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March 1998
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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Solid Waste Segregation and Recycling

in cooperation with
National Steel and Shipbuilding Company
San Diego, California

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

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SOLID WASTE SEGREGATION AND RECYCLING

March 1998

Prepared for:

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Panel SP-1

Submitted by:

Austin Environmental, Inc.
San Diego, CA

Solid Waste Segregation & Recycling

NSRP Project No. N1-94-05

Introduction,
Summary
&
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Introduction: Solid waste disposal is a significant burden to overhead in a shipyard environment. In many areas of the United States disposal capacity is being reduced and the cost of disposal is continuing to climb. At the same time, the value of recyclable materials in many areas is rising. Waste products, other than the usual scrap metals can add significant value to a shipyard's waste stream. Finally, the issue of liability for inadvertent disposal of hazardous waste into the company's non-hazardous waste receptacles remains an ongoing concern. This project represented a consolidated effort to examine shipyard waste streams to determine ways to reduce the cost of processing solid waste, increase the value of recyclable materials and reduce liability by prevention of inadvertent disposal of hazardous waste.

Project Background: This project consisted of a two phase technical approach. Phase I involved the collection and evaluation of data concerning solid waste management and scrap recycling including:

- Previous research / studies
- Agency and existing literature
- Surveys of existing shipyard practices
- Inspections and on-site interviews of shipyards, scrap yards and recycling facilities

The collected data was used to:

- Identify all sources of waste
- Identify components of processes that produce waste
- Identify opportunities for reduction, reuse or recycling of waste streams
- Identify existing and successful methods for reduction, reuse or recycling
- Identify and evaluate new technologies as they apply to reduction, reuse or recycling
- Apply currently available/used technologies (off the shelf) to waste streams

After the specific shipyard waste streams were identified during the data collection phase, methods to control and process waste generated in the shipyard were evaluated. These included:

- Incorporating reduction, reuse or recycling steps into existing processes
- Eliminating unnecessary contributors to waste streams
- Developing standard operating procedures based on reduction, reuse or recycling opportunities into waste generating processes
- Developing standard operating procedures for waste stream segregation
- Apply reduction, reuse or recycling opportunities to the segregated waste streams

- Outlining equipment, materials and costs of implementing reduction, reuse or recycling programs
- Identifying all necessary equipment used in the handling, segregation and transportation of waste and/or scrap material

Phase II of the technical approach was an investigation as to how shipyards could improve the efficiencies of waste and scrap management in their facilities, including:

- Use of available equipment within the shipyard
- Improving existing equipment for the purpose of reduction, reuse and recycling
- Incorporation of existing commercial waste handling equipment within the shipyard

This final report has been prepared based on the results of the project research. In addition to this report, a disk containing life cycle analysis and scrap equipment cost evaluation spreadsheets are included.

Discussion of Research:

Data Gathering and Evaluation. Information concerning waste management and scrap recycling was gathered through several sources. Federal and state environmental agencies with responsibilities concerning solid and/or hazardous waste management were contacted directly and were requested to provide information. A general literature search was conducted to locate relevant information. World Wide Web sites with information concerning waste and recycling were identified and appropriate information was acquired. After this information was compiled all significant references were assembled into an annotated bibliography with abstracts (Task One - Tab One).

In order to collect data concerning the actual activities of U.S. shipyards a detailed survey (Task One - Tab Two) was developed and sent to over thirty ship building and repair facilities (including shipyards with multiple sites). Approximately twenty facilities responded with information, which was tabulated and summarized. On-site visits were made to six shipyards to gather more detailed information concerning waste handling processes, equipment and procedures. This information was summarized for three representative facilities (Task One - Tab Three).

Data evaluation consisted of identifying which processes within the shipyard generated waste (Task Two - Tab One), and then identifying the sources of waste from specific processes (Task Two - Tab Two). After the processes and components were identified, current opportunities for reduction, reuse, recycling and disposal of the waste streams were evaluated (Task Two - Tab Three).

To assist the shipyard in instituting improved waste and scrap management procedures, a justification for incorporating reduction, reuse and recycling methods into existing processes was prepared (Task Three - Tab One). Development of waste reduction and scrap recycling standard operation procedures for all the identified waste generating process components was then completed (Task Three - Tab Two). The concept of “Life Cycle and Total Cost Assessment” as applicable to shipyards was advanced with a primer on how to apply Total Cost Assessment concepts and instructions for using Project Analysis and Life Cycle Assessment Worksheets (Task Three - Tab Three, Task Three - Tab Four, Task Three - Tab Five respectively).

Methods for processing solid waste were developed into standard operating procedures together with detailed process flow charts (Task Four - Tab One and Tab Two).

Equipment required to conducted reuse, recycling and reduction operations within the shipyard was identified and summarized in the form of an Process/Equipment Matrix (Task Five - Tab One). Existing commercial waste handling and processing equipment was identified and compared to types of equipment normally found in the form of a comparison matrix shipyards (Task Six - Tab One). Identical, dissimilar and modifiable equipment was also identified.

The applicability of existing commercial waste processing equipment was determined by researching processes and equipment used in Municipal Material Recovery Facilities (“MRF”). In order to determine empirical values for the waste processing cost analysis, actual loads of solid waste from two shipyards were processed to determine value and processing efficiency (Task Six - Tab Two). A detailed cost analysis to process waste and recover recyclable materials was performed and the results were used to evaluate the advantages to incorporating specialized waste handling equipment into the shipyard (Task Six - Appendix A).

<u>Summary of Results and Findings</u>: The results of this study have revealed several pertinent points which can be immediately applied to ship building and repair facilities in order to reduce their costs of waste disposal, determine if recovery of recyclable materials are cost-effective and reduce liability for inadvertent disposal of hazardous waste. The findings of the investigation are as follows:

- The volume of both solid and hazardous waste generated can be significantly reduced by implementing effective source control and waste segregation procedures.
- The value of recyclable materials will help off set processing costs incurred to recover them, but will typically not provide enough revenue to sustain a material recovery effort.
- The incorporation of commercial waste handling and processing equipment

into the shipyard will not produce the required increases in efficiencies to justify their purchase, unless very large amounts of waste are to be processed.

- The greatest benefit to sorting and segregating recoverable materials from the shipyard waste stream is the ***reduction in volume and weight*** of the waste which must be disposed. By diverting recovered materials away from disposal, significant reduction costs can be achieved.
- Identification and removal of hazardous waste from the solid waste stream can be done during segregation for recyclable material recovery. This will reduce the shipyard's potential liability, while reducing the cost of disposal.
- State laws and regulations may place operational restrictions and/or performance requirements on any facility conducting waste processing activities on-site. Before conducting such operations, state and local requirements must be investigated to determine if their scope and applicability would include the proposed shipyard operations.

Recommendations:

The project findings are indicative of the following recommendations to shipbuilding and repair facilities:

- Point of Generation waste segregation efforts are recommended to reduce the volume of solid waste generated within the facility. These efforts will also reduce the amount of hazardous waste generated by the commingling of hazardous waste with non-hazardous waste and help prevent the inadvertent disposal of hazardous waste with solid waste.
- A program to manually sort and segregation solid waste to recover recyclable materials is recommend to reduce the volume and weigh of the solid waste stream. While the value of the recyclable materials will usually not cover labor cost to sort the material, the reduction in disposal cost should provide an adequate pay back margin.

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Solid Waste Segregation & Recycling Project

Task One

Surveys & Annotated Bibliography

Solid Waste Segregation & Recycling Project

Abstracts for Solid Waste & Recycling Literature

Business Guide for Reducing Solid Waste, EPA/530-K-92-004, Washington, D.C., November 1993

Presents an overview on developing and implementing a waste reduction program, including a series of worksheets designed to help conduct a waste assessment and devise a program tailored for a company's specific goals. The worksheets lead through a set of calculations to estimate the types and amounts of waste generated, identify potential waste reduction options, and determine which options will work for the facility.

