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EPA Office of Compliance Sector Notebook Project:

PROFILE OF THE SHIPBUILDING AND REPAIR INDUSTRY

November 1997

Office of Compliance
Office of Enforcement and Compliance Assurance
U.S. Environmental Protection Agency
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This report is one in a series of volumes published by the U.S. Environmental Protection Agency (EPA) to provide information of general interest regarding environmental issues associated with specific industrial sectors. The documents were developed under contract by Abt Associates (Cambridge, MA), Science Applications International Corporation (McLean, VA), and Booz-Allen & Hamilton, Inc. (McLean, VA). This publication may be purchased from the Superintendent of Documents, U.S. Government Printing Office. A listing of available Sector Notebooks and document numbers is included on the following page.

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Electronic versions of all Sector Notebooks are available free of charge at the following web address: **www.epa.gov/oeca/sector**. Direct technical questions to the "Feedback" button at the bottom of the web page.

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*Spanish translations available.

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(SIC 3731)
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AFS - AIRS Facility Subsystem (CAA database)
AIRS - Aerometric Information Retrieval System (CAA database)
BIFs - Boilers and Industrial Furnaces (RCRA)
BOD - Biochemical Oxygen Demand
CAA - Clean Air Act
CAAA - Clean Air Act Amendments of 1990
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS - CERCLA Information System
CFCs - Chlorofluorocarbons
CO - Carbon Monoxide
COD - Chemical Oxygen Demand
CSI - Common Sense Initiative
CWA - Clean Water Act
D&B - Dun and Bradstreet Marketing Index
ELP - Environmental Leadership Program
EPA - United States Environmental Protection Agency
EPCRA - Emergency Planning and Community Right-to-Know Act
FIFRA - Federal Insecticide, Fungicide, and Rodenticide Act
FINDS - Facility Indexing System
HAPs - Hazardous Air Pollutants (CAA)
HSDB - Hazardous Substances Data Bank
IDEA - Integrated Data for Enforcement Analysis
LDR - Land Disposal Restrictions (RCRA)
LEPCs - Local Emergency Planning Committees
MACT - Maximum Achievable Control Technology (CAA)
MCLGs - Maximum Contaminant Level Goals
MCLs - Maximum Contaminant Levels
MEK - Methyl Ethyl Ketone
MSDSs - Material Safety Data Sheets
NAAQS - National Ambient Air Quality Standards (CAA)
NAFTA - North American Free Trade Agreement
NCDB - National Compliance Database (for TSCA, FIFRA, EPCRA)
NCP - National Oil and Hazardous Substances Pollution Contingency Plan
NEIC - National Enforcement Investigation Center
NESHAP - National Emission Standards for Hazardous Air Pollutants
NO_2 - Nitrogen Dioxide
NOV - Notice of Violation
NO_X - Nitrogen Oxides
NPDES - National Pollution Discharge Elimination System (CWA)
NPL - National Priorities List
NRC - National Response Center

NSPS -	New Source Performance Standards (CAA)
OAR -	Office of Air and Radiation
OECA -	Office of Enforcement and Compliance Assurance
OPA -	Oil Pollution Act
OPPTS -	Office of Prevention, Pesticides, and Toxic Substances
OSHA -	Occupational Safety and Health Administration
OSW -	Office of Solid Waste
OSWER -	Office of Solid Waste and Emergency Response
OW -	Office of Water
P2 -	Pollution Prevention
PCS -	Permit Compliance System (CWA Database)
POTW -	Publicly Owned Treatments Works
RCRA -	Resource Conservation and Recovery Act
RCRIS -	RCRA Information System
SARA -	Superfund Amendments and Reauthorization Act
SDWA -	Safe Drinking Water Act
SEPs -	Supplementary Environmental Projects
SERCs -	State Emergency Response Commissions
SIC -	Standard Industrial Classification
SO_2 -	Sulfur Dioxide
SO_X -	Sulfur Oxides
TOC -	Total Organic Carbon
TRI -	Toxic Release Inventory
TRIS -	Toxic Release Inventory System
TCRIS -	Toxic Chemical Release Inventory System
TSCA -	Toxic Substances Control Act
TSS -	Total Suspended Solids
UIC -	Underground Injection Control (SDWA)
UST -	Underground Storage Tanks (RCRA)
VOCs -	Volatile Organic Compounds

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SHIPBUILDING AND REPAIR INDUSTRY
(SIC 3731)

I. INTRODUCTION TO THE SECTOR NOTEBOOK PROJECT

I.A. Summary of the Sector Notebook Project

Integrated environmental policies based upon comprehensive analysis of air, water, and land pollution are a logical supplement to traditional single-media approaches to environmental protection. Environmental regulatory agencies are beginning to embrace comprehensive, multi-statute solutions to facility permitting, enforcement and compliance assurance, education/ outreach, research, and regulatory development issues. The central concepts driving the new policy direction are that pollutant releases to each environmental medium (air, water, and land) affect each other, and that environmental strategies must actively identify and address these inter-relationships by designing policies for the "whole" facility. One way to achieve a whole facility focus is to design environmental policies for similar industrial facilities. By doing so, environmental concerns that are common to the manufacturing of similar products can be addressed in a comprehensive manner. Recognition of the need to develop the industrial "sector-based" approach within the EPA Office of Compliance led to the creation of this document.

The Sector Notebook Project was originally initiated by the Office of Compliance within the Office of Enforcement and Compliance Assurance (OECA) to provide its staff and managers with summary information for eighteen specific industrial sectors. As other EPA offices, states, the regulated community, environmental groups, and the public became interested in this project, the scope of the original project was expanded to its current form. The ability to design comprehensive, common sense environmental protection measures for specific industries is dependent on knowledge of several inter-related topics. For the purposes of this project, the key elements chosen for inclusion are: general industry information (economic and geographic); a description of industrial processes; pollution outputs; pollution prevention opportunities; Federal statutory and regulatory framework; compliance history; and a description of partnerships that have been formed between regulatory agencies, the regulated community, and the public.

For any given industry, each topic listed above could alone be the subject of a lengthy volume. However, in order to produce a manageable document, this project focuses on providing summary information for each topic. This format provides the reader with a synopsis of each issue, and references where more in-depth information is available. Text within each profile was researched from a variety of sources, and was usually condensed from more detailed sources pertaining to specific topics. This approach allows for a wide coverage of activities that can be further explored based upon the citations and references listed at the end of this profile. As a check on the information included, each notebook went through an external review process. The Office of Compliance appreciates the efforts of all those that participated in this process and enabled us to develop more complete, accurate and up-to-date summaries. Many of those who reviewed this notebook are listed as contacts in Section IX and may be sources of additional information. The individuals and groups on this list do not necessarily concur with all statements within this notebook.

I.B. Additional Information

Providing Comments

OECA's Office of Compliance plans to periodically review and update the notebooks and will make these updates available both in hard copy and electronically. If you have any comments on the existing notebook, or if you would like to provide additional information, please send a hard copy and computer disk to the EPA Office of Compliance, Sector Notebook Project, 401 M St., SW (2223-A), Washington, DC 20460. Comments can also be uploaded to the Enviroene World Wide Web for general access to all users of the system. Follow instructions in Appendix A for accessing this system. Once you have logged in, procedures for uploading text are available from the on-line Enviroene Help System.

Adapting Notebooks to Particular Needs

The scope of the industry sector described in this notebook approximates the national occurrence of facility types within the sector. In many instances, industries within specific geographic regions or states may have unique characteristics that are not fully captured in these profiles. The Office of Compliance encourages state and local environmental agencies and other groups to supplement or re-package the information included in this notebook to include more specific industrial and regulatory information that may be available. Additionally, interested states may want to supplement the "Summary of Applicable Federal Statutes and Regulations" section with state and local requirements. Compliance or technical assistance providers may also want to develop the "Pollution Prevention" section in more detail. Please contact the appropriate specialist listed on the opening page of this notebook if your office is interested in assisting us in the further development of the information or policies addressed within this volume. If you are interested in assisting in the development of new notebooks for sectors not covered in the original eighteen, please contact the Office of Compliance at 202-564-2395.

II. INTRODUCTION TO THE SHIPBUILDING AND REPAIR INDUSTRY

This section provides background information on the size, geographic distribution, employment, production, sales, and economic condition of the ship building and repair industry. Facilities described within this document are described in terms of their Standard Industrial Classification (SIC) codes.

II.A. Introduction, Background, and Scope of the Notebook

The shipbuilding and repair industry builds and repairs ships, barges, and other large vessels, whether self-propelled or towed by other craft. The industry also includes the conversion and alteration of ships and the manufacture of offshore oil and gas well drilling and production platforms. The shipbuilding and repair industry described in this notebook is categorized by the Office of Management and Budget (OMB) under the Standard Industrial Classification (SIC) code 3731. This notebook does not cover the related sector SIC 3732 Boat Building and Repairing. The boat building and repair industry is engaged in the manufacturing and repairing of smaller non-ocean going vessels primarily used for recreation, fishing, and personnel transport. OMB is in the process of changing the SIC code system to a system based on similar production processes called the North American Industrial Classification System (NAICS). (In the NAIC system, shipbuilding and repair facilities are all classified as NAIC 336611.)

II.B. Characterization of the Shipbuilding and Repair Industry

Shipyards, or facilities that build and/or repair ships, operate on a job basis. With the exception of about nine U.S. Navy owned shipyards (which are not included in SIC 3731), the U.S. shipbuilding and repair industry is privately owned. Unlike most other industries, each year only a small number of valuable orders are received that often take years to fill. Orders for ships and ship repairs are primarily placed by companies or the federal government. Companies that place orders often include commercial shipping companies, passenger and cruise companies, ferry companies, petrochemical companies, commercial fishing companies, and towing and tugboat companies. The principal federal government agencies placing shipbuilding and repair orders include the Naval Sea Systems Command, the Military Sealift Command, the Army Corps of Engineers, the U.S. Coast Guard, the National Oceanic and Atmospheric Administration, the National Science Foundation, and the Maritime Administration.

II.B.1. Product Characterization

Shipyards are often categorized into a few basic subdivisions either by type of operations (shipbuilding or ship repairing), by type of ship (commercial or military), and shipbuilding or repairing capacity (first-tier or second-tier).

Ships themselves are often classified by their basic dimensions, weight (displacement), load-carrying capacity (deadweight), or their intended service. In the U.S., there are considerable differences between shipyard operations when constructing ships for commercial purposes and when constructing ships for the military.

Commercial Ships

An important difference between commercial ships and military ships is that the commercial ship market is much more cost competitive. Unlike the military market, the commercial ship market must also compete internationally. The cost of building and maintaining a ship must be low enough such that the owners can make a reasonable profit. This has a significant impact on the manner in which commercial ships are built and repaired. The intense global competition in this industry is the main reason that since World War II, U.S. shipyards have produced relatively few commercial ships. In this regard, since 1981 the U.S. shipyards received less than one percent of all commercial orders for large ocean going vessels in the world, and no commercial orders for large ocean going cruise ships (ASA, 1997).

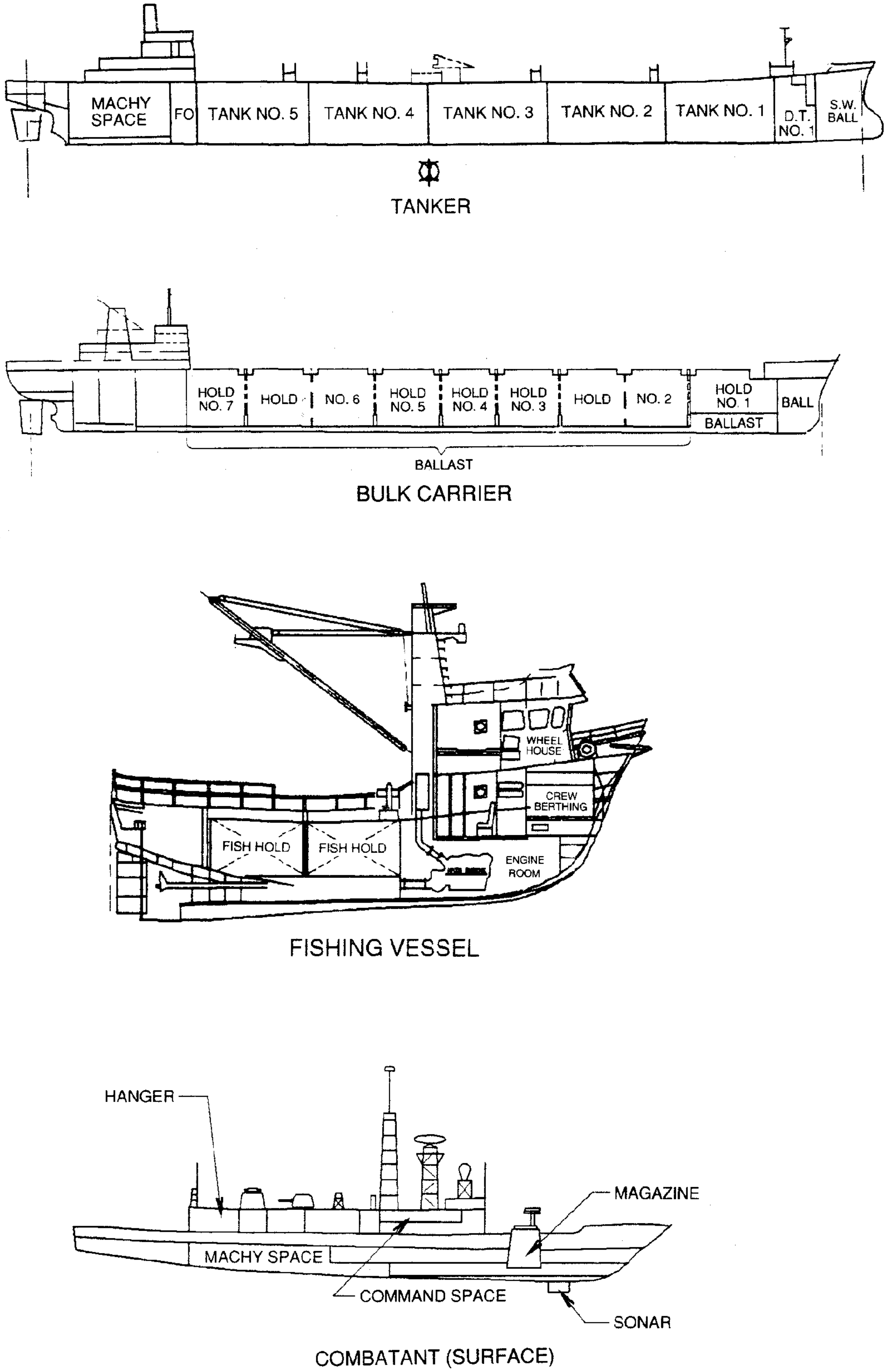
Commercial ships can be subdivided into a number of classes based on their intended use. Commercial ship classes include dry cargo ships, tankers, bulk carriers, passenger ships, fishing vessels, industrial vessels, and others (Storch et al., 1995). Dry cargo ships include break bulk, container, and roll-on/roll-off types. Profiles of a number of ship types are shown in Figure 1.

Military Ships

Military ship orders have been the mainstay of the industry for many years. The military ship market differs from the commercial market in that the major market drivers are agency budgets as set by government policy.

The military ship market can be divided into combatant ships and ships that are ordered by the government, but are built and maintained to commercial standards rather than military standards. (Storch et al., 1995) Combatant ships are primarily ordered by the U.S. Navy and include surface combatants, submarines, aircraft carriers, and auxiliaries. Government owned non-combatant ships are mainly purchased by the Maritime Administration's National Defense Reserve Fleet (NDRF) and the Navy's Military Sealift Command (MSC). Other government agencies that purchase non-combatant ships are the Army Corp of Engineers, National Oceanic and Atmospheric Administration, and the National Science Foundation. Such ships often include cargo ships, transport ships, roll on/roll off ships, crane ships, tankers, patrol ships, and ice breakers.

Figure 1: Profiles of Ship Types



Source: Adapted from *Ship Production*, Storch, et. al., *Ship Repairing*

Ship repair operations include repainting, overhauls, ship conversions, and alterations. Almost all shipyards that construct new ships also do major ship repairs. In addition, about 200 shipyards concentrate solely on ship repairing and do not have the necessary facilities to construct ships (Storch et. al., 1995). Only about 31 shipyards have "major dry-docking facilities" capable of removing ships over 122 meters in length from the water (MARAD, 1995). Dry-docking facilities, or "full service" repair yards, allow repairs and maintenance below a ship's water line. The remaining repair yards can either dry-dock vessels under 122 meters or have no dry-docking facilities. Shipyards with no dry-docking facilities, called topside yards, perform above-water ship and barge repairs. Such facilities generally employ fewer than 100 people and are often capable of transporting workers and materials to the ship (Storch et al., 1995).

First and Second-Tier Shipyards

U.S. shipyards are also classified by MARAD as either first-tier shipyards or second-tier shipyards. First-tier shipyards make up the "U.S. major shipbuilding base" (MSB). As defined by MARAD and the Department of Transportation in "Report on Survey of U.S. Shipbuilding and Repair Facilities," 1995, the MSB is comprised of privately owned shipyards that are open and have at least one shipbuilding position capable of accommodating a vessel of 122 meters (383 feet) or more. With few exceptions, these shipyards are also major repair facilities with drydocking capabilities (U.S. Industrial Outlook, 1994). In 1996 there were 16 of these major shipbuilding facilities in the U.S.

Second-tier shipyards are comprised of the many small and medium-size shipyards that construct and repair smaller vessels (under 122 meters) such as military and non-military patrol boats, fire and rescue vessels, casino boats, water taxis, tug and towboats, off-shore crew and supply boats, ferries, fishing boats, and shallow draft barges (MARAD, 1996). A number of second-tier shipyards are also able to make topside repairs to ships over 122 meters in length.

II.B.2. Industry Size and Geographic Distribution

According to the *1992 Census of Manufacturers* data (the most recent Census data available), there were approximately 598 shipbuilding and repairing yards under SIC code 3731. The payroll for this year totaled $3.6 billion for a workforce of 118,000 employees, and value of shipments totaled $10.6 billion. Based on the Census of Manufacturers data, the industry is very labor intensive. The value of shipments per employee (a measure of labor intensiveness) is $90,000, which is about one third that of the steel manufacturing industry ($245,000 per employee) and only five percent that of the petroleum refining industry ($1.8 million per employee).

According to the *Census of Manufacturers*, most shipyards are small. About 72 percent of the shipyards employ fewer than 50 people in 1992 (see Table 1). It is the relatively few (but large) shipyards, however, that account for the majority of the industry's employment and sales. Less than five percent of the shipyards account for almost 80 percent of the industry's employment and sales.

Table 1: Facility Size Distribution for the Shipbuilding and Repair Industry

Employees per Facility	**Facilities**		**Employees**	
	Number of Facilities	Percentage of Facilities	Number of Employees	Percentage of Employees
1-9	230	38%	900	1%
10-49	203	34%	4,600	4%
50-249	113	19%	12,900	11%
250-499	25	4%	8,200	7%
500-2499	21	4%	17,100	14%
2500 or more	6	1%	74,600	63%
Total	598	100%	118,300	100%

Source: U.S. Department of Commerce, Census of Manufacturers, 1992.

Geographic Distribution

The geographic distribution of the shipbuilding and repair industry is concentrated on the coasts. Other important areas are the southern Mississippi River and Great Lakes regions. According to the *1992 U.S. Census of Manufacturers*, there are shipyards in 24 states. The top states in order are: Florida, California, Louisiana, Texas, Washington, and Virginia. Together, these states account for about 56 percent of U.S. shipyards. Figure 2 shows the U.S. distribution of facilities based on data from the Census of Manufacturers.

Figure 2: Geographic Distribution of Shipyards

Source: U.S. Census of Manufacturers, 1992.

Dun & Bradstreet's *Million Dollar Directory,* compiles financial data on U.S. companies including those operating within the shipbuilding and repair industry. Dun & Bradstreet ranks U.S. companies, whether they are a parent company, subsidiary or division, by sales volume within their assigned 4-digit SIC code. Readers should note that: (1) companies are assigned a 4-digit SIC that resembles their principal industry most closely; and (2) sales figures include total company sales, including subsidiaries and operations (possibly not related to shipbuilding and repair). Additional sources of company specific financial information include Standard & Poor's *Stock Report Services*, *Ward's Business Directory of U.S. Private and Public Companies*, Moody's Manuals, and annual reports.

Table 2: Top U.S. Companies with Shipbuilding and Repair Operations

Rank[a]	Company[b]	1996 Sales (millions of dollars)
1	Newport News Shipbuilding and Dry Dock Co. Newport News, VA	1,756
2	Ingalls Shipbuilding Inc. - Pascagoula, MS	1,125
3	General Dynamics Corp. (Electric Boat) - Groton, CT	980
4	Bath Iron Works Corp. - Bath, ME	850
5	Avondale Industries Inc., Shipyards Division New Orleans, LA	576
6	National Steel and Shipbuilding Co. (NASSCO) San Diego, CA	500
7	Trinity Marine Group - Gulfport, MS	400
8	Norfolk Shipbuilding and Drydock Corp. - Norfolk, VA	212
9	American Commercial Marine Service Co. - Jeffersonville, IN	166
10	Atlantic Marine - Jacksonville, FL	121

Note: [a]Not all sales can be attributed to the companies' shipbuilding and repair operations.
[b] Companies shown listed SIC 3731.

Source: *Dunn & Bradstreet's Million Dollar Directory - 1996.*

II.B.3. Economic Trends

General Economic Health

In general, the U.S. shipbuilding and repair industry is in a depressed state. At its height in the mid-1970s, the industry held a significant portion of the international commercial market while maintaining its ability to supply all military orders. Since then, new ship construction, the number of shipbuilding and repair yards, and overall industry employment have decreased sharply. The decline has been especially severe in the construction of commercial vessels at first tier shipyards which fell from about 77 ships (1,000 gross tons or more) per year in the mid-1970s to only about eight ships total through the late 1980s and early 1990s. In the 1980s, the industry's loss of the commercial market share was somewhat offset by a substantial increase in military ship orders. Following the naval expansion, however, the industry entered the 1990s with a much smaller military market and a negligible share of the commercial market.

The second tier shipyards and the ship repairing segment of the industry has also suffered in recent decades; however, its decline has not been as drastic. The second tier shipyards, comprised of small and medium size facilities, were able to keep much of their mainly commercial market share. These shipyards build vessels used on the inland and coastal waterways which by law must be built in the U.S.

The U.S. shipbuilding and repairing industry's loss of the commercial shipbuilding market has been attributed to a number of factors. First, a world wide shipbuilding boom in the 1970s created a large quantity of surplus tonnage which suppressed demand for years. Another significant factor reducing U.S. shipbuilding and repair industry's ability to compete internationally are the substantial subsidies that many nations provide to their domestic shipbuilding and repair industries. Also, until 1980, over 40 percent of U.S.-built merchant ships received Construction Differential Subsidies (CDS) based on the difference between foreign and domestic shipbuilding costs. The program was eliminated in 1981, further reducing the industry's competitiveness.

Another trend in the industry has been a movement toward consolidation. In recent years many shipyards have been closed or purchased by larger ship building and repair companies.

Government Influences

The U.S. shipbuilding and repair industry is highly dependent on the Federal Government, its primary market, for its continued existence. Direct purchases of military ships and military ship repair services by the Federal Government account for about 80 percent of the industry's sales (Census of Manufacturers, 1992). In addition, the industry receives a small amount of support through a few federal tax incentives and financing assistance programs.

MARAD provides assistance to U.S. ship owners through the Federal Ship Mortgage Insurance (Title XI) and Capital Construction Fund programs. Under Title XI, the Federal Government guarantees repayment of private sector mortgage obligations for operators that purchase ships from U.S. shipyards. Although the Capital Construction Fund has not been funded in recent years, in the past it has allowed operators to establish tax-deferred funds for procuring new or reconstructed vessels from U.S. shipyards (U.S. Industrial Outlook, 1994). Another program, MARITECH, is jointly funded by the Federal Government and industry and is administered by the Department of Defense's Advanced Research Projects Agency (ARPA), in collaboration with MARAD. MARITECH provides matching Government funds to encourage the shipbuilding industry to direct and lead in the development and application of advanced technology to improve its competitiveness and to preserve its industrial base. (For more information on MARITECH, see Section VIII.A.)

Such outside support is not unique to the U.S. Worldwide, many nations provide substantial subsidies to their shipbuilding and repair industries. The governments of most trading nations support their domestic industries because they believe that it is in their best interest economically and militarily. Maintaining a shipbuilding industrial base helps to safeguard a nation's control over getting its products to foreign markets, and ensures that it will have the means to replace its merchant or naval fleets in a time of national emergency. As a result of these external influences, the industry does not behave according to the simple economic supply and demand model. Rather, the policies of national governments in conjunction with economic forces dictate economic activity in this sector.

Like many other nations, the U.S. has a policy of maintaining a shipbuilding and repair industrial base that can be expanded in time of war (Storch, et al., 1995). National policy, therefore, will continue to be the primary factor influencing the industry's economic trends in the U.S.

Domestic Market

The military still is, and will continue to be, the primary source of work for the industry. However, the Navy's new ship procurement has sharply declined since the accelerated Navy ship construction in the 1980s. This work is expected to continue to decline at least through the remainder of the 1990s. Some industry analysts predict that a number of the first tier shipyards, which fill most of the military orders, will close in coming years.

While military shipbuilding is on the decline, the forecast for the commercial sector is more promising. Domestic demand for commercial shipbuilding and repair has increased dramatically in recent years and is expected to continue to increase throughout the 1990s. There have been significant increases in barge construction in recent years. In 1996, 1,070 hopper barges were delivered by U.S. shipyards, more than double the number delivered in 1995. This number is expected to grow to over 1,500 in 1997. Demand is also expected to be particularly high for tankers; especially for new double-hull tankers in response to the 1990 Oil Pollution Act requirements.

International Market

Currently, the U.S. holds less than one half of one percent of the world market share of commercial shipbuilding and repair. South Korea and Japan currently dominate the world market. Each holds about 30 percent of the gross tonnage of merchant ships on order. Germany, Poland, Italy, and China each hold between four and five percent of the commercial market. However, a number of major commercial ship orders were received by first and second tier shipyards in 1995 and 1996. The chief driving forces for this increase in U.S. commercial ship production is a general increase in worldwide demand stemming from an aging merchant fleet and an improving global economy. The elevated demand is expected to continue over the next three to five years.

Through the OECD in December 1994, an agreement was reached by the Commission of the European Communities, and the Governments of Finland, Japan, South Korea, Norway, Sweden and the United States to establish more normal competitive conditions in the shipbuilding industry. The agreement is expected to remove government support and unfair pricing practices in the industry. If and when this agreement is implemented, it is expected to have a positive impact on the world market by discouraging "ship dumping" practices that are believed to have been damaging shipbuilders. It is hoped that the agreement will also bring to light the actual economic advantage and competitiveness of the various countries and individual ship builders. In addition, the shipowners will no longer be able to buy ships at subsidized or dumped prices reducing the likelihood of speculative buying.

Recognizing the unique need for the Administration, Congress and the shipbuilding industry to work together in order for the U.S. to become competitive once again in the international shipbuilding market, President Clinton submitted a Report to Congress entitled "Strengthening America's Shipyards: A Plan for Competing in the International Market." In that report, the President outlined a number of steps to be taken "to ensure a successful transition to a competitive industry in a truly competitive marketplace." The Administration's five step plan included:

- Ensuring Fair International Competition
- Improving Competitiveness
- Eliminating Unnecessary Government Regulation
- Financing Ship Sales Through Title XI Loan Guarantees, and
- Assisting International Marketing.

III. INDUSTRIAL PROCESS DESCRIPTION

This section describes the major industrial processes within the shipbuilding and repair industry, including the materials and equipment used and the processes employed. The section is designed for those interested in gaining a general understanding of the industry, and for those interested in the inter-relationship between the industrial process and the topics described in subsequent sections of this profile -- pollutant outputs, pollution prevention opportunities, and Federal regulations. This section does not attempt to replicate published engineering information that is available for this industry. Refer to Section IX for a list of resource materials and contacts that are available.

This section specifically contains a description of commonly used production processes, associated raw materials, the by-products produced or released, and the materials either recycled or transferred off-site. This discussion, coupled with schematic drawings of the identified processes, provide a concise description of where wastes may be produced in the process. This section also describes the potential fate (via air, water, and soil pathways) of these waste products.

III.A. Industrial Processes in the Shipbuilding and Repair Industry

The shipbuilding and repair industry has characteristics of both a manufacturing industry and the construction industry. The industry uses and produces a wide variety of manufactured components in addition to basic construction materials. As with the construction industry, shipbuilding and repair requires many workers with many different skills all working in an established organization structure.

New ship construction and ship repairing have many industrial processes in common. They both apply of essentially the same manufacturing practices, processes, facilities, and support shops. Both ship repair and new construction work require highly skilled labor because many of the operations (especially in ship repair) have limited potential for automation. Both require excellent planning, engineering, and interdepartmental communications. New ship construction, however, generally requires a greater amount of organization because of the size of the workforce, size of the workload, number of parts, and the complexity of the communications (e.g., production plans and schedules) surrounding the shipbuilding work-flow (NSRP, 1993).

III.A.1. Shipyard Layout

Shipbuilding and repair facilities are generally made up of several specific facilities laid out to facilitate the flow of materials and assemblies. Most shipyards were built prior to the Second World War. Changes in shipyard layout were made piecemeal, responding to advances in technology, demands for different types of ships, and availability of land and waterfront. As a result, there is no typical shipyard layout. There are, however, a number of specific facilities that are common to most large shipyards. These facilities include: drydocks, shipbuilding positions, piers and berthing positions, workshops (e.g., machine, electrical, pipe, assembly, paint and blast, carpenter, and sheet metal shops), work areas (steel storage, platen lines, and construction areas), warehouses, and offices. A shipyard layout containing many of these facilities is shown in Figure 3.

