agency guidelines concerning the preparation of environmental impact statements. This index can be used to identify sections of the document which contain data and information germane to any portion of the Federal Register guidelines.

TABLE B-1. CROSS-INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT PORTIONS OF THE DOCUMENT

Agency guidelines for preparing regulatory action environmental impact statements (39 FR 37419)	Location within Background Information Document
1. Background and summary of regulatory alternatives	
Summary of the regulatory alternatives	The regulatory alternative(s) from which standards will be chosen for proposal are summarized in Chapter 1, Section 1.1.
Statutory basis for proposing standards	The statutory basis for proposing standards is summarized in Chapter 2, Section 2.1
Relationship to other regulatory agency actions	The relationships between EPA and other regulatory agency actions are discussed in Chapter 3.
Industries affected by the regulatory alternatives	A discussion of the industries affected by the regulatory alternatives is presented in Chapter 3, Section 3.1. Further details covering the business and economic nature of the industry are presented in Chapter 9, Section 9.1.
Specific processes affected by the regulatory alternatives	The specific processes and facilities affected by the regulatory alternatives are summarized in Chapter 1, Section 1.1. A detailed technical discussion of the processes affected by the regulatory alternatives is presented in Chapter 3, Section 3.2.
2. Regulatory alternatives	
Control techniques	The alternative control techniques are discussed in Chapter 4.
Regulatory alternatives	The regulatory alternative selected as MACT is defined in Chapter 6, Section 6.4. A summary of MACT is also included in Chapter 1, Section 1.1.
3. Environmental impact of the regulatory alternatives	
Primary impacts directly attributable to the regulatory alternatives	The primary impacts on mass emissions and ambient air quality due to MACT is discussed in Chapter 6, Section 6.4 and Chapter 7, Section 7.1. Tables summarizing the environmental impacts are included in Chapter 1.
Secondary or induced impacts	Secondary impacts for MACT are discussed in Chapter 7, Sections 7.1, 7.2, 7.3, 7.4, and 7.5.
4. Other considerations	A summary of the potential adverse environmental impacts associated with MACT is included in Chapter 1, Section 1.2, and Chapter 7. Potential socioeconomic and inflationary impacts are discussed in Chapter 9, Section 9.2. Irreversible and irretrievable commitments of resources are discussed in Chapter

APPENDIX C.

PRELIMINARY ANALYSIS OF ABRASIVE BLASTING AND PAINT (SOLIDS) OVERSPRAY

APPENDIX C.

PRELIMINARY ANALYSIS OF ABRASIVE BLASTING AND PAINT (SOLIDS) OVERSPRAY

This appendix typically contains emission source test data, but no test data were available (exists) for outdoor surface coating operations conducted within the shipbuilding and ship repair industry. In the absence of any emission source test data, this appendix provides the documentation developed as a preliminary analysis of HAP emissions generated by abrasive blasting and paint (solids) overspray. Three memos from the project file dated May 27, 1992, June 26, 1992, and October 28, 1992 have been included as attachments to Appendix C. These memos provide estimates of the magnitude of (potential) HAP emissions resulting from blasting and paint overspray, as well as cost effectiveness of various control options.

As an overview summary, the estimated airborne emissions of inorganic HAP's from blasting and paint (solids) overspray are on the order of a few kilograms (or pounds) per year (kg/yr [lb/yr]). Combined with the cost of the control options such as alternative blast media or vacuum blasting, the cost effectiveness was calculated to be several million dollars per megagram (Mg [ton]) of reduced HAP emissions. Based on this information, the decision was made not to include abrasive blasting or paint (solids) overspray as part of standard.

When these memos were prepared, the Agency planned to recommend into their rules. Subsequently, the Agency instead provided a report (EPA 453/R-94-032) that presented information on control technology for this industry that States could evaluate in developing their individual rules. Now, as part of this proposal, the Agency is requesting public comment on its recommendation for BACM included in the Preamble. The proposed BACM is identical to the proposed MACT for coatings and solvents.

Attachment 1

Date:

May 27, 1992

Subject:
Shipbuilding and Ship Repair NESHAP
Abrasive Blasting Operations and HAP Emissions
EPA Contract 68-D1-0115 : Work Assignment No. 25
ESD Project No. 91/53B ; MRI Project No. 6500-25

From:
Dave Reeves

To:
Laurel Driver
ESD/CPB/CAS (MD-13)
U. S. Environmental Protection Agency
Research Triangle Park, N.C. 27711

This memo provides a preliminary estimate of the magnitude of (potential) HAP emissions from abrasive blasting operations. The information on abrasive blasting has been compiled from the CTG Section 114 information requests, site visit questionnaires, available literature, and phone conversations with industry representatives. Both the abrasive media and the surface being abraded may emit HAP's. Some marine paints contain small amounts of heavy metals such as lead and chromium as pigment or as a trace contaminant with other metals like zinc.