Pollution Reduction Strategies in the Fiberglass Boatbuilding and Open Mold Plastics Industries, Davis, Darryl; Lao, Y. J., Dept. of Natural Resources and Community Development North Carolina, Pollution Prevention Pays Program Raleigh, N.C. 1987

This book provides an overview of the industry, the incentives for pollution reduction including economic, regulatory, liability and psychological factors. Production-based pollution reduction strategies and some case studies are described for air assisted airless spray guns, resin impregnators, resin roller dispensers, vacuum bag molding, resin transfer molding, resin transfer molding, and rotational molding. Managing contaminated solvents, facility based pollution reduction management strategies, and materials safety information are discussed. This book provides an overview of the industry, the Resources and Community Development North Carolina Pollution incentives for pollution reduction including economic, regulatory, liability and psychological factors. Production-based pollution reduction strategies and some case studies are described for air assisted airless spray guns, resin impregnators, resin roller dispensers, vacuum bag molding, resin transfer molding, resin transfer molding, and rotational molding. Managing contaminated solvents, facility based pollution reduction management strategies, and materials safety information are discussed. This book provides an overview of the industry, the incentives for pollution reduction including economic, regulatory, liability and psychological factors. Production-based pollution reduction strategies and some case studies are described for air assisted airless spray guns, resin impregnators, resin dispensers, vacuum bag molding, resin transfer molding, resin transfer molding, and rotational molding. Managing contaminated solvents, facility based pollution reduction management strategies, and materials safety information are discussed.

Guides to Pollution Prevention: The Marine Maintenance And Repair Industry, EPA/625/7-91/015, Washington, D.C., October 1991

This guide provides an overview of the marine maintenance and repair operations that generate waste and presents options for pollution prevention through source reduction and recycling. Options are offered for wastes from chemical stripping, abrasive blasting, paints and solvents, equipment cleaning, machine shops, engine repair shops, specialty shops and vessel cleaning. Spill control is also discussed. Case studies of three marine repair and service yards are included along with pollution prevention guidelines and worksheets to assist yard operators in performing a self-assessment. Additional sources of information on pollution prevention are also listed.

Best Management Practices for Small Boatyards, Lake Union Association, June 1, 1989

This document describes management for boatyards servicing vessels 65 feet or smaller. Employee and customer education, hazardous waste disposal, painting procedures, permit requirements, chemical storage, oil, grease and fuel spills, and other practices relevant to small boatyards are discussed with recommended practices for each.

Waste Minimization Opportunity Assessment, Philadelphia Naval Shipyard, United States Environmental Protection Agency. Office of Research and Development Risk Reduction Engineering Laboratory (U.S.) Science Applications International Corporation Publisher: Cincinnati, Ohio : Risk Reduction Engineering Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, 1990

This report describes a project performed by Science Applications International Corporation (SAIC) for the Philadelphia Naval Shipyard (PNSY). The purpose of the project was to develop waste minimization plans for the shipyard using the EPA's Waste Minimization Assessment Manual. This manual provides a systematic planned procedure for identifying ways to reduce or eliminate waste. The procedures consist of four major steps: 1) planning and organization, 2) assessment, 3) feasibility analysis, and 4) implementation. This project completed the first three steps of the procedures for several selected industrial activities including: KRC-7X dragout reduction and bath maintenance, KRC-7X two-stage rinse, booth guard system, paint sludge dewatering, high volume, low pressure painting, operator training and awareness, and recovery of concentrated citric acid solution.

Navy Establishes HM Minimization Program for Forces Afloat, Johnson, Sandie 1987

This article describes the U.S. Navy's approach to hazardous materials pollution prevention, which is constrained by the unique conditions of Naval vessels. The Navy's program centers on limiting each ship's hazardous materials inventory to items found on lists developed for each type of for each type of vessel.

Handbook of Solid Waste Management, Kreith, F., 1994, McGraw-Hill, Inc. New York, N.Y.,

Provides tools needed to design a solid waste management system capable of disposing of waste in a cost-efficient and environmentally responsible manner. Text focuses on the six primary functions of an integrated system - source reduction, toxicity reduction, recycling and reuse, composting, waste-to-energy combustion, and examines its problems, costs, and legal and social ramifications.

Hazardous Waste Source Reduction Guidance Manual, California Department of Toxic Substances Control Doc. No. 001, Sacramento, CA., May 1994,

Provides guidance for California generators to examine their current hazardous waste generating processes for hazardous waste minimization opportunities, and create plans for the implementation of workable alternatives.

Waste Recycling and Pollution Control Handbook, Bridgewater, A.V. Ph.D, & Mumford, C.J. Ph.D., 1979, Van Nostrand Reinhold Company New York, N.Y.

Examines solid waste disposal and recovery practices - for industrial, household and special types of waste - are investigated. The author assesses methods, including landfill, combined facilities and incineration.

40 CFR 190-259 RCRA, Solid Wastes, Environmental Protection Agency, Government Printing Office, Washington, D.C.

Provides Environmental Protection Agency regulatory guidance for the identification, handling, and disposal of solid wastes.

40 CFR 260-299 RCRA, Hazardous Wastes, Environmental Protection Agency, Government Printing Office, Washington, D.C.

Provides Environmental Protection Agency regulatory guidance for the identification, handling, and disposal of hazardous wastes.

California Integrated Waste Management Board Program Descriptions, CALEPA, Sacramento, CA

Provides waste reduction and specific programs of the California Integrated Waste Management Board.

Hazardous Waste Reduction Assessment Handbook Marine Ship and Boat Yards Performing Maintenance and Repair, CALEPA, Department of Toxic Substances Control, Office of

Pollution Prevention and Technology Development, Sacramento, CA May 1991

Provides information that will help ship and boat yards reduce the amount of hazardous waste that is generated.

Hazardous Waste Minimization Checklist and Assessment Manual for Marine Ship and Pleasure Vessel Boat Yards, CALEPA, Department of Toxic Substances Control, Office of Pollution Prevention and Technology Development, Sacramento, CA September 1993

Supplements Hazardous Waste Reduction Assessment Handbook for Marine Ship and Boat Yards Performing Maintenance and Repair. Aids shipyards and pleasure vessel boat yards in evaluating their facilities for waste minimization opportunities. Recycling or resource recovery measures for wastes that can not be prevented from minimization are discussed.

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Hazardous Waste & Hazardous Materials; a journal for technology, health,, environment and policy, Supersedes: Hazardous Waste, SPONSOR: Hazardous Materials Control Research Institute; PUBLISHER: Mary, Ann Liebert, Inc., 1651 Third Ave., New York, NY 10128, quarterly

Hazardous Waste Consultant, McCoy and Associates, Inc., 13701 W. Jewell Ave., Ste. 252, Lakewood, CO 80228-4173,, bimonthly

Hazardous Waste News; including nuclear waste bulletin, Incorporates: Lab Waste and Hazards Management, Business Publishers, Inc., 951 Pershing Dr., Silver Spring, MD 20910-4464, weekly

Hazardous Waste Report, Key Title, Aspen Publishers, Inc., 1600 Research Blvd., Rockville, MD 20850, biweekly

Journal of Environmental Economics and Management, Key Title, Academic Press, Inc.; Journal Division, 1250 Sixth Ave., San Diego, CA 92101, bimonthly

National Environmental Enforcement Journal, Formerly: Environmental Protection Report, National Association of Attorneys General, 444 N. Capitol St., N.W., Ste. 403, Washington, DC 20001, monthly (11 per yr.)

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Springer Series on Environmental Management, Springer-Verlag, 175 Fifth Ave., New York, NY 10010, irreg., latest 1986

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Toxic Materials News, Business Publishers, Inc., 951 Pershing Dr., Silver Spring, MD 20910-4464, weekly

Toxic Substances Journal, Key Title, Hemisphere Publishing Corporation; Subsidiary of: Taylor &, Francis Group, 79 Madison Ave., New York, NY 10016-7892, quarterly

Toxics Law Reporter, The Bureau of National Affairs, Inc., 1231 25th St., N.W., Washington, DC 20037, Suber. to: 9435 Key West Ave.,, Rockville, MD 20850, weekly

U.S. Environmental Protection Agency. Journal Holdings Report, U.S. Environmental Protection Agency; Information Management, and Services Division, 401 M St., S.W., Rm. 2003, PM 211D, Washington, DC 20460, Orders to:, National Technical Information Service, 5285 Port

Royal Rd.,, Springfield, VA 22161, annual

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U.S. Environmental Protection Agency. Pesticides Enforcement Division., Notices of Judgement under Federal Insecticide, Fungicide, and, Rodenticide Act, Variant title: Pesticide Enforcement, U.S. Environmental Protection Agency, M St., N.W., Washington, DC 20460, irreg

Update: Waste Disposal, Recycling, Resource., Recovery, Department of Sanitation; New York (City), 51 Chambers St., New York, NY 10007, monthly

Waste Age, National Solid Wastes Management Association, Ste. 1000, 1730 Rhode Island Ave. N.W., Washington, DC 20036, monthly

Waste Disposal and Pollution Control, Incorporates: From the State Capitals. Environmental Health: Former, titles: From the State Capitals. Waste Disposal and Pollution Control:, From the State Capitals. Sewage and Waste Disposal: ISSN 0016-1926, Wakeman-Walworth, Inc., Box 1939, New Haven, CT 06509, 12 per yr

