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Guides to Pollution Prevention

The Marine Maintenance And Repair Industry

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The Marine Maintenance and Repair Industry

Risk Reduction Engineering Laboratory
and
Center for Environmental Research Information
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, OH 45268

Notice

This guide has been subjected to the U.S. Environmental Protection Agency's peer and administrative review and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

The document is intended as advisory guidance only to marine maintenance and repair yards in developing approaches for pollution prevention. Compliance with environmental and occupational safety and health laws is the responsibility of each individual business and is not the focus of this document.

Worksheets are provided for conducting waste minimization assessments of marine yards. Users are encouraged to duplicate portions of this publication as needed to implement a waste minimization program.

Foreword

Marine repair service yards are highly diversified in terms of the types of services and products supplied. Services typically include repair and maintenance of mechanical systems, structural components, upholstery, electrical systems, and finished surfaces. Typical wastes generated from these operations include oils, coolants, lubricants and cleaning agents; various chemicals; paints and coatings; as well as dusts from sanding, sand blasting, polishing and refinishing operations.

Reducing the generation of these wastes at the source, or recycling the wastes on or off site, will benefit the marine yards by reducing raw material needs, reducing disposal costs, and lowering the liabilities associated with hazardous waste disposal. This guide provides and overview of the maintenance and repair operations that generate waste and presents options for minimizing waste generation through source reduction and recycling.

Acknowledgments

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Much of the information in this guide that provides a national perspective on the issues of waste generation and minimization was provided originally to the U.S. Environmental Protection Agency by Versar, Inc. and Jacobs Engineering Group, Inc. in *Waste Minimization - Issues and Options, Volume II,* Report No. PB87-114369 (1986)

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Section 1
Introduction

This guide is designed to provide marine maintenance and repair yards with waste minimization options appropriate for this industry. It also provides worksheets designed to be used for a waste minimization assessment of a marine repair and service yard, to be used in developing an understanding of the yard's waste generating processes and to suggest ways to reduce the waste. The guide should be used by site operators and environmental engineers of marine repair and service yards. Others who may find this document useful are regulatory agency representatives, industry suppliers and consultants.

In the following sections of this guide you will find:

- A profile of marine maintenance and repair yards and their operations (Section 2);
- Waste minimization options for marine maintenance and repair yards (Section 3);
- Waste minimization assessment guidelines and worksheets (Section 4);
- Appendices, containing:
  - Summaries of three waste minimization assessments;
  - Where to get help: Additional sources of information on pollution prevention.

The worksheets and the list of waste minimization options for marine maintenance and repair yards were developed through assessments of three repair and maintenance facilities commissioned by the California Department of Health Services (Calif. DHS 1989). The three yards' repair and maintenance operations, and waste generation and management practices were surveyed, and their existing and potential waste minimization options were characterized. Economic analyses were performed on selected options.

Overview of Waste Minimization Assessment

Waste minimization is a policy specifically mandated by the U.S. Congress in the 1984 Hazardous and Solid Wastes Amendments to the Resource Conservation and Recovery Act (RCRA). As the federal agency responsible for writing regulations under RCRA, the U.S. Environmental Protection Agency (EPA) has an interest in ensuring that new information is made available to the industries concerned. This guide is one of the approaches EPA is using to provide industry-specific information about waste minimization. The options and procedures outlined can also be used in efforts to minimize other wastes generated in a business.

In the working definition used by EPA, waste minimization consists of source reduction and recycling. Of the two approaches, source reduction is considered environmentally preferable to recycling. While a few states consider *treatment* of waste an approach to waste minimization, EPA does not, and thus treatment is not addressed in this guide.

Waste Minimization Opportunity Assessment

EPA has developed a general manual for waste minimization in industry. *The Waste Minimization Opportunity Assessment Manual* (USEPA 1988) tells how to conduct a waste minimization assessment and develop options for reducing hazardous waste generation at a facility. It explains the management strategies needed to incorporate waste minimization into company policies and structure, how to establish a company-wide waste minimization program, conduct assessments, implement options, and make the program an ongoing one.

A Waste Minimization Opportunity Assessment (WMOA), sometimes called a waste minimization audit, is a systematic procedure for identifying ways to reduce or eliminate waste. The four phases of a waste minimization opportunity assessment are: planning and organization, assessment, feasibility analysis, and implementation. The steps involved in conducting a waste minimization assessment are outlined in Figure 1 and presented in more detail in the paragraphs below. Briefly, the assessment consists of a careful review of a plant's operations and waste streams and the selection of specific areas to assess. After a particular waste stream or area is established as the WMOA focus, a number of options with the potential to minimize waste are developed and screened. The technical and economic feasibility of the selected options are then evaluated. Finally, the most promising options are selected for implementation.

Planning and Organization Phase

Essential elements of planning and organization for a waste minimization program are: obtaining management commitment for the program; setting waste minimization

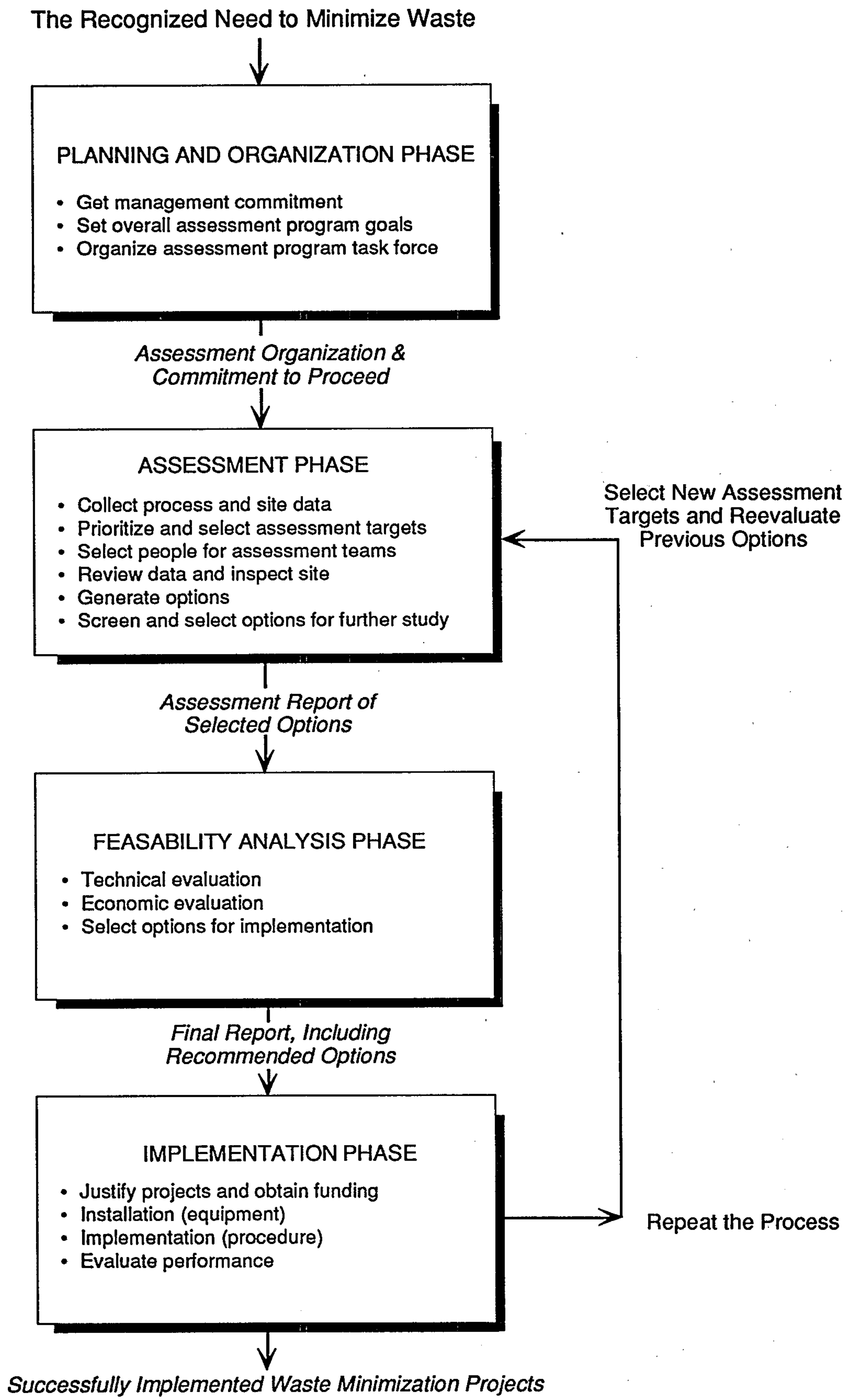

Figure 1. The Waste Minimization Assessment Procedure

goals; and organizing an assessment program task force.

Assessment Phase

The assessment phase involves a number of steps:

- Collect process and site data
- Prioritize and select assessment targets
- Select assessment team
- Review data and inspect site
- Generate options
- Screen and select options for feasibility study

Collect process and facility data. The waste streams at a facility should be identified and characterized. Information about waste streams may be available on hazardous waste manifests, National Pollutant Discharge Elimination System (NPDES) reports, routine sampling programs and other sources.

Developing a basic understanding of the processes that generate waste at a facility is essential to the WMOA process. Block diagrams should be prepared to identify the quantity, types and rates of waste generating processes. Also, preparing overall material balances for the facility can be useful in tracking various waste stream components and identifying losses or emissions that may have been unaccounted for previously.

Prioritize and select assessment targets. Ideally, all waste streams in a facility should be evaluated for potential waste minimization opportunities. With limited resources, however, a plant manager may need to concentrate waste minimization efforts in a specific area. Such considerations as quantity of waste, hazardous properties of the waste, regulations, safety of employees, economics, and other characteristics need to be evaluated in selecting a target stream.

Select assessment team. The team should include people with direct responsibility and knowledge of the particular waste stream or area of the plant. Operators of equipment and the person who sweeps the floor should be included, for example.

Review data and inspect site. The assessment team evaluates process data in advance of the inspection. The inspection should follow the target process from the point where raw materials enter the facility to the points where products and wastes leave. The team should identify the suspected sources of waste. This may include the maintenance operations and areas for storage of raw materials and finished product and for work in progress. The inspection may result in the formation of preliminary conclusions about waste minimization opportunities. Full confirmation of these conclusions may require additional data collection, analysis, and/or site visits.

Generate options. The objective of this step is to generate a comprehensive set of waste minimization options for further consideration. Since technical and economic concerns will be considered in the later feasibility step, no options are ruled out at this time. Information from the site inspection, as well as trade associations, government agencies, technical and trade reports, equipment vendors, consultants, and plant engineers and operators may serve as sources of ideas for waste minimization options.

Both source reduction and recycling options should be considered. Source reduction may be accomplished through good operating practices, technology changes, and input material changes. Recycling includes use and reuse of a waste stream and reclamation.

Screen and select options for feasibility study. This screening process is intended to select the most promising options for full technical and economic feasibility study. Through either an informal review or a quantitative decision-making process, options that appear marginal, impractical or inferior are eliminated from consideration.

Feasibility Analysis Phase

An option must be shown to be technically and economically feasible in order to merit serious consideration for adoption at a facility. A technical evaluation determines whether a proposed option will work in a specific application. Both process and equipment changes need to be assessed for their overall effects on waste quantity and product quality. An economic evaluation is carried out using standard measures of profitability, such as payback period, return on investment, and net present value. As in any project, the cost elements of a waste minimization project can be broken down into capital costs and operating costs. Savings and changes in revenue also need to be considered.

Implementation Phase

An option that passes both technical and economic feasibility reviews should then be implemented at a facility. It is then up to the WMOA team, with management support, to continue the process of tracking wastes and identifying opportunities for waste minimization by periodic reassessments. Such ongoing reassessments and the initial investigation of waste minimization opportunities can be conducted using this manual.

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Section 2
Marine Maintenance and Repair Industry Profile

Industry Description

This study focuses on those marine repair and service facilities that fall under the Standard Industrial Classification (SIC) codes 3731 and 3732 that include ship and boat building and repair facilities. The establishments in this industry are engaged in general ship and boat painting and repair, both to the ship or boat structure and the engines or power plants. The industry is comprised of approximately 700 establishments and employs over 176,000 personnel. The total value of shipments including new products, repair, and maintenance services for this industry was estimated at $14 billion (USDC 1989). Table 1 lists the value of repair and maintenance services alone executed by these industries, namely boat building and repair (SIC code 3731) and ship building and repair (SIC code 3732).

There are two distinct marine repair and service industry subsets, boat yards and ship yards, with different characteristics. Boat repair yards are more numerous, comprising over 75 percent of the total, and smaller, with over 80 percent of the yards employing fewer than 20 people. Boat repair yards concentrate primarily on recreational and some small commercial craft, usually constructed of wood, fiberglass, or aluminum. Services offered are generally limited to painting hull and topside structures and engine repair, while other required services are subcontracted out. However, some boat yards include full repair.

The smaller ship yards typically service smaller commercial fishing vessels and barges, while the larger yards build and repair freighters, tankers, naval vessels, liners. A variety of services may be offered, depending on the particular yard. The smallest yards generally limit their activities to painting and/or servicing engines. A large shipyard resembles an industrial complex; its operations include structural repairs, painting, engine or power plant maintenance, machine shops, electroplating, air conditioning and refrigeration service, electrical repair, and other cleaning and repairing services.

Some of the repair services offered, particularly hull maintenance, require that the vessel be removed from the water. There are basically three mechanisms by which this is accomplished, all of which affect waste generation and management. Large yards frequently use conventional dry docks in which the ship is floated into the dock, sea walls are closed, and the water is removed, leaving the ship supported in a dry basin. The interior of a dry dock is below mean sea level. The second mechanism is the railway dock, whereby the ship is moved up onto dry land via a railway extending down into the water. The third mechanism suitable only for small vessels, is the traveling hoist, which lifts the vessel out of the water and sets it on supports on dry land.

Table 1. Value of Marine Repair and Maintenance Services

SIC Code	Product	Value of Services (in million dollars)
37314	Ship repair, military	1927.7
37316	Ship repair, non-military	806.2
37310	Ship building and repairing, not covered above	253.8
37328	Boat repair, military and non-miliatry	203.0
37320	Boat building and repair, not covered above	723.8

Source: 1987 Census of Manufacturers (USDC 1989)

Raw Materials

Many of the services provided by the industry involve the use of materials and operations that are widely used in many other service industries, such as automobile repair, painting services, body shops, and home maintenance. Typical input materials used in the more common processes as listed below are:

Processes	Input Materials
Paint removal	Chemical paint strippers, blast media
Painting	Antifouling paints
Engine repair	Degreasing solvents, carburetor cleaner
Machine Shop	Degreasing solvents, cutting fluids
Specialty repair shops	Cleaning solvents, acids and alkalies, chlorinated solvents
Metal finishing	Cyanide, heavy metal baths, acids and alkalies
Fiberglass-reinforced and composite plastic fabrication	Fiberglass and reinforcement, resins and solvent, curing and mold release agents

Description of Services

The services offered by marine maintenance and repair yards involve a number of operations that generate waste: painting activities, engine and power plant service, specialty repairs, vessel cleaning, and fueling and marina services. In the following paragraphs, the operations and waste generation are described.

Painting Activities

Painting is probably the most common operation in marine maintenance and repair yards. There are three basic painting-related activities that generate hazardous wastes: Surface preparation, painting, and equipment cleaning.

Surface Preparation

Very few surfaces, whether marine or otherwise, can be painted without suitable preparation. Proper surface preparation is essential to ensure adequate adhesion, durability, and dependability of the surface coating. Abrasive blasting and chemical stripping, described next, are some of the common surface preparation techniques used in the industry.