Model shipyards from the East and West Coasts (NORSHIPCO and NASSCO, respectively) were chosen for HAP emission comparisons. Total HAP emissions (element specific) are calculated and presented for each of the model shipyards. NORSHIPCO's Berkley facility and NASSCO were chosen based on the amount of blasting and painting done, as well as the availability of HAP "solids" data on the paints applied. Both facilities represent large shipyards with 3,000 to 4,000 employees and major painting operations. Actual data from the CTG Section 114 responses were used for HAP emission calculations.

Combined emission estimates were calculated for each facility and a summary table is provided for comparing the two shipyards.

BLAST MEDIA

Black Beauty™ seems to be the medium of choice for several large shipyards, especially those on the East Coast. Black Beauty™ consists of crushed slag from coal-fired utility boilers and is relatively cheap (around $35 to $58 per ton) compared to other media. It is usually recovered on-site and then land-filled as a non-hazardous waste.

The first data we reviewed came from the virgin and spent (used) media analyses provided in three test reports from NORSHIPCO. These data were based on analysis of the leachate and showed only trace amounts (0.005 to 0.97 ppm) of toxic chemicals. Based on this data, the blast media is considered non-hazardous material by the state of Virginia (for a disposal determination only; leachate tests are usually specific to waste disposal considerations). However, the leachate test method does not give an accurate analysis of the actual composition of the material as it would be released into the air.

After receiving some of the CTG Section 114 responses, Virginia Materials Corporation was identified as a major supplier of Black Blast™ abrasive media to several East Coast shipyards. Upon request, a technical data sheet and an elemental analysis report on Black Blast™ was provided--see attached sheets. Chromium was identified at a 20 ppm level and lead at 10 ppm. These concentrations multiplied by the annual Black Blast™ usage result in total HAP amounts (lb) used as part of the abrasive blasting operations.

Many of the West Coast shipyards use copper slag for abrasive blasting operations. NASSCO in San Diego, California identified Minerals Research and Recovery, Inc. of Tuscon, Arizona as a major supplier of Sharpshot M - 60™, copper slag. Technical data sheets were provided and a total metal analysis (TTLC) test report shows chromium at 100 ppm (mg/kg) and lead at 20 ppm.

Both types of abrasive media (Black Blast™ and Sharpshot M-60™) are on the Navy's Qualified Products List: QPL-22262. The allowable limit for chromium is 2,500 ppm and 1,000 ppm for lead, per the Navy's military specification, MIL-A-22262A.

An area of great uncertainty is how much of the media actually becomes airborne as a result of the surface blasting. Some small media is typically recovered at the shipyards, we decided to use a range of 1 to 10 percent for our emission calculations. This is believed to be a conservative estimate based on most comments on what is thought to become airborne and actually carried beyond the drydock or fenceline boundary of the shipyard.

Chromium and lead were chosen for example calculations since they have the highest concentrations of the HAP components in the abrasive media. From the data supplied by the model shipyards (in the CTG Section 114 responses), the HAP usage/emissions were calculated and summarized--see attached table. Using the 1 and 10 percent emission (airborne) factors, annual chromium and lead emissions from the model shipyards are:

	Chromium, lb		Lead, lb		Total HAP, lb	
	1%	10%	1%	10%	1%	10%
NORSHIPCO, %	2.8	28	1.4	14	17	175
NASSCO	4.7	47	0.9	9	8.4	84

ABRADED PAINT

In order to estimate HAP emissions from the abraded paint removed during abrasive blasting operations, an assumption involving the amount of HAP's contained in the "old" coatings must be made. We decided to base our estimate on the HAP data provided by the model shipyards on the marine paints (total gallons) applied in 1991, as reported in the Section 114 responses.

Most of the paints containing HAP-solids material were either inorganic zincs used for corrosion resistance or yellow striping (safety marking) paint which contains lead chromate as the primary pigment. In recent phone conversations with two of the major marine coating manufacturers (International Paint and Ameron), the technical managers indicated that lead is being eliminated from their manufacturing processes. The replacement material for the pigment use is a synthetic organic material that is more expensive.

At NORSHIPCO, there were 120,148 gallons of marine paint applied - which contained a total of 189 lb of HAP-solids material. Lead accounted for 94 percent and chromium 6 percent of the HAP-solids. The average HAP-solids content of all marine paints used at NORSHIPCO in 1991 is 0.0016 lb/gal (189/120,148).

chromium 11 percent, and antimony compounds 4 percent. The average HAP-solids content of all marine paints applied at NASSCO in 1991 is 0.015 lb/gal (856/58357).

Another assumption was made to correlate the amount of "old" paint removed by abrasive blasting. Using the Navy's Mil-Specs as a reference, we assumed an average dry film thickness (dft) of 15 mils was removed. Most interior and exterior surfaces of a Navy ship have 6 to 10 mil (dft) specs. Antifoulant coatings used on the underwater hulls of surface ships and submarines are the exception and can have coating thicknesses of 20 to 25 mils (dft) - depending on service life requirements. We chose 15 mils to be conservative on our estimates and present a worst case scenario. It should be noted some industry representatives estimated as much as 50 percent of the original coating can wear off during service in the harsh marine environment.