Waste Management: Nuclear, Chemical, Biological, Municipal, Formerly: Nuclear and Chemical Waste Management: ISSN 0191-815X, Pergamon Press, Inc.; Journals Division, Maxwell House, Fairview Park, Elmsford, NY 10523, quarterly

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Waste Recovery Report; recycling and reprocessing of resources, Formerly (until 1985): Recovery Engineering News, I C 0 N Information Concepts, Inc., 211 S. 45th St., Philadelphia, PA 19104, monthly

Waste Treatment Technology News, Business Communications Co., Inc. (Norwalk), 25 Van Zant St., Norwalk, CT 06855, monthly

SOLID WASTE SEGREGATION & RECYCLING PROJECT

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Solid Waste Segregation & Recycling Project

NSRP Survey

Company Name: ______________________________

Company Address: ______________________________
No. Street

____
City, State, Zip Code

Point of Contact: ______________________________

Phone Number/Extension: ______________________________

SURVEY INSTRUCTIONS:

Column One: This column provides a listing of shipyard processes that produce hazardous and non- hazardous waste streams. Each process is then broken down into various waste streams. If a particular process is not applicable to your shipyard, please annotate **"N/A"** next to the process. If you have identified waste streams not listed for a particular process, please add them in the spaces provided. Note: There is space to add additional shipyard processes and their associated wastes at the end of the survey.

Column Two: Enter the known or estimated volume of waste generated annually (use the most recent year for which you have data) in either tons or gallons.

Column Three: Under waste classification, check the box which identifies how each waste is classified. For example:

> If the waste stream meets the EPA definition of hazardous waste, please annotate the waste as **"HAZ".**
>
> **"NON"** refers to waste that would normally be disposed of in a landfill.
>
> **"SCRAP"** refers to waste that has, or may have, an intrinsic value - such as ferrous and non-ferrous metals, paper, etc.

If the waste stream does not meet the EPA definition of hazardous, but is considered by your state to be hazardous, list it under "**OTHER**". For example,in California, asbestos and used oil are considered to be hazardous wastes, and would be entered in the "**OTHER**" column.

Column Four: Please report your known or estimated annual disposal costs for each waste stream. If the waste has positive value, i.e., sold to a scrap dealer or recycler, please indicate annual revenues by placing a (+) before the value.

Column Five: Please report your known or estimated material costs to replace wastes such as abrasive blast or solvents.

Column Six: Please identify the current methods your yard uses for waste reduction. For example:

"SR" stands for source reduction, i.e. the procedures your shipyard uses to reduce waste at the source of generation. For example, in painting and coating operations, if only eight gallons of epoxy are needed, only eight gallons are mixed as opposed to mixing ten gallons.

"RR" stands for resource recovery, i.e. used oil may be utilized in your facility boiler as a fuel.

"R" stands for recycling methods, such as using a solvent distillation unit to reclaim spend solvents.

"T" is for treatment. Your facility may treat the waste stream in order to reduce the quantity of hazardous waste, i.e. acid solutions may be utilized to pickle piping. The spent acid could be treated by neutralization, thus making it non-hazardous and sewerable.

Check **"N"** if no minimization procedures are utilized for a particular waste stream.

(1) PROCESS - WASTE STREAM	(2) VOLUME TONS/YEAR OR GALLONS/ YEAR	(3) WASTE CLASSIFI-CATION				(4) DISPOSAL COSTS $/YEAR	(5) MATERIAL COST $/YR.	(6) CURRENT PRACTICES				
		HAZ	NON	SCRAP	OTHER			SR	RR	R	T	N
Vehicle Maintenance												
Antifreeze												
Batteries												
Waste Oil												
Transmission Fluid												
Painting and Surface Coating												
Paint Solids												
Paint Liquids												
Paint Sludges												

(1) PROCESS - WASTE STREAM	(2) VOLUME TONS/YEAR OR GALLONS/ YEAR	(3) WASTE CLASSIFI-CATION				(4) DISPOSAL COSTS $/YEAR	(5) MATERIAL COST $/YR.	(6) CURRENT PRACTICES				
		HAZ	NON	SCRAP	OTHER			SR	RR	R	T	N
Spent Solvents												
Abrasive Blasting Operations												
Copper Slag												
Coal Slag												
Garnet												
Steel Shot												
Aluminum Oxide												
Walnut Shells												
Silica Sand												
Slurry Blasting												

(1) PROCESS - WASTE STREAM	(2) VOLUME TONS/YEAR OR GALLONS/ YEAR	(3) WASTE CLASSIFI-CATION				(4) DISPOSAL COSTS $/YEAR	(5) MATERIAL COST $/YR.	(6) CURRENT PRACTICES				
		HAZ	NON	SCRAP	OTHER			SR	RR	R	T	N
Machining Operations												
Cutting Fluids												
Fines												
Plating/Rinsing Operations												
Rinsate												
Tank Bottoms												
Cleaning Solutions												

(1) PROCESS - WASTE STREAM	(2) VOLUME TONS/YEAR OR GALLONS/ YEAR	(3) WASTE CLASSIFI-CATION				(4) DISPOSAL COSTS $/YEAR	(5) MATERIAL COST $/YR.	(6) CURRENT PRACTICES				
		HAZ	NON	SCRAP	OTHER			SR	RR	R	T	N
Marine Cleaning Operations												
Cleaning Soln.												
Tank Bottoms												
Waste Oil												
Bilge Water												
Oily Water												
Fluid Removal												
Oil-Petroleum												

(1) PROCESS - WASTE STREAM	(2) VOLUME TONS/YEAR OR GALLONS/ YEAR	(3) WASTE CLASSIFI- CATION				(4) DISPOSAL COSTS $/YEAR	(5) MATERIAL COST $/YR.	(6) CURRENT PRACTICES				
		HAZ	NON	SCRAP	OTHER			SR	RR	R	T	N
Oil-Synthetic												
Tank Preservation												
Sodium Chromate												
Electroplating Operations												
Plating Soln.												
Rinsate												
Tank Bottoms												
Cleaning Soln.												

(1) PROCESS - WASTE STREAM	(2) VOLUME TONS/YEAR OR GALLONS/ YEAR	(3) WASTE CLASSIFI-CATION				(4) DISPOSAL COSTS $/YEAR	(5) MATERIAL COST $/YR.	(6) CURRENT PRACTICES				
		HAZ	NON	SCRAP	OTHER			SR	RR	R	T	N
Electric Motor Insulating Operations												
Varnish Insulation												
Drippings												
Cleaning Solvent												
Building Maintenance												
Paint Waste												
Maintenance Chemicals												
Ballasts												
Fluorescent Lights												

(1) PROCESS - WASTE STREAM	(2) VOLUME TONS/YEAR OR GALLONS/ YEAR	(3) WASTE CLASSIFI- CATION				(4) DISPOSAL COSTS $/YEAR	(5) MATERIAL COST $/YR.	(6) CURRENT PRACTICES				
		HAZ	NON	SCRAP	OTHER			SR	RR	R	T	N
Equipment Maintenance												
Lubricants												
Refrigerants												
Paint Waste												
Wood Finishing and Fabrication												
Stains												
Varnish												

(1) PROCESS - WASTE STREAM	(2) VOLUME TONS/YEAR OR GALLONS/ YEAR	(3) WASTE CLASSIFI- CATION				(4) DISPOSAL COSTS $/YEAR	(5) MATERIAL COST $/YR.	(6) CURRENT PRACTICES				
		HAZ	NON	SCRAP	OTHER			SR	RR	R	T	N
Fiberglass Fabrication												
Solvent												
Resin												
Metals Preparation and Treatment												
Cleaning Soln.												
Contaminated Rags												
Burn Table												
Table Coolants												

(1) PROCESS - WASTE STREAM	(2) VOLUME TONS/YEAR OR GALLONS/ YEAR	(3) WASTE CLASSIFI-CATION				(4) DISPOSAL COSTS $/YEAR	(5) MATERIAL COST $/YR.	(6) CURRENT PRACTICES				
		HAZ	NON	SCRAP	OTHER			SR	RR	R	T	N
Burn slag												
Insulation and Lagging												
Asbestos												
Fiberglass												
Other Process (list process and waste stream)												

(1) PROCESS - WASTE STREAM	(2) VOLUME TONS/YEAR OR GALLONS/ YEAR	(3) WASTE CLASSIFI-CATION				(4) DISPOSAL COSTS $/YEAR	(5) MATERIAL COST $/YR.	(6) CURRENT PRACTICES				
		HAZ	NON	SCRAP	OTHER			SR	RR	R	T	N
Other Process (list process and waste stream)												
Other Process (list process and waste stream)												

Other Process (list process and waste stream)												

Non-Hazardous Waste streams:

Scrap metals. Please describe methods, if any, your shipyard uses to sort and recycle scrap metals.

