Shipbuilding & Ship Repair

Sector At-a-Glance

Number of Facilities:	680
Value of Shipments:	$12 Billion
Number of Employees:	89,000

Source: U.S. Census Bureau, 2001[1]

Profile The shipbuilding and ship repair sector[2] builds and repairs ships, barges, and other large vessels. The sector also includes operations that convert or alter ships as well as facilities that manufacture offshore oil and gas well drilling and production platforms. Most facilities that build ships also have the ability to repair ships, although some smaller yards do only repair work. Most shipyards are concentrated along the coasts, the Ohio and Mississippi Rivers, and the Great Lakes.[3]

The shipbuilding and ship repair industry has been in decline due to intense global competition and a decrease in the number of military ship orders. Throughout the 1990s, naval ship procurement averaged only six ships per year, the lowest level since 1932.[4] From 1993 to 2001, the industry's workforce decreased by 20%.[5]

Production Process New ship construction and ship repair have many industrial processes in common, including machining and metal working, metal plating and surface finishing, surface preparation, solvent cleaning, application of paints and coatings, and welding. In addition to these processes:

- New ship construction often includes parts fabrication and preassembling operations that involve cutting, shaping, bending, machining, blasting, and painting.
- Typical maintenance and repair operations include: blasting and repainting, rebuilding and installation of machinery, system replacement and overhauls, maintenance and installation, structural reconfiguration, and major remodeling of ship interiors or exteriors.

Partnerships The American Shipbuilding Association (ASA) and the Shipbuilders Council of America (SCA) have formed a partnership with EPA's Sector Strategies Program to improve the environmental performance of the shipbuilding and ship repair industry.[6]

Key Environmental Opportunities The shipbuilding and ship repair sector is working with EPA to improve the industry's performance by:

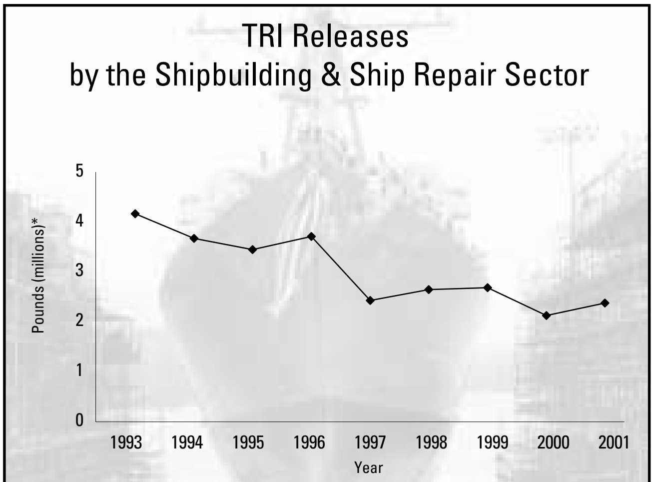
- Managing and minimizing waste;
- Reducing air emissions;
- Improving water quality; and
- Promoting environmental management systems.

Managing and Minimizing Waste

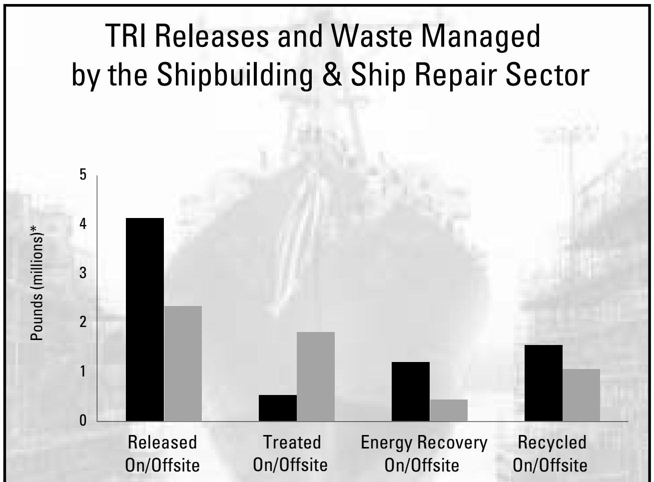
Over the past decade, the shipbuilding and ship repair sector has made progress in reducing waste generation and increasing reuse and recycling rates. Given the diversity of their industrial processes, shipbuilding and ship repair facilities use a variety of chemicals and report on the release and management of many of those materials through EPA's Toxics Release Inventory (TRI). Between 1993 and 2001, normalized TRI releases by shipyards decreased by 43%. In 2001, treatment, energy recovery, and recycling accounted for 58% of this sector's waste management.[7]

Improvements in hazardous waste management at shipyards can be attributed to several practices, including:

- Development of improved coating application technologies, such as in-line plural component mixers that only mix the amount of coating necessary, as it is required, to avoid the waste of excess paint;
- Use of paint waste for fuel blending, rather than solidifying it for land disposal;
- Reclamation of spent solvents from spray paint equipment; and
- Recycling of spent abrasive for use as an aggregate material in the production of asphalt and cement "clinker".