III.A.2. Docking and Launching Facilities

There are few shipyards that have the capability to construct or repair vessels under cover; in most cases shipbuilding and repair are done largely out of doors. Much of this work is done over, in, under, or around water, which can inadvertently receive a portion of shipyard pollutant outputs. The docking facilities, or the mechanisms used to remove ships from the water for repair or to construct and launch ships, can affect waste generation and management.

Ships can be either wet-docked or drydocked. A wet-dock or berth is a pier or a wet slip position that a ship can dock next to and tie up. A ship that has its entire hull exposed to the atmosphere is said to be drydocked. A number of different drydocking and launching facilities exist including building ways, floating drydocks, graving docks, and marine railways.

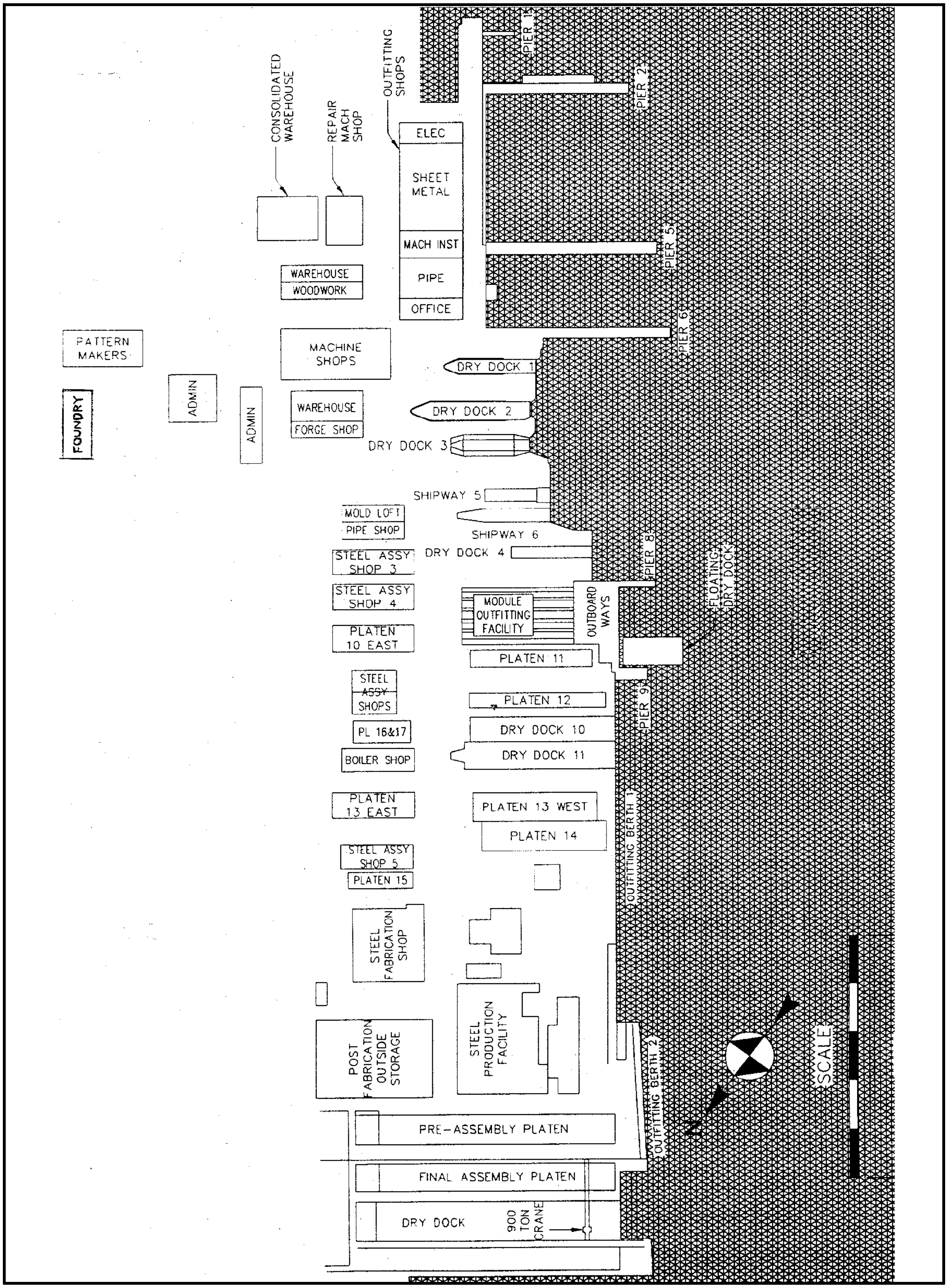
Building Ways

Building ways are used only for building ships and releasing them into the adjacent waters. New ships are constructed and launched from one of two main types of building ways: longitudinal end launch ways and side launch ways (NSRP, 1993).

Floating Drydocks

Floating drydocks are floating vessels secured to land that have the ability to be lowered under the water's surface in order to raise ships above the water surface. Floating drydocks are generally used for ship repair, but in some cases ship construction is performed. When the drydock is submerged by filling ballast tanks with water, ships are positioned over bilge and keel blocks located on the deck of the drydock. The ship's position over the drydock is maintained while the ballast tanks are pumped out, which raises the dock and the ship above the water surface (NSRP, 1993).

Figure 3: Example Shipyard Layout



Source: Maritime Administration, *Report on Survey of U.S. Shipbuilding and Repair Facilities,* *Graving Docks*

Graving docks are man-made rectangular bays where water can be let in and pumped out. Ships are floated into the dock area when the dock is full of water. Water-tight gates are closed behind the ship and the water is pumped from inside the dock area to the outside adjacent waters. Large pumping systems are typically used to remove all but a few inches of the water. Graving docks usually have a sloping dock floor which directs the water to channels leading to smaller pumps which empty the final few inches of water as well as any rain or water runoff which enters the dock (NSRP, 1993).

Marine Railways

Marine railways have the ability to retrieve and launch ships. They are similar to end-launch building ways, but usually much smaller. Marine railways essentially consist of a rail-car platform and a set of railroad tracks. The rails are secured to an inclined cement slab that runs the full length of the way and into the water to a depth necessary for docking ships. Motor and pulley systems are located at the head of marine railways to pull the rail-car platform and ship from the water (NSRP, 1993).

III.A.3. Ship Construction Processes

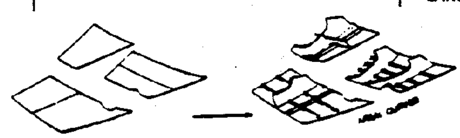
Most new ship construction projects are carried out using zone-oriented methods, such as the hull block construction method (HBCM). In HBCM, the ship structure is physically divided into a number of blocks. The definition of hull blocks has an enormous impact on the efficiency of the ship construction. Therefore, blocks are carefully designed to minimize work and to avoid scheduling problems. Blocks are constructed and pieced together in five general manufacturing levels. Figure 4 summarizes the various manufacturing levels.

The first level involves the purchasing and handling of raw materials and fabricating these materials into the most basic parts. The primary raw materials include steel plates, bars, and structural members. Parts fabrication or pre-assembling operations often involve cutting, shaping, bending, machining, blasting, and painting of these materials. Fabricated parts include steel plates and steel members used as structural parts, machined parts, piping, ventilation ducts, electrical components (motors, lights, transformers, gauges, etc.), and a wide variety of other miscellaneous parts. Parts fabrication is carried out throughout the shipyard in a number of different shops and work areas depending on the specific raw materials being handled (see Section III.A.7 for a description of typical operations conducted in shipyard shops).

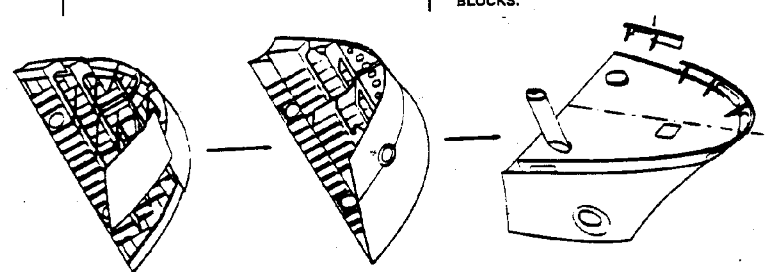
Level 2 of new ship construction involves the joining of different fabricated parts from Level 1 into assembled parts. In the third level of manufacturing the fabricated and/or assembled parts are fitted together into a sub-block assembly which are in turn fitted together in Level 4 to form blocks. Blocks are three dimensional sections of the ship and are the largest sections of the ship to be assembled away from the erection site. Blocks are designed to be stable configurations that do not require temporary support or reinforcement. Often, at least one side of a block forms part of the outside hull of the ship. Blocks are built and transported through the shipyard and welded together at a building position where the ship is erected. The size of the blocks that a shipyard can build is dependent on the shipyard capacity to assemble, transport, and lift the blocks and units onto the ship under construction. In Level 5 the ship is erected from the blocks (Storch, 1995).

Figure 4: General Ship Manufacturing Levels

LEVEL # 1	PURCHASING AND PRE-ASSEMBLY	A) PURCHASING OF RAW MATERIALS, B) TRANSFORMING THE MATERIALS INTO PARTS. (i.e., PLATE STEEL INTO SHAPES AND PIPE INTO PIPE SPOOLS)
LEVEL #s 2 & 3	SUB-ASSEMBLY	JOINING THOSE PARTS PRODUCED AT LEVEL #1 INTO LARGER SUB-ASSEMBLIES.



LEVEL # 4	ASSEMBLY AND OUTFITTING	JOINING PARTS AND SUB-ASSEMBLIES TOGETHER TO FORM LARGE SECTION OF THE SHIP CALLED HULL BLOCKS.



LEVEL # 5	ERECTION	INSTALLATION OF THE HULL BLOCK ONTO THE SHIP UNDER CONSTRUCTION, THUS THE SHIP IN BEING ERECTED.
LEVEL # 6	SYSTEM COMPLETION AND TEST AND TRIAL	SYSTEMS ON THE SHIP (i.e., ELECTRICAL, HEATING AND VENTILATION, PLUMBING, ETC.) ARE CONNECTED TOGETHER, TESTED, AND TESTED BEFORE DELIVERY TO THE CUSTOMER.

Source: Adapted from NSRP, *Introduction to Production Processes and Facilities in the Steel Shipbuilding and Repair Industry*, 1993.

Another important aspect of ship construction is outfitting. Outfitting, which involves the fabrication and installation of all the parts of a ship that are not structural in nature, is carried out concurrently with the hull construction. Outfit is comprised of the ship's plumbing, derricks, masts, engines, pumps, ventilation ducts, electrical cable, stairs, doors, ladders, and other equipment. The basic raw materials include pipes, sheet metal, electrical components, and machinery. A zone-oriented method is typically used to assemble the parts that form major machinery spaces onboard the ship including engine rooms, pump rooms, and auxiliary machinery spaces. Parts or fittings can be assembled onboard the ship during hull erection, on the blocks or subblocks, or independent of the hull structure in units of similar parts (NSRP, 1993).

III.A.4. Major Production Facilities

Most shipbuilding yards have in common the following major facilities, work areas, or specialized equipment.

Prime Line

The prime line is a large machine that blasts and primes (paints) raw steel sheets, preparing them for production. Steel sheets, parts, and shapes enter one end of the prime line, go through a blasting section, then through a priming section. The primer is referred to as construction primer, and is used to prevent corrosion during the production process. Section III.A.9 discusses surface preparation and coating operations in more detail (NSRP, 1993).

Panel Lines

Panel lines typically consist of motor driven conveyors and rollers used to move large steel plates together for joining. The use of panel lines introduced manufacturing production line techniques into the steel shipbuilding industry. Joining of plates involves the welding of the seams either on one side or two sides. Two sided welding requires the panel line to be capable of turning the steel plates over after one-side is welded. Vertical stiffeners are also welded on the panel line often using automated welding machines. After welding, excess steel is cut off using gas cutting equipment. Panel assemblies are typically moved through the line with the aid of magnetic cranes (NSRP, 1993).

Platen Lines

The platen lines (or platens) are the area in the shipyard where blocks are assembled. Therefore, platens form assembly lines where the steel structures of construction blocks are fabricated. Sub-assemblies from the panel line and plate shop are brought together at the platen and assembled into blocks. The platen mainly provides locations for sub-assembly construction, block layout, tack-welding, and final weld out. The platen lines are serviced by welding and steel cutting equipment and cranes for materials movement (NSRP, 1993).

Rolls

Rolls are large facilities that bend and shape steel plates into curved surface plates for the curved portion of the hull. Rolls consist of large cylindrical steel shafts and a motor drive. Rolls vary greatly in size and technology from shipyard to shipyard. Some of the newer rolls are computer controlled, while the older machines are manually operated (NSRP, 1993).

Pin Jigs

Pin jigs are platen lines used to assemble the curved blocks that form the outside of the hull's curved surface. The pin jig is simply a series of vertical screw jacks that support curved blocks during construction. A pin jig is set up specifically for the curved block under construction. The jig heights are determined from the ship's engineering drawings and plans (NSRP, 1993).

Rotary Tables

Rotary tables are facilities that hull blocks are set into and which mechanically rotate the block. The ability to easily rotate an entire block in a single location reduces the number of time-consuming crane lifts that would otherwise be needed. Rotary tables also exploit the increased efficiencies experienced when workers are able to weld on a vertical line (down hand). Down hand welding provides a higher quality weld with higher efficiency rates. Turn tables are also used for outfitting materials on the block because of easier access to outfitting locations (NSRP, 1993).

Materials Handling

Materials handling is an important aspect of efficient shipbuilding. Considerable coordination is needed between materials delivery and the production schedule. Materials need to be delivered to the proper location in the shipyard at the proper time to be installed on the construction block. Typical materials handling equipment includes conveyors, cranes, industrial vehicles (e.g., forklifts, flatbeds, carts, special lift vehicles, etc.), and containers (NSRP, 1993).

III.A.5. Welding

The structural framework of most ships is constructed of various grades of mild and high strength steel. Aluminum and other nonferrous materials are used for some superstructures (deck-houses) and other areas requiring specific corrosion resistance and structural requirements. However, other common materials such as stainless steel, galvanized steel, and copper nickel alloys, are used in far less quantities than steel (ILO, 1996).

The primary raw material for ship construction is steel plate. Steel plates are typically cut to the desired size by automatic burners before being welded together to form the structural components of the vessel.

Shipyard welding processes are performed at nearly every location in the shipyard. The process involves joining metals by bringing the adjoining surfaces to extremely high temperatures to be fused together with a molten filler material. An electric arc or gas flame are used to heat the edges of the joint, permitting them to fuse with molten weld fill metal in the form of an electrode, wire, or rod. There are many different welding techniques used by the industry. Most welding techniques can be classified as either electric arc or gas welding, with electric arc being the most common (ILO, 1996).

An important factor impacting the strength of welds is arc shielding, isolating the molten metal weld pool from the atmosphere. At the extremely high temperatures used in welding, the molten metal reacts rapidly with oxygen and nitrogen in the atmosphere which decreases the weld strength. To protect against this weld impurity and ensure weld quality, shielding from the atmosphere is required. In most welding processes, shielding is accomplished by addition of a flux, a gas, or a combination of the two. Where a flux material is used, gases generated by vaporization and chemical reaction at the electrode tip result in a combination of flux and gas shielding that protect the weld from the atmosphere. The various types of electric arc welding (shielded metal arc, submerged arc, gas metal arc, gas tungsten arc, flux core arc, and plasma-arc) all use different methods to accomplish arc shielding (ILO, 1996).

III.A.6. Ship Repairing Processes

Ship repair generally includes all ship conversions, overhauls, maintenance programs, major damage repairs, and minor equipment repairs. Although specific repair methods vary from job to job, many of the operations are identical to new ship construction operations. Repair operations, however, are typically on a smaller scale and are performed at a faster pace. Jobs can last anywhere from one day to over a year. Repair jobs often have severe time constraints requiring work to be completed as quickly as possible in order to get the ships back in service. In many cases, piping, ventilation, electrical, and other machinery are prefabricated prior to the ship's arrival. Often, repair jobs are an emergency situation with very little warning, which makes ship repair a fast moving and unpredictable environment. Typical maintenance and repair operations include:

- Blasting and repainting the ship's hull, freeboard, superstructure, and interior tanks and work areas

- Major rebuilding and installation of machinery such as diesel engines, turbines, generators, pump stations, etc.

- Systems overhauls, maintenance, and installation (e.g., piping system flushing, testing, and installation)

- System replacement and new installation of systems such as navigational systems, combat systems, communication systems, updated piping systems, etc.

- Propeller and rudder repairs, modification, and alignment

- Creation of new machinery spaces through cut outs of the existing steel structure and the addition of new walls, stiffeners, vertical, webbing, etc.

In addition, some larger shipyards are capable of large repair and conversion projects that could include: converting supply ships to hospital ships, cutting a ship in half and installing a new section to lengthen the ship, replacing segments of a ship that has run aground, completing rip-out, structural reconfiguration and outfitting of combat systems, major remodeling of ships' interiors or exteriors (NSRP, 1993).

III.A.7. Support Shops and Services

Shipyards typically have a number of support shops that either process specific raw materials (e.g., pipes, electric, sheet metal, machinery, plates, paint, etc.) or provide specialty services (e.g., carpentry, maintenance, materials transporting, warehousing, etc.). In many ways, support shops are small manufacturers producing goods to support the production effort (NSRP, 1993). Common shipbuilding and repair yard support shops and services are described below.

Pipe Shop

The pipe shop is responsible for manufacturing and assembling piping systems. Piping systems are the largest outfitting task in shipbuilding. Small pipe sections known as "pipe spools" are assembled in the pipe shop and transported to the stages of construction (i.e., assembly, on-block, on-unit, and on-board). Pipe spools are shaped and manufactured per engineering design, are scheduled for construction, and sent to the various stages for installation. Many pipe shops will tag the spools to identify the location for installation on the block and ship. A typical ship may have anywhere from 10,000 to 25,000 pipe spools. Some of the processes in the pipe shop include: pipe welding, pipe bending, flux removal, grit-blast, pickling, painting, galvanizing, and pressure testing. Some of the equipment used by the pipe shop are as follows: pipe welders, lathes, pipe cutting saws, shears, grinders, chippers, hole cutters, pipe benders, pickling tanks, and transportation equipment (NSRP, 1993).

Machine Shop

The machine shop serves the entire shipyard's machining needs though the exact functions of the shipyard machine shops vary throughout the shipbuilding industry. Shipyard machine shops perform functions ranging from rebuilding pumps to turning 25 foot long propeller drive shafts on lathes. Equipment in the machine shop consists of: end mills, lathes, drill presses, milling machines, band saws, large presses, work tables, and cleaning tanks (NSRP, 1993).

Sheet Metal Shop

The sheet metal shop is generally responsible for fabricating and installing ventilation ducting and vent spools. Using engineering drawings and special sheet metal tools this shop produces ventilation systems for new construction, as well as repair work. The shop cuts, shapes, bends, welds, stamps, paints, and performs a variety of manufacturing operations for ship ventilation systems. Many sheet metal shops are also responsible for assembling large ducting fans and heating and air conditioning components. Sheet metal workers perform the installation of the ducting in various stages of construction such as on-block, on-unit, onboard (NSRP, 1993).

Electrical Shop

Electrical shops in the shipyard perform a variety of functions throughout the industry. In many cases, the electrical shop installs, rebuilds, builds, and tests electrical components (e.g., motors, lights, transformers, gauges, etc.). The electrical shop electricians also install the electrical equipment on the ship either on-block or onboard. On-block is where the electrical parts are installed and onboard is where cables are routed throughout the ship connecting the electrical systems together. Electric shops generally have plating tanks, dip tanks for lacquer coatings, electrical testing equipment, and other specialized equipment (NSRP, 1993).

Foundry/Blacksmith Shop

The blacksmith shop is an older term used for the shipyard shop that performs forging or castings. Forging and casting at shipyards are somewhat rare. Over the years, forging and casting functions have been shifted to subcontractors off-site. The subcontractors are usually foundries whose primary function is forging and casting. Shipyards that have blacksmith shops maintain large furnaces and other foundry equipment (NSRP, 1993).

Plate Shop

The plate shop is a generic term used for the area and process in the shipyard that provides steel parts cutting, bending, and sub-assembly. The plate shop uses information from engineering drawings to produce plate shapes. The shapes are cut and formed as needed. Most plate shops have manual and computer controlled machinery. The types of machinery commonly found in the plate shop are cutting machines, steel bending machines and plate bending rolls, shearing machines, presses, hole punching equipment, and furnaces for heat treatment. The plate shop sends the parts and sub-assemblies that they manufacture to the stages of construction, or the platen area for installation (NSRP, 1993).

Production Services

Services provided by this department include: carpentry, scaffolding erection, crane operations, rigging, facility and equipment maintenance, and other production support activities. The production services may be grouped into one department or divided into unique shops for each service provided (NSRP, 1993).

III.A.8. Solvent Cleaning and Degreasing

Solvent cleaning and degreasing are common in the shipbuilding and repair industry (although many facilities are replacing solvent cleaning and degreasing with aqueous and alkaline cleaning and degreasing). Solvent cleaning and degreasing are typically accomplished by either cold cleaning or vapor degreasing. Cold cleaning refers to operations in which the solvent is used at room temperature. The surfaces or parts are soaked in a tank of solvent, or sprayed, brushed, wiped, or flushed with solvent. Diphase cleaning is sometimes used to combine a water rinse before and after the solvent cleaning into a single step. In diphase cleaning, water insoluble halogenated solvents and water are placed in a single tank where they separate with the solvent on the bottom. Parts are lowered through the water bath before reaching the solvent and then are rinsed through the water level as they are removed from the tank.

In vapor degreasing, parts and surfaces are cleaned with a hot solvent vapor. Solvent in a specially designed tank is boiled creating a solvent vapor in the upper portion of the tank. The parts are held in the vapor zone where solvent vapor condenses on the surface removing dirt and oil as it drips back into the liquid solvent. In this way, only clean solvent vapors come in contact with the part. A condensing coils at the top of the tank reduces the amounts of solvents escaping to the atmosphere (NSRP, 1993).

III.A.9. Surface Preparation

To a large extent, the effectiveness of the surface coating relies on the quality of surface preparation. All paints will fail eventually, but the majority of premature failures are due to loss of adhesion caused by improper surface preparation. Surface preparation is also typically one of the most significant sources of shipyard wastes and pollutant outputs. Section III.B.1 discusses waste generation and pollution outputs from these operations.

Surface preparation techniques are used to remove surface contaminants such as mill scale, rust, dirt, dust, salts, old paint, grease, and flux. Contaminants that remain on the surface are the primary causes of premature failure of coating systems. Depending on the surface location, contaminants, and materials, a number of different surface preparation techniques are used in the shipbuilding and repair industry:

- Solvent, Detergent, and Steam Cleaning
- Blasting
- Hand Tool Preparation
- Wet Abrasive Blasting and Hydroblasting
- Chemical Preparation

Solvent, Detergent, and Steam Cleaning

The process of removing grease, oil and other contaminants with the aid of solvents, emulsions, detergents, and other cleaning compounds is frequently used for surface preparation in the shipbuilding industry. Solvent cleaning involves wiping, scrubbing, immersion in solvent, spraying, vapor degreasing, and emulsion cleaning the surface with rags or brushes until the surface is cleaned. The final wipe down must be performed with a clean rag or brush, and solvent. Inorganic compounds such as chlorides, sulfates, weld flux, rust and mill scale cannot be removed with organic solvents.

In many cases steam cleaning is a better alternative to solvent wipe down. Steam cleaning or high pressure washing is used to remove dirt and grime that is present on top of existing paint and bare steel. Many hot steam cleaners with detergents will remove most petroleum products and sometimes, old chipping paint. After steam cleaning the part should be rinsed with fresh water and allowed to dry. Often the surface is ready to prime, although many surfaces will require further preparation before painting.

Blasting

Abrasive blasting is the most common method for paint removal and surface preparation. Copper slag, coal slag, steel grit, and steel shot are common blasting abrasives. Copper and steel grit consist of small angular particles, while steel shot is made up of small round balls. Copper slag can generally be used only once or twice before it becomes too small to be effective. Steel grit and shot can typically be used between 50 and 5,000 times before becoming ineffective. Metallic grit and shot are available in varying ranges of hardness and size.

Centrifugal blasting machines, also called roto-blasting or automatic blasting, are one of the more popular methods of blasting steel surfaces. In centrifugal blasting, metallic shot or grit is propelled to the surface to be prepared by a spinning wheel. Centrifugal blasting machines tend to be large and not easily mobilized. Therefore, they are not applicable to all shipyard blasting needs. Parts to be prepared must be brought to the machine and passed through on a conveyor or rotary table. On flat surfaces, centrifugal blasting machines can produce uniform blasting results at high production rates. More time is required to prepare surfaces that are hard to reach. The process allows easy recovery of abrasive materials for reuse and recycling which can result in significant savings in materials and disposal costs. Large centrifugal blasting machines are often found in the prime line for preparing raw steel sheets before priming. Other centrifugal blasting machines are smaller and can be used to prepare small parts, pipe spools, and steel subassemblies prior to painting.

Air nozzle blasting (or dry abrasive blasting) is one of the most common types of blasting in the shipbuilding and repair industry. In air nozzle blasting, abrasive is conveyed to the surface to be prepared in a medium of high pressure air (approximately 100 pounds per square inch) through a nozzle at velocities approaching 450 feet per second. Abrasives are copper slag, coal slag and other metallic grit. Typically copper slag is used on the west coast and coal slag is used on the east coast. Traditionally sand was used, but metallic grit has replaced it due to the adverse health and environmental effects of silica dust associated with sand. Air nozzle blasting is generally carried out manually by shipyard workers either within a building or in the open air, depending on the application. If the application allows, blast booths can be used for containing abrasives.

Hand Tool Preparation

Hand tools such as grinders, wire brushes, sanders, chipping hammers, needle guns, rotary peening tools, and other impact tools are commonly used in the shipyard for surface preparation. The hand tools are ideal for small jobs, hard to reach areas, and areas where blasting grit would be too difficult to contain. Cleaning surfaces with hand tools seems comparatively slow although, when removing heavy paint formulations and heavy rust, they are effective and economical. Impact tools like chipping and needle guns are best for removing heavy deposits of brittle substances (e.g., rust and old paint). Hand tools are generally less effective when removing tight surface mill scale or surface rusting, because they can damage the metal surface. Surface preparation hand tools are generally pneumatic instead of electric because they are lighter, easy to handle, do not overheat, and there is no risk of electric shock.

Wet Abrasive Blasting and Hydroblasting

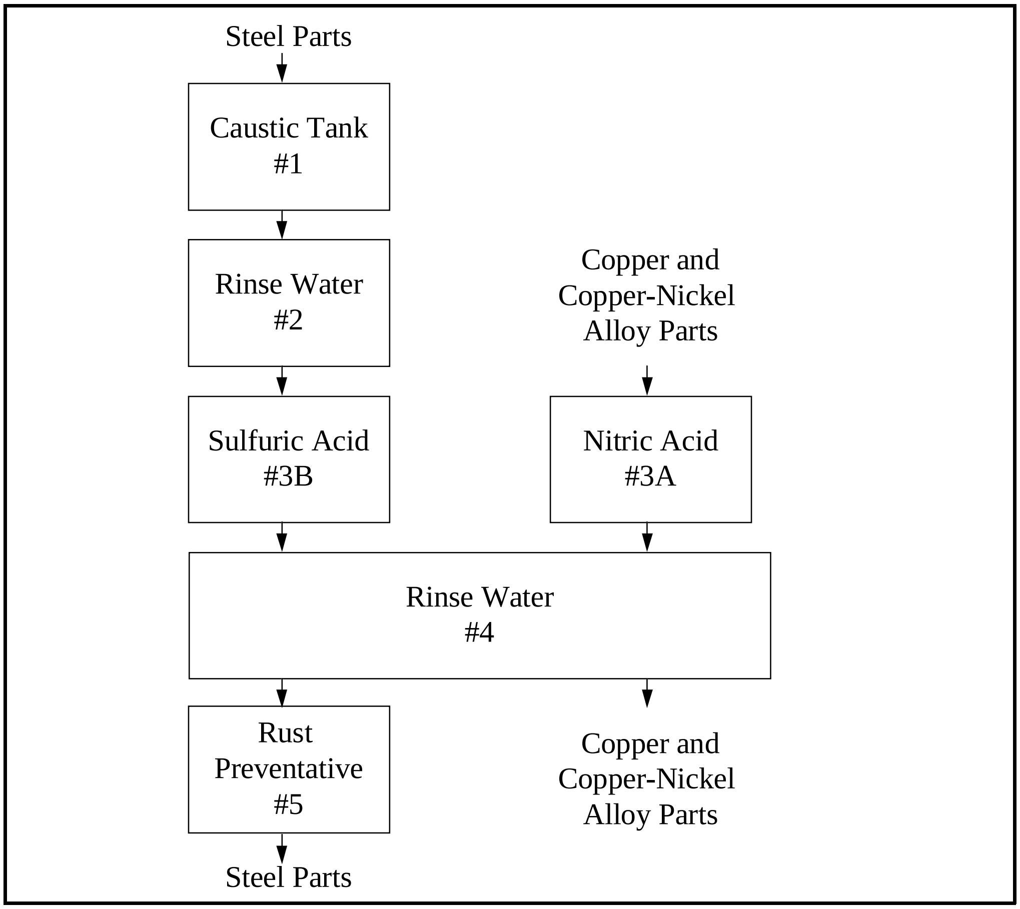
Wet abrasive blasting and hydroblasting are generally performed on ships being repaired in a floating drydock, graving dock, or other building or repair position. Wet abrasive blasting involves blasting with a mixture of water, air and solid abrasives. Wet abrasive blasting does not occur throughout the shipyard like dry abrasive blasting because of the problem of water blast containment. In part due to lack of customer acceptance, wet abrasive blasting is not common in the shipbuilding and repair industry at this time. Instead, hydroblasting is a widely used wet blasting technique which uses only high pressure water to remove chipping paint, marine growth, mud, and salt water from the ship's hull. A small amount of rust inhibitor may be used in the water to prevent flash rusting. Hydro basting is often followed by air nozzle blasting for final surface preparation.