Scrap Paper. Please describe methods, if any, your shipyard uses to sort and recycle scrap paper, i.e. bond, newspaper, cardboard, etc.

Scrap Plastics. Please describe methods, if any, your shipyard uses to sort and recycle scrap plastics, i.e. shrinkwrap, packaging materials, visqueen, etc.

Other recycling efforts. Please indicate any other non-hazardous materials that are recycled at your facility.

Thank you for completing the survey. Please return it, using the enclosed stamped self addressed envelope, by October 9, 1995.

Hazardous Waste Streams

Process/ Waste Stream	Bath Iron Works	NORSHIPCO	Atlantic Marine
Vehicle Maintenance			
Antifreeze	Recycle offsite	Stored and saved for reuse. Filtered onsite.	Recycle offsite
Batteries	Recycle offsite 500-700 batteries/ year UPS for ships	Traded one for one.	Recycle offsite
Waste Oil	Solid for recycle 700 - 1000 gallon/ month	Treated at oily water separator then used in onsite boiler.	Sold
Transmission Fluid	Combined with waste oil	Combined with waste oil.	Combined with other oily wastes
Tires	Disposed in landfill.	Disposed in landfill.	Recycled to company that
Freon	No	Recycled in house with filter system.	Recycled in house with filter system
	200 - 250 vehicles		
Painting and Surface Coating			
Paint Solids	Special waste Sent off site for fuel blend	Landfill.	Sent off site for disposal as fuel blend
Paint Liquids	Same as above	Fuel blended offsite.	Same as above
Paint Sludge	Same as above	Same as above.	Same as above
Spent Solvents	Recycle onsite however	Recycle onsite however	Recycled through onsite

Process/ Waste Stream	Bath Iron Works	NORSHIPCO	Atlantic Marine
	distiller broken	distiller broken.	distiller 45% recovery.
Disposables	Compacted then landfill 650 cu yd/year	Landfill.	Sent off site for disposal as fuel blend.
Abrasive Blasting Operations			
Copper Slag	Not used	Not used.	Not used
Coal Slag	#3 special waste recycled by use as medium for asphalt	#1 Separated, cleaned and sold to asphalt company.	Tested to determine non-hazardous then provided to asphalt/ concrete company - no cost.
Garnet	#4 same as above	Not used.	Some recovery and reuse. Residue disposed with coal slag.
Steel Shot	#2 same as above	#2 Reused	Wheelabrator blast house with recycling system.
Aluminum Oxide	#1 same as above	#3 Reused	Not used
Walnut Shells	#4 landfill	Not used.	Not used
Silica Sand	not used	#4 Reused.	Not used
Slurry Blasting			Not used
Baghouse waste		Mixed with coal slag.	Mixed with coal slag
Machining Operations			
Cutting Fluids	Gravity drained then reused	Processed thru oily water separator.	Closed loop recycled.
Fines	Recycled with scrap metals.	Recycled with scrap metals.	Recycled with metals.

Process/ Waste Stream	Bath Iron Works	NORSHIPCO	Atlantic Marine
Plating/ Rinsing Operations No plating operation.			
Rinsate			
Tank Bottoms			

Process/ Waste Stream	Bath Iron Works	NORSHIPCO	Atlantic Marine
Cleaning Solutions			
Marine Cleaning Operations			
Cleaning Solutions	Power wash hot water (new construction)	Processed thru oily water separator, oils to storage for boiler, water to POTW.	In house oily water separator. Water discharged to POTW.
Tank Bottoms	N/A new construction	Same as above	Compacted and disposed off as non- hazardous waste.
Waste Oil	Combined with automotive waste oil for recycle offsite	Same as above	Processed onsite then sold. Paid $12/bbl
Bilge Water	Biodegrade-able soap POTW	Same as above	Processed in-house. Cost approximately $0.04/gallon.
Oily Water	Gravity separated water	Same as above	Processed in house.

Process/ Waste Stream	Bath Iron Works	NORSHIPCO	Atlantic Marine
	to POTW oil recycled offsite.		
Fluid Removal			
Oil- Petroleum	New construction	Processed thru oily water separator, oil to storage for boiler, water to POTW.	Processed if required then sold.
Oil-Synthetic	New construction	Same as above	Same as above.
Tank Preservation	New construction	Same as above	Not used.

Process/ Waste Stream	Bath Iron Works	NORSHIPCO	Atlantic Marine
Sodium Chromate	Not used.	Not used.	Not used.
Electroplating Operations Process not used.			
Plating Solution			
Rinsate			
Tank Bottoms			
Cleaning Solution			

Process/ Waste Stream	Bath Iron Works	NORSHIPCO	Atlantic Marine
Electric Motor Insulating Operations			
Varnish Insulation	N/A new construction	Treated as industrial waste.	Subcontractor utilized.
Drippings	N/A new construction	Same as above.	Same as above.
Cleaning Solvent	N/A new construction	Some aqueous based which is processed thru oily water separator. Others Safety-Kleen.	Same as above.
Building Maintenance			
Paint Waste	Combined with yard waste	Combined with other paint waste.	Handled with other paint waste.
Maintenance Chemicals	Minimal	Biodegradable cleansers to POTW	Biodegradable cleansers utilized which can go to POTW.
Ballasts	Landfill.	Landfill.	Landfill. PCB free yard.
Fluorescent Lights	Recycle off site	Landfill.	Sent off site for disposal $0.08 per foot.
Equipment Maintenance			
Lubricants	Combined with oily waste.	Burned in onsite boiler.	Mixed with oily waste.
Refrigerants	Not applicable.	Recycled onsite or	Subcontractor utilized.

Process/ Waste Stream	Bath Iron Works	NORSHIPCO	Atlantic Marine
		subcontractor utilized.	
Paint Waste	Combined with yard paint waste.	Combined with yard paint waste.	Mixed with other paint waste. Aerosol can rupture accomplished on aerosol cans.
Wood Finishing and Fabrication			
Stains	Minimal	Landfill.	Handled with other solvent paint waste.
Varnish	Minimal	Combined with yard paint waste if sludge or liquid. Solids to landfill.	Same as above.
Fiberglass Fabrication Process not accomplished-subcontractor utilized.			
Solvent			
Resin			
Metals Preparation and Treatment			
Cleaning Solution	N/A	Cleaning solutions sent to oily water separator for processing.	Pre-cleaned metals purchased.
Contaminated Rags	Rags recycled thru local laundry	Landfill.	Disposed of as industrial waste.

Process/ Waste Stream	Bath Iron Works	NORSHIPCO	Atlantic Marine
Burn Table			
Table Coolants	Processed in house water to POTW 15,000/6 months	Processed in oily water separator.	Processed in house at oily-water separator.
Burn Slag	Landfill 3 -5 ton/year	Landfill.	Combined with tank bottoms.
Insulation and Lagging			
Asbestos	Yard maintenance subcontractor	Stored then disposed in approved landfill.	Subcontractor utilized.
Fiberglass	Landfill	Landfill.	Disposed in landfill.

Non-Hazardous Waste Streams

Process/ Waste Stream	Bath Iron Works	NORSHIPCO	Atlantic Marine
Scrap Metals			
Non-ferrous metals	Segregated at shop level then sold on yearly	Segregated at shop level then sold on yearly	Separated at shop level into 6 cu yd skip boxes

Process/ Waste Stream	Bath Iron Works	NORSHIPCO	Atlantic Marine
	contract 18M lbs/yr scrap metals	contract.	then consolidated and sold.
Ferrous metals	Segregated at shop level (includes punctured and crushed aerosol cans) then sold on yearly contract.	Same as above.	Same as above.
Scrap Paper			
Bond	Combined with newspapers and sold	Segregated at source. No value other than environment conscious.	Old records consolidated then shredded. $0.04 per lb.
Cardboard	Baled and sold	Compacted. No value.	Broke down then sent to industrial waste.
Newspaper	Combined with other paper	Segregated at source. No value other than environment conscious.	Same as above
Scrap Plastics			
Shrink-wrap	Baled	Landfill.	Landfill.
Packaging materials	Landfill	Landfill.	Landfill.
Visqueen	Landfill.	Landfill.	Landfill.