* Normalized by annual value of shipments
Sources: U.S. EPA, Toxics Release Inventory (TRI)
U.S. Census Bureau, Annual Survey of Manufactures



* Normalized by annual value of shipments
Sources: U.S. EPA, Toxics Release Inventory (TRI)
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Reducing Air Emissions

Because most large ships are built of steel, they must be periodically cleaned and coated in order to preserve the steel and to provide specific performance characteristics to the surface. Over the past decade, the shipbuilding and ship repair sector has reduced particulate matter (PM) emissions during surface preparation and volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions during the application of paint and coatings.

Particulate Matter Emissions

Surface preparation is critical to the coating life cycle, as it provides both the physical and chemical requirements for long-term coating adhesion. To prepare surfaces for coating applications, shipyards predominantly use a dry-abrasive blasting process. This dry-abrasive blasting is typically performed outdoors, as the sheer size of a ship makes enclosure difficult and expensive.

The blasting operation generates PM emissions derived from both the break-up of the abrasive material and the removal of the existing coating. Over the past ten years, shipyards have developed ways to reduce PM emissions to the environment, including:

- Temporary containment of blasting operations;
- Material substitutions; and
- Alternative surface preparation technologies.

Early attempts at temporary containment consisted of hanging curtains from scaffolding, wires, dock-arms, and other structures around the ship. Generally, these temporary structures were open at the top and reduced PM emissions by reducing the wind speed in the blasting area. This practice has evolved to include the construction of temporary shrink-wrap enclosures of entire ships in drydock.

Case Study: Temporary Containment at Signal International

Signal International, located in MS and TX, has adapted temporary containment for use on offshore drill rigs. Their containment efforts have resulted in a 90% reduction in PM emissions from dry-abrasive blasting operations.[8]

Shipyards have also reduced PM emissions through material substitutions. Most dry abrasives used outdoors at shipyards are either sand or slags derived from coal-fired utility boilers (coal slag) or smelting (copper slag). Some abrasives result in higher PM emission rates than others. The National Shipbuilding Research Program sponsored research to determine the PM emission rates of the various types of abrasives and to analyze the life cycle costs of material substitution.[9] As a result, many shipyards are now utilizing different abrasives with lower PM emission rates.

Case Study: Material Substitution at Bath Iron Works

In 1994, Bath Iron Works (BIW) in Bath, ME, began substituting garnet abrasive for coal slag in their exterior ship dry-abrasive blasting operations. Garnet abrasive typically produces only 10% of the PM emissions of coal slag. Additionally, less abrasive is required when garnet is substituted for coal slag. BIW reports that a typical ship that once needed 300 to 500 tons of coal slag for surface preparation now requires only 200 tons of garnet.[10]

Alternative surface preparation technologies that reduce or eliminate PM emissions are also being investigated by shipyards. Of the new technologies, Ultra High Pressure Water Jetting (UHPWJ) has made the greatest inroads for surface preparation of exterior ship surfaces. Water-based surface preparation methods emit significantly less PM than dry-abrasive methods. Over the past ten years, manufacturers of UHPWJ equipment have significantly improved the performance and lowered the operating costs of the technology. Currently, 5-10% of the exterior surfaces of ships in the U.S. are prepared with UHPWJ technology.[11]

Volatile Organic Compound and Hazardous Air Pollutant Emissions

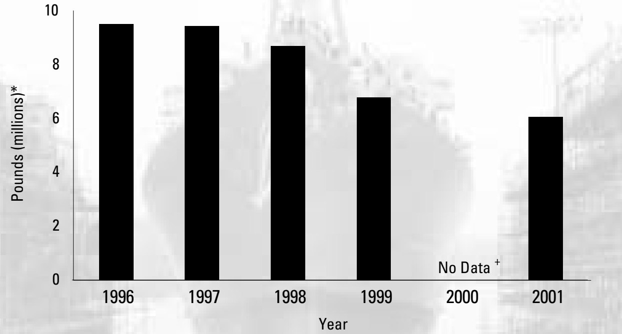
Once the ship's surface is properly prepared, coatings can be applied. The type of coating to be applied (typically down to the level of a specific brand) is specified by the customer (that is, the ship owner/operator) rather than the shipyard. These coatings may contain chemicals that are released to the environment during application.

When coatings are applied indoors, it is possible to utilize pollution control equipment, such as spray booths, to control the release of VOCs and HAPs. At shipyards, however, most coatings are applied outdoors. As a result, VOCs and HAPs may be released to the environment.