Chemical Preparation

Chemical surface preparations consist of paint removers, alkaline cleaning solutions, chlorinated solvents, and pickling. Alkaline cleaning solutions come in a variety of forms and are used in a variety of manners. Alkaline cleaners can be brushed on, sprayed on, and applied in a dip tank. Alkaline dip tanks of caustic soda solution are frequently used for cleaning parts and preparing them for painting. After the surface is cleaned, it is thoroughly rinsed before a coating system is applied. Many solvents and alkaline cleaners cannot be used for nonferrous materials, such as bronze, aluminum, and galvanized steel which are frequently found on ships.

Pickling is a process of chemical abrasion/etching which prepares surfaces for good paint adhesion. The pickling process is used in shipyards mainly for preparing pipe systems and small parts for paint. However, the process and qualities will vary from shipyard to shipyard. The process involves a system of dip tanks. Figure 5 displays how the tanks can be arranged. In pickling steel parts and piping systems, Tank #1 is used to remove any oil, grease, flux, and other contaminants on the surface being pickled. The content in tank #1 are generally a 5-8% caustic soda and water mixture maintained at temperatures of between 180°-200°F. The part is then immersed into tank #2, which is the caustic soda rinse tank (pH 8-13). Next, the steel is dipped into tank #3B, which is a 6-10% sulfuric acid/water mixture maintained between 140°-160°F. Tank #4 is the acid rinse tank that is maintained at a pH of 5-7. Finally the steel pipe or part is immersed in a rust preventative 5% phosphoric mixture in tank #5. The part is allowed to fully dry prior to paint application.

Figure 5: Typical Pickling Tank Arrangement



Some ships have large piping systems that are predominantly copper-nickel alloy or copper. Pickling of copper is generally only a two-step process. The first step is to dip the pipe into tank #3A, a 3-6% nitric acid solution maintained at 140°-160°F. The nitric acid removes any flux and greases that are present on the surface and prepares the surface for paint. Next, the pipe is dipped into the acid rinse tank (#4), after which it is considered to be treated. Once the part is dry, the final coating can be applied.

Metal Plating and Surface Treatment

Metal plating and surface treatment are used in shipyards to alter the surface properties of the metal in order to increase corrosion or abrasion resistance, and to improve electrical conductivity (Kura, 1996). Metal plating and surface treatment includes chemical and electrochemical conversion, case hardening, metallic coating, and electroplating. Thorough descriptions of these processes and their associated wastes are contained in the *Fabricated Metal Products Industry Sector Notebook.*

III.A.10. Painting Processes

Proper surface coating system application is essential in the shipbuilding and repair industry. The corrosion and deterioration associated with the marine environment has detrimental effects on ships and shipboard components. Maintaining ships' structural integrity and the proper functioning of their components are the main purposes of shipboard coating systems.

Painting is performed at almost every location within shipyards. This is due to the wide variety of work performed throughout shipyards. The nature of shipbuilding and repair requires several types of paints to be used for a variety of applications. Paint types range from water-based coatings to high performance epoxy coatings. The type of paint needed for a certain application depends on the environment that the coating will be exposed. In general there are six areas where shipboard paint requirements exist:

- Underwater (Hull Bottom)
- Waterline
- Topside Superstructures
- Internal Spaces and Tanks
- Weather Decks
- Loose Equipment

Because paint systems are often specified by the customer or are supplied by the ship owner, shipyards often may not be able to choose or recommend a particular system. Navy ships may require a specific type of paint for every application through a military specification (Mil-spec). Many factors are considered when choosing a particular application. Among the factors are environmental conditions, severity of environmental exposure, drying and curing times, application equipment and procedures, etc.

Paint Coating Systems

Paints are made up of three main ingredients: pigment, binder, and a solvent vehicle. Pigments are small particles that generally determine the color as well as many other properties associated with the coating. Examples of pigments include: zinc oxide, talc, carbon, coal tar, lead, mica, aluminum, and zinc dust. The binder can be thought of as the glue that holds the paint pigments together. Many paints are referred to by their binder type (e.g., epoxy, alkyd, urethane, vinyl, phenolic, etc.). The binder is also very important for determining a coating's performance characteristics (e.g., flexibility, chemical resistance, durability, finish, etc.). The solvent is added to thin the paints so that it will flow to the surface and then dry. The solvent portion of the paint evaporates when the paint dries. Some typical solvents include acetone, mineral spirits, xylene, methyl ethyl ketone, and water.

Anticorrosive and antifouling paints are typically used on ship's hulls and are the main two types of paint used in the shipbuilding industry. Antifouling paints are used to prevent the growth of marine organisms on the hull of vessels. Copper-based and tributyl-tin-based paints are widely used as antifouling paints. These paints release small quantities of toxics which discourage marine life from growing on the hull. Anticorrosive paints are either vinyl, lacquer, urethane, or newer epoxy-based coating systems (ILO, 1996).

The first coating system applied to raw steel sheets and parts is generally pre-construction primer. This pre-construction primer is sometimes referred to as shop primer. This coat of primer is important for maintaining the condition of the part throughout the construction process. Pre-construction priming is performed on steel plates, shapes, sections of piping, and ventilation ducting. Most pre-construction primers are zinc-rich with organic or inorganic binders. Zinc silicates are predominant among the inorganic zinc primers. Zinc coating systems protect coatings in much the same manner as galvanizing. If zinc is coated on steel, oxygen will react with the zinc to form zinc oxide, which forms a tight layer that does not allow water or air to come into contact with the steel (ILO, 1996).

Paint Application Equipment

There are many types of paint application equipment used in the shipbuilding industry. Two main methods used are compressed air and airless sprayers. Compressed air sprayers are being phased out in the industry because of the low transfer ability of the system. Air assisted paint systems spray both air and paint, which causes some paint to atomize and dry quickly prior to reaching the intended surface. The transfer efficiency of air assisted spray systems can vary from 65% to 80%. This low transfer efficiency is due mainly to overspray, drift, and the air sprayer's inefficiencies (ILO, 1996).

The most widely used form of paint application in the shipbuilding industry is the airless sprayer. The airless sprayer is a system that simply compresses paint in a hydraulic line and has a spray nozzle at the end. Airless sprayers use hydrostatic pressure instead of air to convey the paint. They are much cleaner to operate and have fewer leaking problems because the system requires less pressure. Airless sprayers can have up to 90% transfer efficiency. A new technology that can be added to the airless sprayer is called High Volume Low Pressure (HVLP). HVLP offers an even higher transfer efficiency, in certain conditions (ILO, 1996).

Thermal spray is the application of aluminum or zinc coatings to steel for long term corrosion protection. Thermal spray can also be referred to as metal spray or flame spray. Thermal spray is significantly different than conventional coating practices due to its specialized equipment and relatively slow production rates. The initial cost of thermal spray is usually high compared to painting, although when the life-cycle is taken into account, thermal spray becomes more economically attractive. Many shipyards have their own thermal spray machines and other shipyards will subcontract their thermal coating work. Thermal spray can occur in a shop or onboard the ship. There are two basic types of thermal coating machines: combustion wire and arc spray. The combustion wire type consists of combustible gasses and flame system with a wire feed controller. The combustible gasses melt the material to be sprayed onto the parts. The electric arc spray machine instead uses a power supply arc to melt the flame sprayed material (ILO, 1996).

Painting Practices and Methods

Painting is performed in nearly every area in the shipyard from the initial priming of the steel to the final paint detailing of the ship. Methods for painting vary greatly from process to process. Mixing of paint is performed both manually and mechanically and should be done in an area contained by berms, tarps, secondary containment pallets. Outdoor as well as indoor painting occurs in the shipyard. Shrouding fences, made of steel, plastic, or fabric, are frequently used to help contain paint overspray by blocking the wind and catching paint particles (NSRP, 1996).

Hull painting occurs on both repair ships and new construction ships. Hull surface preparation and painting on repair ships is normally performed when the ship is fully drydocked (i.e., graving-dock or floating drydock). For new construction, the hull is prepared and painted at a building position using one of the techniques discussed in the previous sections. Paint systems are sprayed onto the hull using airless sprayers and high reach equipment such as man-lifts, scissor lifts, or portable scaffolding (ILO, 1996).

The superstructure of the ship consists of the exposed decks, deck houses, and structures above the main deck. In many cases, scaffolding is used onboard the ship to reach antennas, houses, and other superstructures. Shrouding is usually put into place if it is likely that paint or blast material will fall into adjacent waters. On repair ships, the ship's superstructure is painted mostly while berthed. The painters access the superstructures with existing scaffolding, ladders, and various lifting equipment that was used during surface preparation. The shrouding system (if applicable) that was used for blast containment will stay in place to help contain any paint overspray (ILO, 1996).

Tanks and compartments onboard ships must be coated and re-coated to maintain the longevity of the ship. Re-coating of repair ship tanks requires a large amount of surface preparation prior to painting. The majority of the tanks are at the bottom of the ship (e.g., ballast tanks, bilges, fuel, etc.). The tanks are prepared for paint by using solvents and detergents to remove grease and oil build-up. The associated waste-water developed during tank cleaning must be properly treated and disposed of. After the tanks are dried, they are blasted with a mineral slag. Once the surface is blasted and the grit is removed, painting can begin. Adequate ventilation and respirators are a strict requirement for all tank and compartment surface preparation and painting (ILO, 1996).

Painting is also carried out after the assembly of hull blocks. Once the blocks leave the assembly area, they are frequently transported to a blast area where the entire block is prepared for paint. At this point, the block is usually blasted back down to bare metal (i.e., the construction primer is removed). However, many shipyards are now moving towards implementing a preconstruction primer that does not need to be removed. The most frequent method for block surface preparation is air nozzle blasting. The paint system is applied by painters generally using airless spray equipment on access platforms. Once the block's coating system has been applied, the block is transported to the on-block stage where outfitting materials are installed (ILO, 1996).

Many parts need to have a coating system applied prior to installation. For example, piping spools, vent ducting, foundations, and doors are painted before they are installed on-block. Some small parts painting occurs in the various shops while others are painted in a standard location operated by the paint department (ILO, 1996). Indoor painting of this type usually occurs in a spray booth. Spray booths capture overspray, control the introduction of contaminants to the workplace environment, and reduce the likelihood of explosions and fires. Paint booths are categorized by the method used for collecting the overspray (EPA, 1995).

The two primary types of paint booths are dry filter and water wash booths. Dry filter booths use filter media (usually paper or cloth filters) to screen out the paint solids by pulling prefiltered air through the booth, past the spraying operation, and through the filter media. Water wash booths use a "water curtain" to capture paint overspray by pulling air containing entrained paint overspray through a circulated water stream which "scrubs" the overspray from the air. Water is periodically added to the paint booth reservoir to compensate for evaporative losses, and chemicals are periodically added to improve paint sludge formation. The sump is periodically discharged, usually during general system cleaning or maintenance (EPA, 1995).

III.A.11. Fiberglass Reinforced Construction Operations

Many of the medium and small shipyards manufacture and repair fiberglass ships and boats or construct fiberglass parts for steel ships. The process involves combining polymerizing resin with fiberglass reinforcing material. The resin is polymerized with a catalyst or curing agent. Once cured, the hard resin cannot be softened or reshaped and is stronger than composite plastics without the reinforcing. Fiberglass material consists of a woven mat of glass-like fibers. The fiberglass content of the reinforced product ranges from 25 to 60 percent.

A number of different processes are used, but the mold-based process is the most common for this industry. Mold-based fiberglass reinforced construction typically involves either the hand application or spray application of fiberglass reinforcing. In the hand application method, the reinforcing material is manually applied to a mold wetted with catalyzed resin mix or gelcoat and then sprayed or brushed with more resin or gelcoat. In the sprayup method, catalyzed resin and fiberglass reinforcement are mechanically sprayed onto the mold surface.

Molds are used to give structure and support to the shape of the structure being built. Most molds are made of wood with a plastic finish. Typical resins used include: polyesters, epoxies, polyamides, and phenolics. The type of resin to be used in a particular process depends on the specific properties required for the end product. The resin is supplied in liquid form and may contain a solvent. Resin preparation involves mixing with solvents, catalysts, pigments, and other additives. Solvents are typically acetone, methanol, methyl ethyl ketone, and styrene. Catalysts are typically amines, anydrides, aldehyde condensation products, and Lewis acid products. Gelcoat is a pigmented polyester resin or a polyester resin-based paint containing approximately 35 percent styrene that is applied to the mold or surface with an air atomizer or airless spray gun. A catalyst is injected into the resin in a separate line or by hand mixing in order to thermoset the polyester resin.

III.B. Raw Material Inputs and Pollutant Outputs

Raw material inputs to the shipbuilding and repair industry are primarily steel and other metals, paints and solvents, blasting abrasives, and machine and cutting oils. In addition, a wide variety of chemicals are used for surface preparation and finishing such as solvent degreasers, acid and alkaline cleaners, and cyanide and metal bearing plating solutions. Pollutants and wastes generated typically include VOCs, particulates, waste solvents, oils and resins, metal bearing sludges and wastewater, waste paint, waste paint chips, and spent abrasives. The major shipyard activities that generate wastes and pollutant outputs are discussed below and are summarized in Table 3.

III.B.1. Surface Preparation

The materials used and wastes generated during surface preparation depend on the specific methods used. The surface preparation method is chosen based on the condition of the metal surface (e.g., coated with paint, rust, scale, dirt, grease, etc.), the type of coating to be applied, the size, shape, and location of the surface, and the type of metal. Material inputs used for preparing surfaces include: abrasive materials such as steel shot or grit, garnet, and copper or coal slag; and cleaning water, detergents, and chemical paint strippers (e.g., methylene chloride-based solutions, caustic solutions, and solvents). In the case of hydroblasting, only water and occasionally rust inhibitor are required (NSRP, 1996).

Air Emissions

Air emissions from surface preparation operations include particulate emissions of blasting abrasives, and paint chips. Particulates emissions can also contain toxic metals which are a concern both in the immediate area surrounding the work and if they are blown off-site or into surrounding surface waters. Particulate emissions are typically controlled by preparing surfaces indoors when possible or by surrounding the work area with shrouding fences made of steel, plastic, or fabric. Other air emissions that could potentially arise during surface preparation operations are VOCs and hazardous air pollutants (HAPs) arising from the use of solvent cleaners, paint strippers, and degreasers.

Residual Wastes

The primary residual waste generated is a mixture of paint chips and used abrasives. Paint chips containing lead or antifouling agents may be hazardous, but often in practice the concentration of toxic compounds is reduced due to the presence of considerable amounts of spent blasting medium. The resulting mixed waste may be nonhazardous (Kura, 1996). Waste sludge containing paint chips and surface contaminants may also be generated in the case of hydroblasting or wet abrasive blasting. Blasting abrasives and paint chips that collect in tank vessels, ship decks, or drydocks should be thoroughly cleaned up and collected after work is completed or before the drydock is flooded or submerged. Particular attention should be paid to the cleanup of paint chips containing the antifouling tributyl-tin (TBT) compounds which have been shown to be highly toxic to oysters and other marine life (Levy, 1996).

Wastewater

Significant quantities of wastewater can be generated when cleaning ship cargo tanks, ballast tanks, and bilges prior to surface preparation and painting. Such wastewater is often contaminated with cleaning solvents, and oil and fuel from bilges and cargo tanks. Wastewater contaminated with paint chips and surface contaminants is generated when hydroblasting and wet abrasive blasting methods are used (EPA, 1991).

III.B.2. Painting

Material inputs for painting are primarily paints and solvents. Solvents are used in the paints to carry the pigment and binder to the surface, and for cleaning the painting equipment. VOCs and HAPs from painting solvents are one of the most important sources of pollutant outputs for the industry. Paints also may contain toxic pigments such as chromium, titanium dioxide, lead, copper, and tributyl-tin compounds. Water is also used for equipment cleaning when water-based paints are used.

Air Emissions

Painting can produce significant emissions of VOCs and HAPs when the solvents in the paint volatilize as the paint dries. Other sources of VOCs and HAPs may arise when solvents are used to clean painting equipment such as spray guns, brushes, containers, and rags. Sprayed paint that does not reach the surface being coated, or overspray, is another source of painting air emissions. The solvents in the overspray rapidly volatilize and the remaining dry paint particles can drift off-site or into nearby surface waters.

Residual Wastes

Solid wastes associated with painting are believed to be the largest category of hazardous waste produced in shipyards (Kura, 1996). Typical wastes associated with painting include leftover paint, waste paint containers, spent equipment, rags and other materials contaminated with paint, spent solvents, still bottoms from recycled cleaning solvents, and sludges from the sumps of water wash paint spray booths. Wastes associated with antifouling bottom paints are sometimes collected separately from the typically less toxic topside and interior paints. Antifouling paints contain toxic metal or organometallic biocides such as cuprous oxide, lead oxide, and tributyl-tin compounds. (Kura, 1996)

Wastewater

Wastewater contaminated with paints and solvents may be generated during equipment cleaning operations; however, water is typically only used in cleaning water-based paints. Wastewater is also generated when water curtains (water wash spray booths) are used during painting. Wastewater from painting water curtains commonly contains organic pollutants as well as certain metals. The wastewater can be treated at the source using filtration, activated carbon adsorption, or centrifugation and then reused instead of being discharged (EPA, 1995).

III.B.3. Metal Plating and Surface Finishing

Material inputs for metal plating and finishing include the solutions of plating metals such as chromium, aluminum, brass, bronze, cadmium, copper, iron, lead, nickel, zinc, gold, platinum, and silver. In addition, cyanide solutions, solvents, rinse water, and rust inhibitors are used. Many of the wastes generated from metal plating and surface finishing operations are considered hazardous resulting from their toxicity. Thorough descriptions of these processes and their associated wastes are contained in the *Fabricated Metal Products Industry Sector Notebook.*

Air Emissions

Air emissions arise from metal mists, fumes, and gas bubbles from the surface of the liquid baths and the volatilization of solvents used to clean surfaces prior to plating or surface finishing.

Residual Wastes

Solid wastes include wastewater treatment sludges, still bottoms, spent metal plating solutions, spent cyanide solutions, and residues from tank cleaning. Often, the solid waste generated contains significant concentrations of toxic metals, cyanides, acids, and alkalies.

Wastewater

Wastewaters are primarily rinse waters, quench water, and waste tank cleaning water contaminated with metals, cyanides, acids, alkalies, organics, and solvents. Wastewaters are typically either sent off-site for treatment or disposal or are treated onsite by neutralization and conventional hydroxide precipitation prior to discharging either to a POTW or surface waters under an NPDES permit.

III.B.4. Fiberglass Reinforced Construction

Material inputs for fiberglassing operations include fiberglass, mold or reinforcing materials (wood and plastic), resins, solvents, and curing catalysts. Unsaturated polyester resins, such as orthophthalic polyester, isophthalic polyester, and bisphenol polyester are the most commonly used resins. Other resins include epoxies, polyamides and phenolic compounds. Resins typically are not hazardous; however, the solvent in which the resin is dissolved may be hazardous. In addition, some catalysts may be hazardous. Catalysts include amines (e.g., diethylenetriamine and triethylenetetramone), anhydrides, aldehyde condensation products, and Lewis acid catalysts.

Typical hazardous wastes include containers contaminated with residual chemicals, wash-down wastewater, spent cleaning solvents from equipment cleanup, scrap solvated resin left over in mix tanks, diluted resin and partially cured resin. For a detailed description of fiberglassing operations and associated wastes, refer to EPA's *Pollution Prevention Guide for the Fiberglass-Reinforced and Composite Plastics Industry, October 1991*.

Air Emissions

Organic vapors consisting of VOCs are emitted from fresh resin surfaces during the fabrication process and from the use of solvents for cleanup. The polyester resins used in gelcoating operations have a styrene content of approximately 35 percent. Emissions of styrene and other solvent VOCs during spraying, mixing, brushing, and curing can be significant. In addition, emissions of solvent vapors arise when acetone and methylene chloride are used to clean fiber glassing equipment (Kura, 1996).

Residual Wastes

Residual wastes generated from fiberglass operations include, gelcoat and resin overspray, unused resins that have exceeded their shelf life, fiberglass boxes, gelcoat drums, waste solvents, and cleanup rags (Kura, 1996).

III.B.5. Machining and Metalworking

Machining and metal working operations such as cutting, pressing, boring, milling, and grinding, typically involve the use of a high speed cutting tool. Friction at the cutting edge of the blade creates heat that could permanently deform the metal being machined or the cutting tool. Coolants, such as cutting oils and lube oils are, therefore, supplied to the leading edge of the tool to remove excessive heat (Kura, 1996). Solvents are frequently used to clean parts and tools prior to and after machining.

Air Emissions

Fugitive air emissions arise from the use of solvents for cleaning and degreasing.

Residual Wastes

Waste cutting oils, lube oils, and degreasing solvents are the major residual wastes generated. Metal shavings and chips are also generated. Typically these are separated from coolants, if necessary, and recycled along with scrap metal (Kura, 1996).

Wastewater

Wastewaters containing cleaning solvents and emulsified lubricants, coolants, and cutting oils may produced if parts are cleaned or rinsed with water. In addition, some modern lubricating oils and grease are being formulated with limited or no mineral oil content. These lubricants are known as high water content fluids. When spent they can result in wastewater comprised of a maximum of 15 percent mineral oil emulsified in water (Water Environment Federation, 1994).

III.B.6. Solvent Cleaning and Degreasing

The type of solvent used in parts and surface cleaning and degreasing depends on the type of contaminants to be removed, degree of cleaning needed, properties of the surfaces to be cleaned, and properties of the various solvents (stability, toxicity, flammability, and cost). Both halogenated and nonhalogenated solvents are used and mixtures of different solvents are common. Typical cleaning and degreasing solvents include mineral spirits, aromatic hydrocarbons (e.g., xylenes, toluene, etc.), aliphatic hydrocarbons, ketones, esters, alcohols, glycol ethers, phenols, turpentine, and various halogenated solvents (e.g., trichloroethylene, 1,1,1-trichloroethane, perchloroethylene, etc.).

Air Emissions

Solvent vapors comprised of VOCs and HAPs are a significant pollutant output of cleaning and degreasing operations. Fugitive emissions arise from vapor degreasers, solvent tanks and containers, solvent stills, solvent soaked rags, and residual solvents on parts and surfaces.

Residual Wastes

Residual wastes may include contaminated or spent solvents, solvents that have become contaminated or deteriorated due to improper storage or handling, solvent residues and sludges from tank bottoms and still bottoms, solvent contaminated rags and filter cartridges, and solvent contaminated soil from solvent spills.

Wastewater

Wastewater containing solvents are generated when cleaning or rinsing parts or surfaces, and when cleaning equipment, tanks, and process lines with water. Wastewater contaminated with solvents is also generated when water from diphase parts cleaning operations is replaced.

Table 3: Material Inputs and Potential Pollutant Outputs for the Shipbuilding and Repair Industry

Industrial Process	Material Inputs	Air Emissions	Wastewater	Residual Wastes
Surface Preparation	Abrasives (steel shot, lead shot, steel grit, garnet, copper slag, and coal slag), detergents, solvent paint strippers and cleaners, and caustic solutions.	Particulates (metal, paint, and abrasives) and VOCs from solvent cleaners and paint strippers.	Wastewater contaminated with paint chips, cleaning and paint stripping solvents, surface contaminants, and oil residues from bilges and cargo tanks.	Paint chips (potentially containing metals, tributyl-tin), spent abrasives, surface contaminants, and cargo tank residues.
Metal Plating and Surface Finishing	Plating metals, cyanide solutions, cleaning solvents, rinse water, acid and caustic solutions and rust inhibitors.	Metal mists and fumes, and VOCs from solvents.	Rinse and quench water contaminated with metals, cyanides, acids, alkalies, organics, and solvents.	Sludge from wastewater treatment, spent plating solutions and cyanide solutions, bath cleaning residues.
Painting	Paints, solvents, and water.	VOCs from paint solvents and equipment cleaning solvents, and overspray.	Waste equipment cleaning water and water wash spray paint booth sump water contaminated with paints and solvents.	Leftover paint and solvents, waste paint and solvent containers, spent paint booth filters, and spent equipment.
Fiberglass Reinforced Construction	Fiberglass, resin, solvents, curing catalysts, and wood and plastic reinforcing materials.	VOC emissions released during construction operations and curing (e.g., styrene) and during cleaning with solvents (e.g., acetone and methylene chloride).	Little or no wastewater generated.	Waste fiberglass, gelcoat, resin, unused resin that has exceeded its shelf life, spent solvents, and used containers.
Machining and Metal Working	Cutting oils, lube oils, and solvents.	VOC emissions from the use of cleaning and degreasing solvents.	Wastewater containing solvents, emulsified lubricating and cutting oils and coolants.	Waste cutting oils, lube oils, and metal chips and shavings.

Sources: Kura, Bhaskar, *Typical Waste Streams in a Shipbuilding Facility*, and U.S. EPA, Office of Research and Development, *Guides to Pollution Prevention, The Marine Maintenance and Repair Industry*.

III.C. Management of Chemicals in Wastestream

The Pollution Prevention Act of 1990 (PPA) requires facilities to report information about the management of Toxics Release Inventory (TRI) chemicals in waste and efforts made to eliminate or reduce those quantities. These data have been collected annually in Section 8 of the TRI reporting Form R beginning with the 1991 reporting year. The data summarized below cover the years 1993-1996 and is meant to provide a basic understanding of the quantities of waste handled by the industry, the methods typically used to manage this waste, and recent trends in these methods. TRI waste management data can be used to assess trends in source reduction within individual industries and facilities, and for specific TRI chemicals. This information could then be used as a tool in identifying opportunities for pollution prevention compliance assistance activities.

While the quantities reported for 1994 and 1995 are estimates of quantities already managed, the quantities listed by facilities for 1996 and 1997 are projections only. The PPA requires these projections to encourage facilities to consider future waste generation and source reduction of those quantities as well as movement up the waste management hierarchy. Future-year estimates are not commitments that facilities reporting under TRI are required to meet.

Table 4 shows that the TRI reporting shipyards managed about six million pounds of production related wastes (total quantity of TRI chemicals in the waste from routine production operations in column B) in 1995. From the yearly data presented in column B, the total quantities of production related TRI wastes increased between 1994 and 1995. This is likely in part because the number of chemicals on the TRI list nearly doubled between those years. Production related wastes were projected to decrease between 1996 and 1997.

Values in column C are intended to reveal the percentage of production related wastes that are either transferred off-site or released to the environment. Column C is calculated by dividing the total TRI transfers and releases (reported in Sections 5 and 6 of the TRI Form R) by the total quantity of production-related waste (reported in Section 8). Since the TRI releases and transfers from Sections 5 and 6 of the TRI Form R should all be accounted for in Section 8 of Form R, the percentages shown in column C should always be less than 100 percent. For the shipbuilding and repair industry, the TRI data shows that erroneous reporting in Form R by a number of shipyards in both 1994 and 1995 has undermined the data resulting in unusually high values in Column C.

If it is assumed that the proportions of production related wastes managed onsite and off-site using the methods shown in columns D-I were reported correctly, the data would indicate that about 60 percent of the TRI wastes are managed off-site through recycling, energy recovery, or treatment (columns G, H, and I, respectively) in 1995. Only about one percent of the wastes were managed on-site. The remaining portion of TRI chemical wastes (about 44 percent), shown in column J, were released to the environment through direct discharges to air, land, water, and underground injection, or was disposed off-site.

Table 4: Source Reduction and Recycling Activity for Shipyards (SIC 3731) as Reported within TRI

A	B	C	On-Site			Off-Site			J
			D	E	F	G	H	I	
Year	Quantity of Production-Related Waste (10^6 lbs.)[a]	% Released and Transferred[b]	% Recycled	% Energy Recovery	% Treated	% Recycled	% Energy Recovery	% Treated	% Released and Disposed[c] Off-site
1994	5.32	113%	1.1%	0.0%	0.7%	36.1%	12.6%	3.6%	46%
1995	6.45	100%	0.5%	0.0%	0.7%	45.7%	11.2%	2.2%	44%
1996	5.62	---	0.7%	0.0%	0.7%	40.1%	11.3%	3.1%	44%
1997	5.59	---	0.8%	0.0%	0.7%	40.6%	11.1%	3.1%	44%

Source: *1995 Toxics Release Inventory Database.*

[a] Within this industry sector, non-production related waste < 1% of production related wastes for 1995.

[b] Total TRI transfers and releases as reported in Section 5 and 6 of Form R as a percentage of production related wastes.

[c] Percentage of production related waste released to the environment and transferred off-site for disposal.

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IV. CHEMICAL RELEASE AND TRANSFER PROFILE

This section is designed to provide background information on the pollutant releases that are reported by this industry. The best source of comparative pollutant release information is the Toxic Release Inventory (TRI). Pursuant to the Emergency Planning and Community Right-to-Know Act, TRI includes self-reported facility release and transfer data for over 600 toxic chemicals. Facilities within SIC Codes 20 through 39 (manufacturing industries) that have more than 10 employees, and that are above weight-based reporting thresholds are required to report TRI on-site releases and off-site transfers. The information presented within the sector notebooks is derived from the most recently available (1995) TRI reporting year (which includes over 600 chemicals), and focuses primarily on the on-site releases reported by each sector. Because TRI requires consistent reporting regardless of sector, it is an excellent tool for drawing comparisons across industries. TRI data provide the type, amount and media receptor of each chemical released or transferred.

Although this sector notebook does not present historical information regarding TRI chemical releases over time, please note that in general, toxic chemical releases have been declining. In fact, according to the 1995 Toxic Release Inventory Public Data Release, reported onsite releases of toxic chemicals to the environment decreased by 5 percent (85.4 million pounds) between 1994 and 1995 (not including chemicals added and removed from the TRI chemical list during this period). Reported releases dropped by 46 percent between 1988 and 1995. Reported transfers of TRI chemicals to off-site locations increased by 0.4 percent (11.6 million pounds) between 1994 and 1995. More detailed information can be obtained from EPA's annual Toxics Release Inventory Public Data Release book (which is available through the EPCRA Hotline at 800-535-0202), or directly from the Toxic Release Inventory System database (for user support call 202-260-1531).