Process/ Waste Stream	Bath Iron Works	NORSHIPCO	Atlantic Marine
Scrap Wood			
Wood	Chipped	Chipped provided gratis to local horsebreeder. Investigating compacting for use as fuel blending.	Chipped and given away.
Pallets/ reels	Sold	Sold	Sold
Yard Trash Waste			
Dumpsters	Sorted and recoverable material pulled.	Sorted and recoverable material pulled.	Sorted and recoverable material pulled.

NSRP

Solid Waste Segregation & Recycling Project

Task Two

Identification of Shipyard Wastes

Identification Of Sources of Waste from Shipyard Operations

As a result of document search and significant shipyard experience a survey was developed which identified the processes that generated waste and the actual waste streams. This survey was mailed to eighteen shipyards for verification of the waste processes and waste streams. One shipyard forwarded the survey onto thirteen associate yards.

A total of fifteen responses to the survey were received. These surveys verified the universality of the processes and waste streams in the survey. Of the fifteen responses one shipbuilder, one ship repairer and thirteen shipyards specializing in smaller vessel building and repair reported. The data does not reflect the volumes of the various waste streams seen in at a ship builder or repair yards; however the survey results do verify the completeness of the survey in the identification of the waste processes and waste streams.

The following processes were identified as sources of waste:

Insulation and Lagging	Abrasive Blasting
Abrasive Blasting Operations	Machining Operations
Electric Motor Repair	Burn Table
Vehicle Maintenance	Painting and Coating Operations
Marine Cleaning Operations	Building Maintenance
Metal Fabrication	Equipment Maintenance and Repair
Wood Finishing and Fabrication	Fiberglass Fabrication
Administrative Support	Equipment/Material Packaging

It is significant to note that none of the shipyards visited nor none of the ship or boatyards that reported, currently have the capability to plate or electroplate. The reason for this is most likely the extremely hazardous nature of the chemicals involved in these operations, the cost of waste disposal, and minimal need for plating or electroplating.

Components of Shipyard Processes that Produce Waste

This section identified the various shipyard processes that result in the generation of waste. The following table provides a breakdown of all waste streams derived from each identified process.

Vehicle Maintenance	Antifreeze
	Batteries
	Waste Oil
	Transmission Fluid
	Freon
Painting and Surface Coating	Paint Solids
	Paint Liquids
	Paint Sludge's
	Spent Solvent
	Disposable (paint brushes, rollers, etc.)
Abrasive Blasting Operations	Coal Slag
	Copper Slag
	Steel Shot
	Silica Sand
	Garnet
Machining Operations	Cutting Fluids
	Fines
Marine Cleaning Operations	Cleaning Solutions
	Tank Bottoms
	Waste Oil
	Bilge Water
	Oily Water
Fluid Removal	Oil-Petroleum
	Oil-Synthetic
	Tank Preservation
	Sodium Chromate
Electric Motor Repair	Varnish Insulation
	Drippings
	Cleaning Solvent

Building Maintenance	Paint Waste
	Maintenance Chemicals
	Ballast
	Fluorescent Lights
Equipment Maintenance and Repair	Lubricants
	Refrigerants
	Paint Waste
Wood Finishing and Fabrication	Stains
	Varnish
	Wood
Fiberglass Fabrication	Solvent
	Resin
Metals Preparation and Treatment	Cleaning Solutions
	Contaminated Rags
Burn Table	Table Coolants
	Burn Slag
Insulation and Lagging	Asbestos
	Fiberglass
Metal Fabrication	Ferrous Metals
	Non-Ferrous Metals
Support, Paper Products	Cardboard
	Bond Paper
	Newspaper
	Other Paper
Support, Plastics	Packaging Materials
	Visqueen
	Shrink-wrap
Support, Wood	Cable Reels
	Pallets
	Docking Blocks
	Packing Crates
	Scrap Wood

Although the support materials were reported on, no information was received as to the quantities handled. Therefore only the procedures identified by the participants will be reported on.

In order to provide a basis for disposal volumes, a method of quantifying the amounts disposed was used. The quantities were converted to tons, using the following conversion table, so that all could be rated.

Reported Unit	Conversion to Ton
Ton	1 ton/ton
Pounds	0.0005 lb./ton
Gallon *	0.0039 gal/ton
Batteries**	0.0175 battery/ton
Cubic Yard	7 cu yd/ton
Fluorescent Tubes***	0.0005 tube/ton
Ballast's****	0.0025 ballast/ton

* Because of the differences in specific gravity of fluids, a conversion of 7.8 pounds per gallon of fluid was utilized.
**A battery weight of 35 pounds per battery was utilized.
***A tube weight of 1 pound per tube was utilized.
***A ballast weight of 5 pounds per ballast was utilized

Table 1 provides a breakdown utilizing the above conversion table for the reported disposal of waste.

Opportunities for Reduction, Reuse, Reclamation, Recycling and Disposal of Shipyard Waste Streams

The most confusing part of any undertaking is the understanding of the terms as they apply to what needs to be accomplished. For example when we utilize a solvent still to clean our dirty solvent, have we reclaimed or recycled the solvent. In order to clarify the terminology, the following definitions apply to procedures utilized in this document.

Reduction: Waste prevention, or source reduction, is the design, manufacture, purchase, or use of materials and products to reduce the amount and/or toxicity of discarded waste. Strictly speaking, recycling, reclamation and reuse would be examples of reduction. However, when utilized in this document, the actions taken to "prevent" the generation of waste will be considered reduction - source reduction. Shipyard examples of waste reduction would be the mixing of only the amount of paint required to accomplish the coating application, or the training of "blasters" to utilize actions or procedures that reduces the amount of spent abrasive.

Reuse: Reuse is the use of spent materials without prior treatment, usually for the same purpose as it was originally intended. An example would be the reuse of packing materials (popcorn) or containers.

Reclamation: The extraction of useful materials from waste via treatment, and the reuse or recycling of that reclaimed material. A shipyard example would be the separation of oil and water either by gravity separation or process equipment (oily-water separators). The oil can then be recycled for either use in onsite boilers or sold to oil processors.

Recycling: The use of waste stream as a feed stock in the production of a new product or material. A shipyard example would include the recycling of spent copper slag in abrasive into manufacture of cement clinkers.

Disposal: The activities associated with the long-term handling of wastes that are collected and of no further use and the residual matter after wastes have been processed and the recovery of conversion products or energy has been accomplished. Normally, disposal is accomplished by means of sanitary landfill.

SURVEY RESULTS

The survey results revealed that of the fifty-five (55) potential waste streams identified only forty (40) were reported on. The following provides methods utilized by the respondents of the survey for the reduction, reuse, reclamation, recycling and disposal of these waste streams:

SHIPYARD WASTE STREAMS

Steel Shot, Coal Slag, Copper Slag, Garnet, Silica Sand. All these waste streams, once utilized in abrasive blasting, may or may not be considered “hazardous waste,” based on federal and state regulations and material being cleaned. It is important to have a complete understanding of both the hazardous characteristics of the spent abrasive and how the federal and state recycling regulations affect your ability to reclaim or recycle this material.

Reduction: The amount of spent abrasive generated can be significantly reduced (30 to 50 %) if blasters follow proper procedures and techniques.

Reuse: On-site reuse of spent abrasive is not accomplished without prior reclamation to remove contaminates that entrained with the spent abrasive during the blasting process

Reclamation: Depending on the volume of abrasive blasting being generated, it can be cost effective to “reclaim” these blasting mediums. Companies that have found that reclamation is a viable option, process the spent abrasive by essentially sifting the spent abrasive through various sized screens, collecting the correctly sized abrasive particles. Air sorters can also be used to remove dust and other small particles, which have little or no abrasive action and reduce the blasting production rate. This dust typically contains hazardous contaminants from the abrasive blast process such as lead, organotins, chromates, which can render the new waste stream (the dust) a hazardous waste. Due to these factors a cost analysis as well as review of local laws and regulation should be accomplished prior to instituting a reclamation process on site. It must be noted that on-site reclamation of spent abrasive does not produce a mil-spec grade abrasive. This will limit the use of reclaimed abrasive to commercial work only.

See Figures 1, 2, and 3.

The Navy has investigated various methods to reclaim abrasives to produce a mil-spec material. Reclamation has proved to be feasible, but not cost effective. See NSRP N1-93-1 Spent Abrasive Management Options.

Recycling: Recycling spent abrasive has become a viable option to disposal and can be cost effective when compared to the cost of disposal. Several shipyards, especially in California where the abrasive blast medium is considered a special waste or state hazardous waste, have opted to recycling the spent abrasive. A company has been identified which will accept the spent abrasive and utilize it as feed stock in the manufacturing of cement clinkers. Additionally, in the past, asphalt manufacturers have used spent abrasive as aggregate in the production of asphalt and asphalt concrete.