Repainting of a vessel hull generally requires removal of any marine growths and the existing paint coat. The most common method for removal of paint from vessel hulls is abrasive blasting, an efficient and relatively inexpensive approach. Often, the blasting medium itself is not hazardous. The most common materials are garnet or flint grit, and steel shot. Because lead shot and copper slag are or may be inherently hazardous, their use is limited to situations where the blasting medium can be recovered for proper disposal. Grit blasting is not effective on aluminum or fiberglass hulls or delicate steel parts, but plastic media blasting can be used (Ballard 1991). Chemical stripping is also widely used for removing paints. The most common stripping agents are based on methylene chloride, although some users have switched to aqueous solutions of caustic soda.

Painting

Both interiors and exteriors of vessels are painted to improve appearance and/or provide corrosion protection. Surfaces are generally spray painted, but small parts are sometimes hand painted. Most top side and interior paints are not nearly as toxic as antifouling bottom paints, which generally contain toxic pigments such as chromium, titanium dioxide, lead, or tributyl tin compounds.

Equipment Cleaning

Paint spray guns, brushes, and equipment must be cleaned after use to render them reusable. Water and detergent are used for cleaning brushes used for water-based coatings, while brushes that were used for solvent-based coatings are cleaned with suitable cleaning solvents. Although it may be possible to sewer water-based coating rinsate, the spent solvents require management as a hazardous waste.

Engine and Power Plant Service

Engine repair service may be done by the marine maintenance and repair yard or subcontracted out. Engine service for small craft differs little in terms of materials and hazardous wastes derived from automotive engine service. Typical wastes are spent lube and engine oils, degreasing and cleaning solvents, spent batteries, and coolants (USEPA 1991a). Power plant service for larger vessels may consist of more extensive cleaning operations, boiler and turbine maintenance, and possibly parts fabrication and electroplating.

Specialty Repairs

Large yards may operate several specialty repair shops, such as sheet metal shops, patterns shops, electrical repair shops, reinforced plastics fabricating, and metal finishing. Wastes from these shops include solvents, acid and alkaline cleaning wastes, electroplating wastewaters, resins and fugitive air emissions.

Sheet metal fabrication and metal finishing operations typically are comprised of welding, cutting, pressing, boring, milling, machining, buffing and polishing.

Electroplating operations involve two major steps, namely pretreatment and electrodeposition. Alkali and acid rinsing of metal parts are the primary pretreatment steps, although sometimes cyanide stripping is also carried out in this step. Electrodeposition is the process by which a heavy metal such as copper, nickel or chromium is deposited on carbon steel, aluminum and stainless steel surfaces to provide additional corrosion protection.

Reinforced and composite plastics fabrication use various techniques, most commonly hand layup and spray layup, for the combination of resin and reinforcing material. Please refer to the pollution prevention guide for the fiberglass industry for a more complete description (USEPA 1991b).

Vessel Cleaning

The holding tanks that most yards use to store bilge wastes from vessels being serviced may also be used as the repository for all liquid wastes generated at the yard. Wastes

Table 2. Marine Maintenance and Repair Facility Wastes

No.	Operation Origin	Waste Description
1.	All	Leftover raw material containers (e.g. bags, fiber drums) with residual raw materials
2.	Air emissions from storage tanks and open processing equipment emissions	Volatile organic compounds (VOC) emissions
3.	Grit blasting and chemical stripping	Wastewater containing blasting media, organic paint sludges, heavy metals, stripping chemicals, VOC emissions
4.	Spray painting, resin application	Waste paints, thinners, degreasers, solvents, resings and gelcoat, VOC emissions
5.	Engine repair	Waste turbine oil, lubricants, degreasers, mild acids, batteries, carburetor cleaners, VOC emissions
6.	Electroplating/metal finishing operations	Cyanide solutions; heavy metal sludges, corrosive acid and alkali solutions
7.	Machine Shops	Spent cutting and lube oils, scrap metal, degreasers, VOC emissions
8.	Equipment cleaning, area washdown,	Wastewater containing paints, solvents, oils and degreasers
9.	Degreasing, equipment cleaning, chemical paint stripping, reinforced plastic fabrication	Resin and paint contaminated solvents, VOC emissions
10.	Vessel bilge cleaning	Bilge wastes (oily water)

are collected from the yards by vacuum trucks for appropriate disposal. Recognizing to the potential risks associated with on-site storage of liquid wastes, some yards subcontract the cleaning work to outside businesses, which generally take responsibility for appropriately collecting and disposing of these wastes.

Fueling and Marina Services

Most marinas provide routine fueling and related general services for boats; however, the nature of the facilities and the services provided depend on the size and type of the marina. Besides selling fuel and related products and providing for short-term and/or long-term dockage or storage vessels, some marinas may also be equipped to service vessels, and they may specialize in a particular size range of vessels. Inland marinas normally sell gasoline, outboard motor oil, and oil-gas mixtures for outboards. Facilities located on larger rivers, bays, and coastal harbors typically provide the same products plus diesel fuel and other lubricants and fluids (Davis and Piantadosi 1988).

Waste Description

The services offered by different marine yards vary widely, and the quantity of wastes produced varies both with the size of the marine maintenance and repair yard and the type and size of vessel serviced. However, the wastes do not vary widely within a given operation; therefore, waste generation and management will be discussed on an operation-specific basis, rather than in terms of a yard as a whole. Table 2 summarizes the wastes and their operational sources.

Surface preparation and equipment cleaning are the major sources of paint-related hazardous wastes. Many hull paints are antifouling coatings, containing toxic biocides to prevent or minimize marine growths that eventually foul hulls. Most of these toxic agents are heavy metal or organometallic compounds, such as cuprous oxide, lead oxide and tributyl tin compounds. Paint chips containing these antifouling agents are generally hazardous, but in practice the concentration of toxic compounds is reduced by dilution with the blasting medium. The resulting mixed waste may be nonhazardous, however, it is necessary to classify the waste by testing samples before managing it as nonhazardous waste.

Waste from nonblasting mechanical stripping (e.g., scraping, thermal stripping) tends to be predominantly paint residues and, if antifouling paints are involved, is almost certainly hazardous. Since most chemical paint strippers are themselves hazardous, wastes from chemical stripping will probably be hazardous even if the original paint contained no toxic materials. In addition to the above wastes, some chemical strippers can emit high concentrations of volatile organic compounds (VOC) into the air.

Equipment cleaning generates hazardous waste in the form of solvents, thinners, and acids. Paint spray equipment, brushes, and other paint application equipment are generally cleaned with solvents or thinners after use. Evaporation of solvent is associated with solvents applied with rags, and hazardous residuals may be generated during the application of acids by rag or brush. Also, wastewater contaminated with acids is generated by washing off acid-etched hulls.

For recreational boats and small ships, inboard engine repair work differs little from automobile engine repair, and the same types of wastes are generated. These wastes will include lube oils, hydraulic fluids, waste fuels, carburetor cleaner, hydrocarbon solvents (mineral spirits, hexane, or gasoline), oil filters, and batteries. Options for minimizing wastes in automobile repair shops are described in EPA's *Guides to Pollution Prevention: The Automotive Repair Industry* (USEPA 1991a).

Engine repair shops at large yards may be much more sophisticated, since they include machine shops. The quantities of wastes produced are significantly greater than at smaller yards, and may include additional wastes such as machine shop cutting fluids and other degreasing and cleaning solvents, for example, acetone, methyl ethyl ketone (MEK), and possibly chlorinated solvents. The yard may generate solvent-based or caustic boiler cleaning wastes as well.

Machine shops at marine maintenance and repair yards may generate degreasing solvents and cutting oil wastes and at larger yards may perform electroplating, which generates wastes consisting of spent acid, alkali and cyanide cleaning solutions and heavy metal sludges.

Large shipyards frequently operate a variety of specialized on-site repair shops for maintenance and repair of systems unique to large vessels or beyond the capabilities of small yards. These shops and their wastes can include:

- Sheet metal shop for fabrication of structural components. Wastes include degreasing solvents, acid and alkaline cleaning wastes, chromic acid, and contaminated rinse waters.
- Reinforced and composite plastics fabrications. Wastes consist of spent cleaning solvents, gelcoat and resin oversprays, styrene emissions and scrap material.
- Pattern shop. Wastes generated by pattern shops are isocyanates, alcohol, toluene, and other hydrocarbon solvents, and contaminated sawdust.
- Electrical repair. Electrical repair wastes are trichloroethylene, trichloromethane, acetone, methylene chloride paint strippers, and some electroplating wastes.
- Pipe fitting shop. Wastes associated with pipe fitting include chemical paint stripping wastes, degreasing solvents, and acid and caustic cleaning solutions, and metal chips, and cutting oil.
- Air conditioning and refrigeration repair. Wastes consist of phenols, cresols, solvents, and chlorofluorocarbon refrigerants.

Wastes associated with vessel cleaning are typically generated outside the shipyard when the vessel is in use. However, because of the nature of the wastes and the way they are handled, the repair yard is frequently the generator on record. The most common of these wastes, called bilge waste, is composed of wastewater containing oil and fuel removed from vessel bilges. Virtually every yard has facilities for handling this waste. Larger vessels also may generate sanitary wastes, which usually can be sewered directly, and chemical cleaning wastes associated with the cleaning of sanitary systems, which cannot be sewered.

Another waste sometimes generated in the refurbishment of larger, older vessels is asbestos, formerly a common thermal insulating or fire protection material. However, it is being replaced by non-asbestos materials.

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Section 3
Waste Minimization Options for Marine Maintenance and Repair Yards

This section discusses potential waste minimization methods for marine maintenance and repair operations. These methods come from accounts published in the literature and through industry contacts. The primary waste streams associated with maintenance and repair operations are listed in Table 4 along with potential waste minimization methods. The major waste streams are chemical paint stripping wastes; abrasive blast and surface preparation wastes; painting and solvent wastes; equipment cleaning wastes; engine overhauling and repair wastes; machine shop wastes; specialty shop wastes; and vessel cleaning wastes. The waste from a particular operation often enters wastewaters and air as well as having a solid component. For example, abrasive blast and surface preparation wastes may become air particulate matter, trace metal pollutants of potable and navigable water, and contaminants in soil and groundwater.

The waste minimization methods in Table 4 can be classified generally as source reduction, which can be achieved through material substitution, process or equipment modification, or better operating practices; or as recycling.

Source reduction is achieved through better operating practices by employing procedural or administrative policies that result in a reduction of waste. They include:

- Waste stream segregation
- Personnel practices
  - Management initiatives
  - Employee training
  - Employee incentives
- Procedural measures
  - Documentation
  - Material handling and storage
  - Material tracking and inventory control
  - Scheduling

In addition to the specific recommendations provided below, rapidly advancing technology makes it important that companies continually educate themselves about improvements that are waste reducing and pollution preventing. Information sources to help inform companies about such technology include trade associations and journals, chemical and equipment suppliers, equipment expositions, conferences, and industry newsletters. By keeping abreast of changes and implementing applicable technology improvements, companies can often take advantage of the dual benefits of reduced waste generation and a more cost efficient operation.

Chemical Stripping Wastes

Methylene chloride is the most commonly used paint stripping agent, although it is increasingly being replaced by solvents such as dibasic esters which are less volatile and hazardous. Chemical stripping wastes consist primarily of the stripping agent and paint sludges. The following waste reduction methods are suggested to minimize the generation of chemical stripping wastes.

Waste segregation. Segregating the stripping agents from other waste streams will help facilitate cost-efficient reuse and recycling of contaminated strippers. Extreme care must be taken to avoid cross-contaminating the stripping agents.

Use of less toxic stripping agents. Inorganic strippers, usually consisting of aqueous solutions of caustic soda, can substitute for methylene chloride-based strippers in many applications. Although the waste stripper is still hazardous, it is relatively less toxic and easy to treat on site, generating a non-hazardous waste that can possibly be disposed of to the public sewer. Several new less hazardous and toxic degreasing and stripping agents are currently available in the market. Substitutes include dibasic esters (DBE), semi-aqueous terpene- based products, detergent-based products and C9- to C12-based hydrocarbon strippers. Manufacturers claim that these products are non-chlorinated, biodegradable, exhibit low volatility and are not listed as hazardous substances.

Store and reuse stripping agents. Solvent strippers, particularly stripping baths, can generally be reused several times before their effectiveness is compromised. Appropriate collection and storage systems need to be installed if the stripper is to be reused.

Recycle spent strippers. Both spent organic and caustic stripper solutions can be treated to remove contamination. One method of treatment uses centrifuge or filtration systems to separate the paint sludge from the stripper; then makeup chemicals are added to the stripper, which then can be reused. Stripping baths equipped with such treatment systems can

Table 4. Waste Minimization Methods for Marine Maintenance and Repair Yards

Waste Stream	Waste Minimization Methods
Chemical paint stripping wastes	Waste segregation. Non-toxic stripping agents. Maximize stripper usage by reuse. Recycling stripper using appropriate recycling techniques. Better operating practices.
Abrasive blast waste (wet solids and wastewater)	Use alternate blasting media and techniques. Segregation and recycle of blast media. Use blast dust collection systems.
Paint and solvent wastes	Tighter inventory control and good housekeeping. Use water-based and less toxic coatings Solvent reuse and recycling On-site waste exchange. Off-site waste exchange. Waste segregation. Minimization of fugitive overspray.
Equipment cleaning wastes	Segregation of cleaning agents. Recycling of cleaning solvents. Replace solvent cleaners with detergents wherever possible.
Engine repair wastes	Use aqueous degreasers. Use dedicated solvent sinks for parts washing. Segregation of spent engine and lube oils. Recycling of oils and solvents. Waste exchange.
Machine shop wastes	Use of water soluble cutting fluids. Recycling of cutting and lubrication fluids. Segregation and waste exchange of metal and plastic turnings and scrap.
Specialty shop wastes	Good operating practices. Process and equipment modifications. Use of detergent cleaners instead of solvent cleaners.
Vessel cleaning wastes	Use of detergent cleaning agents.
Spills and floor washdowns	Good housekeeping. Proper storage. Spill control measures.

often be used almost indefinitely. While the paint sludge that is separated may have to be treated as a hazardous waste, the quantity is much smaller than the quantity of combined sludge and stripper usually discarded. In addition, recycling and reuse considerably reduces the need for fresh or make-up stripping solution and thus results in substantial savings.

Better operating practices. Chemical stripping of small parts employs dip tanks and generate wastes consisting of spent stripper that clings to the part after rinsing (drag-out). Some reduction in drag-out and contaminated rinse water can be achieved by allowing the dipped parts to drain longer above the dip tank, or by improving the way in which dipped parts are stacked before draining to prevent "pooling" of stripper on the parts.

Abrasive Blast Wastes

Abrasive blasting is often used in preference to chemical stripping for removing paints. While this procedure avoids disposal of chemical strippers, it does not eliminate wastes altogether. The most commonly used blasting media is sand or grit with a large volume of water.

The presence of paint chips containing hazardous metallic and organometallic biocides makes abrasive blasting wastes potentially hazardous. Blast waste water generally constitutes the largest single waste stream from many repair yards. For instance, wet abrasive blasting of an average-sized naval vessel (DDG class) can generate up to 180 tons of wet abrasive and 500,000 gallons of contaminated water (Adema and Smith 1987). Some of the waste minimization options available are:

Use alternate blasting media and techniques. Research and testing is underway on a number of innovative alternatives to both grit blasting and chemical stripping. The alternate techniques include: plastic media blasting, water jet stripping, thermal stripping, dry ice pellets, laser paint stripping, and cryogenic stripping. Descriptions of each of these alternatives are provided below.