The next assumption involved estimating an average surface coverage (square feet per gallon [ft^2/gal]) for all marine coatings. Most marine paint product data sheets list coverages of 100 to 400 ft^2/gal, with a dft of 3 to 6 mils. We chose an average coverage of 125 ft^2/gal (with a dft of 5 mils) for our emission calculations. Using the above assumption, 1 gal of "old" paint solids material is removed for every 42 (125/15 mils/5 mils) sq ft of surface blasted.

Annual HAP contents of the abraded paint were then calculated using the prepared (abrasive blasted) surface area data provided by the model shipyards. NORSHIPCO reported 2,339,000 sq ft prepared which removed 55,690 gal of paint. NASSCO reported 291,250 sq ft prepared which removed 6,935 gal of paint. Annual HAP-solids content of the abraded paint for each facility were determined to be:

NORSHIPCO - 55,690 gal * 0.0016 lb/gal = 89 lb

NASSCO - 6,935 gal * 0.015 lb/gal = 104 lb

Using the same range of 1 to 10 percent to estimate how much of the material becomes airborne, annual chromium and lead emissions from the abraded paint removed during abrasive blasting operations for each of the model shipyards are:

Chromium, lb		Lead, lb		Total HAP, lb	
1%	10%	1%	10%	1%	10%

CONCLUSIONS

The following summary table presents individual/combined chromium and lead emissions from the abrasive media and the abraded paint for both NORSHIPCO and NASSCO shipyards. Using the 1 percent emission (airborne) factor, annual emissions ranged from approximately 2 to 5 lb; using the 10 percent emission factor, the range was 19 to 47 lb.

Based on these calculations and assumptions, it appears that the level of HAP emissions from blasting is very minor compared to the amount of HAP's associated with paints and solvents. Also, when emission rates are compared with the major source cutoffs of 10 tons per year of a single HAP or an aggregate of 25 tons per year of all HAP's, emissions from blasting operations appear insignificant.

We propose the following options for your consideration involving regulation of blast media HAP emissions under this NESHAP: (1) narrowly define the source category so that abrasive blasting operations are specifically excluded; (2) determine or define some de minimis level of emissions below which regulatory action will not be considered; or (3) include abrasive blasting operations as an emission point within the major source shipyards, and therefore, include all follow-up effort (e.g., background discussion, model plants, controls, and costing) involving abrasive blasting. This decision will also provide precedence on how other HAP-emitting shipyard operations such as welding, gas freeing, and metal cutting/fabrication are to be handled.

Before a decision is reached, particularly one involving establishing a de minimis exemption, PAB probably should be consulted regarding the health hazard associated with metals emissions of this magnitude and the issue of industry-specific lesser quantity cutoffs.

TABLE 1. SUMMARY OF ANNUAL HAP EMISSIONS FROM ABRASIVE BLASTING OPERATIONS

Facility	NORSHIPCO	NASSCO
Location	(Berkley yard) Norfolk, Va.	San Diego, Ca.
Abrasive media (type)	Black Blast™ (coal slag)	Sharpshot M-60™ (copper slag)
Media cost, $/ton	58	64
Annual usage, tons	7,011	2,330
Area blasted, ft^2	2,339,000	291,250
HAP content of media		
- Chromium, lb/ton	0.04	0.03
- Lead, lb/ton	0.02	0.21
Annual HAP emissions from media (using 1% emission factor)		
- Chromium, lb	2.8	4.6
- Lead, lb	1.4	1.0
(using 10% emission factor)		
- Chromium, lb	28	46
- Lead, lb	14	10
Annual paint usage, gal	120,148	58,357
Total HAP-solids (lb) in paint	189	856
Avg HAP-solids content, lb/gal	0.0016	0.015
- % Chromium	94	85
- % Lead	6	11
"Old" paint removed, gal	55,690	6,935
Annual HAP emissions from paint (using 1% emission factor)		
- Chromium, lb	0.05	0.11
- Lead, lb	0.84	0.88
(using 10% emission factor)		
- Chromium, lb	0.5	1.1
- Lead, lb	8.4	8.8
Annual combined HAP emissions from blast media and paint		
(using 1% emission factor)		
- Chromium, lb	2.84	4.71
- Lead, lb	1.96	1.88
(using 10% emission factor)		
- Chromium, lb	28.4	47.1
- Lead, lb	19.6	18.8

Attachment 2

Date: June 26, 1992

Subject: Shipbuilding and Ship Repair NESHAP Paint (Solids) Overspray and HAP Emissions
EPA Contract 68-D1-0115; Work Assignment No. 25
ESD Project No. 91/53B; MRI Project No. 6500-25

From: Dave Reeves

To: Laurel Driver
ESD/CPB/CAS (MD-13)
U. S. Environmental Protection Agency
Research Triangle Park, N.C. 27711

This memo provides a preliminary estimate of the magnitude of (potential) HAP emissions from paint (solids) overspray. The information on painting operations has been compiled from the CTG and NESHAP Section 114 information requests, site visit questionnaires, available literature, and phone conversations with industry representatives. The following definition of overspray emissions has been adopted for the shipbuilding and ship repair NESHAP: paint material/components emitted to the air during application and estimated to cross the "plant" (shipyard) boundary while still airborne. This definition is a subset of transfer efficiency estimates involving coating operations.