Wherever possible, the sector notebooks present TRI data as the primary indicator of chemical release within each industrial category. TRI data provide the type, amount and media receptor of each chemical released or transferred. When other sources of pollutant release data have been obtained, these data have been included to augment the TRI information.

TRI Data Limitations

Certain limitations exist regarding TRI data. Release and transfer reporting are limited to the approximately 600 chemicals on the TRI list. Therefore, a large portion of the emissions from industrial facilities are not captured by TRI. Within some sectors, (e.g. dry cleaning, printing and transportation equipment cleaning) the majority of facilities are not subject to TRI reporting because they are not considered manufacturing industries, or because they are below TRI reporting thresholds. For these sectors, release information from other sources has been included. In addition, many facilities report more than one SIC code reflecting the multiple operations carried out onsite. Therefore, reported releases and transfers may or may not all be associated with the industrial operations described in this notebook.

The reader should also be aware that TRI "pounds released" data presented within the notebooks is not equivalent to a "risk" ranking for each industry. Weighting each pound of release equally does not factor in the relative toxicity of each chemical that is released. The Agency is in the process of developing an approach to assign toxicological weightings to each chemical released so that one can differentiate between pollutants with significant differences in toxicity. As a preliminary indicator of the environmental impact of the industry's most commonly released chemicals, the notebook briefly summarizes the toxicological properties of the top five chemicals (by weight) reported by each industry.

Definitions Associated With Section IV Data Tables

General Definitions

SIC Code -- the Standard Industrial Classification (SIC) is a statistical classification standard used for all establishment-based Federal economic statistics. The SIC codes facilitate comparisons between facility and industry data.

TRI Facilities -- are manufacturing facilities that have 10 or more full-time employees and are above established chemical throughput thresholds. Manufacturing facilities are defined as facilities in Standard Industrial Classification primary codes 20-39. Facilities must submit estimates for all chemicals that are on the EPA's defined list and are above throughput thresholds.

Data Table Column Heading Definitions

The following definitions are based upon standard definitions developed by EPA's Toxic Release Inventory Program. The categories below represent the possible pollutant destinations that can be reported.

RELEASES -- are an on-site discharge of a toxic chemical to the environment. This includes emissions to the air, discharges to bodies of water, releases at the facility to land, as well as contained disposal into underground injection wells.

Releases to Air (Point and Fugitive Air Emissions) -- Include all air emissions from industry activity. Point emissions occur through confined air streams as found in stacks, vents, ducts, or pipes. Fugitive emissions include equipment leaks, evaporative losses from surface impoundments and spills, and releases from building ventilation systems.

Releases to Water (Surface Water Discharges) -- encompass any releases going directly to streams, rivers, lakes, oceans, or other bodies of water. Releases due to runoff, including storm water runoff, are also reportable to TRI.

Releases to Land -- occur within the boundaries of the reporting facility. Releases to land include disposal of toxic chemicals in landfills, land treatment/application farming, surface impoundments, and other land disposal methods (such as spills, leaks, or waste piles).

Underground Injection -- is a contained release of a fluid into a subsurface well for the purpose of waste disposal. Wastes containing TRI chemicals are injected into either Class I wells or Class V wells. Class I wells are used to inject liquid hazardous wastes or dispose of industrial and municipal wastewaters beneath the lowermost underground source of drinking water. Class V wells are generally used to inject non-hazardous fluid into or above an underground source of drinking water. TRI reporting does not currently distinguish between these two types of wells, although there are important differences in environmental impact between these two methods of injection.

TRANSFERS -- is a transfer of toxic chemicals in wastes to a facility that is geographically or physically separate from the facility reporting under TRI. Chemicals reported to TRI as transferred are sent to off-site facilities for the purpose of recycling, energy recovery, treatment, or disposal. The quantities reported represent a movement of the chemical away from the reporting facility. Except for off-site transfers for disposal, the reported quantities do not necessarily represent entry of the chemical into the environment.

Transfers to POTWs -- are wastewater transferred through pipes or sewers to a publicly owned treatments works (POTW). Treatment or removal of a chemical from the wastewater depend on the nature of the chemical, as well as the treatment methods present at the POTW. Not all TRI chemicals can be treated or removed by a POTW. Some chemicals, such as metals, may be removed, but are not destroyed and may be disposed of in landfills or discharged to receiving waters.

Transfers to Recycling -- are sent off-site for the purposes of regenerating or recovery by a variety of recycling methods, including solvent recovery, metals recovery, and acid regeneration. Once these chemicals have been recycled, they may be returned to the originating facility or sold commercially.

Transfers to Energy Recovery -- are wastes combusted off-site in industrial furnaces for energy recovery. Treatment of a chemical by incineration is not considered to be energy recovery.

Transfers to Treatment -- are wastes moved off-site to be treated through a variety of methods, including neutralization, incineration, biological destruction, or physical separation. In some cases, the chemicals are not destroyed but prepared for further waste management.

Transfers to Disposal -- are wastes taken to another facility for disposal generally as a release to land or as an injection underground.

IV.A. EPA Toxic Release Inventory for the Shipbuilding and Repair Industry

This section summarizes TRI data of shipbuilding and repair facilities reporting operations under SIC code 3731. Of the 598 shipbuilding and repair establishments reported by the *1992 Census of Manufacturers*, 43 reported to TRI in 1995.

According to the 1995 TRI data, the reporting shipbuilding and repair facilities released and transferred 39 different TRI chemicals for a total of approximately 6.5 million pounds of pollutants during calendar year 1995. These releases and transfers are dominated by volatile organic compounds (VOCs) and metal-bearing wastes which make up 52 percent and 48 percent, respectively, of total releases and transfers.

Transfers of TRI chemicals account for 58 percent of shipbuilding and repair facilities' total TRI-reportable chemicals (3.5 million pounds) while *releases* make up 42 percent (2.5 million pounds).

Releases

Releases to the air, water, and land accounted for 37 percent (2.4 million pounds) of shipyard's total reportable chemicals (see Table 5). Of these releases, over 98 percent are released to the air from fugitive (75 percent) or point (24 percent) sources. VOCs accounted for about 86 percent of the shipbuilding and repair industry's reported TRI releases. The remainder of the releases were primarily metal-bearing wastes. Xylenes, n-butyl alcohol, toluene, methyl ethyl ketone, and methyl isobutyl ketone account for about 65 percent of the industry's reported releases. These organic compounds are typically found in solvents which are used extensively by the industry in thinning paints and for cleaning and degreasing metal parts and equipment. Styrene, reported by eight facilities, accounts for about 4 percent of the industry's releases. Styrene comprises a substantial portion of the resin mixtures and gelcoat used in fiberglass reinforced construction. Finally, copper-, zinc-, and nickel-bearing wastes account for about 14 percent of the industry's reported releases. They are released primarily as fugitive emissions during metal plating operations and as overspray in painting operations and can also be released as fugitive dust emissions during blasting operations.

Transfers

Off-site transfers of TRI chemicals account for 63 percent of shipyard's total TRI reportable chemicals (4.1 million pounds). Over 72 percent of the shipbuilding and repair industry's TRI transfers are sent off-site for recycling followed by about 18 percent sent off-site for energy recovery (see Table 6). Metals accounted for about 67 percent of the industry's reported transfers. VOCs made up almost all of the remainder of transferred TRI chemicals.

About 60 percent of the metals transferred were recycled, and almost all of the remainder were either treated or disposed off-site. Copper, zinc, and chromium made up about 70 percent of the metals transferred off-site. Most of these are in the form of scrap metal, metal shavings and dust, spent plating baths, wastewater treatment sludges, and in paint chips and spent blasting abrasives. About 53 percent of the VOCs transferred were sent off-site for energy recovery with the remainder primarily going to off-site recycling and treatment. Waste solvents containing xylene, n-butyl alcohol, methanol, carbon tetrachloride, and methyl ethyl ketone make up almost 70 percent of the VOCs transferred off-site. These wastes were primarily transferred for energy recovery.

Table 5: 1995 TRI Releases for Shipbuilding and Repair Facilities (SIC 3731), by Number of Facilities Reporting (Releases reported in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	LAND DISPOSAL	TOTAL RELEASES	AVG. RELEASES PER FACILITY
XYLENE (MIXED ISOMERS)	30	853,863	99,379	9,292	0	0	962,534	32,084
N-BUTYL ALCOHOL	15	278,218	60,802	2,691	0	0	341,711	22,781
COPPER COMPOUNDS	8	91,410	0	3,968	0	250	95,628	11,954
STYRENE	8	7,209	87,069	250	0	0	94,528	11,816
ZINC COMPOUNDS	6	75,417	27,278	2,920	0	250	105,865	17,644
ZINC (FUME OR DUST)	5	81,088	0	8,260	0	0	89,348	17,870
CHROMIUM COMPOUNDS	4	631	7,250	256	0	0	8,137	2,034
METHYL ETHYL KETONE	4	77,928	0	0	0	0	77,928	19,482
TOLUENE	4	25,806	30,239	0	0	0	56,045	14,011
PROPYLENE	4	755	250	0	0	0	1,005	251
NICKEL	4	20	0	16	0	0	36	9
COPPER	4	20	0	261	0	0	281	70
NICKEL COMPOUNDS	3	30,592	0	294	0	250	31,136	10,379
METHANOL	3	2,172	13,222	250	0	0	15,644	5,215
1,2,4-TRIMETHYLBENZENE	3	42,399	18,100	0	0	0	60,499	20,166
METHYL ISOBUTYL KETONE	3	55,979	0	0	0	0	55,979	18,660
MANGANESE	3	3,884	0	0	0	0	3,884	1,295
CHROMIUM	3	260	0	10	0	0	270	90
LEAD COMPOUNDS	2	546	0	261	0	250	1,057	529
MANGANESE COMPOUNDS	2	620	0	250	0	250	1,120	560
FREON 113	2	14,672	0	0	0	0	14,672	7,336
ETHYLBENZENE	2	16,993	1,159	0	0	0	18,152	9,076
ETHYLENE GLYCOL	2	256	26	0	0	0	282	141
METHYL TERT-BUTYL ETHER	2	425	99,555	250	0	0	100,230	50,115
BARIUM COMPOUNDS	1	3,600	0	0	0	0	3,600	3,600
CERTAIN GLYCOL ETHERS	1	22,000	5,000	0	0	0	27,000	27,000
BENZENE	1	426	84,999	0	0	0	85,425	85,425
1,1,1-TRICHLOROETHANE	1	67,000	0	0	0	0	67,000	67,000
DICHLOROMETHANE	1	8,400	0	0	0	0	8,400	8,400
DICHLOROTETRAFLUOROETHANE (CFC-114)	1	250	0	0	0	0	250	250
DICYCLOPENTADIENE	1	18	6,072	0	0	0	6,090	6,090
TRICHLOROETHYLENE	1	15,600	0	0	0	0	15,600	15,600
CUMENE	1	7	2,611	0	0	0	2,618	2,618
1,2-DICHLOROETHANE	1	31	2,634	0	0	0	2,665	2,665
ACRYLONITRILE	1	250	5	250	0	0	505	505
N-HEXANE	1	57	11,608	0	0	0	11,665	11,665
2-ETHOXYETHANOL	1	0	12,975	0	0	0	12,975	12,975
CYCLOHEXANE	1	16	3,864	0	0	0	3,880	3,880
LEAD	1	0	0	0	0	0	0	0
	43	1,778,818	574,097	29,479	0	1,250	2,383,644	55,434

Table 6: 1995 TRI Transfers for Shipbuilding and Repair Facilities (SIC 3731), by Number of Facilities Reporting (Transfers reported in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
XYLENE (MIXED ISOMERS)	30	250	35	223,254	14,020	407,986	645,545	21,518
N-BUTYL ALCOHOL	15	250	255	24,500	3,620	116,929	145,554	9,704
COPPER COMPOUNDS	8	1,525	3,878	647,200	44,700	.	697,303	87,163
STYRENE	8	0	2,835	118,127	2,420	30,837	154,219	19,277
ZINC COMPOUNDS	6	1,950	2,828	.	36,028	.	40,806	6,801
ZINC (FUME OR DUST)	5	14	229,950	12,240	28,382	1,837	272,423	54,485
CHROMIUM COMPOUNDS	4	261	250	647,200	2,650	.	650,361	162,590
METHYL ETHYL KETONE	4	0	.	.	.	45,705	45,705	11,426
TOLUENE	4	0	15	.	20	15,745	15,780	3,945
PROPYLENE	4	0	.	.	.	.	0	0
NICKEL	4	5	2,286	232,848	.	.	235,139	58,785
COPPER	4	5	3,678	251,005	.	.	254,688	63,672
NICKEL COMPOUNDS	3	251	.	.	7,000	.	7,251	2,417
METHANOL	3	0	5	73,286	20	2,045	75,356	25,119
1,2,4-TRIMETHYLBENZENE	3	0	.	.	.	33,883	33,883	11,294
METHYL ISOBUTYL KETONE	3	0	.	.	.	3,615	3,615	1,205
MANGANESE	3	0	.	431,480	.	.	431,480	143,827
CHROMIUM	3	5	1,000	126,008	.	.	127,013	42,338
LEAD COMPOUNDS	2	251	900	1,064	3,244	.	5,459	2,730
MANGANESE COMPOUNDS	2	0	.	.	.	.	0	0
FREON 113	2	0	.	55,438	.	.	55,438	27,719
ETHYLBENZENE	2	0	15	.	20	7,214	7,249	3,625
ETHYLENE GLYCOL	2	250	5	.	20	.	275	138
METHYL TERT-BUTYL ETHER	2	0	15	32,736	20	.	32,771	16,386
BARIUM COMPOUNDS	1	0	.	.	100	.	100	100
CERTAIN GLYCOL ETHERS	1	0	.	.	.	22,000	22,000	22,000
BENZENE	1	0	15	.	20	.	35	35
1,1,1-TRICHLOROETHANE	1	250	.	.	.	.	250	250
DICHLOROMETHANE	1	0	.	.	.	21,500	21,500	21,500
DICHLOROTETRAFLUOROETHANE (CFC-114)	1	0	.	.	.	.	0	0
DICYCLOPENTADIENE	1	0	15	.	20	.	35	35
TRICHLOROETHYLENE	1	250	.	1,200	250	.	1,700	1,700
CUMENE	1	0	5	.	20	.	25	25
1,2-DICHLOROETHANE	1	0	5	.	20	.	25	25
ACRYLONITRILE	1	0	.	69,716	.	.	69,716	69,716
N-HEXANE	1	0	15	.	20	.	35	35
2-ETHOXYETHANOL	1	0	.	.	.	200	200	200
CYCLOHEXANE	1	0	5	.	20	.	25	25
LEAD	1	0	250	.	.	.	250	250
	43	5,517	248,260	2,947,302	142,634	709,496	4,053,209	94,260

The TRI database contains a detailed compilation of self-reported, facility-specific chemical releases. The top reporting facilities for the shipbuilding and repair industry are listed below in Tables 7 and 8. Facilities that have reported only the primary SIC codes covered under this notebook appear on Table 7. Table 8 contains additional facilities that have reported the SIC codes covered within this notebook, or SIC codes covered within this notebook and one or more SIC codes that are not within the scope of this notebook. Therefore, the second list may include facilities that conduct multiple operations -- some that are under the scope of this notebook, and some that are not. Currently, the facility-level data do not allow pollutant releases to be broken apart by industrial process.

Table 7:Top 10 TRI Releasing Shipbuilding and Repair Facilities Reporting Only SIC 3731 [1]

Rank	Facility	Total TRI Releases in Pounds
1	Newport News Shipbuilding - Newport News, VA	309,000
2	Atlantic Marine Inc. - Mobile, AL	268,670
3	Platzer Shipyard Inc. - Houston, TX	268,442
4	Norshipco - Norfolk, VA	229,000
5	Bethlehem Steel Corp.-Port Arthur, TX	133,020
6	Cascade General, Inc. - Portland, OR	116,929
7	Trinity Industries-Gulfport, MS	90,983
8	Todd Pacific Shipyards - Seattle, WA	85,081
9	Avondale Industries Inc. - Avondale, LA	84,650
10	Jeffboat - Jeffersonville, IN	82,108

Source: *US Toxics Release Inventory Database, 1995.*

[1] Being included on this list does not mean that the release is associated with non-compliance with environmental laws.

Table 8: Top 10 TRI Releasing Facilities Reporting Only SIC 3731 or SIC 3731 and Other SIC codes [2]

Rank	SIC Codes Reported in TRI	Facility	Total TRI Releases in Pounds
1	3731, 3441, 3443	Ingalls Shipbuilding Inc.-Pascagoula, MS	723,560
2	3731	Newport News Shipbuilding - Newport News, VA	309,000
3	3731	Atlantic Marine Inc. - Mobile, AL	268,670
4	3731	Platzer Shipyard Inc. - Houston, TX	268,442
5	3731	Norshipco - Norfolk, VA	229,000
6	3731	Bethlehem Steel Corp.-Port Arthur, TX	133,020
7	3731	Cascade General, Inc. - Portland, OR	116,929
8	3731	Trinity Industries-Gulfport, MS	90,983
9	3731	Todd Pacific Shipyards - Seattle, WA	85,081
10	3731	Avondale Industries Inc. - Avondale, LA	84,650

Source: *US Toxics Release Inventory Database, 1995.*

IV.B. Summary of Selected Chemicals Released

The following is a synopsis of current scientific toxicity and fate information for the top chemicals (by weight) that facilities within this sector self-reported as released to the environment based upon 1995 TRI data. Because this section is based upon self-reported release data, it does not attempt to provide information on management practices employed by the sector to reduce the release of these chemicals. Information regarding pollutant release reduction over time may be available from EPA's TRI and 33/50 programs, or directly from the industrial trade associations that are listed in Section IX of this document. Since these descriptions are cursory, please consult the sources referenced below for a more detailed description of both the chemicals described in this section, and the chemicals that appear on the full list of TRI chemicals appearing in Section IV.A.

The brief descriptions provided below were taken from the Hazardous Substances Data Bank (HSDB) and the Integrated Risk Information System (IRIS). The discussions of toxicity describe the range of possible adverse health effects that have been found to be associated with exposure to these chemicals. These adverse effects may or may not occur at the levels released to the environment. Individuals interested in a more detailed picture of the

[2] Being included on this list does not mean that the release is associated with non-compliance with enviromental laws.

chemical concentrations associated with these adverse effects should consult a toxicologist or the toxicity literature for the chemical to obtain more information. The effects listed below must be taken in context of these exposure assumptions that are more fully explained within the full chemical profiles in HSDB. For more information on TOXNET[3] , contact the TOXNET help line at 1-800-231-3766.

Xylenes (Mixed Isomers) (CAS: 1330-20-7)

Sources. Xylenes are used extensively as cleaning solvents and in thinning paints.

Toxicity. Xylenes are rapidly absorbed into the body after inhalation, ingestion, or skin contact. Short-term exposure of humans to high levels of xylene can cause irritation of the skin, eyes, nose, and throat, difficulty in breathing, impaired lung function, impaired memory, and possible changes in the liver and kidneys. Both short- and long-term exposure to high concentrations can cause effects such as headaches, dizziness, confusion, and lack of muscle coordination. Reactions of xylene (see environmental fate) in the atmosphere contribute to the formation of ozone in the lower atmosphere. Ozone can affect the respiratory system, especially in sensitive individuals such as asthma or allergy sufferers.

Carcinogenicity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. A portion of releases to land and water will quickly evaporate, although some degradation by microorganisms will occur. Xylenes are moderately mobile in soils and may leach into groundwater, where they may persist for several years. Xylenes are volatile organic chemicals. As such, xylene in the lower atmosphere will react with other atmospheric components, contributing to the formation of ground-level ozone and other air pollutants.

[3] TOXNET is a computer system run by the National Library of Medicine that includes a number of toxicological databases managed by EPA, National Cancer Institute, and the National Institute for Occupational Safety and Health. For more information on TOXNET, contact the TOXNET help line at 800-231-3766. Databases included in TOXNET are: CCRIS (Chemical Carcinogenesis Research Information System), DART (Developmental and Reproductive Toxicity Database), DBIR (Directory of Biotechnology Information Resources), EMICBACK (Environmental Mutagen Information Center Backfile), GENE-TOX (Genetic Toxicology), HSDB (Hazardous Substances Data Bank), IRIS (Integrated Risk Information System), RTECS (Registry of Toxic Effects of Chemical Substances), and TRI (Toxic Chemical Release Inventory). HSDB contains chemical-specific information on manufacturing and use, chemical and physical properties, safety and handling, toxicity and biomedical effects, pharmacology, environmental fate and exposure potential, exposure standards and regulations, monitoring and analysis methods, and additional references.

Zinc and Zinc Compounds (CAS: 7440-66-6; 20-19-9)

Sources. To protect metal from oxidizing, it is often coated with a material that will protect it from moisture and air. In the galvanizing process, steel is coated with zinc.

Toxicity. Zinc is a nutritional trace element; toxicity from ingestion is low. Severe exposure to zinc might give rise to gastritis with vomiting due to swallowing of zinc dusts. Short-term exposure to very high levels of zinc is linked to lethargy, dizziness, nausea, fever, diarrhea, and reversible pancreatic and neurological damage. Long-term zinc poisoning causes irritability, muscular stiffness and pain, loss of appetite, and nausea.

Zinc chloride fumes cause injury to mucous membranes and to the skin. Ingestion of soluble zinc salts may cause nausea, vomiting, and purging.

Carcinogenicity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. Significant zinc contamination of soil is only seen in the vicinity of industrial point sources. Zinc is a relatively stable soft metal, though burns in air. Zinc bioconcentrates in aquatic organisms.

n-Butanol (n-Butyl Alcohol) (CAS: 71-36-3)

Sources. n-Butanol is used extensively for thinning paints and equipment cleaning.

Toxicity. Short-term exposure usually results in depression of the central nervous system, hypotension, nausea, vomiting, and diarrhea. Butanols may cause gastrointestinal hemorrhaging. Eye contact may cause burning and blurred vision. Hypotension and cardiac arrhythmias may occur. Inhaling n-butanol may cause pulmonary edema. Headache, dizziness, and giddiness may occur. Liver injury may occur but is probably rare. Dermatitis and hypoglycemia may result from exposure to this chemical. Chronic exposure may result in dry, cracked skin, and eye inflammation. Workers have exhibited systemic effects of the auditory nerve as well as vestibular injury.

Carcinogenicity. There are currently no long-term studies in humans or animals to suggest that this chemical is carcinogenic. Based on this evidence, U.S. EPA has indicated that this chemical cannot be classified as to its human carcinogenicity. There is some evidence of chromosomal abnormalities in short-term tests in bacteria and hamster cells, which may suggest potential carcinogenicity.

Environmental Fate. This chemical may volatilize from soil surface. In addition, the chemical may biodegrade from the soil, and leach to groundwater. n-Butanol released to water is expected to biodegrade and volatilize from the water surface, and is not expected to bioconcentrate in fish. People are exposed primarily from contact with products containing n-butanol.

Copper and Copper Compounds (CAS: 7440-50-8)

Sources. Copper and copper compounds are commonly used as biocides in anti-fouling paints. Many ship parts requiring anti-corrosive characteristics (e.g., piping) are fabricated or plated with copper and copper alloys.

Toxicity. Metallic copper probably has little or no toxicity, although copper salts are more toxic. Inhalation of copper oxide fumes and dust has been shown to cause metal fume fever, irritation of the upper respiratory tract, nausea, sneezing, coughing, chills, aching muscles, gastric pain, and diarrhea. However, the respiratory symptoms may be due to a non-specific reaction to the inhaled dust as a foreign body in the lung, and the gastrointestinal symptoms may be attributed to the conversion of copper to copper salts in the body.

It is unclear whether long-term copper poisoning exists in humans. Some have related certain central nervous system disorders, such as giddiness, loss of appetite, excessive perspiration, and drowsiness to copper poisoning. Long-term exposure to copper may also cause hair, skin, and teeth discoloration, apparently without other adverse effects.

People at special risk from exposure to copper include those with impaired pulmonary function, especially those with obstructive airway diseases, since the breathing of copper fumes might cause exacerbation of pre-existing symptoms due to its irritant properties.

Ecologically, copper is a trace element essential to many plants and animals. However, high levels of copper in soil can be directly toxic to certain soil microorganisms and can disrupt important microbial processes in soil, such as nitrogen and phosphorus cycling.

Carcinogenicity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. Copper is typically found in the environment as a solid metal in soils and soil sediment in surface water. There is no evidence that biotransformation processes have a significant bearing on the fate and transport of copper in water.

Styrene (CAS: 100-42-5)

Sources. Styrene is a major constituent of fiberglass resins and gelcoats.

Toxicity. Short-term exposure may cause irritation to eyes, lungs, stomach, and skin. Problems may occur in the central nervous system as a result of serious exposure and may also occur in the peripheral nervous system. Short-term exposure from inhalation is commonly associated with "styrene sickness", which includes vomiting, loss of appetite, and a drunken feeling. Short-term exposure also irritates the respiratory tract, and is associated with asthma and pulmonary edema.

Long-term exposure in those working with styrene has been associated with impaired nervous system functions including memory, learning, and motor skills and impaired psychiatric functioning. Styrene may also cause gene mutations and birth defects. Styrene has been shown to cause liver damage.

Carcinogenicity. The International Agency for Research on Cancer notes that evidence of carcinogenicity in experimental animals indicates that styrene is a possible carcinogen in humans. However, U.S. EPA is currently reviewing the evidence for carcinogenicity of styrene, and may arrive at a different decision.

Environmental Fate and Potential for Human Exposure. If styrene is released to air, it will quickly react with hydroxyl radicals and ozone. At night, air concentrations of styrene will degrade by reacting with nitrate radicals. Styrene released to water volatilizes and biodegrades, but does not hydrolyze. In soil, styrene biodegrades and is fairly immobile in soil. Styrene has been found in drinking water, but not in 945 groundwater supplies. The chemical has been found in industrial effluents and in air surrounding industrial sources and in urban areas. The chemical has been found in some food packaged in polystyrene containers.

IV.C. Other Data Sources

The toxic chemical release data obtained from TRI captures only about seven percent of the facilities in the shipbuilding and repair industry. However, it allows for a comparison across years and industry sectors. Reported chemicals are limited to the approximately 600 TRI chemicals. A large portion of the emissions from shipbuilding and repair facilities, therefore, are not captured by TRI. The EPA Office of Air Quality Planning and Standards has compiled air pollutant emission factors for determining the total air emissions of priority pollutants (e.g., total hydrocarbons, SOx, NOx, CO, particulates, etc.) from many shipbuilding and repair sources.

The Aerometric Information Retrieval System (AIRS) contains a wide range of information related to stationary sources of air pollution, including the emissions of a number of air pollutants which may be of concern within a particular industry. With the exception of volatile organic compounds (VOCs), there is little overlap with the TRI chemicals reported above. Table 9 summarizes annual releases (from the industries for which a Sector Notebook Profile was prepared) of carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter of 10 microns or less (PM10), total particulate matter (PT), sulfur dioxide (SO_2), and volatile organic compounds (VOCs).