Plastic media blasting. When chemical stripper is applied to a large area and then washed off, large volumes of hazardous wastewater can be created. The military has experimented extensively with plastic media blasting (PMB) as a substitute for chemical stripping, with mixed results. Three disadvantages are that PMB will not work well on epoxy or urethane paints, and the blasting equipment is more expensive than conventional grit blasting equipment and requires more highly trained operators. On the positive side, the same types and quantities of solid wastes are generated as with grit blasting, but the plastic media tend to be more easily recyclable through the use of pneumatic media classifiers that are part of the stripping equipment. Thus, the main waste to be disposed of is the paint waste itself. Abrasion eventually turns the plastic media into fine dust, that must be disposed of. Based on research conducted by the military, chemical stripping a fighter aircraft will generate about 250,000 gallons of stripper waste; by contrast, PMB will generate two 55-gallon drums of paint chips, and 200 pounds of nonrecoverable dry spent plastic medium (Calif. DHS 1989). In addition, PMB can be used on fiberglass boats, which cannot be stripped chemically (Ballard 1991).

Water jet stripping. A cavitating water jet stripping system has been developed to remove most paints, separate the paint chips from the water, and treat the water to eliminate dissolved toxic materials. Relatively little hazardous waste is generated by this process. However, it is not as efficient as conventional grit blasting and the equipment has higher capital and operating costs.

Thermal stripping. Thermal stripping utilizes a flame or stream of superheated air to heat and soften the paint layer, thus allowing it to be peeled relatively easily. This method is applicable only to some situations; for instance it is not applicable to surfaces that might be heat-sensitive. In addition this process is more labor-intensive than other stripping methods. The advantage of this method is that it generates only one waste stream, namely a waste paint.

Dry ice pellets. Carbon dioxide (CO2) dry ice pellets can be used as a blast medium that generates no media waste. After use, the dry ice evaporates, leaving only paint chips that can be swept up and placed in containers for disposal. The cost of the dry ice, storage, and handling equipment could be substantial, limiting applicability of this method. (Yaroschak 1989).

Laser paint stripping. Laser paint stripping has been developed that generates "zero" residue. A pulsed CO2 laser, controlled by an industrial robot, is used as the stripping agent. This method is complex, capital intensive and requires highly-skilled operators. (Yaroschak 1989).

Cryogenic stripping. In cryogenic stripping, parts are immersed in liquid nitrogen, followed by gentle abrasion or plastic shot blasting to remove the brittle paint coating. This process requires special equipment for handling the liquid nitrogen and is applicable only for small objects.

Segregate and recycle blast media

Most abrasive blast media are recyclable or reusable. In many cases, the contaminated grit can be reused several times to blast additional vessels before becoming too contaminated or worn for further use. Because of the difference in density between the grit materials and the waste paint chips, it is possible to separate the grit from the paint waste. Cyclone separators, gravity shakers, air separators, water separators, and other systems can separate the paint residues from the grit, which can then be reused.

Recycling is routinely performed when using steel shot, lead shot, or plastic media because of the cost of the blast media. In the case of "sand" blasting, the sand does not have enough value to justify recycling. However, if the sand blast waste is determined to be hazardous, requiring off-site disposal, then this medium may become costly enough to justify recycling. Natural organic abrasives, like walnut shells or rice hulls, do not recycle well and are susceptible to biological growth and deterioration.

Use dust collection systems

Dedicated bag-house filters may be installed on enclosed blasting stations to collect the blast dust emissions. One approach to prevent fugitive dust emissions from open space blasting operations would be to enclose the area with plastic sheeting or screening, thus confining the waste to the immediate vicinity of the blasting. After blasting has been completed, the waste should be collected, transferred to dumpsters or other containers, and transported off site.

Paint and Solvent Wastes

Methods for minimizing paint and solvent wastes include tighter inventory control and good housekeeping, input material substitution, solvent recycling and minimizing fugitive oversprays.

Tighter inventory control and good housekeeping. Rigid inventory control provides a very effective means of source reduction at virtually no cost to the operator and can be implemented in several ways. In smaller yards, an owner may monitor employee operations and make verbal or written comments on product usage and suggested limits. In larger yards where monitoring of employees can be more difficult, the owner or manager can limit access to storage areas containing raw materials, forcing employees to stretch the use of raw materials and providing the owner/manager a means of monitoring raw material use. In an effort to minimize paint waste, many small yards either purchase paint specifically for each job or require the vessel owner to supply the paint.

Good housekeeping can provide very effective source reduction. Examples of good housekeeping for paints and solvents include storage area leak control and containment, which can be easily implemented at no cost, and improvements in drum location, product transfer, leak collection, and drum transport, which can limit product loss.

Raw material substitution. The bottoms of all vessels are coated with special antifouling paints, which are highly toxic and thus hazardous materials. The purpose of such paints is to prevent, or at least retard, growth of marine organisms (e.g. barnacles). Hence, there are no non-toxic alternative materials for this service. Cuprous oxide and copper flake rank among the least toxic, but effective, antifoulants, while arsenic and mercurials rank among the most toxic. Tributyltin compounds are also extensively used and are suspected to be highly toxic.

Paints for parts of the vessel that are not immersed in water can be non-toxic. Part of the paint waste problem can be alleviated by using water-based instead of solvent-based paints. This has become standard practice in many industries and helps to reduce not only hazardous paint wastes, but also solvent cleanup wastes. Some people believe that water-based coatings do not provide the same protection that solvent-based coatings do (Higgins 1985). Solvent-based coatings are generally more durable, tend to be less corrosive to the metals being coated, and dry quickly. The longer drying time of water-based coatings is exacerbated by the high relative humidity of marine air. Water-based coatings are suitable for areas where decoration is more critical than protection, such as vessel interiors or decorative topside work.

Powder coatings, based on finely pulverized plastics, have been substituted for paints in some industrial applications. This technique uses no solvent and eliminates VOC emissions, but requires that the coated surface be oven-cured at about 400°F. Hence, it not suitable for large or heat sensitive components and is not used to any significant degree for marine maintenance or repair. In addition, the application equipment is more expensive than conventional paint applicators, and highly-trained operators are necessary.

Solvent recycling. Aside from raw material substitution, the best way to minimize solvent waste generation is to directly reuse the solvents as much as possible, and then recover and recycle them. Processes for recycling thinners and solvents are well established and widely used in many industrial sectors especially the automotive paint industry. A waste minimization study of the automotive paint industry indicated that all companies contacted used some form of on-site or off-site thinner reclamation. Those generators who did not find it economical to recycle contaminated thinners on site sent their solvents to commercial recyclers for recovery (Calif. DHS 1987). Reclaimed thinners were often sold back to the generators after recovery. Thinner recyclers can reprocess 70 to 80 percent of the incoming spent thinners into reusable products (Stoddard 1981).

There are several alternatives for resource recovery and recycling on site. Gravity separation, for example, is inexpensive and easy to implement. This method of reclamation separates a thinner or solvent from the contaminant solids under quiescent conditions. The clear supernatant thinner can be decanted using a drum pump and a float valve, and can be used as a cleaning solvent or where thinner purity is not critical, as in parts washer systems. Gravity separation can provide valuable savings to any marine or boat yard by reducing both waste quantities and new solvent purchases.

For larger shipyards, on-site distillation may be cost effective. Distillation of solvent and thinner wastes can significantly reduce the quantities of waste solvents disposed of, and the purchase of new materials. A waste minimization guide for the automotive repair industry includes a description and evaluation of several of the leading solvent recovery systems (USEPA 1991a).

On-site waste exchange. Larger shipyards should also consider on-site waste exchange. Solvents contaminated in one process or shop may be usable as cleaning solvents in a less demanding operation elsewhere in the shipyard. Yard and shop managers need to discuss their individual solvent needs and waste characteristics to determine the potential for this type of on-site reuse.

Off-site services. In general, three types of off-site services are offered. The simplest involves collecting all recyclable wastes and hauling them to a commercial recycler who either recovers them or processes them into fuel, depending on the quality of the waste. This is similar to the practice currently being followed at most yards for bilge wastes.

In a second type of service, the marine maintenance and repair yard purchases thinners from suppliers who also collect and recycle the wastes, a common practice among automobile painting companies. Some suppliers may include the cost of waste collection and recycling in the price of their thinner. This increases the thinner cost but eliminates separate hauling and disposal or recycle costs, and also reduces the administrative burden on the owner or manager of the yard.

Other companies provide a third type of service, in which a parts washer system is leased to the client. The parts washer system can be as simple as a sink atop a drum of solvent. Solvent is pumped out of the drum into the sink for washing parts and equipment; used solvent drains back into the drum, and solids settle to the bottom of the drum. Either on a fixed schedule or whenever the solvent becomes too contaminated for further use, the service company removes the drum and leaves a drum of fresh solvent in its place. This service is widespread among automotive repair shops and other shops where large quantities of solvent are used to clean small parts.

Waste segregation. Regardless of whether on-site recycling, on-site reuse, or off-site recycling is adopted, an essential waste management practice is waste segregation — placing different wastes into different containers for recovery or disposal. This practice is critical to the success of any program designed to reduce or recycle waste solvents, because solvents are much easier to directly reuse or recycle if they are segregated, minimizing solvent contamination. Mixing different solvents or putting wastewaters, oils, excess paints, or paint strippers into common liquid waste drums can make solvent reuse or recycling, difficult and impractical. For instance, when an incompatible solvent or water is added to a chlorinated solvent, hydrochloric acid can form slowly due to hydrolysis. This renders the solvent unsuitable for direct reuse until the acid is neutralized or otherwise removed.

One related practice that can facilitate segregation and reduce the potential for solvent contamination is to standardize the use of solvents at a yard. This would be useful primarily at larger shipyards, where different shops might purchase their materials separately. Centralizing and controlling solvent purchases would reduce the potential for cross-contamination, minimize the number of different solvents purchased and increase the potential for on-site reuse.

Waste segregation can also reduce the overall quantities of hazardous waste generated. When only a single container is provided for collecting all waste materials, it is common for nonhazardous wastes to be placed in the same container with hazardous wastes, increasing the amount of hazardous waste being generated. By providing separate, clearly- labelled containers for each waste type, non-hazardous waste will not be added to hazardous wastes. Many companies have noticed a decrease in the total amount of hazardous waste being sent off site after implementing waste segregation programs.

Minimization of fugitive oversprays. Paint overspray is not usually collected or managed. However, at those marineyards which conduct painting operations at the water's edge or in uncontained areas, overspray can be a major component of runoff into adjoining surface waters. Overspray in non-marine industries is controlled by improved painting techniques, including air-assisted airless; high volume, low pressure turbine; air-atomized electrostatic; and airless electrostatic application techniques (USEPA 1991c). However, the compatibility of such techniques in marine applications needs to be evaluated. Operators should be trained in ways to minimize paint usage such as maintaining a fixed distance from the surface while triggering the paint gun and releasing the trigger when the gun is not aimed at the target. Overspray can be confined by the use of plastic sheeting under and around the vessel being painted.

Equipment Cleaning Wastes

Painting sprayers, brushes, and equipment must be cleaned after use. Whenever possible, water-based coatings should be used. If solvents are needed, the best way to minimize solvent waste generation is by reusing the spent solvents as much as possible, and then recycling them. These options are discussed above.

Machine Shop Wastes

The major hazardous wastes from metal machining are waste cutting oils and degreasing solvents. The currently preferred method to reduce quantities of both is to substitute a water-soluble cutting fluid. This practice has been adopted in many machine shops without adversely impacting work efficiency or quality, and without increasing the annual operating cost appreciably.

Many machine shops successfully recycle spent coolant from machining operations, and a number of proprietary systems are available. This option may require monitoring coolant strength (using a refractometer), removing tramp oil and adding stabilizer and inhibitor chemicals. Recycling is most easily implemented when a standardized type of coolant is used throughout the shop.

Most shops already collect scrap metals from machining operations and sell these to metal recyclers. Metal chips which have been removed from the coolant by filtration should be drained and included in this collection.

The solvents used in machine shops are those used in automotive repair and other surface cleaning operations, and they should be segregated for reuse as discussed under "Waste Segregation." The waste cutting oils are amenable to the same types of off-site oil recycling as engine lube oils. A more detailed discussion on minimizing wastes from machine shops can be found in a waste audit report for finished metal products (Calif. DHS 1989b).

Engine Repair Shop Wastes

Most marine engine repair work is similar to automobile repair work. Typical wastes include solvents, waste turbine oils, fuels, and batteries. Of these, the solvents are generally the only wastes suitable for recovery and recycle on site. The discussion of solvents above is applicable to solvents generated from engine repair.

In qualifying new or rebuilt turbines, thousands of gallons of lightly-used turbine oil may be generated as waste. The oil may be used for only a few minutes to a few hours and holds excellent potential for recycling (Davis 1990). There are a number of recycling operations equipped to re-refine contaminated oil. Some states such as North Carolina operate portions of their motor fleet on this waste oil. In addition there are several waste exchanges that use the oil as a feedstock for other processes. However to derive maximum economic benefit, some care must be exercised in handling the waste product. Waste oil containers should be clearly labelled and kept secure to avoid cross contamination with other chemicals and to keep water and general trash out. Incompatible products should be kept separate, as directed by the firm that will be accepting the waste. If the waste is badly contaminated, then its value for burning, recycling, or other use is greatly diminished, and the waste generator will be forced to pay a much higher price for disposal. (Editor's note: Although some marine yards are equipped to burn used oil as a heating fluid, EPA does not consider this as waste minimization).

A discussion on the recycling of the other engine repair waste streams can be found in a section on off-site recycling in the waste audit study of the automotive repair industry. This study also includes economic evaluations of two other source reduction techniques, namely the use of aqueous degreasers and commercial solvent sinks for parts washing (Calif. DHS 1987a).

Specialty Shop Wastes

Again the most common waste generated is spent solvents, which should be handled as recommended in the earlier sections on solvent wastes. However, many other types of wastes can be generated depending on the nature of the specialty shop operation. Some of the typical specialty shops are pattern shops, sheet metal fabrication, electroplating, plastics fabrication, air conditioning and refrigeration servicing and repair shops. Waste minimization techniques specific to the above operations are discussed in other industry-specific reports.

For instance, California Department of Health Services has published waste minimization reports for the metal finishing industry, mechanical equipment repair shops, and several other operations and industries. For additional information on the reports published by EPA and different states, please consult the agencies listed in Appendix B.

Yards that work extensively with fiberglass-reinforced plastic (e.g. repairing boat hulls) should refer to the EPA pollution prevention guide for the fiberglass-reinforced plastic fabrication industry, which describes specific waste minimization techniques for such operations (USEPA 1991b). Additional details have been published by the North Carolina Pollution Prevention Pays Program (Davis and Piantadosi 1988).

Vessel Cleaning Wastes

Vessel cleaning wastes are generated on board. Upon return to port, however, these wastes are removed and managed by the repair yard, making the yard the generator of record. Since the yard is not the source of vessel waste, there is little that the yard can do to reduce that generation. Wastes may also be generated from the cleaning of boiler tanks, sanitary systems, and other tank systems on larger ships. If chemical cleaners are used, these wastes will probably be hazardous. It may be possible, in some cases, to substitute a detergent cleaner or, in the case of a sanitary system, a bacterial enzyme cleaner, either of which may be sewerable. The generator must contact the local sewer authority to verify whether the wastes are sewerable.

In order to reduce the risks associated with on-site storage of liquid wastes, some yards subcontract the entire cleaning operation to an outside firm specializing in the collection and appropriate disposal of such wastes.