38. Introduction

Marine painting operations at shipyards involve large quantities of HAP's, but most of the HAP's are solvents (e.g., xylene, toluene, and methyl isobutyl ketone) and are assumed to be 100 percent emitted to the air. Some marine paints contain small amounts of heavy metals such as lead and chromium as pigment or as a trace contaminant with other metals like zinc. The solids portion of marine paints can be emitted to the air as paint overspray. The purpose of this memo is to discuss and estimate HAP solids emissions from paint overspray in shipyards. The HAP solids portion of marine paints is an active part of the reformulation efforts already underway. Marine coating

Spray painting produces large quantities of wasted paint caused by turbulence of the high-velocity air impacting and rebounding from the surface and carrying paint with it. This wasted paint is referred to as "overspray." The skill of the painter has a significant impact on the transfer efficiency because angle of spray and distance from gun to surface, both of which affect efficiency, are at the control of the operator. Many other variables such as equipment (gun/nozzle) design and climatic conditions (wind, temperature, and humidity) can affect the amount of overspray.

Most ship exterior surfaces (particularly the hull) are very large and relatively flat and, therefore, have less overspray compared to small components with irregular shapes. Ship interiors and indoor painting operations also have minimal overspray emissions of solids material since they are enclosed and there is more time for the overspray paint solids to settle out. Interior painting usually involves some type of exhaust ducting to remove overspray from the work area.

In order to estimate HAP emissions from paint overspray, an assumption involving the amount of HAP's contained in the marine coatings must be made. We decided to base our estimate on the HAP data provided by two example shipyards on the marine paints (total gallons), as reported in the Section 114 responses.

Actual shipyards from the East and West Coasts (NORSHIPCO and NASSCO, respectively) were chosen for HAP emission comparisons. Total emissions of HAP solids (element-specific and combined) were calculated and presented for each of the example shipyards. NORSHIPCO's Berkley facility and NASSCO were chosen based on the amount of painting done as well as the availability of HAP solids data on the paints applied. Both facilities represent large shipyards with 3,000 to 4,000 employees and major painting operations. Actual data from the Section 114 responses for the shipbuilding CTG were used to calculate HAP emissions.

Most of the paints containing HAP solids material were either inorganic zincs used for corrosion resistance or yellow striping (safety marking) paint, which contains lead chromate as the primary pigment. In recent phone conversations with two of the major marine coating manufacturers (International Paint and Ameron), the technical managers indicated that lead is being eliminated from their manufacturing processes. The replacement pigment material is a non-HAP synthetic organic material that is more expensive

39. <u>HAP Solids Content and Emissions</u>

According to the Section 114 response, in 1991 at NORSHIPCO, there were 120,148 gallons (gal) of marine paint applied, which contained a total of 189 pounds (lb) of HAP solids material. Lead accounted for 94 percent and chromium 6 percent of the HAP solids material. NASSCO reported 58,357 gal of paint applied with a total HAP solids content of 665 lb. Lead accounted for 94 percent and chromium, 6 percent.

For a first estimate of HAP solids emissions, we considered all HAP solids material as actual HAP's (emitted to the air and carried beyond the "fenceline" boundary of the shipyard). A range of 10 to 50 percent overspray was chosen based on the EPA SARA Title III Section 313 Release Reporting Guidance Document <u>Estimating Chemical Releases From Spray Application of Organic Coatings</u>. The following HAP solids emissions from paint overspray for the shipyards are believed to be worst-case estimates:

Facility	NORSHIPCO	NASSCO
Location	(Berkley yard) Norfolk, VA	San Diego, CA
Annual paint usage, gal	120,148	58,357
Total HAP solids (lb) in paint	189	665
HAP solids content, lb		
Chromium	11	39
Lead	178	626
Total HAP's	189	665
Annual HAP solids emissions (using 10% overspray factor)		
- Chromium, lb	1.1	3.9
- Lead, lb	17.8	62.6
- Total HAP's, lb	18.9	66.5
(using 50% overspray factor)		
- Chromium, lb	5.5	19.5
- Lead, lb	89.0	313.0
- Total HAP's, lb	94.5	332.5

An area of great uncertainty is how much of the paint solids material actually remains airborne as a result of the paint overspray and is carried beyond the fenceline boundaries of the shipyard. This is particularly difficult to estimate since most ship painting operations are performed on vessels in or near some industry representatives estimate that 90 to 95 percent of the paint solids material in overspray is confined (falls to the ground) within the shipyard property, the following analysis was performed assuming 1 to 10 percent of the paint solids material becomes and remains airborne HAP particulate for the emission estimates.