Table 9: Air Pollutant Releases (tons/year)

Industry Sector	CO	NO_2	PM_{10}	PT	SO_2	VOC
Metal Mining	4,670	39,849	63,541	173,566	17,690	915
Nonmetal Mining	25,922	22,881	40,199	128,661	18,000	4,002
Lumber and Wood Production	122,061	38,042	20,456	64,650	9,401	55,983
Furniture and Fixtures	2,754	1,872	2,502	4,827	1,538	67,604
Pulp and Paper	566,883	358,675	35,030	111,210	493,313	127,809
Printing	8,755	3,542	405	1,198	1,684	103,018
Inorganic Chemicals	153,294	106,522	6,703	34,664	194,153	65,427
Organic Chemicals	112,410	187,400	14,596	16,053	176,115	180,350
Petroleum Refining	734,630	355,852	27,497	36,141	619,775	313,982
Rubber and Misc. Plastics	2,200	9,955	2,618	5,182	21,720	132,945
Stone, Clay and Concrete	105,059	340,639	192,962	662,233	308,534	34,337
Iron and Steel	1,386,461	153,607	83,938	87,939	232,347	83,882
Nonferrous Metals	214,243	31,136	10,403	24,654	253,538	11,058
Fabricated Metals	4,925	11,104	1,019	2,790	3,169	86,472
Electronics and Computers	356	1,501	224	385	741	4,866
Motor Vehicles, Bodies, Parts and Accessories	15,109	27,355	1,048	3,699	20,378	96,338
Dry Cleaning	102	184	3	27	155	7,441
Ground Transportation	128,625	550,551	2,569	5,489	8,417	104,824
Metal Casting	116,538	11,911	10,995	20,973	6,513	19,031
Pharmaceuticals	6,586	19,088	1,576	4,425	21,311	37,214
Plastic Resins and Manmade Fibers	16,388	41,771	2,218	7,546	67,546	74,138
Textiles	8,177	34,523	2,028	9,479	43,050	27,768
Power Generation	366,208	5,986,757	140,760	464,542	13,827,511	57,384
Shipbuilding and Repair	**105**	**862**	**638**	**943**	**3,051**	**3,967**

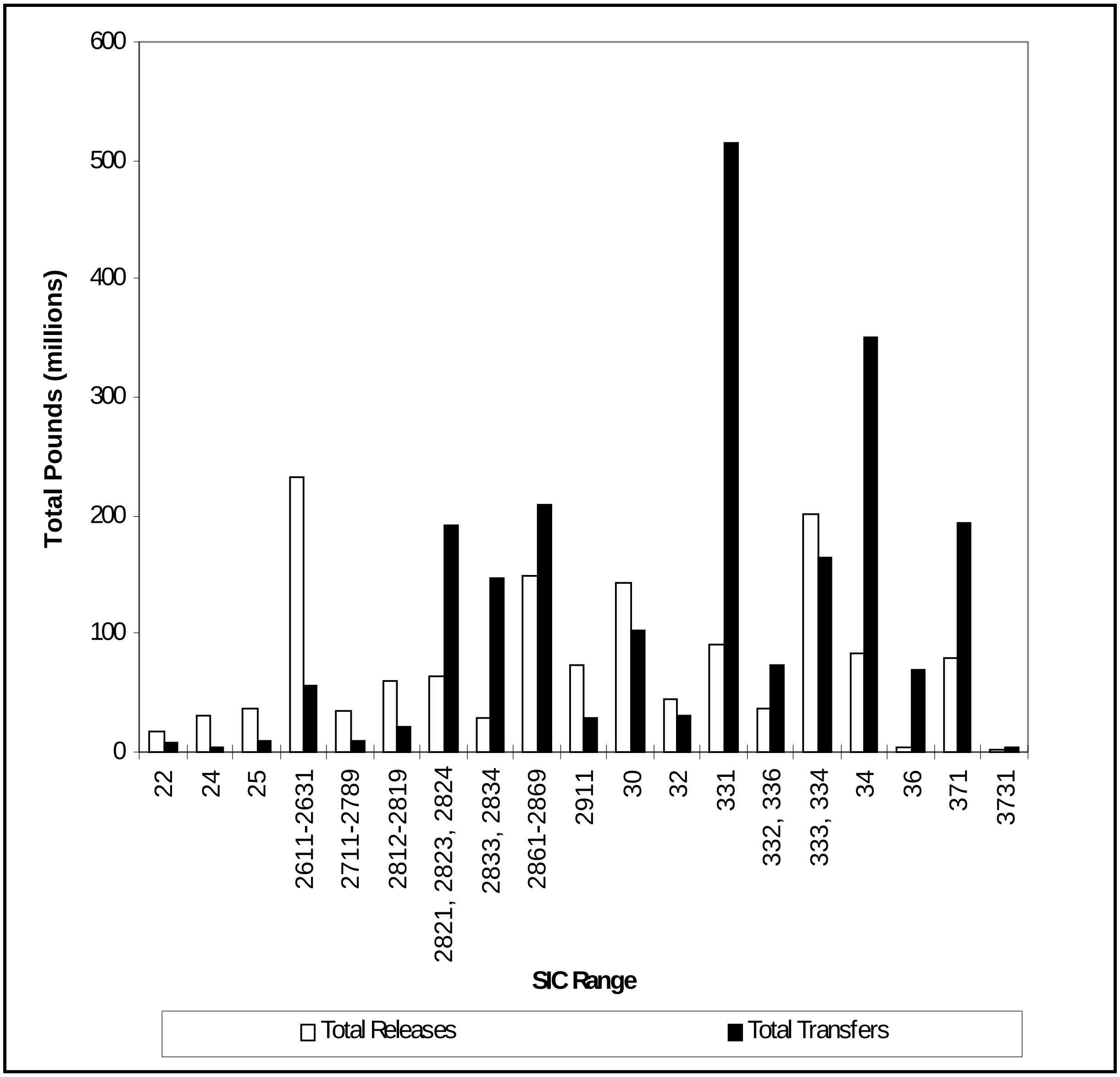
Source: U.S. EPA Office of Air and Radiation, AIRS Database, 1997.

IV.D. Comparison of Toxic Release Inventory Between Selected Industries

The following information is presented as a comparison of pollutant release and transfer data across industrial categories. It is provided to give a general sense as to the relative scale of TRI releases and transfers within each sector profiled under this project. Please note that the following figure and table do not contain releases and transfers for industrial categories that are not included in this project, and thus cannot be used to draw conclusions regarding the total release and transfer amounts that are reported to TRI. Similar information is available within the annual TRI Public Data Release Book.

Figure 10 is a graphical representation of a summary of the 1995 TRI data for the shipbuilding and repair industry and the other sectors profiled in separate notebooks. The bar graph presents the total TRI releases and total transfers on the vertical axis. The graph is based on the data shown in Table 10 and is meant to facilitate comparisons between the relative amounts of releases, transfers, and releases per facility both within and between these sectors. The reader should note, however, that differences in the proportion of facilities captured by TRI exist between industry sectors. This can be a factor of poor SIC matching and relative differences in the number of facilities reporting to TRI from the various sectors. In the case of the shipbuilding and repair industry, the 1995 TRI data presented here covers 43 facilities. These facilities listed SIC 3731 (Shipbuilding and Repair) as primary SIC codes.

Figure 6: Summary of TRI Releases and Transfers by Industry



Source: US EPA 1995 Toxics Release Inventory Database.

SIC Range	Industry Sector	SIC Range	Industry Sector	SIC Range	Industry Sector
22	Textiles	2833, 2834	Pharmaceuticals	333, 334	Nonferrous Metals
24	Lumber and Wood Products	2861-2869	Organic Chem. Mfg.	34	Fabricated Metals
25	Furniture and Fixtures	2911	Petroleum Refining	36	Electronic Equip. and Comp.
2611-2631	Pulp and Paper	30	Rubber and Misc. Plastics	371	Motor Vehicles, Bodies, Parts, and Accessories
2711-2789	Printing	32	Stone, Clay, and Concrete	**3731**	**Shipbuilding and Repair**
2812-2819	Inorganic Chemical Manufacturing	331	Iron and Steel		
2821, 2823, 2824	Plastic Resins and Manmade Fibers	332, 336	Metal Casting		

Table 10: Toxics Release Inventory Data for Selected Industries

Industry Sector	SIC Range	# TRI Facilities	TRI Releases: Total Releases (million lbs.)	TRI Releases: Ave. Releases per Facility (pounds)	TRI Transfers: Total Transfers (million lbs.)	TRI Transfers: Ave. Trans. per Facility (pounds)	Total Releases +Transfers (million lbs.)	Average Releases + Transfers per Facility (pounds)
Textiles	22	339	17.8	53,000	7.0	21,000	24.8	74,000
Lumber and Wood Products	24	397	30.0	76,000	4.1	10,000	34.1	86,000
Furniture and Fixtures	25	336	37.6	112,000	9.9	29,000	47.5	141,000
Pulp and Paper	2611-2631	305	232.6	763,000	56.5	185,000	289.1	948,000
Printing	2711-2789	262	33.9	129,000	10.4	40,000	44.3	169,000
Inorganic Chem. Mfg.	2812-2819	413	60.7	468,000	21.7	191,000	438.5	659,000
Plastic Resins and Manmade Fibers	2821,2823, 2824	410	64.1	156,000	192.4	469,000	256.5	625,000
Pharmaceuticals	2833, 2834	200	29.9	150,000	147.2	736,000	177.1	886,000
Organic Chemical Mfg.	2861-2869	402	148.3	598,000	208.6	631,000	946.8	1,229,000
Petroleum Refining	2911	180	73.8	410,000	29.2	162,000	103.0	572,000
Rubber and Misc. Plastics	30	1,947	143.1	73,000	102.6	53,000	245.7	126,000
Stone, Clay, and Concrete	32	623	43.9	70,000	31.8	51,000	75.7	121,000
Iron and Steel	331	423	90.7	214,000	513.9	1,215,000	604.6	1,429,000
Metal Casting	332, 336	654	36.0	55,000	73.9	113,000	109.9	168,000
Nonferrous Metals	333, 334	282	201.7	715,000	164	582,000	365.7	1,297,000
Fabricated Metals	34	2,676	83.5	31,000	350.5	131,000	434.0	162,000
Electronics and Computers	36	407	4.3	11,000	68.8	169,000	73.1	180,000
Motor Vehicles, Bodies, Parts, and Accessories	371	754	79.3	105,000	194	257,000	273.3	362,000
Shipbuilding and Repair	**3731**	**43**	**2.4**	**55,000**	**4.1**	**94,000**	**6.5**	**149,000**

Source: *US EPA Toxics Release Inventory Database, 1995.*

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V. POLLUTION PREVENTION OPPORTUNITIES

The best way to reduce pollution is to prevent it in the first place. Some companies have creatively implemented pollution prevention techniques that improve efficiency and increase profits while at the same time minimizing environmental impacts. This can be done in many ways such as reducing material inputs, re-engineering processes to reuse by-products, improving management practices, and employing substitution of toxic chemicals. Some smaller facilities are able to actually get below regulatory thresholds just by reducing pollutant releases through aggressive pollution prevention policies.

The Pollution Prevention Act of 1990 established a national policy of managing waste through source reduction, which means preventing the generation of waste. The Pollution Prevention Act also established as national policy a hierarchy of waste management options for situations in which source reduction cannot be implemented feasibly. In the waste management hierarchy, if source reduction is not feasible the next alternative is recycling of wastes, followed by energy recovery, and waste treatment as a last alternative.

In order to encourage these approaches, this section provides both general and company-specific descriptions of some pollution prevention advances that have been implemented within the shipbuilding and repair industry. While the list is not exhaustive, it does provide core information that can be used as the starting point for facilities interested in beginning their own pollution prevention projects. This section provides summary information from activities that may be, or are being implemented by this sector. When possible, information is provided that gives the context in which the technique can be used effectively. Please note that the activities described in this section do not necessarily apply to all facilities that fall within this sector. Facility-specific conditions must be carefully considered when pollution prevention options are evaluated, and the full impacts of the change must examine how each option affects air, land and water pollutant releases.

Much of the information contained in this Section was obtained from *Hazardous Waste Minimization Guide for Shipyards*, produced by the National Shipbuilding Research Program (NSRP) in cooperation with the U.S. Navy and National Steel and Shipbuilding Company (NASSCO). The Guide provides and extensive discussion of pollution prevention opportunities available to shipyards which could not all be reproduced in this document. For further details on pollution prevention opportunities for shipyards, readers are encouraged to consult the Guide and the additional references listed in Section IX of this sector notebook. In addition, many of the pollution prevention opportunities listed in the *Profile of the Fabricated Metal Products Industry Sector Notebook* can also be applied to the shipbuilding and repair industry.

V.A. Surface Preparation

The majority of wastes generated during surface preparation are spent abrasives mixed with paint chips. One way the volume of waste generated can be reduced is by using blast media that is relatively easy to reuse. Some abrasives, such as mineral abrasives, are not easily reused. Copper slag has a very low reuse factor and in general, can be used no more than twice before breaking down.

Steel Shot and Grit

One of the most widely used reusable abrasives is steel grit, which is a crushed form of steel shot. While slags and sands can only be used a couple of times, steel abrasives can be used 50 times or more. With reused steel abrasive, care must be taken to watch that the abrasive does not become rounded. The abrasive works best if it has a sharp angular shape. Steel shot and grit require a high initial outlay of capital, but they can be used repeatedly to the point that they are more cost effective than copper slag. This medium is only deemed hazardous when it is contaminated with a sufficient amount of paint chips.

Improving Recyclability of Abrasive Blasting Media

In order to realize the maximum usage of reusable grit, measures must be taken to ensure it can be reused. Some media, such as steel shot, can be reused hundreds of times. It is important that the used grit is recovered as much as possible. With wheelabrator type equipment, this is done automatically. The used abrasive may be vacuumed up or mechanically fed to the blasting equipment. Containment of the abrasive allows it to be recovered, where otherwise it could suffer from loss to overspray. Protection from the weather, such as rain, will also prolong the life of the grit. It is very important that waste streams, especially hazardous waste, are not mixed with used blasting media. Outside debris and other waste could render the grit unfit for reuse.

Often, air powered cleaning equipment is used to screen abrasive to separate it from large paint particles. These systems may also remove lighter dust from the heavy abrasive. This media separation can be especially important when the paint being removed contains heavy metals. An alternative to on-site reclamation is to send it for processing off-site.

Plastic Media Blasting

As a substitute for other blast media, the military has experimented extensively with plastic media stripping. This process is particularly good for stripping coatings from parts with fragile substrates such as zinc, aluminum, and fiberglass. It can be a lengthy process because it strips paint layer by layer.

The same types and quantities of waste are generated as with grit blasting, but the plastic medium is more recyclable with the use of pneumatic media classifiers that are part of the stripping equipment. The only waste requiring disposal is the paint waste itself. However, the use of plastic media is fairly limited in shipyards. Plastic blasting media do not work well on epoxy paints. In addition, the blasting equipment is expensive and requires trained operators.

Water Jet Stripping (Hydroblasting)

Hydroblasting is a cavitating high pressure water jet stripping system that can remove most paints. These system may use pressures as high as 50,000 psig. Hydroblasting is an excellent method for removing even hard coatings from metal substrates. The process can be used for stripping hulls, removing scales and deposits from heat exchangers, and removing rubber liners. Some systems automatically remove the paint chips or stripped material from the water and reuse the water for further blasting. By recirculating the water in this manner, the amount of waste is greatly reduced. Wastewater from this process is usually suitable for sewer disposal after the paint particles are removed. Although this process produces very little waste, it is not always as efficient as abrasive grit blasting and has relatively high capital and maintenance costs.

V.B. Painting and Coating

Painting and coating operations are typically the largest single source of VOC emissions from shipyards. In addition, paint waste can account for more than half of the total hazardous waste generated at shipyards. Paint waste at a shipyard may include leftover paint in containers, overspray, paint that is no longer usable (Non-spec paint), and rags and other materials contaminated with paint. In many cases, the amount of paint waste generated can be reduced through the use of improved equipment, alternative coatings, and good operating practices.

Regulations under the CAA aimed at reducing VOC emissions by limiting VOC content in paints were finalized in 1996. Shipyards required to comply with these rules and wishing to implement the pollution prevention options discussed below, should consult the regulations to determine the practical and legal implications of these options.

V.B.1. Application Equipment

In order to effectively reduce paint waste and produce a quality coating, proper application techniques should be supplemented with efficient application equipment. Through the use of equipment with high transfer efficiencies, the amount of paint lost to overspray is minimized.

High Volume Low Pressure (HVLP) Spray Guns

The HVLP spray gun is basically a conventional air spray gun with modifications and special nozzles that atomize the paint at very low air pressures. The atomizing pressure of HVLP systems is often below 10 psi. The design of this gun allows better transfer efficiency and reduced overspray than that of conventional air guns. The low application pressure decreases excessive bounceback and allows better adhesion of the coating to the substrate.

Although improvements are consistently being made to overcome its limitations, most HVLP systems have some definite drawbacks, including difficulty atomizing viscous coatings, sensitivity to variations in incoming pressure, sensitivity to wind, and slow application rates.

Airless Spray Guns

Instead of air passing through the spray gun, an airless system applies static pressure to the liquid paint. As the paint passes through the nozzle, the sudden drop in pressure atomizes the paint and it is carried to the substrate by its own momentum. Pressure is applied to the paint by a pump located at a remote supply. These systems have become favorable over conventional air-spray systems for three main reasons: 1) reduced overspray and rebound, 2) high application rates and transfer efficiency, and 3) permits the use of high-build coatings with the result that fewer coats are required to achieve specific film thickness.

One major disadvantage of some airless spray systems is the difficulty applying very thin coats. If coatings with less than a mil in thickness are required, such as primers applied to objects that require weld ability, it may be difficult to use an airless system.

Electrostatic Spray

Electrostatic spray system utilize paint droplets that are given a negative charge in the vicinity of a positively charged substrate. The droplets are attracted to the substrate and a uniform coating is formed. This system works well on cylindrical and rounded objects due to its “wrap-around” effect that nearly allows the object to be coated from one side. Very little paint is lost to overspray, and it has been noted to have a transfer efficiency of over 95%.

In order for an electrostatic system to operate properly, the correct solvent balance is needed. The evaporation rate must be slow enough for the charged droplets to reach the substrate in a fluid condition to flow out into a smooth film, but fast enough to avoid sagging. The resistivity of the paint must also be low enough to enable the paint droplets to acquire the maximum charge.

Although the operating costs of electrostatic spray systems are relatively low, the initial capital investment can be high. This system has been found to work extremely well in small parts painting applications. Sometimes the installation of an electrostatic powder coating system can replace a water curtain spray paint booth.

Heated Spray

When paint is heated, its viscosity is reduced allowing it to be applied with a higher solids content, thus requiring less solvent. When the paint is heated in a special container and supplied to the gun at 140° to 160°F, coatings of 2 to 4 mils dry-film thickness can be applied in one operation, resulting in considerable savings in labor cost. In addition, much of the associated solvent emissions are eliminated.

Heating the coating prior to application can be used with both conventional and airless spray applications. An in-line heater is used to heat the coating before it reaches the gun. As the coating is propelled through the air, it cools rapidly and increases viscosity after it hits the surface, allowing for better adhesion to the substrate.

Plural Component Systems

A common problem that shipyards face when working with two-part coatings is overmixing. Once the component parts of a catalyst coating are mixed, the coating must be applied. Otherwise, the excess unused coating will cure and require disposal. Additionally, the coating equipment must be cleaned immediately after use.

One large advantage of plural component technology is the elimination of paint waste generated by mixing an excess amount of a two part coating. This is achieved through the use of a special mixing chamber that mixes the pigment and catalyst seconds before the coating is applied. Each component is pumped through a device that controls the mixing ratio and then is combined in a mixing chamber. From the mixing chamber, the mixed coating travels directly to the spray guns. The only cleaning that is required is the mixing chamber, gun, and the length of supply hose connecting them.

Recycle Paint Booth Water

Various methods and equipment are used to reduce or eliminate the discharge of the water used in water-wash booths (water curtain). These methods and equipment prevent the continuous discharge of booth waters by conditioning (i.e., adding detacifiers and paint-dispersing polymers) and removing paint solids. The most basic form of water maintenance is the removal of paint solids by manual skimming and/or raking. This can be performed without water conditioning since some portion of solvent-based paints usually float and/or sink. With the use of detacifiers and paint-dispersing polymer treatments, more advanced methods of solids removal can be implemented. Some common methods are discussed below.

Wet-Vacuum Filtration. Wet-vacuum filtration units consist of an industrial wet-vacuum head on a steel drum containing a filter bag. The unit is used to vacuum paint sludge from the booth. The solids are filtered by the bag and the water is returned to the booth. Large vacuum units are also commercially available that can be moved from booth to booth by forklift or permanently installed near a large booth.

Tank-Side Weir. A weir can be attached to the side of a side-draft booth tank, allowing floating material to overflow from the booth and be pumped to a filtering tank for dewatering.

Consolidator. A consolidator is a separate tank into which booth water is pumped. The water is then conditioned by the introduction of chemicals. Detacified paint floats to the surface of the tank, where it is skimmed by a continuously moving blade. The clean water is recycled to the booth.

Filtration. Various types of filtration units are used to remove paint solids from booth water. This is accomplished by pumping the booth water to the unit where the solids are separated and returning the water to the booth. The simplest filtration unit consists of a gravity filter bed utilizing paper or cloth media. Vacuum filters are also employed, some of which require precoating with diatomaceous earth.

Centrifuge Methods. Two common types of centrifugal separators are the hydrocyclone and the centrifuge. The hydrocyclone is used to concentrate solids. The paint booth water enters a cone-shaped unit under pressure and spins around the inside surface. The spinning imparts an increased force of gravity, which causes most of the solid particles to be pulled outward to the walls of the cone. Treated water exits the top of the unit and the solids exit from the bottom. Some systems have secondary filtration devices to further process the solids. The centrifuge works in a similar manner, except that the booth water enters a spinning drum, which imparts the centrifugal force needed for separating the water and solids. Efficient centrifugation requires close control of the booth water chemistry to ensure a uniform feed. Also, auxiliary equipment such as booth water agitation equipment may be needed (EPA, 1995).

Convert Wash-Water Booths to Dry Filter Booths

Water-wash booths can be converted to or replaced by dry filter booths. The dry filter booths have the potential to eliminate the discharge of wastewater, but they create a solid waste stream. The choice between using a water-wash booth or a dry filter booth is primarily based on the quantity of overspray. It is usually cost effective to use a dry filter booth when paint usage does not exceed 20 gallons/8 hour shift/10 feet of chamber width.

A 1989 Navy study concluded that conversion from wet to dry booths can be cost effectively performed over a range of operational scenarios. The Navy work included a survey of military and industrial facilities that have successfully made the conversion and an economic analysis based on typical Navy painting operational parameters (EPA, 1995).

V.B.2. Alternative Coatings

The use of solvent-based coatings can lead to high costs to meet air and water quality regulations. In efforts to reduce the quantity and toxicity of waste paint disposal, alternative coatings have been developed that do not require the use of solvents and thinners.

Powder Coatings

Metal substrates can be coated with certain resins by applying the powdered resin to the surface, followed by application of heat. The heat melts the resin, causing it to flow and form a uniform coating. The three main methods in use for applying the powder coating are fluidized bed, electrostatic spray, and flame spraying.

Flame spraying is the most applicable method for shipyards. The resin powder is blown through the gun by compressed air. The particles are melted in a high temperature flame and propelled against the substrate. This process is used widely with epoxy powders for aluminum surfaces.

The electrostatic application method uses the same principles as the electrostatic spray. The resin powder is applied to the surface electrostatically. Heat is applied to the covered surface and the powder melts to form the coating. The transfer efficiency and recyclability of this method is very high.

The elimination of environmental problems associated with many liquid based systems is one of the major advantages of powder coatings. The use of powder coatings eliminates the need for solvents and thereby emits negligible volatile organic compounds (VOCs). Powder coatings also reduce the waste associated with unused two-part coatings that have already been mixed. Since powder overspray can be recycled, material utilization is high and solid waste generation is low. Recent case studies demonstrate that powder coating systems can be cleaner, more efficient, and more environmentally acceptable, while producing a higher quality finish than many other coating systems.

Water-Based Paints

Water-based coatings are paints containing a substantial amount of water instead of volatile solvents. Alkyd, polyester, acrylic, and epoxy polymers can be dissolved and dispersed by water. In addition to reduction in environmental hazards due to substantially lower air emissions, a decrease in the amount of hazardous paint sludge generated can reduce disposal cost.

The application for water-based coatings in the shipyard are limited. Some of the areas of use may include the inside of the superstructure of a vessel, and other surfaces that are protected from extreme conditions.

V.B.3. Good Operating Practices

In many cases, simply altering a painting process can reduce wastes through better management.

Coating Application

A good manual coating application technique is very important in reducing waste. Most shipyards rely primarily on spraying methods for coating application. If not properly executed, spraying techniques have a high potential for creating waste; therefore, proper application techniques are very important.

Reducing Overspray One of the most common means of producing paint waste at shipyards is overspray. Overspray not only wastes some of the coating, it also presents environmental and health hazards. It is important that shipyards try to reduce the amount of overspray as much as possible. Techniques for reducing overspray include: 1) triggering the paint gun at the end of each pass instead of carrying the gun past the edge of the surface before reversing directions, 2) avoiding excessive air pressure, and 3) keeping the gun perpendicular to the surface being coated.

Uniform Finish Application of a good uniform finish provides the surface with quality coating with a higher performance than an uneven finish. An uneven coating does not dry evenly and commonly results in using excess paint.

Overlap An overlap of 50 percent can reduce the amount of waste by increasing the production rate and overall application efficiency. Overlap of 50 percent means that for every pass that the operator makes with the spray gun, 50 percent of the area covered by the previous pass is also sprayed. If less than a 50 percent overlap is used, the coated surface may appear streaked. If more than a 50 percent overlap is used, the coating is wasted and more passes are required to coat the surface.

General Housekeeping

Small quantities of paint and solvents are frequently lost due to poor housekeeping techniques. There are a variety of ways that can be implemented to control and minimize spills and leaks. Specific approaches to product transfer methods and container handling can effectively reduce product loss.

The potential for accidents and spills is at the highest point when thinners and paints are being transferred from bulk drum storage to the process equipment. Spigots, pumps, and funnels should be used whenever possible.

Evaporation can be controlled by using tight fitting lids, spigots, and other equipment. The reduction in evaporation will increase the amount of available material and result in lower solvent purchase cost.

Paint Containers

A significant portion of paint waste is the paint that remains inside a container after the container is emptied, and paint that is placed in storage, not used, and becomes outdated or non-spec. Shipyards should try to consolidate paint use to facilitate the purchase of paint in bulk. Since large bulk containers have less surface area than an equivalent volume of small cans, the amount of drag-on paint waste is reduced. Large bulk containers can sometimes be returned to the paint supplier to be cleaned for reuse.

If the purchase of paint in bulk containers is not practical, the paint should be purchased in the smallest amount required to minimize outdated or non-spec paint waste. Workers should not have to open a gallon can when only a quart is required. Usually, any paint that is left in the can will require disposal as hazardous waste.

V.C. Metal Plating and Surface Finishing

Pollution prevention opportunities in metal plating and surface finishing operations are discussed in detail in NSRP's *Hazardous Waste Minimization Guide for Shipyards* and in the *Profile of the Fabricated Metal Products Industry Sector Notebook.* Readers are encouraged to consult these documents for pollution prevention information relating to metal plating and surface finishing.

V.D. Fiberglass Reinforced Construction

Material Application

Major waste reduction is available by optimizing material application processes. These processes include spray delivery systems and non-spray resin application methods. Non-spray application methods include closed mold systems, vacuum bag mold systems, resin roller dispensers, prespray fiber reinforcing, and in-house resin impregnation. These no-spray techniques reduce material waste and energy costs during application. The lower application pressures reduce the cost and maintenance of pressure lines, pumps, controls, and fittings. Routine cleanups of work areas are also reduced.

Spray Delivery Systems

The fabrication process for fiberglass construction and the wastes produced are highly dependent on the equipment and procedures used. The current system of resin and gelcoat delivery systems include high-pressure air, medium-pressure airless, and low-pressure air-assisted airless spray guns.

- The high-pressure air system is used less due to the large amount of expensive high-pressure compressed air required and significant air emissions generated.

- The airless method produces a pressurized resin stream electrostatically atomized through a nozzle. The nozzle orifice and spray angle can be varied by using different tips. The size of the orifice affects the delivery efficiency, with larger orifices resulting in greater raw material loss. Airless spray guns are considered to be very efficient in the delivery of resin to the work surface.

- The air-assisted airless technology modifies the airless gun by introducing pressurized air on the outer edge of the resin stream as it exits the pressure nozzle. The air stream forms an envelope which focuses the resin to follow a controllable spray pattern. Since more resin ends up on the mold with this technology, the amount of spraying is reduced leading to a reduction in air emissions. It is estimated that a savings of 5 to 20 percent in net loss of resin spray waste for the air-assisted airless gun is achieved compared to the airless gun.

Resin Roller Application

This application uses pumped resin and catalyst from drums or bulk containers. The resin and catalyst are precisely metered in a gun-type line much like the paint plural component systems. A resin roller dispenser transfers the catalyzed resin to the mold surface. This eliminates the material lost due to overspray and bounceback of the resin. Air emissions are also greatly reduced with this type of delivery system.

Thermoplastic Resins

Thermoplastic resins have the advantage of being easily recycled by applying heat which returns the resin to a liquid state. In its liquid state, the resin can be reused in the manufacture of other fiberglass components in shipbuilding. The use of thermoplastics offers faster curing cycles, lower emission during processing, lower costs per pound of raw material used, ease of recycling material, and, in some cases, lower labor costs. With the recent advances in the processing technologies and thermoplastic resin systems, the shipbuilding industries are reexamining the application of thermoplastics versus thermosets material systems.

V.E. Solvent Cleaning and Degreasing

Shipyards often use large quantities of solvents in a variety of cleaning and degreasing operations including parts cleaning, process equipment cleaning, and surface preparation for coating applications. The final cost of solvent used for various cleanup operations is nearly twice the original purchase price of the virgin solvent. The additional cost is primarily due to the fact that for each drum purchased, extra disposal cost, hazardous materials transportation cost, and manifesting time and expense are incurred. With the rising cost of solvents and waste disposal services, combined with continuously developing regulation, reducing the quantities of solvents used and solvent wastes generated can be extremely cost effective.

Eliminating the Use of Solvents

Eliminating the use of solvents avoids any waste generation associated with spent solvent. Elimination can be achieved by utilization of non-solvent cleaning agents or eliminating the need for cleaning altogether. Solvent elimination applications include the use of water-soluble cutting fluids, protective peel coatings, aqueous cleaners, and mechanical cleaning systems.

<u>Water-soluble Cutting Fluids</u>. Water-soluble cutting fluids can often be used in place of oil-based fluids. The cutting oils usually consist of an oil-in-water emulsion used to reduce friction and dissipate heat. If these fluids need to be removed after the machining process is complete, solvents may be needed.

In efforts to eliminate solvent degreasing and its subsequent waste, special water-soluble cutting fluids have been developed. Systems are available that can clean the cutting fluid and recycle the material back to the cutting operation. Obstacles to implementing this method are: cost (water-soluble fluids are generally more expensive), procurement (there are only a few suppliers available), and the inability to quickly switch between fluid types without thoroughly cleaning the equipment.

<u>Aqueous Cleaners</u> Aqueous cleaners, such as alkali, citric, and caustic base, are often useful substitutes for solvents. There are many formulations that are suited for a variety of cleaning requirements. Many aqueous cleaners have been found to be as effective as the halogenated solvents that are commonly employed.

The advantages of substituting aqueous cleaners include minimizing worker's exposure to solvent vapors, reducing liability and disposal problems associated with solvent use, and cost. Aqueous cleaners do not volatilize as quickly as other solvents, thereby reducing losses due to evaporation. Since most aqueous cleaners are biodegradable, disposal is not a problem once the organic or inorganic contaminants are removed.

The use of aqueous cleaners can also result in cost savings. Although some aqueous cleaners may cost less than an equivalent amount of solvent, the purchase price of each is about the same. The cost of disposal, loss due to evaporation, and associated liabilities, however, favor aqueous cleaners.

The disadvantages of aqueous cleaners in place of solvents may include: possible inability of the aqueous cleaners to provide the degree of cleaning required, incompatibility between the parts being cleaned and the cleaning solution, need to modify or replace existing equipment, and problems associated with moisture left on parts being cleaned. Oils removed from the parts during cleaning may float on the surface of the cleaning solution and may interfere with subsequent cleaning. Oil skimming is usually required.