Spill Control

Spill control is especially important at marine maintenance and repair yards, because most yards abut the ocean. It is common for yards to be designed so that they slope toward the ocean. Consequently, any spilled materials will be eventually washed into the ocean. Unless spills can be prevented or contained in the yard, it may become necessary to implement run-on/runoff controls for the yard, consisting of curbs or berms around the yard perimeter to confine all contamination to the yard, and having surfaces sloping toward a collection dump to allow all contaminated materials to be collected, stored and disposed of properly. A detailed discussion on waste containment and confinement strategies, including design illustrations, can be found in Marine Maintenance and Repair: Waste Reduction and Safety Manual (Davis and Piantadosi 1988).

The potential for spills and leaks of thinners and solvents is highest when a product is transferred from bulk drum storage to the point of use. Spigots or pumps should always be used when dispensing new materials, and funnels should be used to transfer waste materials into storage containers. Materials should never be poured directly from drums into smaller containers.

If drum handling is necessary, the drums should be moved correctly using powered equipment or hand trucks to prevent damage or punctures to the drums. Under no circumstances should drums be tipped or rolled, even when empty. Negligent handling may damage the seams, which could leak or rupture in future use.

The risk of spills increases in both frequency and magnitude when fueling services are included with yard services. Storage tanks should have secondary containment. Other ways to reduce the risk and to minimize spills include (Davis and Piantadosi, 1988):

- Watch the fuel tank vent to avoid overfilling.
- Be sure fuel flow has stopped before removing the fuel nozzle from the fill pipe.
- Provide a drip pan for the fuel nozzle.
- Be sure the proper type of fuel is selected, to avoid cross-contamination.
- Practice preventive maintenance on the entire fueling system.

Derelict vessels can be one of the most intractable waste problems facing a marine yard. Usable parts are generally salvaged and reused, leaving a useless hull. Metal hulls often can be sold as scrap, but wood and fiberglass hulls have almost no commercial value. Burning of wooden hulls is illegal in many places and strongly discouraged in most others, so usually the wreck is left for eventual natural decomposition. Fiberglass vessels can sometimes be used in constructing artificial reefs, although this may be expensive. The best advice to a yard regarding minimization of this type of waste is to prevent derelicts from accumulating, since they tend to attract even more derelicts (Davis and Piantadosi 1988).

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Section 4
Waste Minimization Assessment Worksheets

The worksheets provided in this section are intended to assist marine maintenance and repair yards in systematically evaluating waste generating processes and in identifying waste minimization opportunities. These worksheets include only the waste minimization assessment phase of the procedure described in *The Waste Minimization Opportunity Assessment Manual.* A comprehensive waste minimization assessment includes a planning and organizational step, an assessment step that includes gathering background data and information, a feasibility study on specific waste minimization options, and an implementation phase. For a full description of waste minimization assessment procedures, refer to the manual. Table 5 lists the worksheets included in this section. After completing the worksheets, the assessment team should evaluate the applicable waste minimization options and develop an implementation plan.

***Table 5.** List of Wast Mimization Assessment Worksheets*

No.	Title	Descriptions
1a.	Waste Sources	Wastes generated from shop and parts clean-up.
1b.	Waste Sources	Wastes generated by maintenance shops.
2a.	Waste Minimization: Material Handling	Questionnaire on material handling techniques.
2b.	Waste Minimization: Material Handling	Questionnaire on material handling.
3.	Option Generation: Material Handling	Waste minimization options for material handling.
4a.	Waste Minimization: Parts Cleaning	Questionnaire on procedures used for parts cleaning.
4b.	Waste Minimization: Parts Cleaning	Questionnaire on procedures used for parts cleaning.
5.	Option Generation: Parts Cleaning	Waste minimization options for parts cleaning.
6a.	Waste Minimization: Waste Handling	Questionnaire on waste handling operations.
6b.	Waste Minimization: Waste Handling	Questionnaire on waste handling operations
7.	Option Genration: Waste Handling	Waste minimization options for waste hadling
8a.	Waste Minimization: Material Substitution	Questionnaire for material substitution.
8b.	Wste Minimization: Substitution	Questionnaire for material substitution.
9.	Option Generation: Material Substitution	Waste minimization options for material substitution.
10.	Waste Minimization: Good Operating Practices	Questionnaire on good operating practices
11.	Option Generation: Good Operating Practices	Waste minimization options that are good operating practices

Firm ____ Site ____ Date ____	Waste Minimization Assessment Proj. No. ____	Prepared By ____ Checked By ____ Sheet ___ of ___ Page ___ of ___

WORKSHEET 1a

WASTE SOURCES

Shop Clean-Up	Significance at Plant		
	Low	Medium	High
____ Obsolete raw materials			
____ Spills & leaks (liquids)			
____ Spills (powders)			
____ Dirty rags			
____ Used sawdust			
____ Area wash water			
____ Clarifier sludges			
____ Container disposal (metal)			
____ Container disposal (paper/plastic)			
____ Pipeline/tank drainage			
____ Evaporative losses			
____ Other			
Parts Cleaning			
____ Spent solvent cleaner			
____ Spent carburetor cleaner			
____ Spent brake cleaner			
____ Evaporative losses			
____ Leaks and spills (solvents)			
____ Spent alkaline cleaner			
____ Leaks and spills (alkali)			
____ Rinse water discharge			
____ Sludges			
____ Filter waste			

Firm ______ Site ______ Date ______	Waste Minimization Assessment Proj. No. ______	Prepared By ______ Checked By ______ Sheet ___ of ___ Page ___ of ___

WORKSHEET

1b

WASTE SOURCES

Maintenance Shop Wastes	Significance at Plant		
	Low	Medium	High
Motor oil			
Oil filters			
Gear and lube oils			
Transmission fluid			
Brake fluid			
Radiator coolant			
Gasoline			
Brakes (asbestos)			
Radiators (lead)			
Batteries (lead & acid)			
Junk parts			
Abrasive paint stripping wastes			
Organic chemical stripping wastes			
Inorganic chemical stripping wastes			
Paint overspray			
Electroplating wastes			
Fiberglass fabrication (solvent) wastes			
Fiberglass fabrication (gelcoat) wastes			
Fiberglass roving/chopping dusts			

Firm ____ Site ____ Date ____	**Waste Minimization Assessment** Proj. No. ____	Prepared By ____ Checked By ____ Sheet __ of __ Page __ of __

WORKSHEET

2a

WASTE MINIMIZATION: Material Handling

A. DRUMS, CONTAINERS, AND PACKAGES

Are drums, packages and containers inspected for damage before being accepted? ☐ yes ☐ no

Are employees trained in ways to safely handle the types of drums and packages received? ☐ yes ☐ no

Are they properly trained in handling of spilled raw materials? ☐ yes ☐ no

Is there a formal personnel training program on raw material handling, spill prevention proper storage techniques, and waste handling procedures? ☐ yes ☐ no

Describe handling procedures for damaged items: ____

How often is training given and by whom? ____

Is obsolete raw material returned to the supplier? ☐ yes ☐ no

Is inventory used in first-in first-out order? ☐ yes ☐ no

Is the inventory system computerized? ☐ yes ☐ no

Does the current inventory control system adequately prevent waste generation? ☐ yes ☐ no

What information does the system track? ____

Are stored items protected from damage, contamination, or exposure to rain, snow, sun and heat? ☐ yes ☐ no

Is the dispensing of raw materials supervised and controlled? ☐ yes ☐ no

Are users required to return empty containers before being issued new supplies? ☐ yes ☐ no

Do you maintain and enforce a clear policy of using raw materials only for their intended use? ☐ yes ☐ no

Firm ____ Site ____ Date ____	**Waste Minimization Assessment** Proj. No. ____	Prepared By ____ Checked By ____ Sheet ___ of ___ Page ___ of ___

WORKSHEET
2b

WASTE MINIMIZATION:
Material Handling

B. BULK LIQUIDS HANDLING

What safeguards are in place to prevent spills and avoid ground contamination during the filling of storage tanks?

- High level shutdown/alarms ☐
- Flow totalizers with cutoff ☐
- Secondary containment ☐
- Other ☐

Describe the system: ____

Are air emissions from solvent storage tanks controlled by means of:

Conservation vents	☐ yes	☐ no
Nitrogen blanketing	☐ yes	☐ no
Absorber/Condenser	☐ yes	☐ no
Other vapor loss control system	☐ yes	☐ no

Describe the system: ____

Are all storage tanks routinely monitored for leaks? If yes, describe procedure and monitoring frequency for above-ground/vaulted tanks: ____

Underground tanks: ____

How are the liquids in these tanks dispensed to the users? (i.e., in small containers or hard piped.) ____

What measures are employed to prevent the spillage of liquids being dispensed? ____

When a spill of liquid occurs in the facility, what cleanup methods are employed (e.g., wet or dry)? Also discuss the way in which the resulting wastes are handled: ____

Firm ____ Site ____ Date ____	**Waste Minimization Assessment** Proj. No. ____	Prepared By ____ Checked By ____ Sheet __ of __ Page __ of __

WORKSHEET 3

OPTION GENERATION: Material Handling

Meeting Format (e.g., brainstorming, nominal group technique) ____
Meeting Coordinator ____
Meeting Participants ____

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
A. Drums, Containers, and Packages		
Raw Material Inspection		
Proper Storage/Handling		
Return Obsolete Material to Supplier		
Minimize Inventory		
Computerize Inventory		
Formal Training		
Waste Segregation		
B. Bulk Liquids Handling		
High Level Shutdown/Alarm		
Flow Totalizers with Cutoff		
Secondary Containment		
Air Emission Control		
Leak Monitoring		

Firm ______ Site ______ Date ______	**Waste Minimization Assessment** Proj. No. ______	Prepared By ______ Checked By ______ Sheet ___ of ___ Page ___ of ___

WORKSHEET

4a

WASTE MINIMIZATION:
Parts Cleaning

A. SOLVENTS

Do you use parts cleaning solvent for uses other than cleaning parts? ☐ yes ☐ no

Have you established guidelines as to when parts should be cleaned with solvents? ☐ yes ☐ no

Do you use solvent sinks instead of pails or dunk buckets? ☐ yes ☐ no

Are solvent sinks and/or buckets located near service bays? ☐ yes ☐ no

Do you allow cleaned parts to drain inside the sink for a few minutes to minimize dripping of residual solvent onto the shop floor? ☐ yes ☐ no

Are you careful when immersing and removing parts from the solvent bath so as not to create splashes? ☐ yes ☐ no

Do you keep all solvent sinks/buckets covered when not in use? ☐ yes ☐ no

Do you lease your solvent sinks? ☐ yes ☐ no

If yes, does your lease include solvent supply and spent solvent waste handling? ☐ yes ☐ no

If you own your solvent sinks, does a registered waste hauler collect your dirty solvent for recycling or treatment? ☐ yes ☐ no

Do you own on-site solvent recovery equipment such as a distillation unit? ☐ yes ☐ no

If yes, how are the solvent residues handled? ______________________

____

____

What other methods are you using to reduce solvent use/waste? ______________________

____

____

B. AQUEOUS CLEANERS

Do you use dry pre-cleaning methods such as baking and/or wire brushing to reduce loading on the aqueous cleaner? ☐ yes ☐ no

Have you switched from caustic-based cleaning solutions to detergent-based cleaners? ☐ yes ☐ no

Do you use drip trays on hot tanks to minimize the amount of cleaner dripped on the floor? ☐ yes ☐ no

Firm ______ Site ______ Date ______	**Waste Minimization Assessment** Proj. No. ______	Prepared By ______ Checked By ______ Sheet ___ of ___ Page ___ of ___

WORKSHEET
4b

WASTE MINIMIZATION:
Parts Cleaning

B. AQUEOUS CLEANERS (continued)

Are the hot tanks/jet spray washers located near the service bays?	☐ yes	☐ no
Do you pre-rinse dirty engine parts in a tank of dirty cleaning solution so as to reduce loading on the clean tank?	☐ yes	☐ no
Do you routinely monitor solution composition and make adjustment accordingly?	☐ yes	☐ no
Do you routinely remove sludge and solids from the tank?	☐ yes	☐ no
Are sludge and solids screened out before they reach the waste sump?	☐ yes	☐ no
Do you use demineralized water for your cleaning bath make-up ?	☐ yes	☐ no
Have you installed still rinses or converted free running rinses to still rinses? Spent rinse water can be used as make-up to your cleaner bath if you use demineralized water.)	☐ yes	☐ no
Is your cleaning tank agitated?	☐ yes	☐ no
If yes, do you use mechanical agitation instead of air agitation?	☐ yes	☐ no
Do you lease your hot tank(s)/jet spray washer(s)?	☐ yes	☐ no
Do you own your hot tanks/jet spray washer(s)?	☐ yes	☐ no
Do you own on-site aqueous waste treatment equipment?	☐ yes	☐ no
Does a hazardous waste hauler collect aqueous waste for recycling or treatment?	☐ yes	☐ no

If not, how is your waste handled and disposed of? ______________________________

____

____

Firm ______ Site ______ Date ______	**Waste Minimization Assessment** Proj. No. ______	Prepared By ______ Checked By ______ Sheet ___ of ___ Page ___ of ___

WORKSHEET
5

OPTION GENERATION:
Parts Cleaning

Meeting Format (e.g., brainstorming, nominal group technique) ______
Meeting Coordinator ______
Meeting Participants ______

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
A. Solvents		
Proper solvent use		
Established guidelines		
Use solvent sinks		
Careful drainage		
Cover tanks		
Lease equipment/service		
Recycle solvent		
B. Aqueous Cleaners		
Dry pre-cleaning		
Use detergents		
Drip trays		
Pre-rinse parts		
Monitor solution		
Remove sludge and solids		
Employ still rinse		
Use demineralized water		
Use mechanical agitation		
Lease equipment		

Firm ______ Site ______ Date ______	**Waste Minimization Assessment** Proj. No. ______	Prepared By ______ Checked By ______ Sheet ___ of ___ Page ___ of ___

WORKSHEET

6a

WASTE MINIMIZATION: Waste Handling

A. ENGINE, LUBRICATING AND COOLING FLUIDS

Do you test fluid quality, including engine, lubricating and cooling fluids, to determine when they should be changed? ☐ yes ☐ no

When fluids must be drained either to requalify in the case of turbine oils or service a part, are they stored in a clean container so they may be used to refill the turbine or recycle the oil? ☐ yes ☐ no

Have you had experience using any longer lasting synthetic motor, lubricating and cooling fluids? ☐ yes ☐ no

If yes, please explain: ______________________________

____

____

Do you currently employ rigid inventory controls to minimize fluid use? ☐ yes ☐ no

Do you have a waste turbine oil and /or coolant management program in place? ☐ yes ☐ no

If yes, please discuss: ______________________________

____

____

Are all waste fluids kept segregated? ☐ yes ☐ no

If no, have you notified your waste hauler or recycler? ☐ yes ☐ no

Have you ever had a load of waste fluid rejected by a hauler or recycler because of cross contamination? ☐ yes ☐ no

Please describe how you store and dispose of waste fluids (motor and lube oils, greases, transmission fluids and spent anti freezes). ______________________________

____

____

B. PAINT APPLICATION

Do you generate large quantities of waste paint or thinner? ☐ yes ☐ no

Do you currently employ rigid inventory controls to minimize material use? ☐ yes ☐ no

Firm ______ Site ______ Date ______	**Waste Minimization Assessment** Proj. No. ______	Prepared By ______ Checked By ______ Sheet ___ of ___ Page ___ of ___

WORKSHEET
6b

WASTE MINIMIZATION: Waste Handling

B. PAINT APPLICATION (continued)

Discuss how implementing more rigid controls could be accomplished in your shop: ______