Using the above range of 1 to 10 percent to estimate how much of the material stays airborne, annual chromium, lead, and total HAP emissions from the paint overspray for each of the model shipyards are:

	Chromium, lb		Lead, lb		Total HAP, lb	
	1%	10%	1%	10%	1%	10%
NORSHIPCO	0.11	1.1	1.78	17.8	1.89	18.9
NASSCO	0.39	3.9	6.26	6.26	6.65	66.5

40. CONCLUSIONS

The above HAP solids emission estimates present chromium, lead, and total HAP emissions from the paint overspray at both NORSHIPCO and NASSCO shipyards. Using the 1 percent emission (airborne) factor, annual emissions of lead and chromium ranged from approximately 0.1 to 6.3 lb; using the 10 percent emission factor, the range was 1 to 63 lb.

Based on these calculations and assumptions, it appears that the level of HAP solids emissions from paint overspray is minor compared to the amount of HAP emissions associated with paint solvents and cleanup solvents (which is on the order of 200 tons/yr for each of the two facilities). Also, when emission rates are compared with the major source cutoffs of 10 tons/yr of a single HAP or an aggregate of 25 tons/yr of all HAP's, emissions of HAP solids from paint overspray appear insignificant. Paint manufacturers have reported the trend for HAP solids in marine coatings is decreasing, particularly for lead.

We propose the following options for your consideration involving regulation of paint overspray and HAP emissions under this NESHAP: (1) redefine the source category so that HAP solids from paint overspray are handled differently than the solvents or perhaps specifically excluded; (2) determine or define some de minimis level of emissions below which regulatory action will not discussion, model plants, controls, and costing) involving paint overspray.

Before a decision is reached, particularly one involving establishing a de minimis exemption, the Pollutant Assessment Branch probably should be consulted regarding the health hazard associated with metals emissions of this magnitude and the issue of industry-specific lesser quantity cutoffs.

Attachment 3

Date: October 28, 1992

Subject: Shipbuilding and Ship Repair NESHAP
Cost Effectiveness of Reducing HAP Emissions from
Abrasive Blasting Operations at Shipyards
EPA Contract 68-D1-0115 : Work Assignment No. 50
ESD Project No. 91/53B ; MRI Project No. 6501-50

From: David Reeves

To: Laurel Driver
ESD/CPB/CAS (MD-13)
U. S. Environmental Protection Agency
Research Triangle Park, N.C. 27711

This memo provides a preliminary estimate of the cost effectiveness of reducing HAP emissions from abrasive blasting operations used in the shipbuilding and ship repair industry. The two control options evaluated for this cost comparison are alternative blast media (containing no HAP material) and vacuum blasting (where the blasting dust is captured at point of use and therefore not emitted to the air). In the initial analysis, both the abrasive media and the surface being abraded were thought to emit HAP's. Based on the testing done at NORSHIPCO earlier this year, it is now believed that only a small (insignificant for purposes of this memo) amount of the abraded marine paints becomes airborne and would be considered HAP material.

A model shipyard from the East Coast (NORSHIPCO) was chosen for HAP emission/cost effectiveness comparisons. NORSHIPCO's Berkley facility was chosen based on the amount of blasting and painting done, as well as the availability of HAP contents data on the abrasive media used. This facility was also the site of the Ambient Monitoring Test for Total Suspended and PM10 Particulate Emissions During a Ship Sandblasting Operation conducted on July 14 and 15, 1992.

BLAST MEDIA

Black Beauty™ seems to be the medium of choice for several large shipyards, especially those on the East Coast. Black Beauty™ consists of crushed slag from coal-fired utility boilers and is relatively cheap (around $35 to $58 per ton) compared to other media. It is usually recovered on-site and then land-filled as a nonhazardous waste. Total HAP contents were calculated to be 0.25 lb per ton.

GMA Garnet is a natural mixture of almandite garnet and contains no HAP materials. It is considered a low free silica blast media and the sales literature states that it performs three times better (reduces usage) than coal slag. The cost used in GMA's cost model is $340 per ton.

An area of great uncertainty is how much of the media actually becomes airborne as a result of the surface blasting. Some small percentage of the media is expected to become airborne dust particulate. Since we have heard 90 to 95 percent of the used media is typically recovered at the shipyards, we decided to use 10 percent for our emission calculations. This is believed to be a conservative estimate based on most comments on what is thought to become airborne and actually carried beyond the drydock or fenceline boundary of the shipyard.

COST COMPARISON OF REDUCING ANNUAL HAP EMISSIONS
FROM ABRASIVE BLASTING OPERATIONS

Facility	NORSHIPCO (Berkley yard) Norfolk, Va.	
Abrasive media (type)	Black Blast™ (coal slag)	GMA Garnet
Media cost, $/ton	58	340
Annual usage, tons	7,011	2,337*
Total media cost	406,638	794,580
HAP content of media, lb/ton	0.25	0.00
Total HAP content of media	1,753 #	0 #
Annual HAP emissions from media	175 #	0 #
(using 10% emission factor)	(0.0875 tons)	(0 tons)

$$\text{Cost effectiveness: } \frac{\$794{,}580 - \$406{,}638}{0.0875 \text{ tons}} = \frac{\$4{,}433{,}623}{\text{ton of HAP's reduced}}$$

VACUUM BLASTING

The other control option used for cost comparison in reducing HAP emissions was vacuum blasting. Several industry representatives have commented that existing vacuum blasting systems are too slow for shipyard applications. The time a ship is in drydock is expensive for the ship owner and for the shipyard. Servicing as many ships as possible in as short amount of time as possible is vital to most shipyards.