<u>Mechanical Cleaning Systems</u> Utilizing mechanical cleaning systems can also replace solvents in degreasing and cleaning operations. In many cases, a high pressure steam gun or high pressure parts washer can clean parts and surfaces quicker and to the same degree of cleanliness as that of the solvents they replace. Light detergents can be added to the water supply for improved cleaning. The waste produced by these systems is usually oily wastewater. This wastewater can be sent through an oil/water separator, the removed water discharged to the sewer, and the oil residue sent to a petroleum recycler. Some hot water wash and steam systems can be supplemented by emulsifying solutions to speed the process. Although these additives speed the cleaning process, they can make separation of the oil from the water very difficult and create problems with disposal of the waste.

Non-Solvent Based Paint Stripping Non-solvent based paint stripping methods are viable substitutes for solvent stripping. Paint stripping is normally performed by soaking, spraying, or brushing surfaces with a stripping agent such as methylene chloride, chromates, phenols, or strong acids. After the agent has remained on the parts for a period, the surface is rinsed with water and the loosened paint is sprayed or brushed off. The alternatives to solvent stripping agents include aqueous striping agents, use of abrasives, cryogenic stripping, and thermal stripping.

Aqueous stripping agents, such as caustic soda (NaOH), are often employed in place of methylene chloride based strippers. Caustic solutions have the advantage of eliminating solvent vapor emissions. A typical caustic bath consists of about 40 percent caustic solution heated to about 200 degrees Fahrenheit. Caustic stripping is generally effective on alkyl resins and oil paints.

Cryogenic stripping utilizes liquid nitrogen and non-abrasive plastic beads as blasting shot. This method relies on the freezing effect of the liquid nitrogen and the impact of the plastic shot. Subjecting the surface to extremely low temperatures creates stress between the coating and the substrate causing the coating to become brittle. When the plastic shot hits the brittle coating, debonding occurs. The process is non-abrasive, and will not damage the substrate, but effects of the metal shrinkage, due to extremely low temperatures, should be monitored. The process does not produce liquid wastes, and nitrogen, chemically inert, is already present in the atmosphere (U.S. EPA, March 1997).

The most common form of non-solvent paint stripping in shipyards is the use of abrasive blasting. The use of various metallic grit propelled at high pressure against the surface is very effective to remove marine coatings.

Thermal stripping methods can be useful for objects that cannot be immersed. In this process, superheated air is directed against the surface of the object. The high temperatures cause some paints to flake off. The removal results from the drying effects of the air and the uneven expansion of the paint and the substrate. Some paints will melt at high temperatures, allowing the paint to be scraped off. Hand-held units are available that produce a jet of hot air. Electric units and open flame or torch units are also used. While this system is easy to implement, it is limited to items that are not heat sensitive and to coatings that are affected by the heat.

Reducing the Use of Solvent

By eliminating the use or need for solvent cleaning, the problems associated with disposal of spent solvent are also eliminated. In cases where the elimination of solvent use is not possible or practical, utilization of various solvent waste reduction techniques can lead to a substantial savings in solvent waste.

Methods of reducing solvent usage can be divided into three categories: source control of air emissions, efficient use of solvent and equipment, and maintaining solvent quality. Source control of air emissions addresses ways in which more of the solvent can be kept inside a container or cleaning tank by reducing the chances for evaporation loss. Efficient use of solvent and equipment through better operating procedures can reduce the amount of solvent required for cleaning. Maintaining the quality of solvent will extend the lifecycle effectiveness of the solvent.

<u>Source Control of Air Emissions</u> Source control of air emissions can be achieved through equipment modification and proper operation of equipment. Some simple control measures include installation and use of lids, an increase of freeboard height of cleaning tanks, installation of freeboard chillers, and taking steps to reduce solvent drag-out.

All cleaning units, including cold cleaning tanks and dip tanks, should have some type of lid installed. When viewed from the standpoint of reducing air emissions, the roll-type cover is preferable to the hinge type. Lids that swing down can cause a piston effect and force the escape of solvent vapor. In operations such as vapor degreasing, use of lids can reduce solvent loss from 24 percent to 50 percent. For tanks that are continuously in use, covers have been designed that allow the work pieces to enter and leave the tank while the lid remains closed.

In an open top vapor degreaser, freeboard is defined as the distance from the top of the vapor zone to the top of the tank. Increasing the freeboard will substantially reduce the amount of solvent loss. A freeboard chiller may also be installed above the primary condenser coil. This refrigerated coil, much like the cooling jacket, chills the air above the vapor zone and creates a secondary barrier to vapor loss. Reduction in solvent usage, by use of freeboard chillers, can be as high as 60 percent. The major drawback with a freeboard chiller is that it can introduce water (due to condensation from air) into the tank.

In addition to measures that reduce air emissions through equipment modification, it is also possible to reduce emissions through proper equipment layout, operation, and maintenance. Cleaning tanks should be located in areas where air turbulence and temperature do not promote vapor loss.

<u>Maximize the Dedication of the Process Equipment</u> In addition to reduction in vapor loss, reducing the amount of solvent used can be achieved through better operating practices that increase the efficiency of solvent cleaning operations. Maximizing the dedication of the process equipment reduces the

need for frequent cleaning. By using a mix tank consistently for the same formulation, the need to clean equipment between batches is eliminated.

<u>Avoid Unnecessary Cleaning</u> Avoiding unnecessary cleaning also offers potential for waste reduction. For example, paint mixing tanks for two-part paints are often cleaned between batches of the same product. The effect of cross-contamination between batches should be examined from a product quality control viewpoint to see if the cleaning step is always necessary.

Process pipelines are often flushed with some type of solvent to remove deposits on the pipe walls. Cleaning the pipelines can be achieved by using an inert gas propellant to remove deposits. This method can only be used if the pipelines do not have many bends or sharp turns.

<u>Proper Production Scheduling</u> Proper production scheduling can reduce cleaning frequency by eliminating the need for cleaning between the conclusion of one task and the start of the next. A simple example of this procedure is to have a small overlap between shifts that perform the same operation with the same equipment. This allows the equipment that would normally be cleaned and put away at the end of each shift, such as painting equipment, to be taken over directly by the relief.

<u>Clean Equipment Immediately</u> Cleaning equipment immediately after use prevents deposits from hardening and avoids the need for consuming extra solvent. Letting dirty equipment accumulate and be cleaned later can also increase the time required for cleaning.

<u>Better Operating Procedures</u> Better operating procedures can minimize equipment clean-up waste. Some of the methods already discussed are examples of better operating procedures. Better operator training, education, closer supervision, improved equipment maintenance, and increasing the use of automation are very effective in waste minimization.

<u>Reuse Solvent Waste</u> Reuse of solvent waste can reduce or eliminate waste and result in a cost savings associated with a decrease in raw material consumption. The solvent from cleaning operations can be reused in other cleaning processes in which the degree of cleanliness required is much less. This will be discussed in more detail in the next section.

Solvent Recycling

Although not a preferable as source reduction, solvent recycling may be a viable alternative for some shipyards. The goal of recycling is to recover from the waste solvent, a solvent of a similar purity to that of the virgin solvent for eventual reuse in the same operation, or of a sufficient purity to be used in another application. Recycling can also include the direct use of solvent waste from one waste stream in another operation. There are a number of techniques that shipyards can use onsite to separate solvents from contaminants including distillation, evaporation, sedimentation, decanting, centrifugation, filtering, and membrane separation.

V.F. Machining and Metalworking

Coolant fluids account for the largest waste stream generated by machining operations. Waste metalworking fluids are created when the fluids are no longer usable due to contamination by oils or chemical additives. If the contamination rate of the metalworking fluids is reduced, the need to replace them will be less frequent. This will reduce the waste generated.

Preventing Fluid Contamination

Fluid can become hazardous waste if it is contaminated. Although it is not possible to eliminate contamination, it is possible to reduce the rate of contamination and thereby prolong its use.

The primary contaminant in these waste fluids is tramp oil. One way to postpone contamination is to promote better maintenance of the wipers and seals. A preventative maintenance program should be installed and enforced in the machine shop. Scheduled sump and machine cleaning as well as periodic inspections of the wipers and oil seals should be carried out. The responsibility for this should be assigned to some person or group in a position of authority to ensure its success.

Synthetic Fluids

Synthetic fluids have many advantages over the non-synthetic counterparts. Usually the synthetic varieties do not lubricate as effectively, but they are less susceptible to contamination and highly resistant to biological breakdown. Most synthetic fluids have superior longevity and can operate over a large temperature range without adverse side effects. Straight oils should be replaced with synthetic ones when possible.

Recycling Fluids

Once all of the source reduction options have been considered, it is time to explore the possibilities of reuse. It should be noted that in many cases, after the majority of the contaminants have been removed, further treatment with chemicals or concentrated fluid is necessary before the fluids can be recirculated through the machines.

<u>Filtration</u>. Filtration is a common way to remove particles from the fluid as well as tramp oils or other contaminants. Many different types of filters can

be used depending on the medium to be filtered and the amount of filtration desired. Contaminated cutting fluids can be passed through a bag, disc, or cartridge filter or separated in a centrifuge.

Skimming and Flotation. Although it is a slow process, skimming of contaminants is inexpensive and can be very effective. The principle is to let the fluid sit motionless in a sump or a tank, and after a predetermined amount of time, the unwanted oils are skimmed off the surface and the heavier particulate matter is collected off the bottom. A similar technique, flotation, injects high pressure air into contaminated cutting fluid. As the air comes out of solution and bubbles to the surface, it attaches itself to suspended contaminants and carries them up to the surface. The resulting sludge is skimmed off the surface and the clean fluid is reused.

Centrifugation . Centrifugation uses the same settling principles as flotation, but the effects of gravity are multiplied thousands of times due to the spinning action of the centrifuge. This will increase the volume of fluids which can be cleaned in a given amount of time.

Pasteurization. Pasteurization uses heat treatment to kill microorganisms in the fluid and reduce the rate at which rancidity (biological breakdown) will occur. Unfortunately, heat can alter the properties of the fluid and render it less effective. Properties lost in this way are usually impossible to recover.

Downgrading. Sometimes it is possible to use high quality hydraulic oils as cutting fluids. After the oils have reached their normal usable life, they no longer meet the high standards necessary for hydraulic components. At this time they are still good enough to be used for the less demanding jobs. It may be necessary to treat the fluid before it can be reused, but changing fluid's functions in this manner has proven successful in the past.

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VI. SUMMARY OF FEDERAL STATUTES AND REGULATIONS

This section discusses the Federal regulations that may apply to this sector. The purpose of this section is to highlight and briefly describe the applicable Federal requirements, and to provide citations for more detailed information. The three following sections are included:

- Section VI.A. contains a general overview of major statutes
- Section VI.B. contains a list of regulations specific to this industry
- Section VI.C. contains a list of pending and proposed regulations

The descriptions within Section VI are intended solely for general information. Depending upon the nature or scope of the activities at a particular facility, these summaries may or may not necessarily describe all applicable environmental requirements. Moreover, they do not constitute formal interpretations or clarifications of the statutes and regulations. For further information, readers should consult the Code of Federal Regulations and other state or local regulatory agencies. EPA Hotline contacts are also provided for each major statute.

VI.A. General Description of Major Statutes

Resource Conservation and Recovery Act

The Resource Conservation And Recovery Act (RCRA) of 1976, which amended the Solid Waste Disposal Act, addresses solid (Subtitle D) and hazardous (Subtitle C) waste management activities. The Hazardous and Solid Waste Amendments (HSWA) of 1984 strengthened RCRA’s waste management provisions and added Subtitle I, which governs underground storage tanks (USTs).

Regulations promulgated pursuant to Subtitle C of RCRA (40 CFR Parts 260-299) establish a “cradle-to-grave” system governing hazardous waste from the point of generation to disposal. RCRA hazardous wastes include the specific materials listed in the regulations (commercial chemical products, designated with the code "P" or "U"; hazardous wastes from specific industries/sources, designated with the code "K"; or hazardous wastes from non-specific sources, designated with the code "F") or materials which exhibit a hazardous waste characteristic (ignitability, corrosivity, reactivity, or toxicity and designated with the code "D").

Regulated entities that generate hazardous waste are subject to waste accumulation, manifesting, and record keeping standards. Facilities must obtain a permit either from EPA or from a State agency which EPA has authorized to implement the permitting program if they store hazardous wastes for more than 90 days (or 180 days depending on the amount of waste generated) before treatment or disposal. Facilities may treat hazardous wastes stored in less-than-ninety-day tanks or containers without a permit provided the procedure is approved by a state agency having RCRA delegation authority. Subtitle C permits contain general facility standards such as contingency plans, emergency procedures, record keeping and reporting requirements, financial assurance mechanisms, and unit-specific standards. RCRA also contains provisions (40 CFR Part 264 Subpart S and §264.10) for conducting corrective actions which govern the cleanup of releases of hazardous waste or constituents from solid waste management units at RCRA-regulated facilities.

Although RCRA is a Federal statute, many States implement the RCRA program. Currently, EPA has delegated its authority to implement various provisions of RCRA to 47 of the 50 States and two U.S. territories. Delegation has not been given to Alaska, Hawaii, or Iowa.

Most RCRA requirements are not industry specific but apply to any company that generates, transports, treats, stores, or disposes of hazardous waste. Here are some important RCRA regulatory requirements:

- **Identification of Solid and Hazardous Wastes** (40 CFR Part 261) lays out the procedure every generator must follow to determine whether the material in question is considered a hazardous waste, solid waste, or is exempted from regulation.

- **Standards for Generators of Hazardous Waste** (40 CFR Part 262) establishes the responsibilities of hazardous waste generators including obtaining an EPA ID number, preparing a manifest, ensuring proper packaging and labeling, meeting standards for waste accumulation units, and recordkeeping and reporting requirements. Generators can accumulate hazardous waste for up to 90 days (or 180 days depending on the amount of waste generated) without obtaining a permit.

- **Land Disposal Restrictions** (LDRs) (40 CFR Part 268) are regulations prohibiting the disposal of hazardous waste on land without prior treatment. Under the LDRs program, materials must meet LDR treatment standards prior to placement in a RCRA land disposal unit (landfill, land treatment unit, waste pile, or surface impoundment). Generators of waste subject to the LDRs must provide notification of such to the designated TSD facility to ensure proper treatment prior to disposal.

- **Used Oil Management Standards** (40 CFR Part 279) impose management requirements affecting the storage, transportation, burning, processing, and re-refining of the used oil. For parties that merely generate used oil, regulations establish storage standards. For a party considered a used oil processor, re-refiner, burner, or marketer (one who generates and sells off-specification used oil), additional tracking and paperwork requirements must be satisfied.

- RCRA contains unit-specific standards for all units used to store, treat, or dispose of hazardous waste, including **Tanks and Containers**. Tanks and containers used to store hazardous waste with a high volatile organic concentration must meet emission standards under RCRA. Regulations (40 CFR Part 264-265, Subpart CC) require generators to test the waste to determine the concentration of the waste, to satisfy tank and container emissions standards, and to inspect and monitor regulated units. These regulations apply to all facilities that store such waste, including large quantity generators accumulating waste prior to shipment off-site.

- **Underground Storage Tanks** (USTs) containing petroleum and hazardous substances are regulated under Subtitle I of RCRA. Subtitle I regulations (40 CFR Part 280) contain tank design and release detection requirements, as well as financial responsibility and corrective action standards for USTs. The UST program also includes upgrade requirements for existing tanks that must be met by December 22, 1998.

- **Boilers and Industrial Furnaces** (BIFs) that use or burn fuel containing hazardous waste must comply with design and operating standards. BIF regulations (40 CFR Part 266, Subpart H) address unit design, provide performance standards, require emissions monitoring, and restrict the type of waste that may be burned.

EPA's RCRA, Superfund and EPCRA Hotline, *at (800) 424-9346, responds to questions and distributes guidance regarding all RCRA regulations. The RCRA Hotline operates weekdays from 9:00 a.m. to 6:00 p.m., ET, excluding Federal holidays.*

Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), a 1980 law known commonly as Superfund, authorizes EPA to respond to releases, or threatened releases, of hazardous substances that may endanger public health, welfare, or the environment. CERCLA also enables EPA to force parties responsible for environmental contamination to clean it up or to reimburse the Superfund for response costs incurred by EPA. The Superfund Amendments and Reauthorization Act (SARA) of 1986 revised various sections of CERCLA, extended the taxing authority for the Superfund, and created a free-standing law, SARA Title III, also known as the

Emergency Planning and Community Right-to-Know Act (EPCRA).

The CERCLA hazardous substance release reporting regulations (40 CFR Part 302) direct the person in charge of a facility to report to the National Response Center (NRC) any environmental release of a hazardous substance which equals or exceeds a reportable quantity. Reportable quantities are listed in 40 CFR §302.4. A release report may trigger a response by EPA, or by one or more Federal or State emergency response authorities.

EPA implements hazardous substance responses according to procedures outlined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR Part 300). The NCP includes provisions for permanent cleanups, known as remedial actions, and other cleanups referred to as removals. EPA generally takes remedial actions only at sites on the National Priorities List (NPL), which currently includes approximately 1300 sites. Both EPA and states can act at sites; however, EPA provides responsible parties the opportunity to conduct removal and remedial actions and encourages community involvement throughout the Superfund response process.

EPA's RCRA, Superfund and EPCRA Hotline, at (800) 424-9346, answers questions and references guidance pertaining to the Superfund program. This Hotline, which addresses CERCLA issues, operates weekdays from 9:00 a.m. to 6:00 p.m., ET, excluding Federal holidays.

Emergency Planning And Community Right-To-Know Act

The Superfund Amendments and Reauthorization Act (SARA) of 1986 created the Emergency Planning and Community Right-to-Know Act (EPCRA, also known as SARA Title III), a statute designed to improve community access to information about chemical hazards and to facilitate the development of chemical emergency response plans by State and local governments. EPCRA required the establishment of State emergency response commissions (SERCs), responsible for coordinating certain emergency response activities and for appointing local emergency planning committees (LEPCs).

EPCRA and the EPCRA regulations (40 CFR Parts 350-372) establish four types of reporting obligations for facilities which store or manage specified chemicals:

- **EPCRA §302** requires facilities to notify the SERC and LEPC of the presence of any extremely hazardous substance (the list of such substances is in 40 CFR Part 355, Appendices A and B) if it has such substance in excess of the substance's threshold planning quantity, and directs the facility to appoint an emergency response coordinator.

- **EPCRA §304** requires the facility to notify the SERC and the LEPC in the event of a release equaling or exceeding the reportable quantity of a CERCLA hazardous substance or an EPCRA extremely hazardous substance.

- **EPCRA §311 and §312** require a facility at which a hazardous chemical, as defined by the Occupational Safety and Health Act, is present in an amount exceeding a specified threshold to submit to the SERC, LEPC and local fire department material safety data sheets (MSDSs) or lists of MSDSs and hazardous chemical inventory forms (also known as Tier I and II forms). This information helps the local government respond in the event of a spill or release of the chemical.

- **EPCRA §313** requires manufacturing facilities included in SIC codes 20 through 39, which have ten or more employees, and which manufacture, process, or use specified chemicals in amounts greater than threshold quantities, to submit an annual toxic chemical release report. This report, known commonly as the Form R, covers releases and transfers of toxic chemicals to various facilities and environmental media, and allows EPA to compile the national Toxic Release Inventory (TRI) database.

All information submitted pursuant to EPCRA regulations is publicly accessible, unless protected by a trade secret claim.

EPA's RCRA, Superfund and EPCRA Hotline, at (800) 424-9346, answers questions and distributes guidance regarding the emergency planning and community right-to-know regulations. The EPCRA Hotline operates weekdays from 9:00 a.m. to 6:00 p.m., ET, excluding Federal holidays.

Clean Water Act

The primary objective of the Federal Water Pollution Control Act, commonly referred to as the Clean Water Act (CWA), is to restore and maintain the chemical, physical, and biological integrity of the nation's surface waters. Pollutants regulated under the CWA include "priority" pollutants, including various toxic pollutants; "conventional" pollutants, such as biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform, oil and grease, and pH; and "non-conventional" pollutants, including any pollutant not identified as either conventional or priority.

The CWA regulates both direct and indirect discharges. The National Pollutant Discharge Elimination System (NPDES) program (CWA §502) controls direct discharges into navigable waters. NPDES permits, issued by either EPA or an authorized State (EPA has authorized 42 States to administer the NPDES program), contain industry-specific, technology-based and/or water quality-based limits, and establish pollutant monitoring requirements. A facility that intends to discharge into the nation's waters must obtain a permit prior to initiating its discharge. A permit applicant must provide quantitative analytical data identifying the types of pollutants present in the facility's effluent. The permit will then set the conditions and effluent limitations on the facility discharges.

A NPDES permit may also include discharge limits based on Federal or State water quality criteria or standards, that were designed to protect designated uses of surface waters, such as supporting aquatic life or recreation. These standards, unlike the technological standards, generally do not take into account technological feasibility or costs. Water quality criteria and standards vary from State to State, and site to site, depending on the use classification of the receiving body of water. Most States follow EPA guidelines which propose aquatic life and human health criteria for many of the 126 priority pollutants.

Storm Water Discharges

In 1987 the CWA was amended to require EPA to establish a program to address storm water discharges. In response, EPA promulgated the NPDES storm water permit application regulations. These regulations require that facilities with the following storm water discharges apply for an NPDES permit: (1) a discharge associated with industrial activity; (2) a discharge from a large or medium municipal storm sewer system; or (3) a discharge which EPA or the State determines to contribute to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States.

The term "storm water discharge associated with industrial activity" means a storm water discharge from one of 11 categories of industrial activity defined at 40 CFR 122.26. Six of the categories are defined by SIC codes while the other five are identified through narrative descriptions of the regulated industrial activity. If the primary SIC code of the facility is one of those identified in the regulations, the facility is subject to the storm water permit application requirements. If any activity at a facility is covered by one of the five narrative categories, storm water discharges from those areas where the activities occur are subject to storm water discharge permit application requirements.

Those facilities/activities that are subject to storm water discharge permit application requirements are identified below. To determine whether a particular facility falls within one of these categories, consult the regulation.

Category i: Facilities subject to storm water effluent guidelines, new source performance standards, or toxic pollutant effluent standards.

Category ii: Facilities classified as SIC 24-lumber and wood products (except wood kitchen cabinets); SIC 26-paper and allied products (except paperboard containers and products); SIC 28-chemicals and allied products (except drugs and paints); SIC 291-petroleum refining; and SIC 311-leather tanning and finishing, 32 (except 323)-stone, clay, glass, and concrete, 33-primary metals, 3441-fabricated structural metal, and 373-ship and boat building and repairing.

Category iii: Facilities classified as SIC 10-metal mining; SIC 12-coal mining; SIC 13-oil and gas extraction; and SIC 14-nonmetallic mineral mining.

Category iv: Hazardous waste treatment, storage, or disposal facilities.

Category v: Landfills, land application sites, and open dumps that receive or have received industrial wastes.

Category vi: Facilities classified as SIC 5015-used motor vehicle parts; and SIC 5093-automotive scrap and waste material recycling facilities.

Category vii: Steam electric power generating facilities.

Category viii: Facilities classified as SIC 40-railroad transportation; SIC 41-local passenger transportation; SIC 42-trucking and warehousing (except public warehousing and storage); SIC 43-U.S. Postal Service; SIC 44-water transportation; SIC 45-transportation by air; and SIC 5171-petroleum bulk storage stations and terminals.

Category ix: Sewage treatment works.

Category x: Construction activities except operations that result in the disturbance of less than five acres of total land area.

Category xi: Facilities classified as SIC 20-food and kindred products; SIC 21-tobacco products; SIC 22-textile mill products; SIC 23-apparel related products; SIC 2434-wood kitchen cabinets manufacturing; SIC 25-furniture and fixtures; SIC 265-paperboard containers and boxes; SIC 267-converted paper and paperboard products; SIC 27-printing, publishing, and allied industries; SIC 283-drugs; SIC 285-paints, varnishes, lacquer, enamels, and allied products; SIC 30-rubber and plastics; SIC 31-leather and leather products (except leather tanning and finishing); SIC 323-glass products; SIC 34-fabricated metal products (except fabricated structural metal); SIC 35-industrial and commercial machinery and computer equipment; SIC 36-

electronic and other electrical equipment and components; SIC 37-transportation equipment (except ship and boat building and repair); SIC 38-measuring, analyzing, and controlling instruments; SIC 39-miscellaneous manufacturing industries; and SIC 4221-4225-public warehousing and storage.

Pretreatment Program

Another type of discharge that is regulated by the CWA is one that goes to a publicly-owned treatment works (POTW). The national pretreatment program (CWA §307(b)) controls the indirect discharge of pollutants to POTWs by "industrial users." Facilities regulated under §307(b) must meet certain pretreatment standards. The goal of the pretreatment program is to protect municipal wastewater treatment plants from damage that may occur when hazardous, toxic, or other wastes are discharged into a sewer system and to protect the quality of sludge generated by these plants. Discharges to a POTW are regulated primarily by the POTW, rather than the State or EPA.

EPA has developed technology-based standards for industrial users of POTWs. Different standards apply to existing and new sources within each category. "Categorical" pretreatment standards applicable to an industry on a nationwide basis are developed by EPA. In addition, another kind of pretreatment standard, "local limits," are developed by the POTW in order to assist the POTW in achieving the effluent limitations in its NPDES permit.

Regardless of whether a State is authorized to implement either the NPDES or the pretreatment program, if it develops its own program, it may enforce requirements more stringent than Federal standards.

Spill Prevention, Control and Countermeasure Plans

The 1990 Oil Pollution Act requires that facilities that could reasonably be expected to discharge oil in harmful quantities prepare and implement more rigorous Spill Prevention Control and Countermeasure (SPCC) Plan required under the CWA (40 CFR §112.7). There are also criminal and civil penalties for deliberate or negligent spills of oil. Regulations covering response to oil discharges and contingency plans (40 CFR Part 300), and Facility Response Plans to oil discharges (40 CFR §112.20) and for PCB transformers and PCB-containing items were revised and finalized in 1995.

EPA's Office of Water, at (202) 260-5700, will direct callers with questions about the CWA to the appropriate EPA office. EPA also maintains a bibliographic database of Office of Water publications which can be accessed through the Ground Water and Drinking Water resource center, at (202) 260-7786.

Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) mandates that EPA establish regulations to protect human health from contaminants in drinking water. The law authorizes EPA to develop national drinking water standards and to create a joint Federal-State system to ensure compliance with these standards. The SDWA also directs EPA to protect underground sources of drinking water through the control of underground injection of liquid wastes.

EPA has developed primary and secondary drinking water standards under its SDWA authority. EPA and authorized States enforce the primary drinking water standards, which are, contaminant-specific concentration limits that apply to certain public drinking water supplies. Primary drinking water standards consist of maximum contaminant level goals (MCLGs), which are non-enforceable health-based goals, and maximum contaminant levels (MCLs), which are enforceable limits set as close to MCLGs as possible, considering cost and feasibility of attainment.

The SDWA Underground Injection Control (UIC) program (40 CFR Parts 144-148) is a permit program which protects underground sources of drinking water by regulating five classes of injection wells. UIC permits include design, operating, inspection, and monitoring requirements. Wells used to inject hazardous wastes must also comply with RCRA corrective action standards in order to be granted a RCRA permit, and must meet applicable RCRA land disposal restrictions standards. The UIC permit program is primarily State-enforced, since EPA has authorized all but a few States to administer the program.

The SDWA also provides for a Federally-implemented Sole Source Aquifer program, which prohibits Federal funds from being expended on projects that may contaminate the sole or principal source of drinking water for a given area, and for a State-implemented Wellhead Protection program, designed to protect drinking water wells and drinking water recharge areas.

EPA's Safe Drinking Water Hotline, at (800) 426-4791, answers questions and distributes guidance pertaining to SDWA standards. The Hotline operates from 9:00 a.m. through 5:30 p.m., ET, excluding Federal holidays.

Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) granted EPA authority to create a regulatory framework to collect data on chemicals in order to evaluate, assess, mitigate, and control risks which may be posed by their manufacture, processing, and use. TSCA provides a variety of control methods to prevent chemicals from posing unreasonable risk.

TSCA standards may apply at any point during a chemical's life cycle. Under TSCA §5, EPA has established an inventory of chemical substances. If a chemical is not already on the inventory, and has not been excluded by TSCA, a premanufacture notice (PMN) must be submitted to EPA prior to manufacture or import. The PMN must identify the chemical and provide available information on health and environmental effects. If available data are not sufficient to evaluate the chemicals effects, EPA can impose restrictions pending the development of information on its health and environmental effects. EPA can also restrict significant new uses of chemicals based upon factors such as the projected volume and use of the chemical.

Under TSCA §6, EPA can ban the manufacture or distribution in commerce, limit the use, require labeling, or place other restrictions on chemicals that pose unreasonable risks. Among the chemicals EPA regulates under §6 authority are asbestos, chlorofluorocarbons (CFCs), and polychlorinated biphenyls (PCBs).

Under TSCA §8, EPA requires the producers and importers of chemicals to report information on chemicals' production, use, exposure, and risks. Companies producing and importing chemicals can be required to report unpublished health and safety studies on listed chemicals and to collect and record any allegations of adverse reactions or any information indicating that a substance may pose a significant risk to humans or the environment.

EPA's TSCA Assistance Information Service, at (202) 554-1404, answers questions and distributes guidance pertaining to Toxic Substances Control Act standards. The Service operates from 8:30 a.m. through 4:30 p.m., ET, excluding Federal holidays.

Clean Air Act

The Clean Air Act (CAA) and its amendments, including the Clean Air Act Amendments (CAAA) of 1990, are designed to "protect and enhance the nation's air resources so as to promote the public health and welfare and the productive capacity of the population." The CAA consists of six sections, known as Titles, which direct EPA to establish national standards for ambient air quality and for EPA and the States to implement, maintain, and enforce these standards through a variety of mechanisms. Under the CAAA, many facilities will be required to obtain permits for the first time. State and local governments oversee, manage, and enforce many of the requirements of the CAAA. CAA regulations appear at 40 CFR Parts 50-99.