______

______

Are paints mixed according to need? Is the volume of paint mixed based on the surface area to be painted? ☐ yes ☐ no

Does the design of your mixing equipment prevent you from mixing smaller batches of paint? ☐ yes ☐ no

If specialized mixing equipment procedures were available for mixing smaller batches of paint, would you use them? ☐ yes ☐ no

Have you tried high efficiency spray application equipment in your shop? ☐ yes ☐ no

Did it reduce the amount of paint sprayed? ☐ yes ☐ no

Did it affect finish quality? ☐ yes ☐ no

Descibe how you minimize overspray waste. ______

______

______

C. OTHER WASTES

Does a battery collector remove your used batteries? ☐ yes ☐ no

Do you take used batteries to a storage or recycling facility? ☐ yes ☐ no

Does a recycler or equipment leasing service collect your spent antifreeze? ☐ yes ☐ no

Do you use a collection/recycling system to service air conditioning units? ☐ yes ☐ no

Do you sell or give worn parts to a re-manufacturer? ☐ yes ☐ no

Do you have any suggestions for reducing other wastes? ______

______

______

Firm ____ Site ____ Date ____	Waste Minimization Assessment Proj. No. ____	Prepared By ____ Checked By ____ Sheet ___ of ___ Page ___ of ___

WORKSHEET
7

OPTION GENERATION:
Waste Handling

Meeting Format (e.g., brainstorming, nominal group technique) ____

Meeting Coordinator ____

Meeting Participants ____

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
A. Waste Oils and Coolants		
Test fluid quality		
Store fluids for reuse		
Use longer lasting fluids		
Keep wastes segregated		
Send to recycler		
B. Paint Applications		
Use rigid inventory controls		
Mix smaller batches of paint		
Use high-efficiency sprayer		
Minimize overspray		
C. Other Wastes		
Drain filters and dispose properly		
Recycle batteries		
Collect asbestos dust		
Collect/recycle refrigerant		
Sell or give parts to re-manufacturer		

Firm ____ Site ____ Date ____	**Waste Minimization Assessment** Proj. No. ____	Prepared By ____ Checked By ____ Sheet ___ of ___ Page ___ of ___

WORKSHEET
8a

WASTE MINIMIZATION: Material Substitution

A. ABRASIVE BLASTING

Is the blasting media used in the shop considered hazardous (e.g., lead shot)? ☐ yes ☐ no

If so, can other lesser/non-hazardous materials be substituted?(e.g. plastic media) ☐ yes ☐ no

Describe results of any substitution attempts: ____________________

Are dust suppression/collection systems employed during abrasive blasting? ☐ yes ☐ no

Is this dust collected and recycled or reused? ☐ yes ☐ no

Would the installation of a dust collection system allow for reuse? ☐ yes ☐ no

Explain how blasting dusts are handled and the potential for reuse: ____________________

B. CHEMICAL STRIPPING

Are any chemical stripping agents used in the shops considered hazardous (e.g. chlorinated solvents)? ☐ yes ☐ no

If so, can other non-hazardous materials substitute for the hazardous materials? ☐ yes ☐ no

Describe results of any substitutution attempts: ____________________

Can plastic media blasting or water-jet stripping be used as a substitute stripping operation? ☐ yes ☐ no

Has chemical stripping using a smaller volume of stripper been attempted to reduce overall spent stripping solutions? ☐ yes ☐ no

Describe the results of attempts to use smaller volumes of stripping agent: ____________________

Firm ______ Site ______ Date ______	**Waste Minimization Assessment** Proj. No. ______	Prepared By ______ Checked By ______ Sheet ___ of ___ Page ___ of ___

WORKSHEET

8b

WASTE MINIMIZATION: Material Substitution

C. PAINTING OPERATIONS

Have attempts been made to maximize water-based paints (e.g., for interior painting application)?	❑ yes	❑ no
Have you tried substituting water-based for solvent-based paints?	❑ yes	❑ no
Have attempts been made to substitute paints with lower VOC emissions?	❑ yes	❑ no
Are non-toxic paints available in the market?	❑ yes	❑ no
Can you use non-toxic paints where anti-fouling paints are not required?	❑ yes	❑ no

Describe the results of attempts to substitute paints: ______________________________

____

____

Firm ______ Site ______ Date ______	**Waste Minimization Assessment** Proj. No. ______	Prepared By ______ Checked By ______ Sheet __ of __ Page __ of __

WORKSHEET 9

OPTION GENERATION:
Material Substitution

Meeting Format (e.g., brainstorming, nominal group technique) ______

Meeting Coordinator ______

Meeting Participants ______

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
A. Paint Removal		
Blasting media substitution		
Substitute blasting for chemical stripping		
Less hazardous strippers		
B. Painting Operation		
Use low VOC paints		
Use less toxic paints		
Maximize use of water-based paints		

Firm ______ Site ______ Date ______	Waste Minimization Assessment Proj. No. ______	Prepared By ______ Checked By ______ Sheet ___ of ___ Page ___ of ___

WORKSHEET
10

WASTE MINIMIZATION:
Good Operating Practices

A. GOOD OPERATING PRACTICES

Are plant material balances routinely performed?	❑ yes	❑ no
Are they performed for each material of concern (e.g. solvent) separately?	❑ yes	❑ no
Are records kept of individual wastes with their sources of origin and eventual disposal?	❑ yes	❑ no
Are the operators provided with detailed operating manuals or instruction sets?	❑ yes	❑ no
Are all operator job functions well defined?	❑ yes	❑ no
Are regularly scheduled training programs offered to operators?	❑ yes	❑ no
Are there employee incentive programs related to waste minimization?	❑ yes	❑ no
Does the plant have an established waste minimization program in place?	❑ yes	❑ no
If yes, is a specific person assigned to oversee the success of the program?	❑ yes	❑ no

Discuss goals of the program and results: ______

Has a waste minimization assessment been performed at this plant in the past? If yes, discuss: ______

B. HOUSEKEEPING

Are dirty parts removed and placed on a drip pan instead of directly on the shop floor?	❑ yes	❑ no
Are all work areas kept clean and neat?	❑ yes	❑ no
Do your workers wipe up small spills of fluid as soon as they occur?	❑ yes	❑ no
Do you have an award program for workers who keep their work areas clean (i.e.: prevent leaks and spills)?	❑ yes	❑ no
Do you use a laundry service to clean your rags and uniforms?	❑ yes	❑ no
Do you use a biodegradable detergent for cleaning shop floors?	❑ yes	❑ no
Have you tried using a steam cleaner in place of chemical cleaners?	❑ yes	❑ no
Do you discharge area washdown wastewater to a POTW or industrial sewer, instead of to the storm drain?	❑ yes	❑ no

If no, how is this waste handled? ______

Firm ____ Site ____ Date ____	Waste Minimization Assessment Proj. No. ____	Prepared By ____ Checked By ____ Sheet __ of __ Page __ of __

WORKSHEET 11

OPTION GENERATION: Good Operating Practices

Meeting Format (e.g., brainstorming, nominal group technique) ____
Meeting Coordinator ____
Meeting Participants ____

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
Perform Material Balances		
Keep Records of Waste Sources & Disposition		
Waste/Materials Documentation		
Provide operaing Manuals/Instructions		
Employee Training		
Increased Supervision		
Provide Employee Incentives		
Increase Plant Sanitation		
Establish Waste Minimization Policy		
Set Goals for Source Reduction		
Conduct Annual Assessments		
Use Drip Pans		
Wipe up Spills (Cotton Rags, Paper Towells)		
Keep Bays Clean		
Award Program		
Use Laundry Service		
Use Biodegradible Detergents		
Use Steam Cleaners		
Discharge to POTW/Industrial Sewer		

Appendix A
Marine Maintenance and Repair Yards Assessments
Case Studies of Yards A, B, and C

Case Studies of Marine Maintenance and Repair Facilities

In 1987 the California Department of Health Services commissioned a waste minimization study (Calif. DHS 1987) of three marineyards. The objectives of the waste minimization assessments were to:

- Gather site-specific information concerning the generation, handling, storage, treatment, and disposal of hazardous waste;
- Evaluate existing waste reduction practices;
- Develop recommendations for waste reduction through source control, treatment, and recycling techniques; and
- Assess costs/benefits of existing and recommended waste reduction techniques.

Initially, several marine maintenance and repair yards were contacted to solicit voluntary participation in the audit study. Plant selection emphasized small businesses which generally lack the financial and/or internal technical resources to perform a waste reduction assessment. A relatively large yard was also selected for study because it offered the opportunity to evaluate a wide variety of maintenance and repair services, as well as a number of in-place waste reduction measures. Three yards were assessed.

This Appendix presents summary results of the assessments of the yards here identified as A, B, and C and the potentially useful waste minimization options identified through the assessments. Also included are the practices already in use at the yards that have successfully reduced waste generation from past levels. During each of the marine maintenance and repair yard assessments, the assessment team observed the operations; inspected waste management facilities; interviewed the yard manager, environmental compliance personnel, and operations supervisors; and reviewed and copied records pertinent to waste generation and management.

The original assessments may be obtained from:

Mr. Benjamin Fries
California Department of Health Services
Alternative Technology Division
Toxic Substances Control Program
714/744 P Street
Sacramento, CA 94234-7320
(916) 324-1807

In addition, the results of the waste assessments were used to prepare waste minimization assessment worksheets to be completed by other marineyards in self- assessment. Examples of completed worksheets follow the assessment for Company C.

Summary of Waste Minimization Assessment for Company A

Introduction

Company A is a small-sized business in the marineyard maintenance and repair industry employing six to 12 full-time workers. Approximately 15 ships per year are serviced on one marine railway dry dock and a nearby pier. The largest service contracts are supply boats reaching a length of 185 feet, however, the average vessel serviced is approximately 125 feet in length. Maintenance work is limited to sandblasting, painting, welding, and shaft and propeller repairs; engine repair work is performed by subcontractors. The yard's pier and marine railway serve as a general ship servicing area, while the remainder of the yard contains two large structures used for equipment storage, a plastics shop, a machine shop, two paint storage vaults, and a number of smaller shops. The machine shop has been used intermittently for several years. The company does not have a formal waste minimization program.

Raw Materials Usage

Raw materials used in this yard include epoxy and vinyl primers, antifouling paints, and thinners used for painting and parts cleaning. Paint coatings are applied with airless spray guns. Small amounts of muriatic acid are stored in the machine shop and are used for cleaning. Boat hulls are routinely washed down with chlorine bleach. Minor volumes of lubricating and cutting oils are used in the machine shop and other workshops.

Waste Generation

Waste generation rates at this small yard are relatively low. Exact volumes of individual waste streams could not be determined due to the lack of adequate inventory control. For most painting jobs, paints, thinners and other hazardous materials are ordered by the client with delivery directly to the shipyard. After project completion, excess paint supplies are normally returned to the owner of the vessel.

Thinners kept at the yard are reused until spent. Open cans containing waste thinner were observed during inspection of the paint storage vaults. When the thinner becomes too contaminated to be used for brush and parts cleaning, it is stored in a 1,400-gallon aboveground tank. This tank is on paved ground immediately east of the main equipment storage area. Waste oils generated on site are deposited here as well. The tank is old and was observed to be open to the atmosphere. Several times per year, the liquid waste mixture is pumped out by a waste hauler/recycler. Waste sludge accumulates at the bottom of the tank. Surface spills around the tank are usually adsorbed with beach sand.

Sandblasting takes place immediately above the marine railway dock, which is in direct contact with the water in the harbor. Ships are positioned onto the submerged end of the dock and are winched onto the railways and into the yard. Washed beach sand is used as the sandblasting medium. Resulting fines, consisting of sand and paint, accumulate at the bottom of the railway. Every 6 months, approximately 20 cubic yards of sand are dug out by hand. Ocean tidal action washes part of the waste material fines into the harbor.

Recommendations

Suggested recommendations for waste reduction at Company A are outlined below.

Housekeeping

1. Segregation of Wastes. Wastes generated from similar unit processes should be segregated (e.g., paint thinners, waste solvents, waste kerosene, bilge wastes, etc.). Segregation of waste types facilitates reclamation. A separate container should be maintained for each waste type. Only waste oils should be stored in the 1,400-gallon aboveground tank. A separate 55-gallon drum should be used for the storage of all thinner wastes.

2. Use of Lids on Drums. Tight-fitting lids should be used on all waste storage containers to prevent evaporation loss of volatile substances such as paint thinner. Funnels and pumps should be used to transfer wastes from small to large containers to prevent spillage.

3. Spill Containment. Areas used for the storage of hazardous materials and wastes (particularly the 1,400- gallon storage tank) should be bermed to contain any spills that may occur.

4. Inventory Control. More stringent inventory control practices should be maintained. Inventory should be kept to a minimum. Paints maintained in storage should be used before fresh or unopened paints to minimize the possibility that they will solidify and require disposal in the future. If paints in storage cannot be used for final coats, perhaps they may be used as undercoats.

5. Use of Tarps. Tarps should be used during sandblasting operations to prevent the off-site migration of grit, which, unless controlled with tarps, could wash away with the tide to contaminate sediment. Sandblast grit should then be removed on a periodic basis, preferably at the end of each blasting operation.

6. Manifests. Copies of manifests from the past disposal of hazardous waste could not be produced during the assessment. The importance of a proper waste tracking system cannot be overemphasized. Moreover, it is the responsibility of the yard owner or operator to provide proper documentation regarding the types and volumes of hazardous wastes generated, and the disposal or reclamation practices utilized for those wastes.

Off-Site Reclamation

1. Solvent Reclamation Services. There are several services available which offer full service, from the purchase of paints and thinners to the disposal of waste materials. For convenience, a service such as this may be feasible for both the purchase and disposal of waste materials.

2. Paint Gun Cleaning. At least one solvent recycling company provides a self-contained paint gun cleaning unit that reuses thinner for the cleaning of paint application guns and other painting equipment. Periodically, the unit is serviced by the company, and spent thinners are replaced with new material. Wastes are then hauled away by the company. This service minimizes the possibility for solvents to be managed improperly, extends the useful life of the solvent, and ensures that wastes are reclaimed. Some recycling services also provide parts washers for operations in which recycled solvents are used for degreasing.

3. Waste Exchanges. Waste exchanges may be outlets for selling surplus or leftover paint.

On-Site Reclamation

1. Collection of Thinner Wastes. As discussed above, thinners and solvents should be collected in a single container. Under quiescent conditions within the drum, the sludge settles on the bottom, leaving the reusable solvent at the surface. The solvent can then be decanted from the drum and reused for cleaning equipment or for other uses where a high-quality material is not needed. This process can be used to extend the life of thinner and reduce the quantity of hazardous waste generated by the facility.

2. Distillation of Spent Solvents. On-site distillation can be used to recover spent solvents. There are several commercial distillation units that are available for commercial application.

3. On-Site Separation of Bilge Wastes. On-site treatment of bilge wastes will reduce the volume of wastes hauled from the yard. Oil can be separated from waste water using an oil/water separator. The water can then be sewered and the concentrated oil disposed of through a reclamation facility.

Product Substitution

1. Substitution for Solvent-Based Paints. At the present time, there are paint manufacturers which offer a water-based paint as a substitute for solvent-based paints. Water-based paints are less volatile and the equipment used to apply the paints can be cleaned using water instead of solvents. The rinsate generated from cleaning is generally sewerable. Hence, it is advantageous to maximize the use of water-based paints as an alternate to solvent-based paints.

2. Hand Scraping. Wherever practical, hull surfaces should be prepared for painting by hand scraping rather than by sandblasting. The higher labor cost of hand scraping may be offset by the savings in waste management costs. Air-powered mechanical vibrating scrapers may be a viable alternative.