Since service time is such a key factor, the following assumptions were made for our preliminary cost calculations:

1. A large industrial vacuum blast unit can achieve an equivalent rate of surface preparation as an operator using coal slag abrasive media,

2. Cost of such a unit, LTC-2000, is $75,000 (price quoted from LTC International, Inc., on 10/28/92),

3. Disregard operational costs, and

4. Capital costs annualized over 10 year period.

Using the NORSHIPCO test set-up as a basis, 32 blasters using coal slag abrasive worked simultaneously and averaged 58.3 ft^2 during the 12 hour test. The LTC sales representative quoted rates of 60 to 110 ft^2 per hour with one man (nozzle) per unit. The initial capital investment would be 32 * $75,000 = $2,400,000, which would reduce 0.0875 tons of total HAP's. To reduce 1 ton of total HAP emissions, the cost would be:

$$\frac{\$2,400,000}{0.0875 \text{ tons}} = \frac{\$27,428,571}{\text{ton of HAP's reduced}}$$

Disregarding operational costs and annualizing the capital costs over a 10 year period, the cost effectiveness is still greater than $2.7 million per ton of HAP's reduced.

APPENDIX D.

HAP TEST METHOD
(RESERVED)

APPENDIX D.

HAP TEST METHOD
(RESERVED)

APPENDIX
E.

COST ANALYSIS

APPENDIX E.

COST ANALYSIS

Appendix E is a compilation of the background information and methodology used to develop emission reductions in Chapter 7 and costs in Chapter 8. The development of coating parameters (approximate solids content, VOC content, and thinning requirements) is discussed in Section E.1, and calculations of emission reductions and costs associated with the use of lower-VOC coatings are described in Section E.2.

E.1 COATING PARAMETER DEVELOPMENT

The information requests sent to shipyards and coating manufacturers were the primary source of coating information.[1,2] Based on this information and influenced somewhat by rules of some States, VOC rules, all reported coatings used in marine coating operations within U. S. shipyards were categorized. There are 21 special use ("specialty") categories and any coating not meeting one of the specialty category definitions was categorized as "general use." There are only two specialty categories which each accounted for at least 10 percent of the total reported coating used in the industry: inorganic zinc and antifoulant. With general use coatings (mostly epoxies and to a lesser extent alkyds) representing approximately 70 percent of the total reported usage, together the three primary categories account for about 90 percent of total reported coating use. For this report was limited to the three primary coating categories: inorganic zinc, antifoulant, and general use.

Those coatings categorized as "general use" were initially examined to see if rules could be developed based on resin type. As part of the initial cost analysis, there was some comparisons made using an alkyd resin and epoxy resin breakdown of the "general use" coatings. This proved to be less than satisfactory because the coating characteristics and intended use of even a single resin type vary considerably. To eliminate confusion to the reader, any mention of alkyd or epoxy coatings in this appendix should be considered part of the category referred to as "general use." The coating parameters for this category were calculated from alkyd and epoxy information contained in the coatings data base. The development of the coating parameters for alkyds and epoxies individually is discussed in this appendix, as well as that of the combined "general use" category.

E.1.1 Solids (Nonvolatiles) Content

As discussed in Chapter 7, the approximate solids content of the coatings was estimated assuming that a coating is comprised of solids and solvent and their volumes additive. (Clearly, this is not a rigorous approach but was deemed sufficient for purposes of this work.) The solids content of a coating was calculated by assuming that everything in the coating that is not solvent is solids. An example calculation used to aid in estimating company paint costs follows:

Solids (gallon [gal]) + Solvent (gal) = coating volume (gal)

Assuming 1 gal of coating:

Solids (gal) = (1 gal coating) - Solvent (gal)

Divide by total gallons of coating

$$\frac{\text{Solids (gal)}}{\text{1 gal coating}} \cong 1 - \frac{\text{Solvent (gal)}}{\text{gal coating}}$$

$$\text{Solids (\% by volume)} \cong \left[1 - \frac{\text{Solvent (gal)}}{\text{gal coating}}\right] \times 100$$

$$\text{Solids (\% by volume)} \cong \left[1 - \frac{\text{Solvent content of coating (lb VOC/gal coating)}}{\text{density of solvent (lb solvent/gal solvent)}}\right] \times 100$$

Assuming the density of the solvent is 7.0 lb/gal, and that the solvent content of an example coating is 4.0 lb solvent/gal.

$$\text{Solids (\% volume)} \cong [1 - 0.57] \times 100 = 43 \text{ percent}$$

The solids content of several high-usage alkyds and inorganic zincs was provided by the manufacturers based on various test methods. These values were used by the Agency rather than estimating the solids volume in the manner described above.