Pursuant to Title I of the CAA, EPA has established national ambient air quality standards (NAAQSs) to limit levels of "criteria pollutants," including carbon monoxide, lead, nitrogen dioxide, particulate matter, volatile organic compounds (VOCs), ozone, and sulfur dioxide. Geographic areas that meet

NAAQSs for a given pollutant are classified as attainment areas; those that do not meet NAAQSs are classified as non-attainment areas. Under section 110 of the CAA, each State must develop a State Implementation Plan (SIP) to identify sources of air pollution and to determine what reductions are required to meet Federal air quality standards. Revised NAAQSs for particulates and ozone were proposed in 1996 and may go into effect as early as 1997.

Title I also authorizes EPA to establish New Source Performance Standards (NSPSs), which are nationally uniform emission standards for new stationary sources falling within particular industrial categories. NSPSs are based on the pollution control technology available to that category of industrial source.

Under Title I, EPA establishes and enforces National Emission Standards for Hazardous Air Pollutants (NESHAPs), nationally uniform standards oriented towards controlling particular hazardous air pollutants (HAPs). Title I, section 112(c) of the CAA further directed EPA to develop a list of sources that emit any of 189 HAPs, and to develop regulations for these categories of sources. To date EPA has listed 174 categories and developed a schedule for the establishment of emission standards. The emission standards will be developed for both new and existing sources based on "maximum achievable control technology" (MACT). The MACT is defined as the control technology achieving the maximum degree of reduction in the emission of the HAPs, taking into account cost and other factors. Title I, section 112(r) directed EPA to develop a list of hazardous chemicals and regulations to control and prevent accidental releases of these chemicals. Owners and operators of facilities at which such substances are present in more than a threshold quantity will have to prepare risk management plans for each substance used at the facility. EPA may also require annual audits and safety inspections to prevent leaks and other episodic releases.

Title II of the CAA pertains to mobile sources, such as cars, trucks, buses, and planes. Reformulated gasoline, automobile pollution control devices, and vapor recovery nozzles on gas pumps are a few of the mechanisms EPA uses to regulate mobile air emission sources.

Title IV of the CAA establishes a sulfur dioxide and nitrogen oxides emissions program designed to reduce the formation of acid rain. Reduction of sulfur dioxide releases will be obtained by granting to certain sources limited emissions allowances, which, beginning in 1995, will be set below previous levels of sulfur dioxide releases.

Title V of the CAA of 1990 created a permit program for all "major sources" (and certain other sources) regulated under the CAA. One purpose of the operating permit is to include in a single document all air emissions requirements that apply to a given facility. States are developing the permit programs in accordance with guidance and regulations from EPA. Once a

State program is approved by EPA, permits will be issued and monitored by that State.

Title VI of the CAA is intended to protect stratospheric ozone by phasing out the manufacture of ozone-depleting chemicals and restrict their use and distribution. Production of Class I substances, including 15 kinds of chlorofluorocarbons (CFCs) and chloroform, were phased out (except for essential uses) in 1996.

EPA's Clean Air Technology Center, at (919) 541-0800, provides general assistance and information on CAA standards. The Stratospheric Ozone Information Hotline, at (800) 296-1996, provides general information about regulations promulgated under Title VI of the CAA, and EPA's EPCRA Hotline, at (800) 535-0202, answers questions about accidental release prevention under CAA §112(r). In addition, the Clean Air Technology Center's website includes recent CAA rules, EPA guidance documents, and updates of EPA activities (www.epa.gov/ttn then select Directory and then CATC).

VI.B. Industry Specific Requirements

Resource Conservation and Recovery Act (RCRA)

A material is classified under RCRA as a hazardous waste if the material meets the definition of solid waste (40 CFR 261.2), and that solid waste material exhibits one of the characteristics of a hazardous waste (40 CFR 261.20-40) or is specifically listed as a hazardous waste (40 CFR 261.31-33). A material defined as a hazardous waste may then be subject to Subtitle C generator (40 CFR 262), transporter (40 CFR 263), and treatment, storage, and disposal facility (40 CFR 264 and 265) requirements. The shipbuilding and repair industry must be concerned with the regulations addressing all of these.

Several common shipyard operations have the potential to generate RCRA hazardous wastes. Some of these wastes are identified below by process.

Machining and Other Metalworking

- Metalworking fluids contaminated with oils, phenols, creosol, alkalies, phosphorus compounds, and chlorine

Cleaning and Degreasing

- Solvents (F001, F002, F003, F004, F005)
- Alkaline and Acid Cleaning Solutions (D002)
- Cleaning filter sludges with toxic metal concentrations

Metal Plating and Surface Finishing and Preparation

- Wastewater treatment sludges from electroplating operations (F006)
- Spent cyanide plating bath solutions (F007)
- Plating bath residues from the bottom of cyanide plating baths (F008)
- Spent stripping and cleaning bath solutions from cyanide plating operations (F009)

Surface Preparation, Painting and Coating

- Paint and paint containers containing paint sludges with solvents or toxic metals concentrations
- Solvents (F002, F003)
- Paint chips with toxic metal concentrations
- Blasting media contaminated with paint chips

Vessel Cleaning

- Vessel sludges
- Vessel cleaning wastewater
- Vessel cleaning wastewater sludges

Fiberglass Reinforced Construction

- Solvents (F001, F002, F003, F004, F005)
- Chemical additives and catalysts

Shipbuilding and repair facilities may also generate used lubricating oils which are regulated under RCRA but may or may not be considered a hazardous waste (40 CFR 266).

United States Code, Title 10, Section 7311

Title 10, Section 7311 of the U.S. Code applies specifically to the handling of hazardous waste (as defined by RCRA) during the repair and maintenance of naval vessels. The Code requires the navy to identify the types and amounts of hazardous wastes that will be generated or removed by a contractor working on a naval vessel and that the navy compensate the contractor for the removal, handling, storage, transportation, or disposal of the hazardous waste. The Code also requires that waste generated solely by the navy and handled by the contractor bears a generator identification number issued to the navy; wastes generated and handled solely by the contractor bears a generator identification number issued to the contractor; and waste generated by both the navy and the contractor and handled by the contractor bears a generator identification number issued to the contractor and a generator identification number issued to the navy.

Clean Air Act

Under Title III of the 1990 Clean Air Act Amendments (CAAA), EPA is required to develop national emission standards for 189 hazardous air pollutants (NESHAP). EPA is developing maximum achievable control technology (MACT) standards for all new and existing sources. The National Emission Standards for Shipbuilding and Repair Operations (Surface Coating) (40 CFR Part 63 Subpart II) were finalized in 1995 and apply to major source shipbuilding and ship repairing facilities that carry out surface coating operations. Shipyards that emit ten or more tons of any one HAP or 25 or more tons of two or more HAPs combined are subject to the MACT requirements. The MACT requirements set VOC limits for different types of marine coatings and performance standards to reduce spills, leaks, and fugitive emissions. EPA estimates that there are approximately 35 major source shipyards affected by this regulation. Shipbuilding and repair facilities may also be subject to National Emissions Standards for Asbestos (40 CFR Part 61 Subpart M). Both NESHAPs require emission limits, work practice standards, record keeping, and reporting.

Under Title V of the CAAA 1990 (40 CFR Parts 70-72) all of the applicable requirements of the Amendments are integrated into one federal renewable operating permit. Facilities defined as "major sources" under the Act must apply for permits within one year from when EPA approves the state permit programs. Since most state programs were not approved until after November 1994, Title V permit applications, for the most part, began to be due in late 1995. Due dates for filing complete applications vary significantly from state to state, based on the status of review and approval of the state's Title V program by EPA.

A facility is designated as a major source for Title V if it releases a certain amount of any one of the CAAA regulated pollutants (SO_x, NO_x, CO, VOC, PM_{10}, hazardous air pollutants, extremely hazardous substances, ozone depleting substances, and pollutants covered by NSPSs) depending on the region's air quality category. Title V permits may set limits on the amounts of pollutant emissions; require emissions monitoring, and record keeping and reporting. Facilities are required to pay an annual fee based on the magnitude of the facility's potential emissions. It is estimated that approximately 35 shipyards will be designated as major sources and therefore must apply for a Title V permit.

Clean Water Act

Shipbuilding and repair facility wastewater released to surface waters is regulated under the CWA. National Pollutant Discharge Elimination System (NPDES) permits must be obtained to discharge wastewater into navigable waters (40 Part 122). Facilities that discharge to a POTW may be required to meet National Pretreatment Standards for some contaminants. General pretreatment standards applying to most industries discharging to a POTW are described in 40 CFR Part 403. In addition, effluent limitation guidelines, new source performance standards, pretreatment standards for new sources, and pretreatment standards for existing sources may apply to some shipbuilding and repair facilities that carryout electroplating or metal finishing operations. Requirements for the Electroplating Point Source Category and the Metal Finishing Point Source Category are listed under 40 CFR Part 413 and 40 CFR Part 433, respectively.

Storm water rules require certain facilities with storm water discharge from any one of 11 categories of industrial activity defined in 40 CFR 122.26 be subject to the storm water permit application requirements (see Section VI.A). Many shipbuilding and repair facilities fall within these categories. To determine whether a particular facility falls within one of these categories, the regulation should be consulted. Required treatment of storm water flows are expected to remove a large fraction of both conventional pollutants, such as suspended solids and biochemical oxygen demand (BOD), as well as toxic pollutants, such as certain metals and organic compounds.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA) provide the basic legal framework for the federal "Superfund" program to clean up abandoned hazardous waste sites (40 CFR Part 305). Metals and metal compounds often found in shipyards' air emissions, water discharges, or waste shipments for off-site disposal include chromium, manganese, aluminum, nickel, copper, zinc, and lead. Metals are frequently found at CERCLA's problem sites. When Congress ordered EPA and the Public Health Service's Agency for Toxic Substances and Disease Registry (ATSDR) to list the hazardous substances most commonly found at problem sites and that pose the greatest threat to human health, lead, nickel, and aluminum all made the list.

VI.C. Pending and Proposed Regulatory Requirements

Clean Water Act

Effluent limitation guidelines for wastewater discharges from metal products and machinery (MP&M) industries are being developed. MP&M industries have been divided into two groups that originally were to be covered under two separate phases of the rulemaking. Effluent guidelines for Phase I industries and Phase II industries (which includes the shipbuilding and repair industry) will now be covered under a single regulation to be proposed in October 2000 and finalized in December 2002. (Steven Geil, U.S. EPA, Office of Water, Engineering and Analysis Division, (202) 260-9817, email: geil.steve@epamail.epa.gov)

Clean Air Act

In August 1996, EPA published Control Technique Guidelines (CTG) for the control of VOC emissions from surface coating operations in the shipbuilding and ship repair industry. The CTG was issued to assist states in analyzing and determining reasonably available control technology (RACT) standards for major sources of VOCs in the shipbuilding and repair operations located within ozone NAAQS nonattainment areas. EPA estimates that there are approximately 100 facilities that will fall within this category in addition to the approximately 35 major sources identified for the NESHAP MACT standards. Within one year of the publication of the CTG, states must adopt a RACT regulation at least as stringent as the limits recommended in the CTG. Under Section 183(b)(4) of the Clean Air Act, EPA is required to issue the CTG for the shipbuilding and repair industry based on "best available control measures" (BACM) for emissions of VOCs and particulates. In developing the CTG, EPA determined that the MACT standard of the 1995 NESHAP for Shipbuilding and Repair Operations (Surface Coating) is the only technologically and economically feasible level of control for these sources. Therefore, for shipbuilding and repair operations, EPA considers the RACT, BACM, and MACT standards to be identical. For particulate emissions, EPA determined the BACM to be no control. (Mohamed Serageldin, U.S. EPA, Office of Air Quality Planning and Standards, (919) 541-2379)

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VII. COMPLIANCE AND ENFORCEMENT HISTORY

Background

Until recently, EPA has focused much of its attention on measuring compliance with specific environmental statutes. This approach allows the Agency to track compliance with the Clean Air Act, the Resource Conservation and Recovery Act, the Clean Water Act, and other environmental statutes. Within the last several years, the Agency has begun to supplement single-media compliance indicators with facility-specific, multimedia indicators of compliance. In doing so, EPA is in a better position to track compliance with all statutes at the facility level, and within specific industrial sectors.

A major step in building the capacity to compile multimedia data for industrial sectors was the creation of EPA's Integrated Data for Enforcement Analysis (IDEA) system. IDEA has the capacity to "read into" the Agency's single-media databases, extract compliance records, and match the records to individual facilities. The IDEA system can match Air, Water, Waste, Toxics/Pesticides/EPCRA, TRI, and Enforcement Docket records for a given facility, and generate a list of historical permit, inspection, and enforcement activity. IDEA also has the capability to analyze data by geographic area and corporate holder. As the capacity to generate multimedia compliance data improves, EPA will make available more in-depth compliance and enforcement information. Additionally, sector-specific measures of success for compliance assistance efforts are under development.

Compliance and Enforcement Profile Description

Using inspection, violation and enforcement data from the IDEA system, this section provides information regarding the historical compliance and enforcement activity of this sector. In order to mirror the facility universe reported in the Toxic Chemical Profile, the data reported within this section consists of records only from the TRI reporting universe. With this decision, the selection criteria are consistent across sectors with certain exceptions. For the sectors that do not normally report to the TRI program, data have been provided from EPA's Facility Indexing System (FINDS) which tracks facilities in all media databases. Please note, in this section, EPA does not attempt to define the actual number of facilities that fall within each sector. Instead, the section portrays the records of a subset of facilities within the sector that are well defined within EPA databases.

As a check on the relative size of the full sector universe, most notebooks contain an estimated number of facilities within the sector according to the Bureau of Census (See Section II). With sectors dominated by small businesses, such as metal finishers and printers, the reporting universe within the EPA databases may be small in comparison to Census data. However, the group selected for inclusion in this data analysis section should be consistent with this sector's general make-up.

Following this introduction is a list defining each data column presented within this section. These values represent a retrospective summary of inspections and enforcement actions, and reflect solely EPA, State, and local compliance assurance activities that have been entered into EPA databases. To identify any changes in trends, the EPA ran two data queries, one for the past five calendar years (April 1, 1992 to March 31, 1997) and the other for the most recent twelve-month period (April 1, 1996 to March 31, 1997). The five-year analysis gives an average level of activity for that period for comparison to the more recent activity.

Because most inspections focus on single-media requirements, the data queries presented in this section are taken from single media databases. These databases do not provide data on whether inspections are state/local or EPA-led. However, the table breaking down the universe of violations does give the reader a crude measurement of the EPA's and states' efforts within each media program. The presented data illustrate the variations across EPA Regions for certain sectors.[4] This variation may be attributable to state/local data entry variations, specific geographic concentrations, proximity to population centers, sensitive ecosystems, highly toxic chemicals used in production, or historical noncompliance. Hence, the exhibited data do not rank regional performance or necessarily reflect which regions may have the most compliance problems.

Compliance and Enforcement Data Definitions

General Definitions

Facility Indexing System (FINDS) -- this system assigns a common facility number to EPA single-media permit records. The FINDS identification number allows EPA to compile and review all permit, compliance, enforcement and pollutant release data for any given regulated facility.

Integrated Data for Enforcement Analysis (IDEA) -- is a data integration system that can retrieve information from the major EPA program office databases. IDEA uses the FINDS identification number to link separate data records from EPA's databases. This allows retrieval of records from across

[4] EPA Regions include the following states: I (CT, MA, ME, RI, NH, VT); II (NJ, NY, PR, VI); III (DC, DE, MD, PA, VA, WV); IV (AL, FL, GA, KY, MS, NC, SC, TN); V (IL, IN, MI, MN, OH, WI); VI (AR, LA, NM, OK, TX); VII (IA, KS, MO, NE); VIII (CO, MT, ND, SD, UT, WY); IX (AZ, CA, HI, NV, Pacific Trust Territories); X (AK, ID, OR, WA).

media or statutes for any given facility, thus creating a "master list" of records for that facility. Some of the data systems accessible through IDEA are: AIRS (Air Facility Indexing and Retrieval System, Office of Air and Radiation), PCS (Permit Compliance System, Office of Water), RCRIS (Resource Conservation and Recovery Information System, Office of Solid Waste), NCDB (National Compliance Data Base, Office of Prevention, Pesticides, and Toxic Substances), CERCLIS (Comprehensive Environmental and Liability Information System, Superfund), and TRIS (Toxic Release Inventory System). IDEA also contains information from outside sources such as Dun and Bradstreet and the Occupational Safety and Health Administration (OSHA). Most data queries displayed in notebook sections IV and VII were conducted using IDEA.

Data Table Column Heading Definitions

Facilities in Search -- are based on the universe of TRI reporters within the listed SIC code range. For industries not covered under TRI reporting requirements (metal mining, nonmetallic mineral mining, electric power generation, ground transportation, water transportation, and dry cleaning), or industries in which only a very small fraction of facilities report to TRI (e.g., printing), the notebook uses the FINDS universe for executing data queries. The SIC code range selected for each search is defined by each notebook's selected SIC code coverage described in Section II.

Facilities Inspected --- indicates the level of EPA and state agency inspections for the facilities in this data search. These values show what percentage of the facility universe is inspected in a one-year or five-year period.

Number of Inspections -- measures the total number of inspections conducted in this sector. An inspection event is counted each time it is entered into a single media database.

Average Time Between Inspections -- provides an average length of time, expressed in months, between compliance inspections at a facility within the defined universe.

Facilities with One or More Enforcement Actions -- expresses the number of facilities that were the subject of at least one enforcement action within the defined time period. This category is broken down further into federal and state actions. Data are obtained for administrative, civil/judicial, and criminal enforcement actions. Administrative actions include Notices of Violation (NOVs). A facility with multiple enforcement actions is only counted once in this column, e.g., a facility with 3 enforcement actions counts as 1 facility.

Total Enforcement Actions -- describes the total number of enforcement actions identified for an industrial sector across all environmental statutes. A facility with multiple enforcement actions is counted multiple times, e.g., a facility with 3 enforcement actions counts as 3.

State Lead Actions -- shows what percentage of the total enforcement actions are taken by state and local environmental agencies. Varying levels of use by states of EPA data systems may limit the volume of actions recorded as state enforcement activity. Some states extensively report enforcement activities into EPA data systems, while other states may use their own data systems.

Federal Lead Actions -- shows what percentage of the total enforcement actions are taken by the United States Environmental Protection Agency. This value includes referrals from state agencies. Many of these actions result from coordinated or joint state/federal efforts.

Enforcement to Inspection Rate -- is a ratio of enforcement actions to inspections, and is presented for comparative purposes only. This ratio is a rough indicator of the relationship between inspections and enforcement. It relates the number of enforcement actions and the number of inspections that occurred within the one-year or five-year period. This ratio includes the inspections and enforcement actions reported under the Clean Water Act (CWA), the Clean Air Act (CAA) and the Resource Conservation and Recovery Act (RCRA). Inspections and actions from the TSCA/FIFRA/EPCRA database are not factored into this ratio because most of the actions taken under these programs are not the result of facility inspections. Also, this ratio does not account for enforcement actions arising from non-inspection compliance monitoring activities (e.g., self-reported water discharges) that can result in enforcement action within the CAA, CWA, and RCRA.

Facilities with One or More Violations Identified -- indicates the percentage of inspected facilities having a violation identified in one of the following data categories: In Violation or Significant Violation Status (CAA); Reportable Noncompliance, Current Year Noncompliance, Significant Noncompliance (CWA); Noncompliance and Significant Noncompliance (FIFRA, TSCA, and EPCRA); Unresolved Violation and Unresolved High Priority Violation (RCRA). The values presented for this column reflect the extent of noncompliance within the measured time frame, but do not distinguish between the severity of the noncompliance. Violation status may be a precursor to an enforcement action, but does not necessarily indicate that an enforcement action will occur.

Media Breakdown of Enforcement Actions and Inspections -- four columns identify the proportion of total inspections and enforcement actions within EPA Air, Water, Waste, and TSCA/FIFRA/EPCRA databases. Each column is a percentage of either the "Total Inspections," or the "Total Actions" column.

VII.A. Shipbuilding and Repair Industry Compliance History

Table 11 provides an overview of the reported compliance and enforcement data for the shipbuilding and repair industry over the past five years (April 1992 to April 1997). These data are also broken out by EPA Region thereby permitting geographical comparisons. A few points evident from the data are listed below.

- About half of shipbuilding and repair facility inspections and almost 70 percent of enforcement actions occurred in Regions IV and VI, where most facilities in the database search (60 percent) were located.

- In Region III, a relatively large number of inspections (66) were carried out in relation to the number of facilities (6) found in this Region. This is reflected in the relatively low average time between inspections (5 months). However, the Region had the lowest rate of enforcement actions to inspections (0.02).

- Region X showed three facilities in the database search and only eight inspections over the past five years, giving the Region the highest average time between inspections (23 months). However, enforcement actions were brought against all three facilities in this time period, resulting in the highest enforcement to inspection rate (0.38).

Table 11: Five-Year Enforcement and Compliance Summary for the Shipbuilding and Repair Industry									
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Region	**Facilities in Search**	**Facilities Inspected**	**Number of Inspections**	**Average Months Between Inspections**	**Facilities with 1 or More Enforcement Actions**	**Total Enforcement Actions**	**Percent State Lead Actions**	**Percent Federal Lead Actions**	**Enforcement to Inspection Rate**
I	6	6	34	11	4	6	83%	17%	0.18
II	0	0	0	--	0	0	0%	0%	--
III	6	5	66	5	1	1	100%	0%	0.02
IV	13	9	49	16	5	8	100%	0%	0.16
V	1	1	8	8	0	0	0%	0%	--
VI	13	12	72	11	8	14	79%	21%	0.19
VII	0	0	0	--	0	0	0%	0%	--
VIII	0	0	0	--	0	0	0%	0%	--
IX	2	1	6	20	0	0	0%	0%	--
X	3	3	8	23	2	3	67%	33%	0.38
TOTAL	44	37	243	9	20	32	84%	16%	0.13

VII.B. Comparison of Enforcement and Compliance Activity Between Selected Industries

Tables 12 and 13 allow the compliance history of the shipbuilding and repair sector to be compared to the other industries covered by the industry sector notebook project. Comparisons between Tables 12 and 13 permit the identification of trends in compliance and enforcement records of the industry by comparing data covering the last five years (April 1992 to April 1997) to that of the past year (April 1996 to April 1997). Some points evident from the data are listed below.

- Of the sectors shown, the shipbuilding and repair industry had, by far, the smallest number of facilities (44) in the database search. (The facilities presented only include those facilities that report to TRI.)

- The shipbuilding and repair industry had one of the highest enforcement to inspection rates over the past five years (0.13). However, this rate decreased significantly over the past year (0.08).

- Compared to the other sectors shown, the industry was about average in terms of the percent of facilities with violations (86 percent) and enforcement actions (14 percent) in the past year, and in the average time between inspections over the past five years (9 months).

Tables 14 and 15 provide a more in-depth comparison between the shipbuilding and repair industry and other sectors by breaking out the compliance and enforcement data by environmental statute. As in the previous Tables (Tables 12 and 13), the data cover the last five years (Table 14) and the last one year (Table 15) to facilitate the identification of recent trends. A few points evident from the data are listed below.

- Inspections carried out under CAA and RCRA accounted for 81 percent and 89 percent of inspections over the past five years and one year, respectively. RCRA inspections made up only 14 percent of inspections in the past five years, but accounted for 25 percent of enforcement actions.

- Over the past year, a larger percentage of inspections were carried out under CAA (54 percent) compared to the past five years (39 percent).

- Meaningful comparisons of enforcement actions taken under each statute over the past year are not possible since only four enforcement actions (two under RCRA and two under CWA) were taken in this period.

Table 12: Five-Year Enforcement and Compliance Summary for Selected Industries

A	B	C	D	E	F	G	H	I	J
Industry Sector	**Facilities in Search**	**Facilities Inspected**	**Number of Inspections**	**Average Months Between Inspections**	**Facilities with 1 or More Enforcement Actions**	**Total Enforcement Actions**	**Percent State Lead Actions**	**Percent Federal Lead Actions**	**Enforcement to Inspection Rate**
Metal Mining	1,232	378	1,600	46	63	111	53%	47%	0.07
Coal Mining	3,256	741	3,748	52	88	132	89%	11%	0.04
Oil and Gas Extraction	4,676	1,902	6,071	46	149	309	79%	21%	0.05
Non-Metallic Mineral Mining	5,256	2,803	12,826	25	385	622	77%	23%	0.05
Textiles	355	267	1,465	15	53	83	90%	10%	0.06
Lumber and Wood	712	473	2,767	15	134	265	70%	30%	0.10
Furniture	499	386	2,379	13	65	91	81%	19%	0.04
Pulp and Paper	484	430	4,630	6	150	478	80%	20%	0.10
Printing	5,862	2,092	7,691	46	238	428	88%	12%	0.06
Inorganic Chemicals	441	286	3,087	9	89	235	74%	26%	0.08
Resins and Manmade Fibers	329	263	2,430	8	93	219	76%	24%	0.09
Pharmaceuticals	164	129	1,201	8	35	122	80%	20%	0.10
Organic Chemicals	425	355	4,294	6	153	468	65%	35%	0.11
Petroleum Refining	156	148	3,081	3	124	763	68%	32%	0.25
Rubber and Plastic	1,818	981	4,383	25	178	276	82%	18%	0.06
Stone, Clay, Glass and Concrete	615	388	3,474	11	97	277	75%	25%	0.08
Iron and Steel	349	275	4,476	5	121	305	71%	29%	0.07
Metal Castings	669	424	2,535	16	113	191	71%	29%	0.08
Nonferrous Metals	203	161	1,640	7	68	174	78%	22%	0.11
Fabricated Metal Products	2,906	1,858	7,914	22	365	600	75%	25%	0.08
Electronics	1,250	863	4,500	17	150	251	80%	20%	0.06
Automobile Assembly	1,260	927	5,912	13	253	413	82%	18%	0.07
Shipbuilding and Repair	**44**	**37**	**243**	**9**	**20**	**32**	**84%**	**16%**	**0.13**
Ground Transportation	7,786	3,263	12,904	36	375	774	84%	16%	0.06
Water Transportation	514	192	816	38	36	70	61%	39%	0.09
Air Transportation	444	231	973	27	48	97	88%	12%	0.10
Fossil Fuel Electric Power	3,270	2,166	14,210	14	403	789	76%	24%	0.06
Dry Cleaning	6,063	2,360	3,813	95	55	66	95%	5%	0.02

Table 13: One-Year Enforcement and Compliance Summary for Selected Industries									
A	B	C	D	E		F		G	H
				Facilities with 1 or More Violations		Facilities with 1 or more Enforcement Actions			
Industry Sector	Facilities in Search	Facilities Inspected	Number of Inspections	Number	Percent*	Number	Percent*	Total Enforcement Actions	Enforcement to Inspection Rate
Metal Mining	1,232	142	211	102	72%	9	6%	10	0.05
Coal Mining	3,256	362	765	90	25%	20	6%	22	0.03
Oil and Gas Extraction	4,676	874	1,173	127	15%	26	3%	34	0.03
Non-Metallic Mineral Mining	5,256	1,481	2,451	384	26%	73	5%	91	0.04
Textiles	355	172	295	96	56%	10	6%	12	0.04
Lumber and Wood	712	279	507	192	69%	44	16%	52	0.10
Furniture	499	254	459	136	54%	9	4%	11	0.02
Pulp and Paper	484	317	788	248	78%	43	14%	74	0.09
Printing	5,862	892	1,363	577	65%	28	3%	53	0.04
Inorganic Chemicals	441	200	548	155	78%	19	10%	31	0.06
Resins and Manmade Fibers	329	173	419	152	88%	26	15%	36	0.09
Pharmaceuticals	164	80	209	84	105%	8	10%	14	0.07
Organic Chemicals	425	259	837	243	94%	42	16%	56	0.07
Petroleum Refining	156	132	565	129	98%	58	44%	132	0.23
Rubber and Plastic	1,818	466	791	389	83%	33	7%	41	0.05
Stone, Clay, Glass and Concrete	615	255	678	151	59%	19	7%	27	0.04
Iron and Steel	349	197	866	174	88%	22	11%	34	0.04
Metal Castings	669	234	433	240	103%	24	10%	26	0.06
Nonferrous Metals	203	108	310	98	91%	17	16%	28	0.09
Fabricated Metal	2,906	849	1,377	796	94%	63	7%	83	0.06
Electronics	1,250	420	780	402	96%	27	6%	43	0.06
Automobile Assembly	1,260	507	1,058	431	85%	35	7%	47	0.04
Shipbuilding and Repair	**44**	**22**	**51**	**19**	**86%**	**3**	**14%**	**4**	**0.08**
Ground Transportation	7,786	1,585	2,499	681	43%	85	5%	103	0.04
Water Transportation	514	84	141	53	63%	10	12%	11	0.08
Air Transportation	444	96	151	69	72%	8	8%	12	0.08
Fossil Fuel Electric Power	3,270	1,318	2,430	804	61%	100	8%	135	0.06
Dry Cleaning	6,063	1,234	1,436	314	25%	12	1%	16	0.01

**Percentages in Columns E and F are based on the number of facilities inspected (Column C). Percentages can exceed 100% because violations and actions can occur without a facility inspection.*

Table 14: Five-Year Inspection and Enforcement Summary by Statute for Selected Industries