Summary of Waste Minimization Assessment for Company B

Introduction

Company B is a medium-sized operation in the marineyard maintenance and repair industry. Depending on business, the yard employs 25 to 100 workers. Approximately 80 percent of all projects are derived from a master ship repair contract with the United States Navy, which requires in part the removal and disposal of all hazardous wastes on board all vessels. Over 10 naval vessels per year are serviced either at the boat shop or the nearby naval shipyard. Only ships up to 200 feet in length are serviced at the boat shop. The shipyard is bound under contract to utilize paints which meet Navy requirements. In addition, paints are typically ordered directly by the owner of the ship for delivery at the shipyard.

Two large and one smaller marine railway dry docks and a 1,000-ton floating dry dock are used for ship maintenance and repair. In addition, three piers are used for boat storage and servicing. The remainder of the yard consists of a machine shop, welding shop, pipe fitter's shop, carpenter's shop, sheds for painting and equipment storage, and several administrative offices.

Raw Materials Usage

Raw materials used at this yard include epoxy thinners, epoxy and vinyl paints, several solvents, and a variety of oils. The epoxy thinners and paints are utilized in painting. The paints are applied with airless spray guns. Paint usage is approximately 2,000 gallons per year. Since the bulk of the paints and thinners is supplied by the boat owners, some paints are stored in a metal shed. Excess paints are either returned to the ship owners or stored and used for touch-up jobs.

Cleaning solvents, such as kerosene and paint thinner, are utilized in the machine and pipe fitter's shop for parts cleaning at a rate of approximately 55 gallons per month. Waste solvents are stored in 55-gallon drums. Cutting, lubricating, and hydraulic oils are each used in the various shops at rates of approximately 5 gallons per year.

Waste Materials

The majority of hazardous liquid wastes is generated in conjunction with ship cleaning and painting operations. Approximately 15,000 gallons of contaminated water are annually removed from ship bilges, double bottoms, and tank bottoms. This wastewater contains varying amounts of oils, greases, solvents, and sludges. These liquids are pumped directly from the vessels into a waste hauler's tank truck.

Asbestos-containing materials (ACMs) are removed from those sections of Navy ships that are serviced. Abatement procedures adhere to strict government standards. Approximately 20 pounds of ACM are generated monthly. ACMs are double bagged and stored in an on-site container provided by a certified abatement contractor.

Another waste stream is generated in the machine/pipe fitting shop. A 250-gallon sump serves as a catch basin for waste oils and solvents and steam cleaning wastes. In addition, a 200-gallon per day holding tank is located on paved ground between the shop area and the piers. This aboveground tank is often used to store contaminated water and waste solvents. Contents of the sump and day holding tank are pumped out by a waste hauler after the bilge wastes have been removed from a vessel anchored at the pier. While the hazardous waste manifest provided by the disposal contractor specifies the total amount of waste removed, it does not quantify the volumes of waste obtained from the sump or the day holding tank.

Paint wastes are generated at a rate of about 50 gallons per month and consist of waste thinners, spent solvents, and paint pigments. A 55-gallon drum located near the paint shop serves as a waste storage container. Empty paint cans are left exposed to the atmosphere for a minimum of 24 hours before they are crushed and disposed of as rubbish.

Exterior hull cleaning operations are performed on the marine railways. Barnacles and algae are hand-scraped followed by a sand or water blast. Some of the sandblasting wastes get swept into the harbor during washdowns.

Recommendations

Suggested recommendations for waste reduction at Company B are outlined below.

Housekeeping

1. *Segregation of Wastes.* Wastes generated from similar unit processes should be segregated (e.g., paint thinners, waste solvents, waste kerosene, bilge wastes, etc.). Segregation of waste types facilitates reclamation. A separate container should be maintained for each waste type.

2. *Inventory Control.* More stringent inventory control practices should be maintained. Paints maintained in storage should be used before newer paints to minimize the possibility that they will solidify and require disposal in the future. If stored paints cannot be used for final coats, they can possibly be used as undercoats.

3. *Thinner Waste Collection and Reuse.* Spent thinners used for cleaning of painting equipment should be collected in a single 55-gallon container. The thinner will separate, with the paint sludge settling on the bottom. The clear thinner on the top can then be decanted and reused.

4. *Use of Tarps.* Tarps should be used during sandblasting operations to prevent the off-site migration of grit. Sandblast grit should then be removed on a periodic basis, preferably at the end of each blasting.

Off-Site Reclamation

1. *Solvent Reclamation* Service. Currently, there are several services available that provide paints and thinners and also provide a solvent reclamation service.

2. *Paint Gun Cleaning.* At least one recycler provides a self-contained paint gun cleaning unit which reuses thinner. Periodically, the unit is serviced by the company, and spent thinners are replaced with new material; wastes are then hauled away by the company. Some vendors also provide parts washers for operations in which solvents are used for degreasing.

3. *Waste Exchange.* Waste exchanges may be an outlet for selling surplus or leftover paint.

On-Site Reclamation

1. *Collection of Thinner and Solvent Wastes.* As discussed above, thinners and solvents should be collected in a single drum and allowed to separate under quiescent conditions. The clear thinner can then be reused for cleaning operations.

2. *Distillation of Spent Solvents.* On-site distillation can be used to recover spent solvents. There are several commercial distillation units which are available for commercial application.

3. *On-Site Separation of Bilge Wastes.* On-site treatment of bilge wastes will reduce the volume of wastes hauled from the yard. Oil can be separated from waste using an oil/water separator. The water can then be sewered and the concentrated oil disposed of by a reclamation facility.

4. *Recover and Reuse Blasting Medium.* Blasting medium should be recovered and reused. A cyclonic separator can be used to separate paint chips from blasting grit.

Summary of Waste Minimization Assessment for Company C

Introduction

Company C is representative of a small- to medium-sized marine shipyard. It services recreational boats, and performs all boat-related maintenance work such as painting, sandblasting, fiberglassing, and engine, shaft, and rudder repair. Approximately 500 boats and yachts up to 52 feet in length are serviced at this yard annually. The yard has an administrative office building that also houses a retail store for boat parts and accessories. Attached to this building are a machine shop and an engine repair shop. Near this structure is a wooden shack used for the storage of 55-gallon drums of polyester resin, lacquer thinner, acetone, and waste solvent. Another storage shed is located near the pier and houses 55-gallon drums of lubricating and hydraulic oil. At the pier, a travel lift, which is anchored, is used to hoist the boats onto the yard where most of the maintenance work is performed.

Raw Materials Usage

Many different raw materials are used at this yard. Paints and lacquer thinners are utilized for painting operations. Approximately 3 gallons of copper-based antifouling paint are used per day, and thinners are used at a rate of about 5 gallons per month. Leftover paint is stored and applied on touch-up jobs. Polyester resin utilized for fiberglass boat repair is consumed at a rate of approximately 200 gallons per year, and acetone and lacquer thinner at rates of 50 and 450 gallons per year, respectively. Acetone is used to wipe down boat surfaces and remove moisture before paint application. Lacquer thinner is typically utilized for the removal of overspray and wax from painted surfaces.

In the machine and engine repair shops, a closed system cleaning solvent bath has been installed and is used for degreasing machine and engine parts. A recycling service picks up 30 gallons of spent solvent each month. Hydraulic and lubricating oils are consumed at rates of 50 and 100 gallons per year, respectively.

Waste Materials

Several hazardous waste streams are generated at this yard. Solvent and thinner wastes are produced at a rate of approximately 80 gallons per year. Much of the acetone and lacquer thinner is lost due to evaporation during boat surface preparation. The remainder is stored in a 55-gallon waste solvent drum, which is picked up by a hazardous waste contractor every 6 months.

A second solvent waste stream is generated in the machine and engine repair shop. The shop is equipped with a solvent bath utilized for parts and tool cleaning. A waste solvent recycling service picks up about 20 gallons of spent solvent per month and replaces it with fresh solvent. This parts cleaning method minimizes solvent loss due to spillage and evaporation.

Waste oils are generated at approximately 20 gallons per month as a result of engine maintenance operations. The waste oil is stored in drums and is taken to a local service station once monthly, old boat batteries are sold to a battery shop for recycling. Empty paint cans are stored on site, until the residual paint has dried, and are then discarded as rubbish.

Recommendations

Suggested recommendations for waste reduction at Company C are outlined below.

Housekeeping

The housekeeping practices at this yard are, for the most part, excellent. There are, however, several hazardous waste management practices that can be implemented to improve those practices.

1. *Manifests.* Copies of manifests from the past disposal of hazardous waste could not be produced during the assessments. The importance of a proper waste tracking system cannot be overemphasized.

2. *Inventory Control.* Although it appears that inventory is tightly controlled at this facility, additional practices may be implemented to minimize the volume of hazardous waste generated. The quantity of paint required to complete a job is often less than the volume of paint purchased. Paint that is left over is stored in the original sealed containers and used for touch-up as needed in future jobs.

It is possible that a paint which is left unused over a period of time will eventually dry. Since many of these paints are metal-based, they should be disposed of as a hazardous waste. Waste (or spent) paints should therefore be collected and saved for disposal as a hazardous waste. It is recommended that spent paints be collected in a single drum for reclamation or disposal. In order to minimize the volume of hazardous waste generated, spent paints can be used for base coats or in other applications where appearance is not important.

On-Site Reclamation

1. *Separation of Solvent/Thinner Wastes.* At present, thinners and solvents used to clean paint application equipment are collected and stored in a 55-gallon drum. Periodically, this drum is hauled off site by a registered hazardous waste hauler.

Under the quiescent conditions within the drum, separation occurs with the sludge settling to the bottom and reusable solvent at the surface, which can be decanted from the drum and reused for cleaning equipment. This process can be used to extend the life of thinner and reduce the quantity of hazardous waste generated by the facility.

2 . *Distillation.* Distillation can be used to treat solvent and thinner wastes. Distillation units that can be used to reclaim spent solvents are commercially available. A high-quality thinner or solvent that can be reused is recovered from the unit. The remaining sludge is then managed as a hazardous waste. The economics of on-site distillation and recovery of solvent or thinner may be comparable to the costs associated with the purchase of new thinner and the disposal of spent materials.

Off-Site Reclamation

1. *Paint Gun Cleaning Services.* At least one recycler offers a paint gun cleaning service similar in principle to the parts washing service. A self-contained paint gun cleaner is provided to the customer. Periodically, thinner within the cleaner is removed and replaced with clean material. This service minimizes the possibility for solvents to be managed improperly, extends the useful life of the solvent, and ensures that wastes are reclaimed.

2. *Solvent Reclamation Services.* There are several companies that offer full service from the purchase of paints and thinners to the disposal of waste materials. For convenience, a service such as this may be feasible for both the purchase and disposal of waste materials.

Product Substitution

1. *Substitute Water-Based Paints.* There are paint manufacturers which offer water-based paint as a substitute for solvent-based paints. Water-based paints are less volatile and the equipment used to apply the paints can be cleaned using water instead of solvents. The rinsate generated from cleaning is generally sewerable. Hence, it is advantageous to maximize the use of water-based paints as an alternate to solvent-based paints.

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WORKSHEET
1a

WASTE SOURCES

Shop Clean-Up	Significance at Plant		
	Low	Medium	High
Obsolete raw materials	X		
Spills & leaks (liquids)	X		
Spills (powders)	X		
Dirty rags	X		
Used sawdust	X		
Area wash water		X	
Clarifier sludges		X	
Container disposal (metal)	X		
Container disposal (paper/plastic)	X		
Pipeline/tank drainage	X		
Evaporative losses		X	
Other			

Parts Cleaning	Low	Medium	High
Spent solvent cleaner		X	
Spent carburetor cleaner	X		
Spent brake cleaner			
Evaporative losses	X		
Leaks and spills (solvents)	X		
Spent alkaline cleaner	X		
Leaks and spills (alkali)	X		
Rinse water discharge	X		
Sludges	X		
Filter waste	X		

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WORKSHEET

1b

WASTE SOURCES

Maintenance Shop Wastes	Significance at Plant		
	Low	Medium	High
Motor oil	X		
Oil filters	X		
Gear and lube oils	X		
Transmission fluid	X		
~~Brake fluid~~ Not applicable			
Radiator coolant	X		
Gasoline	X		
~~Brakes (asbestos)~~ Not applicable			
Radiators (lead)	X		
Batteries (lead & acid)	X		
Junk parts	X		
Abrasive paint stripping wastes		X	
Organic chemical stripping wastes		X	
Inorganic chemical stripping wastes	X		
Paint overspray		X	
Electroplating wastes	X		
Fiberglass fabrication (solvent) wastes	X		
Fiberglass fabrication (gelcoat) wastes	X		
Fiberglass roving/chopping dusts	X		
Paint thinner		X	

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WORKSHEET

2a

WASTE MINIMIZATION:
Material Handling

A. DRUMS, CONTAINERS, AND PACKAGES

Are drums, packages and containers inspected for damage before being accepted? ☒ yes ☐ no

Are employees trained in ways to safely handle the types of drums and packages received? ☒ yes ☐ no

Are they properly trained in handling of spilled raw materials? ☒ yes ☐ no

Is there a formal personnel training program on raw material handling, spill prevention proper storage techniques, and waste handling procedures? ☐ yes ☒ no

Describe handling procedures for damaged items: Return to vendor

How often is training given and by whom? New hire is trained by supervisor

Is obsolete raw material returned to the supplier? ☒ yes ☐ no

Is inventory used in first-in first-out order? ☒ yes ☐ no

Is the inventory system computerized? ☐ yes ☒ no

Does the current inventory control system adequately prevent waste generation? ☒ yes ☐ no

What information does the system track? Quantity received, date received, expiration date, date and amount used

Are stored items protected from damage, contamination, or exposure to rain, snow, sun and heat? ☒ yes ☐ no

Is the dispensing of raw materials supervised and controlled? ☒ yes ☐ no

Are users required to return empty containers before being issued new supplies? ☐ yes ☒ no

Do you maintain and enforce a clear policy of using raw materials only for their intended use? ☒ yes ☐ no

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WORKSHEET 2b

WASTE MINIMIZATION: Material Handling

B. BULK LIQUIDS HANDLING

What safeguards are in place to prevent spills and avoid ground contamination during the filling of storage tanks?

- High level shutdown/alarms ☐
- Flow totalizers with cutoff ☐
- Secondary containment ☒
- Other ☐

Describe the system: ____

Are air emissions from solvent storage tanks controlled by means of:

Conservation vents	☐ yes	☒ no
Nitrogen blanketing	☐ yes	☒ no
Absorber/Condenser	☐ yes	☒ no
Other vapor loss control system	☐ yes	☒ no

Describe the system: ____

Are all storage tanks routinely monitored for leaks? If yes, describe procedure and monitoring frequency for above-ground/vaulted tanks: Visual during daily walk-around

Underground tanks: Not applicable

How are the liquids in these tanks dispensed to the users? (i.e., in small containers or hard piped.) 1-gallon or 5-gallon containers

What measures are employed to prevent the spillage of liquids being dispensed? ____

When a spill of liquid occurs in the facility, what cleanup methods are employed (e.g., wet or dry)? Also discuss the way in which the resulting wastes are handled: Adsorbed with sand. Oily sand disposed of as hazardous waste.