E.1.2 <u>Other Coating Parameters</u>

The weighted average VOC content and price of the three primary coating categories were calculated for the 1990 baseline and the coatings determined to be compliant with the MACT limits. The VOC content of all the coatings in the shipyard data base was provided by the shipyards and/or the coating suppliers.[1,2] The price of most but not all of the coatings was also provided by the shipyards. The weighted average VOC content at baseline for each of the primary coating categories was calculated by multiplying the VOC content of each coating by its corresponding usage (volume), summing this product, and dividing by the total coating usage.

limits were assumed to be lowered (to come into compliance) so that the VOC contents of the coatings were equal to the weighted average VOC of the set of existing compliant coatings. The weighted average VOC contents for the lower-VOC scenarios were then calculated in the same manner as described for the 1990 data (baseline).

The weighted average price of coatings used for the baseline and MACT was calculated in a similar manner. However, those coatings for which price was not available were not included in this calculation. It was calculated as the weighted average price of existing coatings with VOC contents equal to or less than the MACT limit for each category.

E.1.3 Solvent Usage

Solvent is used in shipyards for two primary uses--cleaning and thinning. For the lower-VOC cost analysis, it was necessary to know only the portion of total solvent used for thinning. It was calculated based on information from the shipyard data base for each model.

Based on total coating usage and the type of work performed (construction versus repair), each shipyard in the data base was "put" into a model yard category. The total solvent usage and thinning solvent usage were calculated for each of the plants, and average usages were developed for each of the model plant categories.

E.2 EMISSION REDUCTIONS AND COSTS

The HAP emission reduction and costs associated with the use of coatings considered compliant with MACT limits were estimated for each of the model yards. Reductions in HAP emissions were determined as part of the environmental impact presented in Chapter 7. In addition, the cost of recordkeeping and reporting associated with rules based on compliant coatings was estimated.

Section E.2.2 discusses costs associated with complaint coatings, and Section E.2.3 discusses recordkeeping and reporting costs.

E.2.1 Emissions Reductions

As presented in Chapter 7, the HAP emissions associated with MACT are based on the assumption that the use of solvent for thinning is a constant percentage of coating use, and that no additional in-line heaters are required. The reduction in HAP emissions which would result from the rule is attributable to three factors: (1) less paint will be used due to the greater solids content of compliant material; and (2) less thinner will be required because fewer gallons of coating will be sprayed. The HAP emissions from thinning solvent were estimated based on average HAP content and the total used at each model yard.

E.2.2 Cost of Using Compliant Coatings

Costs associated with using compliant coatings include any differential in the cost of the coatings, thinning solvent, and any auxiliary equipment, such as in-line paint heaters. The cost of compliance was calculated as the product of these costs and usage rates, Usage rates of compliant coatings and thinning solvent were calculated as described in Section E.2.

E.2.3 Recordkeeping and Reporting Costs

Recordkeeping and reporting costs have been estimated for baseline and compliance with MACT. Additionally, because there is no obvious difference for construction yards versus repair yards, these costs were estimated based only on the size of the shipyard.

The two major cost components are labor and equipment. Labor costs are discussed below in Section E.2.3.1, and equipment costs in Section E.2.3.2.

E.2.3.1 Labor Hours and Costs. The estimated labor hours and costs for baseline and maximum limits are discussed below.

coating regulations. It is assumed that only the large and medium model shipyards are required to prepare annual emission reports to comply both with their permit conditions and with section 313 of the Superfund Amendments and Reauthorization Act of 1986 (SARA 313). The small model shipyards are assumed to have emissions below the cutoff for such reporting requirements and considered too small to be required to submit annual emission reports.

Based on information from two large shipyards, it is assumed that large and medium yards already track paint and solvent use through inventory records.[7-9] These inventory records are electronically coupled with data on the VOC content (for permit reporting requirements) and toxics content (for SARA 313 reports) of the individual paints and solvents.

At baseline, the technical labor for tracking paint and solvent use at large and medium yards is estimated at 75 hours per year (hr/yr) in excess of the labor necessary for normal business inventory procedures, based on 50 weeks (wk) per yr and 1.5 hr/wk. (The 1.5 hr/wk is a standardized factor for "records of all measurements and information required" from the Emission Standards Division (ESD) Regulatory Procedures Manual.[10]) An additional 40 hr/yr is estimated for entering data on the VOC and HAP contents of new paints into the paint data base. Preparation of the annual HAP emission report is also estimated to be 40 hr/yr. Finally, refresher training on proper tracking procedures is estimated to total 4 hr/yr (2 hr/yr each for two employees).