Over the last decade, shipyards have worked to reduce the VOC and HAP emissions during coating application. EPA estimates that the normalized quantity of VOC emissions from shipyards declined by 36% between 1996 and 2001.[12] The normalized quantity of HAP releases, as reported to TRI, declined by 58% between 1993 and 2001.[13]

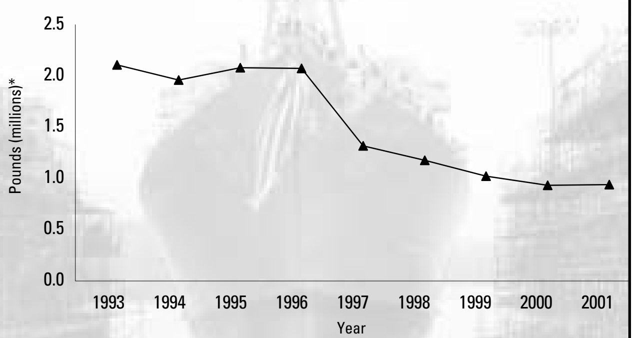
Much of the decline in both VOC and HAP emissions is due to the reformulation of marine coatings. Coatings manufacturers, working in cooperation with shipyards, have reformulated many marine coatings to reduce their VOC and HAP content, while maintaining or improving the performance characteristics required by customers. While more viscous and difficult to apply, these low-VOC, high solids content coatings have become the industry standard due to their excellent performance characteristics.

Volatile Organic Compound Emissions from the Shipbuilding & Ship Repair Sector



+Data for 2000 are not available for this sector
*Normalized by annual value of shipments
Sources: U.S. EPA, National Emission Inventory
U.S. Census Bureau, Annual Survey of Manufactures

TRI Air Toxics+ Releases by the Shipbuilding & Ship Repair Sector



+Includes the Clean Air Act hazardous air pollutants that are reported to TRI
*Normalized by annual value of shipments
Sources: U.S. EPA, Toxics Release Inventory (TRI)
U.S. Census Bureau, Annual Survey of Manufactures

Improving Water Quality

Pollutants generated by shipyards can be released into the environment via stormwater.

Case Study: Stormwater Best Management Practices

In 2002, Gulf Coast shipyards, along with representatives from EPA and state environmental agencies, formed a workgroup to improve shipyard management of stormwater. The workgroup developed a set of practical, cost-effective best management practices (BMP) aimed at reducing pollutant loadings in stormwater. In addition, the BMPs are intended to assist the shipyards in achieving other benefits, such as increased productivity, reduced materials usage and cost, reduced waste generation, reduced risk and liability, improved product quality, and increased customer satisfaction.

In 2004, participating shipyards will test BMP templates for six core shipyard processes that are believed to be major contributors to stormwater pollutant loadings:

- *Removal of hull biofoulants;*
- *Out-of-doors abrasive blasting;*
- *Abrasive materials management;*
- *Out-of-doors spray painting;*
- *Metal grinding; and*
- *Welding, burning, and cutting.*

Once the BMPs are verified, workgroup participants will encourage additional shipyards to use the BMPs to reduce stormwater pollutant loadings from their facilities.[14]

Promoting Environmental Management Systems

The adoption of environmental management systems (EMS) is increasing rapidly in the shipbuilding and ship repair industry. In December 2000, National Steel and Shipbuilding Company (NASSCO) became the first shipyard to implement an EMS and certify it to the ISO 14001 standard. During the subsequent three years there have been at least four new certifications (Bath Iron Works, Coast Guard Shipyard, Electric Boat Corporation, and Northrop Grumman Newport News), and three additional shipyards are ready to declare a functioning EMS (Bender Shipbuilding & Repair Company, FirstWave Marine, and Southwest Marine).

To encourage widespread adoption of EMS in the shipbuilding and ship repair sector, the Sector Strategies Program, ASA, and SCA have developed EMS tools for shipbuilding and ship repair facilities, including a customized EMS Implementation Guide and a brochure highlighting the financial benefits of EMS.[15] ASA and SCA are now taking the lead to continue EMS promotion through mentoring and training sessions.

Many shipyards are finding that EMS can be an effective tool for performance improvement.

Case Study: Improving Performance through EMS

Reducing waste is a common performance improvement objective for shipyards with an EMS. Through their EMS, several shipyards have reduced generation of solid and hazardous waste. For example:

- *Bath Iron Works in Bath, ME, reduced the amount of solid waste disposed by 10% between 2001 and 2002 by expanding its source recycling program and increasing employee education on the importance of recycling waste and reusing material. BIW sustained this effort in 2003 and decreased solid waste disposal by another 1%.*[16]
- *Bender Shipbuilding & Repair Company, in Mobile, AL, reduced hazardous waste generation by decreasing paint and solvent use and recycling sandblasting grit.*[17]
- *NASSCO in San Diego, CA, reduced hazardous waste and minimized VOC emissions generation by increasing its use of plural component paint systems that require less paint and solvent. In addition, NASSCO reduced the risk of unintentionally co-mingling hazardous waste with regular trash by color-coding tubs for waste segregation, conducting training, and examining tub contents prior to consolidation. NASSCO now ties waste segregation scores to housekeeping zones and publishes the scores and names of managers responsible for each zone in its weekly newsletter.*[18]