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WORKSHEET 3

OPTION GENERATION: Material Handling

Meeting Format (e.g., brainstorming, nominal group technique) ____
Meeting Coordinator ____
Meeting Participants ____

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
A. Drums, Containers, and Packages		
Raw Material Inspection	Y	
Proper Storage/Handling	Y	
Return Obsolete Material to Supplier	Y	Some suppliers won't accept
Minimize Inventory	Y	Order paints as needed
Computerize Inventory	N	
Formal Training	N	Done informally
Waste Segregation	Y	
B. Bulk Liquids Handling		
High Level Shutdown/Alarm	N	
Flow Totalizers with Cutoff	N	
Secondary Containment	N	Plan to install more berms
Air Emission Control	N	
Leak Monitoring	Y	

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WORKSHEET

4a

WASTE MINIMIZATION:
Parts Cleaning

A. SOLVENTS

Do you use parts cleaning solvent for uses other than cleaning parts?	☐ yes	☒ no
Have you established guidelines as to when parts should be cleaned with solvents?	☐ yes	☒ no
Do you use solvent sinks instead of pails or dunk buckets?	☒ yes	☐ no
Are solvent sinks and/or buckets located near service bays?	☒ yes	☐ no
Do you allow cleaned parts to drain inside the sink for a few minutes to minimize dripping of residual solvent onto the shop floor?	☒ yes	☐ no
Are you careful when immersing and removing parts from the solvent bath so as not to create splashes?	☒ yes	☐ no
Do you keep all solvent sinks/buckets covered when not in use?	☒ yes	☐ no
Do you lease your solvent sinks?	☒ yes	☐ no
If yes, does your lease include solvent supply and spent solvent waste handling?	☒ yes	☐ no
If you own your solvent sinks, does a registered waste hauler collect your dirty solvent for recycling or treatment?	☐ yes	☐ no
Do you own on-site solvent recovery equipment such as a distillation unit?	☐ yes	☒ no

If yes, how are the solvent residues handled? ____

What other methods are you using to reduce solvent use/waste? ____

B. AQUEOUS CLEANERS

Do you use dry pre-cleaning methods such as baking and/or wire brushing to reduce loading on the aqueous cleaner?	☐ yes	☒ no
Have you switched from caustic-based cleaning solutions to detergent-based cleaners?	☒ yes	☐ no
Do you use drip trays on hot tanks to minimize the amount of cleaner dripped on the floor?	☐ yes	☒ no

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WORKSHEET

4b

WASTE MINIMIZATION:
Parts Cleaning

B. AQUEOUS CLEANERS (continued)

Are the hot tanks/jet spray washers located near the service bays?	☒ yes	☐ no
Do you pre-rinse dirty engine parts in a tank of dirty cleaning solution so as to reduce loading on the clean tank?	☐ yes	☒ no
Do you routinely monitor solution composition and make adjustment accordingly?	☒ yes	☐ no
Do you routinely remove sludge and solids from the tank?	☒ yes	☐ no
Are sludge and solids screened out before they reach the waste sump?	☐ yes	☒ no
Do you use demineralized water for your cleaning bath make-up ?	☐ yes	☒ no
Have you installed still rinses or converted free running rinses to still rinses? Spent rinse water can be used as make-up to your cleaner bath if you use demineralized water.)	☐ yes	☒ no
Is your cleaning tank agitated?	☒ yes	☐ no
If yes, do you use mechanical agitation instead of air agitation?	☐ yes	☒ no
Do you lease your hot tank(s)/jet spray washer(s)?	☒ yes	☐ no
Do you own your hot tanks/jet spray washer(s)?	☐ yes	☒ no
Do you own on-site aqueous waste treatment equipment?	☒ yes	☐ no
Does a hazardous waste hauler collect aqueous waste for recycling or treatment?	☒ yes	☐ no

If not, how is your waste handled and disposed of?______________________________

____

____

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WORKSHEET 5

OPTION GENERATION: Parts Cleaning

Meeting Format (e.g., brainstorming, nominal group technique) Brainstorming

Meeting Coordinator ____

Meeting Participants ____

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
A. Solvents		
Proper solvent use	Y	
Established guidelines	N	Foremen should write up these
Use solvent sinks	Y	
Careful drainage	Y	
Cover tanks	Y	Need to remind workers
Lease equipment/service	Y	
Recycle solvent	Y	Done by contractor
B. Aqueous Cleaners		
Dry pre-cleaning	N	Need to do this as routine
Use detergents	Y	
Drip trays	N	Not a big problem
Pre-rinse parts	N	Look into possible savings
Monitor solution	Y	
Remove sludge and solids	Y	
Employ still rinse	N	Look into this
Use demineralized water	N	Too expensive
Use mechanical agitation	N	Safety concern
Lease equipment	N	Already own this

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WORKSHEET 6a

WASTE MINIMIZATION: Waste Handling

A. ENGINE, LUBRICATING AND COOLING FLUIDS

Do you test fluid quality, including engine, lubricating and cooling fluids, to determine when they should be changed? ☐ yes ☒ no

When fluids must be drained either to requalify in the case of turbine oils or service a part, are they stored in a clean container so they may be used to refill the turbine or recycle the oil? ☐ yes ☒ no

Have you had experience using any longer lasting synthetic motor, lubricating and cooling fluids? ☐ yes ☒ no

If yes, please explain: ____

Do you currently employ rigid inventory controls to minimize fluid use? ☐ yes ☒ no

Do you have a waste turbine oil and /or coolant management program in place? ☐ yes ☒ no

If yes, please discuss: ____

Are all waste fluids kept segregated? ☐ yes ☒ no

If no, have you notified your waste hauler or recycler? ☒ yes ☐ no

Have you ever had a load of waste fluid rejected by a hauler or recycler because of cross contamination? ☐ yes ☒ no

Please describe how you store and dispose of waste fluids (motor and lube oils, greases, transmission fluids and spent anti freezes). *All wastes are put into a common tank and hauled off*

B. PAINT APPLICATION

Do you generate large quantities of waste paint or thinner? ☐ yes ☒ no

Do you currently employ rigid inventory controls to minimize material use? ☒ yes ☐ no

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WORKSHEET 6b

WASTE MINIMIZATION: Waste Handling

B. PAINT APPLICATION (continued)

Discuss how implementing more rigid controls could be accomplished in your shop: Not applicable.

Are paints mixed according to need? Is the volume of paint mixed based on the surface area to be painted? ☒ yes ☐ no

Does the design of your mixing equipment prevent you from mixing smaller batches of paint? ☐ yes ☒ no

If specialized mixing equipment procedures were available for mixing smaller batches of paint, would you use them? ☐ yes ☒ no

Have you tried high efficiency spray application equipment in your shop? ☐ yes ☒ no

Did it reduce the amount of paint sprayed? ☐ yes ☐ no

Did it affect finish quality? ☐ yes ☐ no

Descibe how you minimize overspray waste. Show new painters how to use spray gun.

C. OTHER WASTES

Does a battery collector remove your used batteries? ☒ yes ☐ no

Do you take used batteries to a storage or recycling facility? ☐ yes ☒ no

Does a recycler or equipment leasing service collect your spent antifreeze? ☐ yes ☒ no

Do you use a collection/recycling system to service air conditioning units? ☐ yes ☒ no

Do you sell or give worn parts to a re-manufacturer? ☐ yes ☒ no

Do you have any suggestions for reducing other wastes? ______

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WORKSHEET 7

OPTION GENERATION:
Waste Handling

Meeting Format (e.g., brainstorming, nominal group technique) Brainstorm
Meeting Coordinator
Meeting Participants

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
A. Waste Oils and Coolants		
Test fluid quality	N	Could add as a service
Store fluids for reuse	N	Not enough to justify
Use longer lasting fluids	N	Customer specifies fluids
Keep wastes segregated	N	Should look into this
Send to recycler	N	Fluids now burned
B. Paint Applications		
Use rigid inventory controls	N	Customer provides paint
Mix smaller batches of paint	N	
Use high-efficiency sprayer	N	Evaluate possible savings
Minimize overspray	Y	
C. Other Wastes		
Drain filters and dispose properly	Y	
Recycle batteries	Y	Battery collector does this
Collect asbestos dust	Y	Specialized contractor does this
Collect/recycle refrigerant	N	Don't service A/C units
Sell or give parts to re-manufacturer	N	Contact re-manufacturer about
		interest

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WORKSHEET 8a

WASTE MINIMIZATION: Material Substitution

A. ABRASIVE BLASTING

Is the blasting media used in the shop considered hazardous (e.g., lead shot)? ☐ yes ☒ no

If so, can other lesser/non-hazardous materials be substituted?(e.g. plastic media) ☐ yes ☐ no

Describe results of any substitution attempts: ______

Are dust suppression/collection systems employed during abrasive blasting? ☐ yes ☒ no

Is this dust collected and recycled or reused? ☐ yes ☒ no

Would the installation of a dust collection system allow for reuse? ☐ yes ☒ no

Explain how blasting dusts are handled and the potential for reuse: Collected and hauled off. Reuse is not economical

B. CHEMICAL STRIPPING

Are any chemical stripping agents used in the shops considered hazardous (e.g. chlorinated solvents)? ☒ yes ☐ no

If so, can other non-hazardous materials substitute for the hazardous materials? ☐ yes ☐ no

Describe results of any substitututlon attempts: Have not tested others

Can plastic media blasting or water-jet stripping be used as a substitute stripping operation? ☒ yes ☐ no

Has chemical stripping using a smaller volume of stripper been attempted to reduce overall spent stripping solutions? ☐ yes ☒ no

Describe the results of attempts to use smaller volumes of stripping agent: ______

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WORKSHEET
8b

WASTE MINIMIZATION: Material Substitution

C. PAINTING OPERATIONS

Have attempts been made to maximize water-based paints (e.g., for interior painting application)?	☒ yes	☐ no
Have you tried substituting water-based for solvent-based paints?	☐ yes	☒ no
Have attempts been made to substitute paints with lower VOC emissions?	☒ yes	☐ no
Are non-toxic paints available in the market?	☒ yes	☐ no
Can you use non-toxic paints where anti-fouling paints are not required?	☒ yes	☐ no

Describe the results of attempts to substitute paints: *Must talk to each customer about changing the type of paint*

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WORKSHEET 9

OPTION GENERATION: Material Substitution

Meeting Format (e.g., brainstorming, nominal group technique) ______

Meeting Coordinator ______

Meeting Participants ______

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
A. Paint Removal		
Blasting media substitution	N	Sand is cheap
Substitute blasting for chemical stripping	Y	
Less hazardous strippers	Y	Use these when practical
B. Painting Operation		
Use low VOC paints	Y	
Use less toxic paints	Y	
Maximize use of water-based paints	Y	

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WORKSHEET
10

WASTE MINIMIZATION:
Good Operating Practices

A. GOOD OPERATING PRACTICES

Are plant material balances routinely performed?	☐ yes	☒ no
Are they performed for each material of concern (e.g. solvent) separately?	☐ yes	☒ no
Are records kept of individual wastes with their sources of origin and eventual disposal?	☐ yes	☒ no
Are the operators provided with detailed operating manuals or instruction sets?	☒ yes	☐ no
Are all operator job functions well defined?	☒ yes	☐ no
Are regularly scheduled training programs offered to operators?	☐ yes	☒ no
Are there employee incentive programs related to waste minimization?	☒ yes	☐ no
Does the plant have an established waste minimization program in place?	☒ yes	☐ no
If yes, is a specific person assigned to oversee the success of the program?	☒ yes	☐ no

Discuss goals of the program and results: Just started the program, which is overseen by the yard manager

Has a waste minimization assessment been performed at this plant in the past? If yes, discuss: No

B. HOUSEKEEPING

Are dirty parts removed and placed on a drip pan instead of directly on the shop floor?	☒ yes	☐ no
Are all work areas kept clean and neat?	☒ yes	☐ no
Do your workers wipe up small spills of fluid as soon as they occur?	☒ yes	☐ no
Do you have an award program for workers who keep their work areas clean (i.e.: prevent leaks and spills)?	☐ yes	☒ no
Do you use a laundry service to clean your rags and uniforms?	☒ yes	☐ no
Do you use a biodegradable detergent for cleaning shop floors?	☒ yes	☐ no
Have you tried using a steam cleaner in place of chemical cleaners?	☐ yes	☒ no
Do you discharge area washdown wastewater to a POTW or industrial sewer, instead of to the storm drain?	☒ yes	☐ no

If no, how is this waste handled? ____

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WORKSHEET 11

OPTION GENERATION: Good Operating Practices

Meeting Format (e.g., brainstorming, nominal group technique) Brainstorming
Meeting Coordinator ______
Meeting Participants ______

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
A. General		
Perform Material Balances	N	
Keep Records of Waste Sources & Disposition	N	
Waste/Materials Documentation	Y	manifests only
Provide Operating Manuals/Instructions	Y	
Employee Training	Y	Not regularly scheduled
Increased Supervision	N	Have not increased
Provide Employee Incentives	Y	
Increase Plant Sanitation		
Establish Waste Minimization Policy	Y	
Set Goals for Source Reduction	N	Will consider setting goals
Set Goals for Recycling	N	" " " "
Conduct Annual Assessments	N	Considering this
Use Drip Plans	Y	Not all areas do this now
Wipe up Spills (cotton rags, paper towels)	Y	
Keep Bays Clean	Y	Varies among shops
Award Program	N	This might help housekeeping
Use Laundry Service	Y	
Use Biodegradable detergents	Y	
Use Steam Cleaners	N	
Discharge to POTW/Industrial Sewer	Y	

Appendix B
Where to Get Help
Further Information on Pollution Prevention

Additional information on source reduction, reuse and recycling approaches to pollution prevention is available in EPA reports listed in this section, and through state programs and regional EPA offices (listed below) that offer technical and/or financial assistance in the areas of pollution prevention and treatment.

Waste exchanges have been established in some areas of the U.S. to put waste generators in contact with potential users of the waste. Twenty-four exchanges operating in the U.S. and Canada are listed.

U.S. EPA Reports on Waste Minimization

Waste Minimization Opportunity Assessment Manual. EPA/625/7-88/003.***

Waste Minimization Audit Report: Case Studies of Corrosive and Heavy Metal Waste Minimization Audit at a Specialty Steel Manufacturing Complex. Executive Summary. NTIS No. PB88 - 107180*

Waste Minimization Audit Report: Case Studies of Minimization of Solvent Waste for Parts Cleaning and from Electronic Capacitor Manufacturing Operation. Executive Summary. NTIS No. PB87 - 227013*

Waste Minimization Audit Report: Case Studies of Minimization of Cyanide Wastes from Electroplating Operations. Executive Summary. EPA No. PB87 -229662.*

Report to Congress: Waste Minimization, Vols. I and II. EPA/530-SW-86-033 and-034 Washington, D.C.:U.S.EPA, 1986.**

Waste Minimization - Issues and Options, Vols. I-III EPA/530-SW-86-041 through -043. Washington, D.C.: U.S.EPA, 1986.**

* Executive Summary available from EPA, CERI, Publications Unit, 26 West Martin Luther King Drive, Cincinnati, OH, 45268; full report available from the National Technical Information Service (NTIS), U.S. Department of Commerce, Springield, VA 22161.

** Available from the National Technical Information Service as a five volume set, NTIS NO. PB-87-114-328.

*** Available from EPA, CERI, Publications Unit, 26 West Martin Luther King Drive, Cincinnati, OH 45268, (513) 569-7562.

The Guides to Pollution Prevention manuals*** describe waste minimization options for specific industries. This is a continuing series which currently includes the following titles:

Guides to Pollution Prevention Paint Manufacturing Industry. EPA/625/7-90/005.

Guides to Pollution Prevention The Pesticide Formulating Industry. EPA/625/7-90/004.

Guides to Pollution Prevention The Commercial Printing Industry. EPA/625/7-90/008.

Guides to Pollution Prevention The Fabricated Metal Industry. EPA/625/7-90/006.