Based on these labor requirements, the total baseline technical labor for recordkeeping and reporting at the large and medium model plants is estimated to be 159 hr/yr. There is no cost for small plants, where it is assumed that no reporting is

As presented in Chapter 8, the cost of baseline recordkeeping and reporting was calculated using factors from the ESD Regulatory Procedures Manual (see Table 8-4). Unless otherwise determined, management and clerical labor hours are assumed to be 5 percent and 10 percent of technical hours, respectively. Technical labor, including fringe benefits and overhead, is charged at a rate of $33/hr, management labor is $49/hr, and clerical labor is $15/hr.[11] Using these factors, the baseline recordkeeping and reporting cost for large and medium model yards was calculated as follows:

$$159 \text{ hr/yr} \times [\$33/\text{hr} + (0.05 \times \$49/\text{hr}) + (0.1 \times \$15/\text{hr})] = \$5,875/\text{yr}$$

E.2.3.2 <u>Maximum Limits Under MACT</u>. Table E-1

TABLE E-1. ESTIMATED RECORDKEEPING AND REPORTING LABOR AND COST FOR MAXIMUM STANDARDS

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presents a spreadsheet developed to calculate the technical labor hours and costs for the reporting and recordkeeping required by a rule that imposes maximum never to be exceed HAP limits. The values used in the spreadsheet were derived primarily from information received from shipyards and the ESD Regulatory Procedures Manual. Additional information on the spreadsheet can be found in

Reference 12, Table E-2 repeats the spreadsheet with all calculated values inserted.

TABLE E-2. NESHAP RECORDKEEPING AND REPORTING LABOR AND COST FOR MAXIMUM LIMITS--CALCULATED VALUES

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This methodology assumes that the amount of each paint and thinner that is used must be recorded on a daily basis in sufficient detail that a compliance determination can be made for each day. Each painting area at the shipyard is assumed to have a storage area from which paint and thinner are issued; the employees who oversee the storage areas record the required information for each painting shift. (A painting shift is defined as a work shift during which painting is performed at any single painting area. Thus, for each work shift, the number of painting shifts can be less than but no greater than the number of painting areas at the yard.) The matrix presumes daily records are compiled periodically, and quarterly reports must be prepared. The cost of initial training for the recordkeepers in the first year of implementation, and refresher training in subsequent years is included. Because of this variation in training costs, the total technical labor hr/yr were calculated for the initial year and subsequent years, and the average for the first three years was calculated, as well.

Based on the estimated total technical labor hr/yr, the associated costs for each model plant were calculated as presented above for the baseline cost calculations. Estimated average cost per yard for the first 3 years range from about $10,000/yr for the small model plant to about $40,000/yr for the large model plant.

E.2.3.3 Equipment Costs. A computer is assumed necessary for recording and compiling the records and manipulating the data to generate reports. Information on equipment presently used by this industry came from a large shipyard subject to baseline requirements and a medium shipyard already subject to maximum VOC limits.[7,14] The data received from these two yards and the analysis performed to determine annual costs are summarized in

Table E-3. The average annual equipment cost for each of the

TABLE E-3.

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yards is about $1,400. (As discussed previously, it is assumed that small yards will not be subject to the NESHAP so they incur no equipment cost.)

Under a rule that imposes a maximum limit, it was assumed that all yards are subject to monthly recordkeeping and semi-annual reporting. The same baseline equipment costs were used to evaluate incremental costs that would result from the rule. Since one of the yards that supplied information on the cost of equipment is already subject to maximum limits, it is assumed no additional costs are incurred.[14]

E.3 REFERENCES FOR APPENDIX E

1. Memorandum. deOlloqui, V., Midwest Research Institute, to Project File. List of CTG and NESHAP survey responses and related Trip Reports. November 11, 1992.

2. Memorandum. deOlloqui, V., Midwest Research Institute, to Project File. List of survey responses received from marine coating suppliers. November 16, 1992.

3. Telecon. Caldwell, M. J., Midwest Research Institute, with J. Czajak, Binks Manufacturing. October 14, 1992. In-line paint heaters.

4. Telecon. deOlloqui, V., Midwest Research Institute, with G. Olson, Graco, Inc. October 9, 1992. In-line paint heaters.

5. U. S. Environmental Protection Agency, OAQPS Control Cost Manual, Fourth Edition. Research Triangle Park, N.C. January 1990. EPA 450/3-90-006.

6. U.S. Department of Energy, Energy Information Administration. Monthly Energy Review. April 1991. DOE EIA 0035 (91/04).

7. Telecon. Williamson, M., MRI, with Beacham, T., Norfolk Shipbuilding and Drydock Corporation. June 3, 1993. Recordkeeping and reporting requirements.

8. Telecon. Edgerton, S., MRI, with Ayres, R. P., Newport News Shipbuilding. November 9, 1993. Recordkeeping and reporting requirements.

9. Letter from Ayres, R. P., Newport News Shipbuilding, to Reeves, D., MRI. November 8, 1993. Information on recordkeeping and reporting requirements.

10. U. S. Environmental Protection Agency. ESD Regulatory Procedures Manual. October 1990. Volume X, Section 2.2, p. 17.

11. U. S. Environmental Protection Agency. ESD Regulatory Procedures Manual. October 1990. Volume X, Section 2.2, p. 19.

12. Memorandum from Edgerton, S., MRI, to the project file

13. Telecon. Williamson, M., MRI, with Austin, D., Southwest Marine, Inc. June 7, 1993. Recordkeeping and reporting requirements.

14. Response to Recordkeeping and Reporting Questionnaire. National Steel and Shipbuilding Company. June 23, 1993.