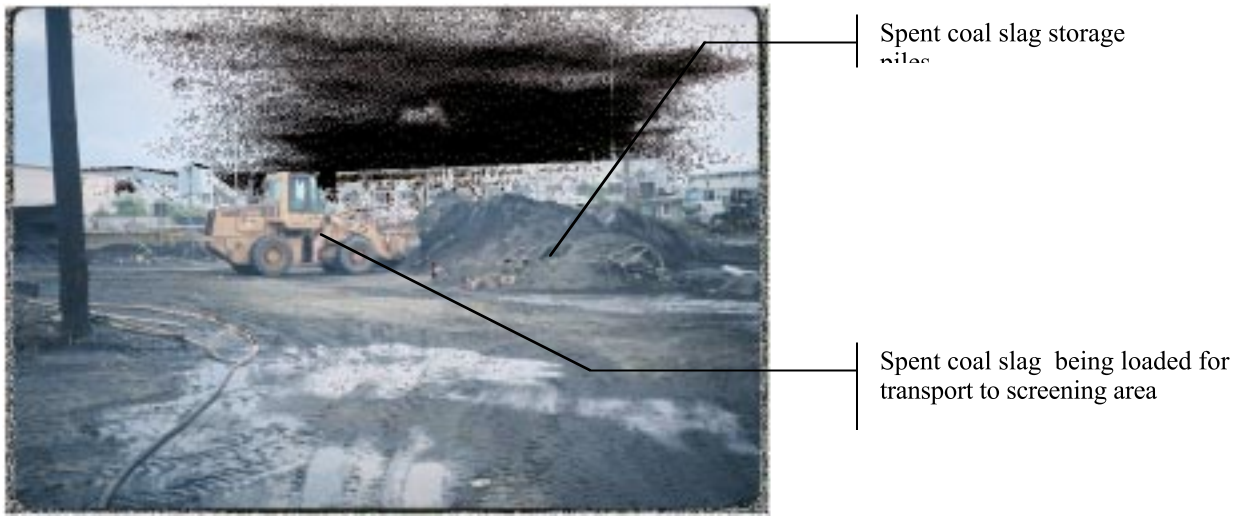


Figure 1: Spent Coat slag storage area

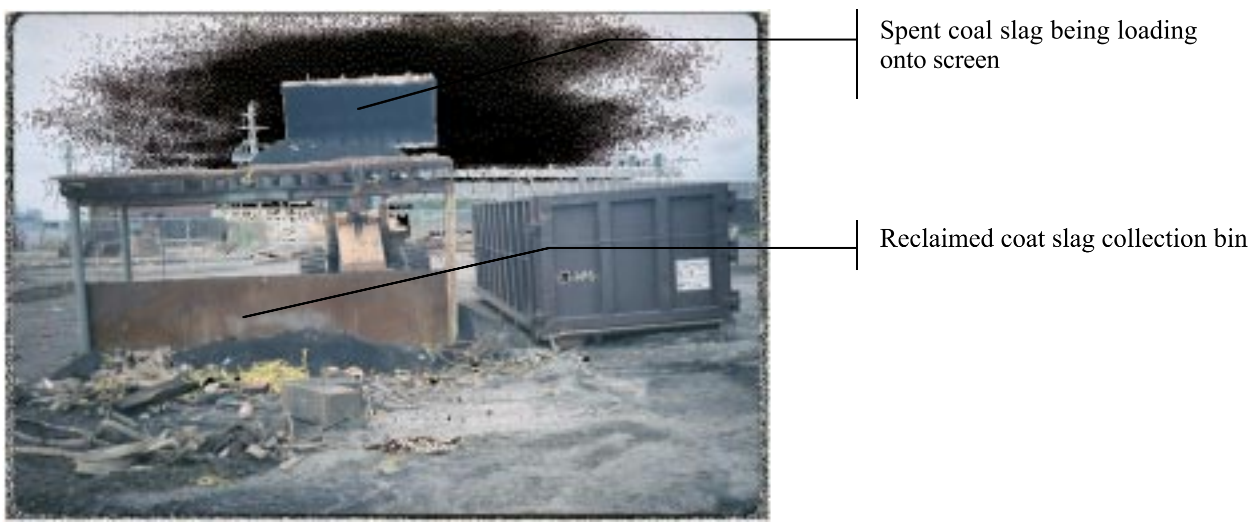


Figure 2: Spent Coal slag screening facility

Figure 3: Removal of debris after screening

See Figures 4 - 9.

Disposal: Depending on test results of the abrasive blast medium and local regulations, the abrasive blast medium may be accepted at the local landfill. Additionally, companies specialize in the removal of the metals from the abrasive for recycling efforts. This process can be expensive costing as much as a dollar per pound of spent abrasive provided.

Cleaning Solutions, Oily Water, and Bilge Water. These waste streams are generated as the result of degreasing and cleaning/emptying ship's bilges, compensating tanks or fuel tanks.

Reduction: Significant reduction of oily water can be seen if tank cleaners utilize minimal amounts of cleaning waters necessary for degreasing and cleaning. Additionally, minor heating of the water will significantly reduce the water required.

Reuse: No reuse these waste streams were reported.

Reclamation: All shipyards reported utilizing a phase/gravity separation method (Baker Tanks) to reduce the volume of these waste streams requiring disposal. This process allows for the disposal of the contaminated water to the sewer system and reclaiming of the oil with the other ship/shipyard waste oils. Periodic testing of the water is required in order to ensure that the separated water meets the effluent discharge limits of the local municipal sewer district. Two larger facilities had water treatment equipment (oily-water separators) that separated the oil from the oily/water and also removed dissolved metals.

See Figures 10, 11, and 12

Recycling: On-site recycling of waste oil as a boiler fuel was reported by one shipyard. Additionally, oil sludge residuals have been recycled for their BTU content in off-site fuel blending facilities.

Disposal: Oil sludge residuals, often recovered from tank cleaning operations, which cannot be recycled for fuel value are usually disposed of as either a special category waste or as hazardous waste.

Burn Slag. This waste stream is generated as the result of cutting plate on a burn table. Slag from the operation falls to a pan, usually filled with water, underneath the burn table where it is cooled and collected.