Guides to Pollution Prevention For Selected Hospital Waste Streams. EPA/625/7-90/009.

Guides to Pollution Prevention Research and Educational Institutions. EPA/625/7-90/010.

Guides to Pollution Prevention The Printed Circuit Board Manufacturing Industry. EPA/625/7-90/007.

Guides to Pollution Prevention The Pharmaceutical Industry. EPA/625/7-91/017.

Guides to Pollution Prevention The Photoprocessing Industry. EPA/625/7-91/012.

Guides to Pollution Prevention The Fiberglass Reinforced and Composite Plastic Industry. EPA/625/7-91/014.

Guides to Pollution Prevention The Automotive Repair Industry. EPA/625/7-91/013.

Guides to Pollution Prevention The Automotive Refinishing Industry. EPA/625/7-91/016.

U.S. EPA Pollution Prevention Information Clearing House (PPIC): *Electronic Information Exchange System (EIES) - User Guide, Version 1.1*. EPA/600/9-89/086

Waste Reduction Technical/ Financial Assistance Programs

The EPA Pollution Prevention Information Clearinghouse (PPIC) was established to encourage waste reduction through technology transfer, education, and public awareness. PPIC collects and disseminates technical and other information about pollution prevention through a telephone hotline and an electronic information exchange network. Indexed bibliographies and abstracts of reports, publications, and case studies about pollution prevention are available. PPIC also lists a calendar of pertinent conferences and seminars; information about activities abroad and a directory of waste exchanges. Its Pollution Prevention Information Exchange System (PIES) can be accessed electronically 24 hours a day without fees.

For more information contact:

PIES Technical Assistance
Science Applications International Corp.
8400 Westpark Drive
McLean, VA 22102
(703) 821-4800

or

U.S. Environmental Protection Agency
401 M Street S. W.
Washington, D. C. 20460

Myles E. Morse
Office of Environmental Engineering
and Technology Demonstration
(202) 475-7161

Priscilla Flattery
Pollution Prevention Office
(202) 245-3557

The EPA's Office of Solid Waste and Emergency Response has a telephone call-in service to answer questions regarding RCRA and Superfund (CERCLA). The telephone numbers are:

(800) 242-9346 (outside the District of Columbia)

(202) 382-3000 (in the District of Columbia)

The following programs offer technical and/or financial assistance for waste minimization and treatment.

Alabama
Hazardous Material Management and Resources Recovery Program
University of Alabama
P.O. Box 6373
Tuscaloosa, AL 35487-6373
(205) 348-8401

Alaska
Alaska Health Project
Waste Reduction Assistance Program
431 West Seventh Avenue, Suite 101
Anchorage, AK 99501
(907) 276-2864

Arkansas
Arkansas Industrial Development Commission
One State Capitol Mall
Little Rock, AR 72201
(501) 371-1370

California
Alternative Technology Division
Toxic Substances Control Program
California State Department of Health Services
714/744 P Street
Sacramento, CA 94234-7320
(916) 324-1807

Connecticut
Connecticut Hazardous Waste Management Service
Suite 360
900 Asylum Avenue
Hartford, CT 06105
(203) 244-2007

Florida
Waste Reduction Assistance Program
Florida Department of Environmental Regulation
2600 Blair Stone Road
Tallahassee, FL 32399-2400
(904) 488-0300

Georgia
Hazardous Waste Technical Assistance Program
Georgia Institute of Technology
Georgia Technical Research Institute
Environmental Health and Safety Division
O'Keefe Building, Room 027
Atlanta, GA 30332
(404) 894-3806

Environmental Protection Division
Georgia Department of Natural Resources
Floyd Towers East, Suite 1154
205 Butler Street
Atlanta, GA 30334
(404) 656-2833

Guam
Solid and Hazardous Waste Management Program
Guam Environmental Protection Agency
IT & E Harmon Plaza, Complex Unit D-107
130 Rojos Street
Harmon. Guam 96911
(671) 646-8863

Illinois
Hazardous Waste Research and Information Center
Illinois Department of Energy and Natural Resources
One East Hazelwood Drive
Champaign, IL 61820
(217) 333-8940

Illinois Waste Elimination Research Center
Pritzker Department of Environmental Engineering
Alumni Building, Room 102
Illinois Institute of Technology
3200 South Federal Street
Chicago, IL 60616
(313)567-3535

Indiana
Environmental Management and Education Program
Young Graduate House, Room 120
Purdue University
West Lafayette, IN 47907
(317) 494-5036

Indiana Department of Environmental Management
Office of Technical Assistance P.O. Box 6015
105 South Meridian Street
Indianapolis, IN 46206-6015
(317) 232-8172

Iowa
Center for Industrial Research and Service
205 Engineering Annex
Iowa State University Ames, IA 50011
(515) 294-3420

Iowa Department of Natural Resources
Air Quality and Solid Waste Protection Bureau
Wallace State Office Building
900 East Grand Avenue
Des Moines, IA 50319-0034
(515) 281-8690

Kansas
Bureau of Waste Management
Department of Health and Environment
Forbesfield, Building 730
Topeka, KS 66620
(913) 269-1607

Kentucky
Division of Waste Management
Natural Resources and Environmental Protection
Cabinet
18 Reilly Road
Frankfort, KY 40601
(502) 564-6716

Louisiana
Department of Environmental Quality
Office of Solid and Hazardous Waste
P.O. Box 44307
Baton Rouge, LA 70804
(504) 342-1354

Maryland
Maryland Hazardous Waste Facilities Siting Board
60 West Street, Suite 200 A
Annapolis, MD 21401
(301) 974-3432

Maryland Environmental Service
2020 Industrial Drive
Annapolis, MD 21401
(301) 269-3291
(800) 492-9188 (in Maryland)

Massachusetts
Office of Technical Assistance
Executive Office of Environmental Affairs
100 Cambridge Street, Room 1094
Boston, MA 02202
(617) 727-3260

Source Reduction Program
Massachusetts Department of Environmental Protection
1 Winter Street
Boston, MA 02108
(617) 292-5982

Michigan
Resource Recovery Section
Department of Natural Resources
P.O. Box 30028
Lansing, MI 48909
(517) 373-0540

Minnesota
Minnesota Pollution Control Agency
Solid and Hazardous Waste Division
520 Lafayette Road
St. Paul, MN 55155
(612) 296-6300

Minnesota Technical Assistance Program
1313 5th Street S.E., Suite 207
Minneapolis, MN 55414
(612) 627-4555 (800)
247-0015 (in Minnesota)

Missouri
State Environmental Improvement and
Energy Resources Agency
P.O. Box 744
Jefferson City, MO 65102
(314) 751-4919

New Hampshire
New Hampshire Department of Environmental Services
Waste Management Division
6 Hazen Drive
Concord, New Hampshire 03301-6509
(603) 271-2901

New Jersey
New Jersey Hazardous Waste Facilities Siting Commission
Room 614
28 West State Street
Trenton, NJ 08608
(609) 292-1459
(609) 292-1026

Hazardous Waste Advisement Program
Bureau of Regulation and Classification
New Jersey Department of Environmental Protection
401 East State Street
Trenton, NJ 08625
(609) 292-8341

Risk Reduction Unit
Office of Science and Research
New Jersey Department of Environmental Protection
401 East State Street
Trenton, NJ 08625
(609) 984-6070

New York
New York State Environmental Facilities Corporation
50 Wolf Road
Albany, NY 12205
(518) 457-3273

North Carolina
Pollution Prevention Pays Program
Department of Natural Resources
and Community Development
P.O. Box 27687
512 North Salisbury Street
Raleigh, NC 27611
(919) 733-7015

Governor's Waste Management Board
325 North Salisbury Street
Raleigh, NC 27611
(919) 733-9020

Technical Assistance Unit
Solid and Hazardous Waste Management Branch
North Carolina Department of Human Resources
P.O. Box 2091
306 North Wilmington Street
Raleigh, NC 27602
(919) 733-2178

Ohio
Division of Solid and Hazardous Waste Management
Ohio Environmental Protection Agency
P.O. Box 1049
1800 WaterMark Drive
Columbus, OH 43266-1049
(614) 481-7200

Oklahoma
Industrial Waste Elimination Program
Oklahoma State Department of Health
P.O. Box 53551
Oklahoma City, OK 73152
(405) 271-7353

Oregon
Oregon Hazardous Waste Reduction Program
Department of Environmental Quality
811 Southwest Sixth Avenue
Portland, OR 97204
(503) 229-5913

Pennsylvania
Pennsylvania Technical Assistance Program
501 F. Orvis Keller Building
University Park, PA 16802
(814) 865-0427

Center of Hazardous Material Research
320 William Pitt Way
Pittsburgh, PA 15238
(412) 826-5320

Bureau of Waste Management
Pennsylvania Department of Environmental Resources
P.O. Box 2063
Fulton Building
3rd and Locust Streets
Harrisburg, PA 17120
(717) 787-6239

Rhode Island
Office of Environmental Coordination
Department of Environmental Management
83 Park Street
Providence, RI 02903
(401) 277-3434
(800) 253-2674 (in Rhode Island)

Center for Environmental Studies
Brown University
P.O. Box 1943
135 Angell Street
Providence, RI 02912
(401) 863-3449

Tennessee
Center for Industrial Services
102 Alumni Hall
University of Tennessee
Knoxville, TN 37996
(615) 974-2456

Virginia
Office of Policy and Planning
Virginia Department of Waste Management
11th Floor, Monroe Building
101 North 14th Street
Richmond, VA 23219
(804) 225-2667

Washington
Hazardous Waste Section
Mail Stop PV-11
Washington Department of Ecology
Olympia, WA 98504-8711
(206) 459-6322

Wisconsin
Bureau of Solid Waste Management
Wisconsin Department of Natural Resources
P.O. Box 7921
101 South Webster Street
Madison, WI 53707
(608) 267-3763

Wyoming
Solid Waste Management Program
Wyoming Department of Environmental Quality
Herschler Building, 4th Floor, West Wing
122 West 25th Street
Cheyenne, WY 82002
(307) 777-7752

Waste Exchanges

Alberta Waste Materials Exchange
Mr. William C. Kay Alberta Research Council
Post Office Box 8330
Postal Station F
Edmonton, Alberta CANADA T6H 5X2
(403) 450-5408

British Columbia Waste Exchange
Ms. Judy Toth
2150 Maple Street
Vancouver, B.C. CANADA V6J 3T3
(604) 731-7222

California Waste Exchange
Mr. Robert McCormick
Department of Health Services
Toxic Substances Control Program
Alternative Technology Division
Post Office Box 942732
Sacramento, CA 94234-7320
(916) 324-1807

Canadian Chemical Exchange*
Mr. Philippe LaRoche
P.O. Box 1135
Ste-Adele, Quebec
CANADA JOR ILO
(514) 229-6511

Canadian Waste Materials Exchange
ORTECH International
Dr. Robert Laughlin
2395 Speakman Drive
Mississauga, Ontario
CANADA L5K IB3
c(416) 822-4111 (Ext. 265)
FAX: (416) 823-1446

Enstar Corporation*
Mr. J.T. Engster
P.O. Box 189
Latham, NY 12110
(518) 785-0470

Great Lakes Regional Waste Exchange
400 Ann Street N.W., Suite 204
Grand Rapids, MI 49504
(616) 363-3262

Indiana Waste Exchange
Dr. Lynn A. Corson
Purdue University School of Civil Engineering
Civil Engineering Building
West Lafayette, IN 47907
(317) 494-5036

Industrial Materials Exchange
Mr. Jerry Henderson
172 20th Avenue
Seattle, WA 98122
(206) 296-4633
FAX: (206) 296-0188

Industrial Materials Exchange Service
Ms. Diane Shockey
Post Office Box 19276
Springfield, IL 62794-9276
(217) 782-0450
FAX: (217) 524-4193

Industrial Waste Information Exchange
Mr. William E. Payne
New Jersey Chamber of Commerce
5 Commerce Street
Newark, NJ 07102
(201) 623-7070

Manitoba Waste Exchange
Mr. James Ferguson
c/o Biomass Energy Institute, Inc.
1329 Niakwa Road
Winnipeg, Manitoba
CANADA R2J 3T4
(204) 257-3891

Montana Industrial Waste Exchange
Mr. Don Ingles
Montana Chamber of Commerce
P.O. Box 1730
Helena, MT 59624
(406) 442-2405

New Hampshire Waste Exchange
Mr. Gary J. Olson
c/o NHRRA
P.O. Box 721
Concord, NH 03301
(603) 224-6996

Northeast Industrial Waste Exchange, Inc.
Mr. Lewis Cutler
90 Presidential Plaza, Suite 122
Syracuse, NY 13202
(315) 422-6572
FAX: (315) 422-9051

* For-Profit Waste Information Exchange

Ontario Waste Exchange
ORTECH International
Ms. Linda Varangu
2395 Speakman Drive
Mississauga, Ontario
CANADA L5K 1B3
(416) 822-4111 (Ext. 512)
FAX: (416) 823-1446

Pacific Materials Exchange
Mr. Bob Smee
South 3707 Godfrey Blvd.
Spokane, WA 99204
(509) 623-4244

Peel Regional Waste Exchange
Mr. Glen Milbury
Regional Municipality of Peel
10 Peel Center Drive
Brampton, Ontario
CANADA L6T 4B9
(416) 791-9400

RENEW
Ms. Hope Castillo
Texas Water Commission
Post Office Box 13087
Austin, TX 78711-3087
(512) 463-7773
FAX: (512) 463-8317

San Francisco Waste Exchange
Ms. Portia Sinnott
2524 Benvenue #35
Berkeley, CA 94704
(415) 548-6659

Southeast Waste Exchange
Ms. Maxie L. May
Urban Institute
UNCC Station
Charlotte, NC 28223
(704) 547-2307

Southern Waste Information Exchange
Mr. Eugene B. Jones
Post Office Box 960
Tallahassee, FL 32302
(800) 441-SWIX (7949)
(904) 644-5516
FAX: (904) 574-6704

Tennessee Waste Exchange
Ms. Patti Christian
226 Capital Blvd., Suite 800
Nashville, TN 37202
(615) 256-5141
FAX: (615) 256-6726

Wastelink, Division of Tencon, Inc.
Ms. Mary E. Malotke
140 Wooster Pike
Milford, OH 45150
(513) 248-0012
FAX: (513) 248-1094

U.S. EPA Regional Offices

Region 1 (VT, NH, ME, MA, CT, RI)
John F. Kennedy Federal Building
Boston, MA 02203
(617) 565-3715

Region 2 (NY, NJ)
26 Federal Plaza
New York, NY 10278
(212) 264-2525

Region 3 (PA, DE, MD, WV, VA)
841 Chestnut Street
Philadelphia, PA 19107
(215) 597-9800

Region 4 (KY, TN, NC, SC, GA, FL, AL, MS)
345 Courtland Street, NE
Atlanta, GA 30365
(404) 347-4727

Region 5 (WI, MN, MI, IL, IN, OH)
230 South Dearborn Street
Chicago, IL 60604
(312) 353-2000

Region 6 (NM, OK, AR, LA, TX)
1445 Ross Avenue
Dallas, TX 75202
(214) 655-6444

Region 7 (NE, KS, MO, IA)
756 Minnesota Avenue
Kansas City, KS 66101
(913) 236-2800

Region 8 (MT, ND, SD, WY, UT, CO)
999 18th Street
Denver, CO 80202-2405
(303) 293-1603

Region 9 (CA, NV, AZ, HI) 75
Hawthorne Street
San Francisco, CA 94105
(415) 744-1305

Region 10 (AK, WA, OR, ID)
1200 Sixth Avenue
Seattle, WA 98101
(206) 442-5810

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