Industry Sector	Facilities Inspected	Total Inspections	Total Enforcement Actions	Clean Air Act		Clean Water Act		RCRA		FIFRA/TSCA/ EPCRA/Other	
				% of Total Inspections	% of Total Actions	% of Total Inspections	% of Total Actions	% of Total Inspections	% of Total Actions	% of Total Inspections	% of Total Actions
Metal Mining	378	1,600	111	39%	19%	52%	52%	8%	12%	1%	17%
Coal Mining	741	3,748	132	57%	64%	38%	28%	4%	8%	1%	1%
Oil and Gas Extraction	1,902	6,071	309	75%	65%	16%	14%	8%	18%	0%	3%
Non-Metallic Mineral Mining	2,803	12,826	622	83%	81%	14%	13%	3%	4%	0%	3%
Textiles	267	1,465	83	58%	54%	22%	25%	18%	14%	2%	6%
Lumber and Wood	473	2,767	265	49%	47%	6%	6%	44%	31%	1%	16%
Furniture	386	2,379	91	62%	42%	3%	0%	34%	43%	1%	14%
Pulp and Paper	430	4,630	478	51%	59%	32%	28%	15%	10%	2%	4%
Printing	2,092	7,691	428	60%	64%	5%	3%	35%	29%	1%	4%
Inorganic Chemicals	286	3,087	235	38%	44%	27%	21%	34%	30%	1%	5%
Resins and Manmade Fibers	263	2,430	219	35%	43%	23%	28%	38%	23%	4%	6%
Pharmaceuticals	129	1,201	122	35%	49%	15%	25%	45%	20%	5%	5%
Organic Chemicals	355	4,294	468	37%	42%	16%	25%	44%	28%	4%	6%
Petroleum Refining	148	3,081	763	42%	59%	20%	13%	36%	21%	2%	7%
Rubber and Plastic	981	4,383	276	51%	44%	12%	11%	35%	34%	2%	11%
Stone, Clay, Glass and Concrete	388	3,474	277	56%	57%	13%	9%	31%	30%	1%	4%
Iron and Steel	275	4,476	305	45%	35%	26%	26%	28%	31%	1%	8%
Metal Castings	424	2,535	191	55%	44%	11%	10%	32%	31%	2%	14%
Nonferrous Metals	161	1,640	174	48%	43%	18%	17%	33%	31%	1%	10%
Fabricated Metal	1,858	7,914	600	40%	33%	12%	11%	45%	43%	2%	13%
Electronics	863	4,500	251	38%	32%	13%	11%	47%	50%	2%	7%
Automobile Assembly	927	5,912	413	47%	39%	8%	9%	43%	43%	2%	9%
Shipbuilding and Repair	**37**	**243**	**32**	**39%**	**25%**	**14%**	**25%**	**42%**	**47%**	**5%**	**3%**
Ground Transportation	3,263	12,904	774	59%	41%	12%	11%	29%	45%	1%	3%
Water Transportation	192	816	70	39%	29%	23%	34%	37%	33%	1%	4%
Air Transportation	231	973	97	25%	32%	27%	20%	48%	48%	0%	0%
Fossil Fuel Electric Power	2,166	14,210	789	57%	59%	32%	26%	11%	10%	1%	5%
Dry Cleaning	2,360	3,813	66	56%	23%	3%	6%	41%	71%	0%	0%

Table 15: One-Year Inspection and Enforcement Summary by Statute for Selected Industries

Industry Sector	Facilities Inspected	Total Inspections	Total Enforcement Actions	Clean Air Act		Clean Water Act		RCRA		FIFRA/TSCA/ EPCRA/Other	
				% of Total Inspections	% of Total Actions	% of Total Inspections	% of Total Actions	% of Total Inspections	% of Total Actions	% of Total Inspections	% of Total Actions
Metal Mining	142	211	10	52%	0%	40%	40%	8%	30%	0%	30%
Coal Mining	362	765	22	56%	82%	40%	14%	4%	5%	0%	0%
Oil and Gas Extraction	874	1,173	34	82%	68%	10%	9%	9%	24%	0%	0%
Non-Metallic Mineral Mining	1,481	2,451	91	87%	89%	10%	9%	3%	2%	0%	0%
Textiles	172	295	12	66%	75%	17%	17%	17%	8%	0%	0%
Lumber and Wood	279	507	52	51%	30%	6%	5%	44%	25%	0%	40%
Furniture	254	459	11	66%	45%	2%	0%	32%	45%	0%	9%
Pulp and Paper	317	788	74	54%	73%	32%	19%	14%	7%	0%	1%
Printing	892	1,363	53	63%	77%	4%	0%	33%	23%	0%	0%
Inorganic Chemicals	200	548	31	35%	59%	26%	9%	39%	25%	0%	6%
Resins and Manmade Fibers	173	419	36	38%	51%	24%	38%	38%	5%	0%	5%
Pharmaceuticals	80	209	14	43%	71%	11%	14%	45%	14%	0%	0%
Organic Chemicals	259	837	56	40%	54%	13%	13%	47%	34%	0%	0%
Petroleum Refining	132	565	132	49%	67%	17%	8%	34%	15%	0%	10%
Rubber and Plastic	466	791	41	55%	64%	10%	13%	35%	23%	0%	0%
Stone, Clay, Glass and Concrete	255	678	27	62%	63%	10%	7%	28%	30%	0%	0%
Iron and Steel	197	866	34	52%	47%	23%	29%	26%	24%	0%	0%
Metal Castings	234	433	26	60%	58%	10%	8%	30%	35%	0%	0%
Nonferrous Metals	108	310	28	44%	43%	15%	20%	41%	30%	0%	7%
Fabricated Metal	849	1,377	83	46%	41%	11%	2%	43%	57%	0%	0%
Electronics	420	780	43	44%	37%	14%	5%	43%	53%	0%	5%
Automobile Assembly	507	1,058	47	53%	47%	7%	6%	41%	47%	0%	0%
Shipbuilding and Repair	**22**	**51**	**4**	**54%**	**0%**	**11%**	**50%**	**35%**	**50%**	**0%**	**0%**
Ground Transportation	1,585	2,499	103	64%	46%	11%	10%	26%	44%	0%	1%
Water Transportation	84	141	11	38%	9%	24%	36%	38%	45%	0%	9%
Air Transportation	96	151	12	28%	33%	15%	42%	57%	25%	0%	0%
Fossil Fuel Electric Power	1,318	2,430	135	59%	73%	32%	21%	9%	5%	0%	0%
Dry Cleaning	1,234	1,436	16	69%	56%	1%	6%	30%	38%	0%	0%

VII.C. Review of Major Legal Actions

Major Cases/Supplemental Environmental Projects

This section provides summary information about major cases that have affected this sector, and a list of Supplemental Environmental Projects (SEPs).

VII.C.1. Review of Major Cases

As indicated in EPA's *Enforcement Accomplishments Report, FY1995 and FY1996* publications, two significant enforcement actions were resolved between 1995 and 1996 for the shipbuilding industry.

U.S. v. First Marine Shipyard Inc., et al. (E.D.NY): On September 30, 1996 the U.S. filed a complaint for CERCLA cost recovery and penalties related to Region II's cleanup of the barge *Nathan Berman*. The complaint seeks recovery of approximately $1,8 million from First Marine Shipyard, Marine Facilities Inc., Marine Movements, Inc., and Peter Frank and Jane Frank Kresch individually. It also includes a second cause of action against First Marine Shipyard for failure to comply with an administrative CERCLA §106 order issued to it in March of 1993.

Cascade General: Cascade General, a ship repair facility in Portland, Oregon, agreed to a penalty of $78,568 for alleged EPCRA violations. The company agreed to pay $39,284 in cash and install air filtration dust collector and solvent recovery systems and to switch to water-based paint to remediate the balance of the penalty. The SEPs will cost about $117,000 to implement. The dust collector will improve air quality in the facility by reducing dust in work areas. The solvent recovery system will reduce by 90% the amount of solvents discharged to the air by recovering batch solvents for reuse in the facility. For TRI reporting years 1988-1993, total releases were reported at 253,000 pounds.

VII.C.2. Supplementary Environmental Projects (SEPs)

Supplemental environmental projects (SEPs) are enforcement options that require the non-compliant facility to complete specific projects. Information on SEP cases can be accessed via the internet at EPA's Enviroene website: http://es.inel.gov/sep.

VIII. COMPLIANCE ASSURANCE ACTIVITIES AND INITIATIVES

This section highlights the activities undertaken by this industry sector and public agencies to voluntarily improve the sector's environmental performance. These activities include those independently initiated by industrial trade associations. In this section, the notebook also contains a listing and description of national and regional trade associations.

VIII.A. Sector-related Environmental Programs and Activities

National Shipbuilding Research Program Panel SP-1

The National Shipbuilding Research Program (NSRP) is a joint industry/government program aimed at improving the global competitiveness of American shipyards. NSRP's mission is to assist the shipbuilding and ship repair industry in achieving and maintaining global competitiveness with respect to quality, time, cost, and customer satisfaction. The program is also expected to significantly reduce the costs and delivery times of ships ordered by the U.S. Navy. NSRP's objectives are reached through individual projects which form the content of the shipbuilding technology program. Joint Government and industry meetings are held to identify final project descriptions. NSRP utilizes a panel structure to develop project proposals and implement projects. The Panel SP-1 focuses on shipbuilding and repair facilities and environmental effects.

The mission of Panel SP-1, Facilities and Environmental Effects, is to support the NSRP by providing leadership and expertise to the shipbuilding and repair industry, with respect to facilities and environmental issues. The following goals have been established by SP-1:

- increase participation of shipyards and other Maritime Associations by 100 percent;
- improve communication and visibility between NSRP Panels, with the Executive Control Board, within NSRP participating shipyards and beyond NSRP;
- be proactive in representing industry views regarding regulatory matters;
- identify, develop and implement cost-effective technologies in facilities and environmental areas;
- educate and assist the shipbuilding and repair industry and its customers in meeting environmental and regulatory requirements; and

- maintain and continue to improve SP-1 expertise.

Panel SP-1 has a number of active and proposed projects. The following is a list of active projects:

- Environmental Studies and Testing
- Environmental Training Modules
- Feasibility and Economic Study of the Treatment, Recycling & Disposal of Spent Abrasives
- Solid Waste Segregation & Recycling
- Title V Permit for Shipyards Strategy Guide for Development of Generated Permit
- Wastewater Treatment Technology Survey
- Impact on Shipyards from the Reauthorization of the Federal Clean Water Act
- Development of Guidance for Selecting Legitimate Recycling Products and Processes
- Developing a Shipyard Program for NPDES Compliance

More information on Panel SP-1 activities can be obtained from the Environmental Resources and Information Center (ERIC), a division of the Gulf Coast Region Maritime Technology Center at the University of New Orleans at (504) 286-6053.

National Defense Center for Environmental Excellence

The National Defense Center for Environmental Excellence (NDCEE) was established by the Department of Defense to provide the military and private sector industrial base clients with environmentally compliant technologies. NDCEE conducts environmental technology research and disseminates information on environmental technologies and regulations. At the Army's Armament Research, Development and Engineering Center at Picatinny Arsenal, NJ, NDCEE has established an industrial-scale facility for the demonstration of nonpolluting surface coatings. The NDCEE demonstration facility is used to validate cost, schedules and performance parameters of new coating technologies. NDCEE also provides assistance in the form of equipment, site engineers, economic analyses, training, and troubleshooting for those clients implementing demonstrated coating technologies at their industrial facility. In its powder coating demonstration line, industrial parts are cleaned, pretreated, sprayed with nonpolluting organic powders, then cured in a process than nearly eliminates volatile organic compounds and hazardous wastes. Contact: Dr. Dale A. Denny, Executive Director, NDCEE, (814) 269-2432.

MARITECH

MARITECH is a five-year jointly funded by the Federal Government and industry and is administered by the Department of Defense's Advanced Research Projects Agency (ARPA), in collaboration with MARAD. MARITECH provides matching Government funds to encourage the shipbuilding industry to direct and lead in the development and application of advanced technology to improve its competitiveness and to preserve its industrial base. In the near-term MARITECH aims to assist industry in penetrating the international marketplace with competitive ship designs, market strategies, and modern shipbuilding processes and procedures. In the long-term, the program is meant to encourage advanced ship and shipbuilding technology projects for promoting continuous product and process improvement in order to maintain and enlarge the U.S. share of the commercial and international market. MARITECH funded $30 million in FY94, $40 million in FY95, $50 million in FY96, and $50 million in FY97 for vessel design and shipyard technology projects.

VIII.B. EPA Voluntary Programs

33/50 Program

The "33/50 Program" is EPA's voluntary program to reduce toxic chemical releases and transfers of seventeen chemicals from manufacturing facilities. Participating companies pledge to reduce their toxic chemical releases and transfers by 33% as of 1992 and by 50% as of 1995 from the 1988 baseline year. Certificates of Appreciation have been given out to participants meeting their 1992 goals. The list of chemicals includes seventeen high-use chemicals reported in the Toxics Release Inventory. Table 16 lists those companies participating in the 33/50 program that reported the four-digit SIC code 3731 to TRI. Some of the companies shown also listed facilities that are not building or repairing ships. The number of facilities within each company that are participating in the 33/50 program and that report the shipbuilding and repair SIC code is shown. Where available and quantifiable against 1988 releases and transfers, each company's 33/50 goals for 1995 and the actual total releases and transfers and percent reduction between 1988 and 1994 are presented. TRI 33/50 data for 1995 was not available at the time of publication.

Twelve of the seventeen target chemicals were reported to TRI by shipbuilding and repair facilities in 1994. Of all TRI chemicals released and transferred by the shipbuilding and repair industry, xylenes (a 33/50 target chemical), was released and transferred most frequently (32 facilities), and was the top chemical by volume released and transferred. Toluene, the next most frequently reported 33/50 chemical, was reported by six facilities. The remaining 33/50 chemicals were each reported by four or fewer facilities.

Table 16 shows that 7 companies comprised of 15 facilities reporting SIC 3731 are participating in the 33/50 program. For those companies shown with more than one shipyard, all shipyards may not be participating in 33/50. The 33/50 goals shown for companies with multiple shipyards are company-wide, potentially aggregating more than one shipyard and facilities not carrying out shipbuilding and repair operations. In addition to company-wide goals, individual facilities within a company may have their own 33/50 goals or may be specifically listed as not participating in the 33/50 program. Since the actual percent reductions shown in the last column apply to all of the companies' shipbuilding and repair facilities and only shipbuilding and repair facilities, direct comparisons to those company goals incorporating non-shipbuilding and repair facilities or excluding certain facilities may not be possible. For information on specific facilities participating in 33/50, contact David Sarokin (202-260-6907) at the 33/50 Program Office.

Table 16: Shipbuilding and Repair Industry Participation in the 33/50 Program

Parent Company (Headquarters Location)	Company-Owned Shipyards Reporting 33/50 Chemicals	Company-Wide % Reduction Goal[1] (1988 to 1995)	1988 TRI Releases and Transfers of 33/50 Chemicals (pounds)	1994 TRI Releases and Transfers of 33/50 Chemicals (pounds)	Actual % Reduction for Shipyards (1988-1994)
Avondale Industries Inc. Avondale, LA	3	54	1,558,614	20,285	99
Bethlehem Steel Corp. Bethlehem, PA	2	50	92,000	129,020	-40
Fulcrum II Limited Partner. (Bath Iron Works) New York, NY	4	24	116,500	15,331	87
General Dynamics Corp. Falls Church, VA	2	84	316,777	8,182	97
Tenneco Inc. (Newport News) Houston, TX	1	8	896,292	268,950	70
U.S. Air Force Washington, DC	1	***	0	108,835	-
Unimar International Inc. Seattle, WA	1	*	0	0	-
TOTAL	15	--	2,980,183	550,603	86

Source: U.S. EPA 33/50 Program Office, 1996.

[1] Company-Wide Reduction Goals aggregate all company-owned facilities which may include facilities not building and repairing ships.

* = Reduction goal not quantifiable against 1988 TRI data.
** = Use reduction goal only.
*** = No numeric reduction goal.

Environmental Leadership Program

The Environmental Leadership Program (ELP) is a national initiative developed by EPA that focuses on improving environmental performance, encouraging voluntary compliance, and building working relationships with stakeholders. EPA initiated a one year pilot program in 1995 by selecting 12 projects at industrial facilities and federal installations which would demonstrate the principles of the ELP program. These principles include: environmental management systems, multimedia compliance assurance, third-party verification of compliance, public measures of accountability, pollution prevention, community involvement, and mentor programs. In return for participating, pilot participants received public recognition and were given a period of time to correct any violations discovered during these experimental projects.

EPA is making plans to launch its full-scale Environmental Leadership Program in 1997. The full-scale program will be facility-based with a 6-year participation cycle. Facilities that meet certain requirements will be eligible to participate, such as having a community outreach/employee involvement programs and an environmental management system (EMS) in place for 2 years. (Contact: http://es.inel.gov/elp or Debby Thomas, ELP Deputy Director, at 202-564-5041)

Project XL

Project XL was initiated in March 1995 as a part of President Clinton's *Reinventing Environmental Regulation* initiative. The projects seek to achieve cost effective environmental benefits by providing participants regulatory flexibility on the condition that they produce greater environmental benefits. EPA and program participants will negotiate and sign a Final Project Agreement, detailing specific environmental objectives that the regulated entity shall satisfy. EPA will provide regulatory flexibility as an incentive for the participants' superior environmental performance. Participants are encouraged to seek stakeholder support from local governments, businesses, and environmental groups. EPA hopes to implement fifty pilot projects in four categories, including industrial facilities, communities, and government facilities regulated by EPA. Applications will be accepted on a rolling basis. For additional information regarding XL projects, including application procedures and criteria, see the May 23, 1995 Federal Register Notice. (Contact: Fax-on-Demand Hotline 202-260-8590, Web: http://www.epa.gov/ProjectXL, or Christopher Knopes at EPA's Office of Policy, Planning and Evaluation 202-260-9298)

Climate Wise Program

Climate Wise is helping US industries turn energy efficiency and pollution prevention into a corporate asset. Supported by the technical assistance, financing information and public recognition that Climate Wise offers, participating companies are developing and launching comprehensive industrial energy efficiency and pollution prevention action plans that save money and protect the environment. The nearly 300 Climate Wise companies expect to save more than $300 million and reduce greenhouse gas emissions by 18 million metric tons of carbon dioxide equivalent by the year 2000. Some of the actions companies are undertaking to achieve these results include: process improvements, boiler and steam system optimization, air compressor system improvements, fuel switching, and waste heat recovery measures including cogeneration. Created as part of the President's Climate Change Action Plan, Climate Wise is jointly operated by the Department of Energy and EPA. Under the Plan many other programs were also launched or upgraded including Green Lights, WasteWi$e and DoE's Motor Challenge Program. Climate Wise provides an umbrella for these programs which encourage company participation by providing information on the range of partnership opportunities available. (Contact: Pamela Herman, EPA, 202-260-4407 or Jan Vernet, DoE, 202-586-4755)

Energy Star Buildings Program

EPA's ENERGY STAR Buildings Program is a voluntary, profit-based program designed to improve the energy-efficiency in commercial and industrial buildings. Expanding the successful Green Lights Program, ENERGY STAR Buildings was launched in 1995. This program relies on a 5-stage strategy designed to maximize energy savings thereby lowering energy bills, improving occupant comfort, and preventing pollution -- all at the same time. If implemented in every commercial and industrial building in the United States, ENERGY STAR Buildings could cut the nation's energy bill by up to $25 billion and prevent up to 35% of carbon dioxide emissions. (This is equivalent to taking 60 million cars of the road). ENERGY STAR Buildings participants include corporations; small and medium sized businesses; local, federal and state governments; non-profit groups; schools; universities; and health care facilities. EPA provides technical and non-technical support including software, workshops, manuals, communication tools, and an information hotline. EPA's Office of Air and Radiation manages the operation of the ENERGY STAR Buildings Program. (Contact: Green Light/Energy Star Hotline at 1-888-STAR-YES or Maria Tikoff Vargas, EPA Program Director at 202-233-9178 or visit the ENERGY STAR Buildings Program website at http://www.epa.gov/appdstar/buildings/)

Green Lights Program

EPA's Green Lights program was initiated in 1991 and has the goal of preventing pollution by encouraging U.S. institutions to use energy-efficient lighting technologies. The program saves money for businesses and organizations and creates a cleaner environment by reducing pollutants released into the atmosphere. The program has over 2,345 participants which include major corporations, small and medium sized businesses, federal, state and local governments, non-profit groups, schools, universities, and health care facilities. Each participant is required to survey their facilities and upgrade lighting wherever it is profitable. As of March 1997, participants had lowered their electric bills by $289 million annually. EPA provides technical assistance to the participants through a decision support software package, workshops and manuals, and an information hotline. EPA's Office of Air and Radiation is responsible for operating the Green Lights Program. (Contact: Green Light/Energy Star Hotline at 1-888-STARYES or Maria Tikoff Vargar, EPA Program Director, at 202-233-9178 the)

WasteWi$e Program

The WasteWi$e Program was started in 1994 by EPA's Office of Solid Waste and Emergency Response. The program is aimed at reducing municipal solid wastes by promoting waste prevention, recycling collection and the manufacturing and purchase of recycled products. As of 1997, the program had about 500 companies as members, one third of whom are Fortune 1000 corporations. Members agree to identify and implement actions to reduce their solid wastes setting waste reduction goals and providing EPA with yearly progress reports. To member companies, EPA, in turn, provides technical assistance, publications, networking opportunities, and national and regional recognition. (Contact: WasteWi$e Hotline at 1-800-372-9473 or Joanne Oxley, EPA Program Manager, 703-308-0199)

NICE^3

The U.S. Department of Energy is administering a grant program called The National Industrial Competitiveness through Energy, Environment, and Economics (NICE^3). By providing grants of up to 45 percent of the total project cost, the program encourages industry to reduce industrial waste at its source and become more energy-efficient and cost-competitive through waste minimization efforts. Grants are used by industry to design, test, and demonstrate new processes and/or equipment with the potential to reduce pollution and increase energy efficiency. The program is open to all industries; however, priority is given to proposals from participants in the forest products, chemicals, petroleum refining, steel, aluminum, metal casting and glass manufacturing sectors. (Contact: http//www.oit.doe.gov/access/nice3, Chris Sifri, DOE, 303-275-4723 or Eric Hass, DOE, 303-275-4728.)

Design for the Environment (DfE)

DfE is working with several industries to identify cost-effective pollution prevention strategies that reduce risks to workers and the environment. DfE helps businesses compare and evaluate the performance, cost, pollution prevention benefits, and human health and environmental risks associated with existing and alternative technologies. The goal of these projects is to encourage businesses to consider and use cleaner products, processes, and technologies. For more information about the DfE Program, call (202) 260-1678. To obtain copies of DfE materials or for general information about DfE, contact EPA's Pollution Prevention Information Clearinghouse at (202) 260-1023 or visit the DfE Website at http://es.inel.gov/dfe.

VIII.C. Trade Associations

American Shipbuilding Association
600 Pennsylvania Ave. Suite 305
Washington, DC 20003
Phone: (202)-544-8170
Fax: (202)-544-9618

Members: 6
Contact: Frank Losey
(202)-544-9614

The American Shipbuilding Association (ASA) is a private, non-profit trade association comprising America's six largest private sector shipyards. The shipyards are: Avondale Industries, Bath Iron Works, Electric Boat, Ingalls Shipbuilding, National Steel & Shipbuilding Company, and Newport News Shipbuilding. These six shipyards employ the large majority of shipbuilding employees in the U.S. More than 98 percent of the Navy's shipbuilding budget is spent on ships constructed in ASA shipyards. The goals of ASA are to preserve and promote the U.S. naval shipbuilding industrial base as well as to educate the U.S. public and government to the importance of shipbuilding to the country. ASA publishes *American Shipbuilder Newsletter* monthly.

National Shipyard Association
1600 Wilson Blvd.
Arlington, VA 22209
Phone: (703) 351-6734
Fax: (703) 351-6736

Members: 44 companies
Staff: 6

The National Shipyard Association (NSA) is a national trade association representing the commercial shipbuilding, repair, and cleaning industry. NSA represents 44 shipyard companies that own and operate over 90 shipyards in 17 states along the Gulf, Pacific, and Atlantic coasts of the U.S. NSA also has among its membership 16 companies that supply services and products to the shipbuilding and repair industry. NSA aims to promote high standards of health, safety, and environmental awareness throughout the industry. NSA publishes a monthly newsletter, *NSA Newsline*.

Shipyard Association for
Environmental Responsibility
Post Office Box 250
Lockport, LA 70374
Phone: (504)-532-7272
Fax: (202)-532-7295

Members: 67
Staff: 5
Contact: Scott Theriot

The Shipyard Association for Environmental Responsibility (SAFER) was formed by 67 shipbuilding and repair facilities in the states of Alabama, Louisiana, Mississippi, and Texas. The goal of SAFER is to work cooperatively with the federal and state agencies to ensure that environmental standards truly reflect the environmental concerns of the vastly different sizes and capabilities of the Gulf Coast shipyards.

Shipbuilders Council of America
901 No. Washington St. Suite 204
Arlington, VA 22314
Phone: (703) 548-7447

Members: 10
Staff: 10
Contact: Penny Eastman

The Shipbuilders Council of America (SCA) was founded in 1921 and is made up of companies engaged in the construction and repair of vessels and other marine craft; manufacturers of all types of propelling machinery, boilers, marine auxiliaries, marine equipment and supplies; and drydock operators. SCA promotes and maintains sound private shipbuilding and ship repairing industries and adequate mobilization potential of shipbuilding and repairing facilities, organizations, and skilled personnel in times of national emergencies. A newsletter, *Shipyard Chronicle*, is published weekly.

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IX. CONTACTS/ACKNOWLEDGMENTS/RESOURCE MATERIALS

For further information on selected topics within the shipbuilding and repair industry a list of contacts and publications are provided below.

Contacts[5]

Name	Organization	Telephone	Subject
Anthony Raia	U.S. EPA - Office of Compliance	(202) 564-6045	Multimedia Compliance
Mohamed Serageldin	U.S. EPA - Office of Air Quality Planning and Standards	(919) 541-2379	Regulatory Requirements (Air)
Steve Guile	U.S. EPA - Office of Water	(202) 260-9817	MP&M water regulations
Bhaskar Kura	University of New Orleans	(504) 280-6572	Multimedia pollutant outputs and pollution prevention

Section II: Introduction to the Shipbuilding and Repair Industry

U.S. Department of Commerce, International Trade Administration, *1994 U.S. Industrial Outlook*, 1995.

U.S. Department of Commerce, Bureau of the Census, *1992 Census of Manufacturers Industry Series: Ship and Boat Building, Railroad and Miscellaneous Transportation Equipment*, 1996.

U.S. Department of Transportation, Maritime Administration, *Outlook for the U.S. Shipbuilding and Repair Industry 1996*, April 1996.

U.S. Department of Transportation, Maritime Administration, *Report on Survey of U.S. Shipbuilding and Repair Facilities 1995*, December 1995.

ICAF Publications, *Shipbuilding Industry Study Report*, 1996, http://198.80.36.91/ndu/icaf /isshp.html, March 1997.

OECD, Overview of the Agreement Respecting Normal Competitive Conditions in the Commercial Shipbuilding and Repair Industry, http://www.oecd.org/dsti/sid/wp7.html, March 1997.

National Shipbuilding Research Program, Panel SP-4), *US Shipbuilding International Market Study 1996-2005*, June 1995. SPFA:0001.

[5] Many of the contacts listed above have provided valuable information and comments during the development of this document. EPA appreciates this support and acknowledges that the individuals listed do not necessarily endorse all statements made within this notebook.

Section III: Industrial Process Description

Kura, Bhaskur (University of New Orleans) and Lacoste, Steve (Avondale Industries, Avondale, LA), *Typical Waste Streams in a Shipbuilding Facility*, 1996.

Storch, R.L., Hammon, C.P., Bunch, H.M., & Moore, R.C., *Ship Production*, 2nd ed., The Society of Naval Architects and Marine Engineers, Jersey City, New Jersey, 1995.

Thornton, James R., *Ship and Boat Building and Repair, ILO Encyclopaedia of Occupational Health and Safety* 4th ed., International Labour Office, Geneva, Switzerland, 1996.

Development Document for the Proposed Effluent Limitations Guidelines and Standards for the Metal Products and Machinery Phase 1 Point Source Category, 1995, U.S. EPA, Office of Water, (EPA-821-R-95-021).

Water Environment Federation, *Pretreatment of Industrial Wastes, Manual of Practice No. FD-3,* Alexandria, Virginia, 1994.

National Shipbuilding Research Program, *Hazardous Waste Minimization Guide for Shipyards*, U.S. Navy and National Steel and Shipbuilding Company (NASSCO), January 1994.

National Shipbuilding Research Program, *Introduction to Production Processes and Facilities in the Steel Shipbuilding and Repair Industry*, U.S. Navy and National Steel and Shipbuilding Company (NASSCO), February 1993.

Levy, Doug, *Boat Paint Tied to Dolphin Deaths*, USA Today, December 31, 1996.

Section IV: Chemical Release and Transfer Profile

1994 Toxics Release Inventory Public Data Release, U.S. EPA Office of Pollution Prevention and Toxics, June 1996. (EPA 745-R-96-002)

Section V: Pollution Prevention Opportunities

National Shipbuilding Research Program, *Hazardous Waste Minimization Guide for Shipyards*, U.S. Navy and National Steel and Shipbuilding Company (NASSCO), January 1994.

Guides to Pollution Prevention, The Marine Maintenance and Repair Industry, U.S. EPA, Office of Research and Development, Cincinnati, OH, October 1991. (EPA/625/7-91/015)

Development Document for the Proposed Effluent Limitations Guidelines and Standards for the Metal Products and Machinery Phase 1 Point Source Category, 1995, U.S. EPA, Office of Water, (EPA-821-R-95-021).

Natan, Thomas E., Jr., *Examples of Successful Pollution Prevention Programs*, from Industrial Pollution Prevention Handbook, ed. Freeman, Harry M., McGraw-Hill, Inc., New York, 1995. pp. 142-144.

Identification of Pollution for Possible Inclusion in Enforcement Agreements Using Supplemental Environmental Projects (SEPs) and Injunctive Relief, Final Report, March 1997. U.S. EPA, Office of Enforcement and Compliance Assurance, (EPA-300-R-97-001).

Section VI: Summary of Applicable Federal Statutes and Regulations

Personal Correspondence with Mohamed Serageldin, U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, March 1997.

Personal Correspondence with Steve Guile, U.S. EPA, Office of Water, Engineering and Analysis Division, Washington, DC, April 1997.

Section VIII: Compliance Activities and Initiatives

National Shipbuilding Research Program, *SNAME Panel SP-1 Newsletter*, Volume 1, Number 1, Summer 1996.