Figure 4: Spent Abrasive Storage - Copper Slag

Figure 5: Spent abrasive screening and Railcar loading facility

Figure 6: Transport of Spent Abrasive to Cement Kiln

Figure 7: California Portland Cement Company

Figure 8: California Portland Cement Company

Figure 9: Cement Clinkers

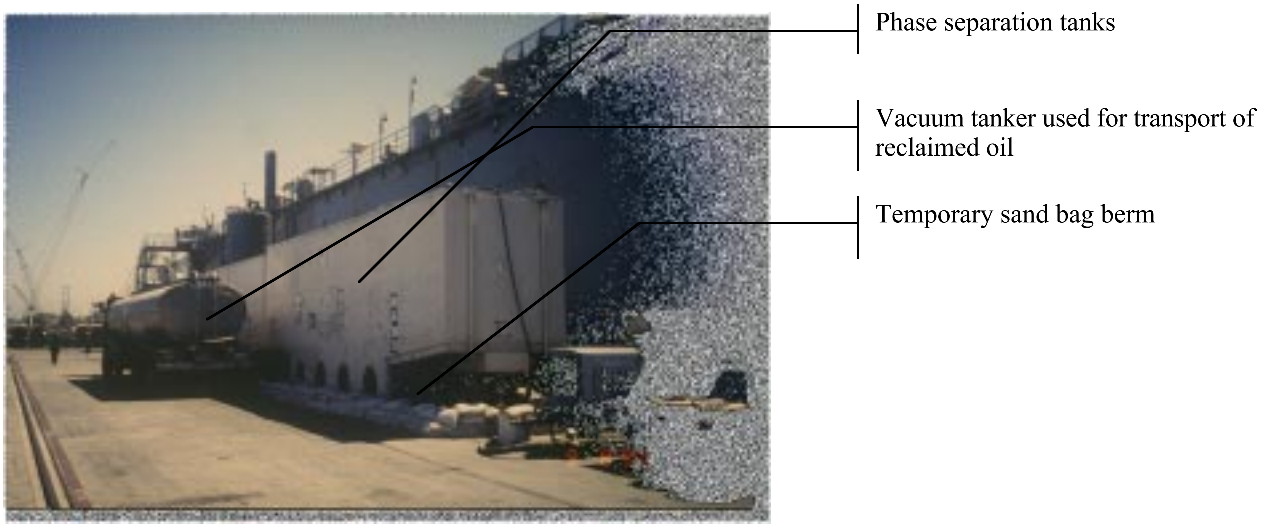


Figure 10: Oil/Separation tank - gravity Separation

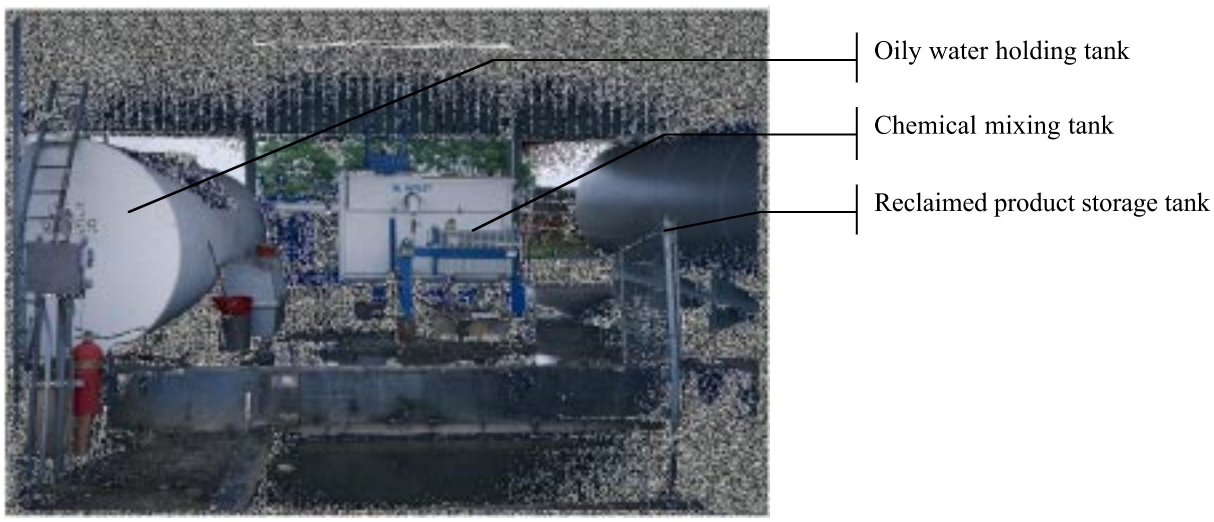


Figure 11: Oily water Separation unit - Air Dissolved Flotation

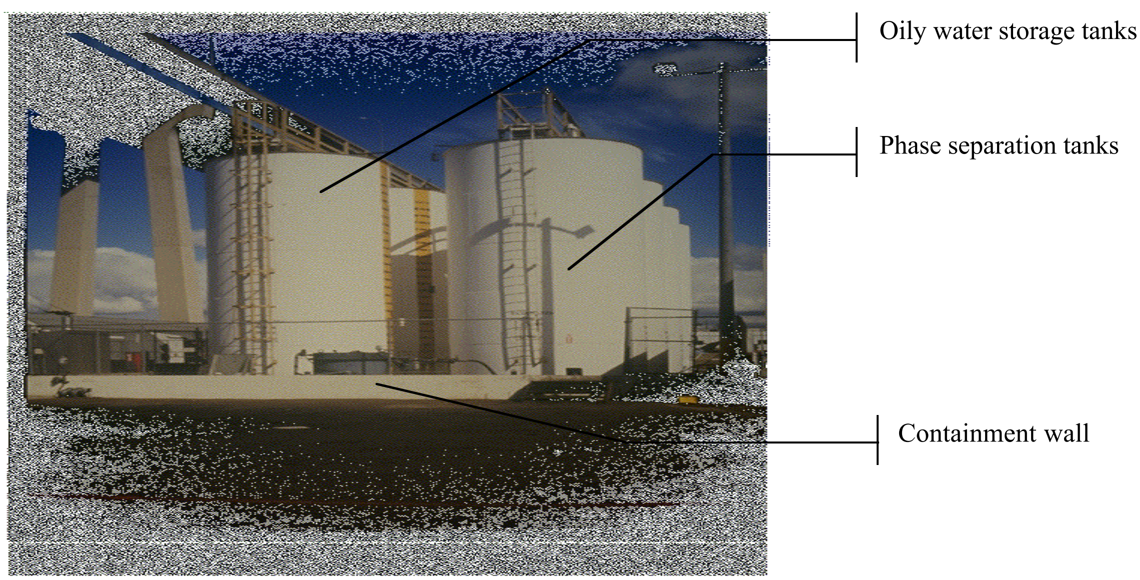


Figure 12: Oily/water storage tanks and treatment facility

Reduction: No methods to reduce this waste stream were identified.

Reuse: No methods to reuse this waste stream were identified.

Reclamation: No methods to reclaim this waste stream were identified.

Recycling: Several companies reported including this waste stream in the recycled metals.

Disposal: Due the molten nature of the slag, the material has less recycle value. Usually this waste is treated as non-hazardous and disposed in the sanitary landfill.

Fiberglass Insulation. This waste stream is developed as the result of either repairs to structural components or piping systems. The fiberglass insulation is removed in order to work on the structural components or piping systems. Additionally some waste is generated during the re-installation process.

Reduction: Methods for reduction would depend on the method of determination of cost for disposal. If the landfill cost is based on volume (cubic yard) then compacting may be a method utilized in order to reduce costs.

Reuse: No methods to reuse this waste stream were identified.

Reclamation: No methods of on-site reclamation of this waste stream were identified.

Recycling: No methods to recycle this waste stream were identified.

Disposal: This waste stream is treated as non-hazardous waste and usually disposed of in the local landfill.

Waste Oil, Lubricants and Transmission Fluids. This waste stream is generated as a result of repairs to shipyard rolling stock (trucks, forklifts, cranes, etc.). Additionally oil is recovered from equipment that utilize oils for lubrication during the repair process. Most companies that were surveyed mixed the various types of oil together.

Reduction: Most of this waste stream is generated during routine maintenance of automobiles, mobile cranes and other shipyard rolling stock. Typically this maintenance is performed on calendar schedule or hours of usage basis. By instituting a performance standard (chemical testing) to determine when an oil, lubricant or fluid must be changed, a significant reduction in the volume of these waste stream can be achieved, in addition to improved maintenance of the rolling stock.

Reuse: None of the facilities visited or surveyed reused waste oil lubricants or fluids.

Reclamation: No methods of on-site reclamation of waste oil lubricants or fluids were identified.

Recycle: One shipyard uses the oil for fuel (BTU recovery) for a boiler in which steam is produced for use throughout the shipyard. The majority of the survey respondents indicated that the oil was either sold and/or disposed of for a minimal price to local companies that either process the oil for reuse or use if for its BTU recovery value.

Disposal: None of the yards disposed of the oil except to off-site recycling companies.

Tank Bottoms Oil, Oil Petroleum/Synthetic. This waste stream is generated as the results of repairs to shipboard fuel or oil tanks. This waste stream is uncontaminated oils and fuels that can not be removed by the use of shipboard piping systems.

Reduction: Ship design and safety requirements (hotwork) prevents utilization of any reduction efforts with this waste stream.

Reuse: These fuels and oils can be reused if the removal process does not contaminate the fuel or oil. However, storage requirements and costs usually result in the cost of reuse being prohibitive. As a result the oils and fuels are usually mixed with waste oils.

Reclamation: The oil recovered after volume reduction can be reclaimed and recycled in most instances, unless contaminated with chlorinated solvents. No shipyard reported on-site reclamation of waste oil. Off-site reclamation and recycling facilities are contracted to transport the waste oil to a central processing facility where the waste oil undergoes treatment to produce a refined oil.

Recycling: One shipyard uses the oil for fuel (BTU recovery) for a boiler in which steam is produced for use throughout the shipyard. The majority of the survey respondents indicated that the oil was either sold and/or disposed of for a minimal price to local companies that either process the oil for reuse or use if for its BTU recovery value.

Disposal: Oil sludge residuals which cannot be recycled for fuel value are usually disposed of as hazardous waste.

Paints Liquid, Paints Solid, Fiberglass Resin, Wood Varnish, Stains, Varnish Insulation (solvent based). This waste stream is generated as a result of coating operations.

Reduction: All respondents reported that procedures have been implemented which reduced the amount of paints and resins mixed to what was required for the process, thus reducing the amount requiring disposal. Additionally, one yard bought two component paints in large quantity and utilized mixing devices which accurately measured and mixed the multi-componets in exact quantities. Large procurement significantly reduced the disposal costs associated with the disposal of paint cans, i.e. emptying of these cans in order to meet EPA empty requirements with resulting material and labor costs.

See Figures 13 and 14

Reuse: No reuse of these wastes streams was reported.

Reclamation: No methods of on-site reclamation of these coatings waste streams were identified other then recovering the solvent portion of some coatings using a solvent still.

Recycling: Solvent based paints can be sold, or disposed of at a reduced price, for their BTU recovery value. The more "pumpable" the waste stream the greater the value due to ease of transferring and processing.

Disposal: Depending of local regulations some municipal landfills will accept the solid paints residuals. Liquid wastes typically can not be disposed of in landfills, but must be treated as hazardous wastes.

Spent Solvent, Fiberglass Solvent, Varnish Solvent. Solvents are used extensively in coating applications for cleanup of residual coatings, equipment utilized in the coating application and overspray in addition to the thinning of the coating themselves.

Reduction: Significant reduction in solvent waste can be realized by conservative application of the solvents. Solvent utilization equipment, such as pump dispensers, will reduce wastage.

Reuse: Several shipyards reported reuse of spent or out-of-spec solvent for the purpose of spray gun cleaning or other cleaning operations where high purity solvents are not required.

Reclamation: The majority of the yards had solvent recovery stills. Most stills will recover in excess of fifty percent of contaminated solvent. This allows the reuse of the reclaimed solvent and results in significant savings. Be sure to factor in operator and equipment costs when performing a cost benefit analysis on using a solvent recovery still.

See Figure 15.

Figure 13: Portable plural component paint mixing system

Figure 14: Stationary plural component paint mixing system

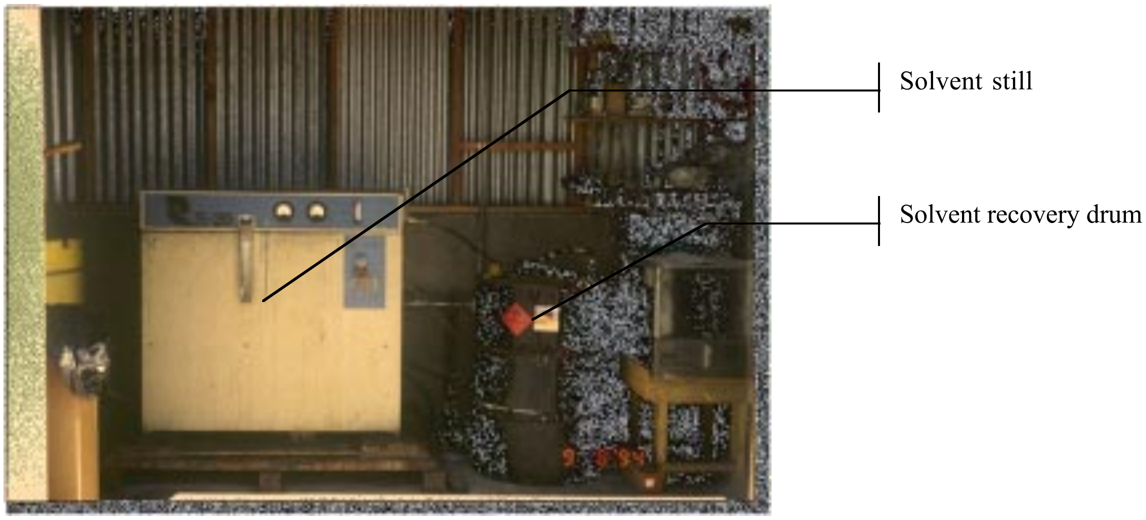


Figure 15: Batch solvent recovery still

Recycling: None of the surveyed facilities reported any type of on-site recycling effort in respect to waste solvents. However, the BYU recovery value of the solvent allows for off site recycling at fuel blending facilities.

Disposal: Solvents which can not be reclaimed or recycled are disposed of has hazardous waste.

Asbestos and Asbestos Contaminated Disposables. This waste stream is generated as the result of repairs to either structural components or piping systems. The insulation containing asbestos is removed in order to work on the structural components or piping systems.

Reduction: As all waste asbestos generated in shipyards is derived from removal of interference activities on ships under repair, opportunities for reduction is not possible.

Reuse: Reuse of asbestos waste is not allowed by federal law.

Reclamation: No methods of on-site reclamation of these waste asbestos were identified.

Recycling: Recycling of waste asbestos is not allowed by federal law.

Disposal: Asbestos is treated as a hazardous or special waste in all states. This waste stream is disposed in specialized landfills that will accept the waste stream.

Antifreeze. Antifreeze is removed from water cooled rolling stock (and diesel powered emergency generators) during repairs or as the result of equipment manufacturers recommended periodic replacement.

Reduction: Most of this waste stream is generated during routine maintenance of automobiles, mobile cranes and other shipyard rolling stock. Typically this maintenance is performed on calendar schedule or hours of usage basis. By instituting a performance standard (hygrometer testing) to determine when antifreeze must be changed, a significant reduction in the volume of this waste stream can be achieved, in addition to improved maintenance of the rolling stock.

Reuse: None of the facilities visited or surveyed reused waste antifreeze.

Reclamation: One facility, because of the large number of engines with antifreeze, reported filtering and reusing onsite. Most other shipyards reported that this waste stream is sent to off-site for reclamation and reuse.

Recycling: No on-site or off-site recycling opportunities for antifreeze were identified.

Disposal: Antifreeze containing ethylene glycol is extremely toxic and must be disposed of as hazardous waste, if it cannot be reclaimed or recycled.

Cutting Finds. Cutting finds are generated as the result of machining of metals.

Reduction: Procurement of the proper size billets and/or precutting can significantly reduce the quantity of metal requiring machining.

Reuse: Due to the nature of the waste stream, reuse is not an option.

Reclamation: Due to the nature of the waste stream, reuse is not an option.

Recycling: All facilities reported that the metal was segregated at point of generation. These metals were combined and sold to recycling venders.

See Figure 16

Disposal: No facility reported disposal as an option for this waste stream.

Batteries:. Utilized extensively in rolling stock in order to provide the motive force during the starting process. Additionally, batteries are utilized extensively in portable equipment as an electrical source.

Reduction: Proper maintenance of rolling stock significantly increases the life of a battery. Also the use of rechargeable batteries vice single use batteries will substantially reduce the number of disposable batteries required. Prior to utilization of rechargeable batteries in test equipment, the manufacturers technical manual needs to be reviewed as some of the materials in the disposable alkaline and nickel cadmium can affect the test results.

Reuse: Other than reuse after re-charging, no opportunities for reuse were reported or identified.

Reclamation: No methods for on-site reclamation were identified. Off-site reclamation is universally performed to recover the lead in lead acid batteries.

Recycling: Shipyards universally reported a policy of battery exchange from their supply venders.

Disposal: Lead-acid batteries must be treated as hazardous waste in the event that disposal is required. Some state and local waste management agencies are considering land fill restrictions on disposable alkaline and nickel cadmium batteries.

Cutting Fluids. These fluids are utilized in the machining of metals as a cooling medium.

Reduction: In order to reduce the hazardous nature of these fluids, most companies have switched from solvent based to water based fluid.

Reuse: Most machining equipment is designed so that the cutting fluid is filtered and reused as part of the machining process.

Reclamation: One facility utilized a centrifugal filtration process to purify the cutting fluid and keep the fluid clean and usable. Universal loop systems are utilized that recycle the cutting fluid. Strainers filter the fluid in order to remove any cutting finds and other contaminants from the fluid.

See Figure 17.

Recycling: Because of the evaporation of the cutting fluid at the site of the cut, recycling is not necessary.

Disposal: Disposable of these fluids is not required as they boil off at the cutting point by the high temperature generated by the cutting process.

Burn Table Coolants. Water is utilized to cool and entrain burn slag and burn gases. Periodically the water is removed in order to remove the burn slag.

Reduction: Procedures can be established to utilize only the minimal amount of water required to cool and entrain the burn slag and gases.

Reuse: Due to the nature of the waste stream, reuse is not an option.

Reclamation: Due to the nature of the waste stream, reclamation is not an option.

Recycling: Due to the nature of the waste stream, recycling is not an option.

Disposal: Most facilities filtered the coolant removing slag and disposed of the coolant to the sewer system.

Ballasts. Lighting ballasts are generated during the repair process of fluorescent light systems.

Reduction: Due to the nature of the waste stream, reduction is not an option.

Reuse: Due to the nature of the waste stream, reuse is not an option.

Reclamation: Due to the nature of the waste stream, reclamation is not an option.

Recycling: Due to the nature of the waste stream, recycling is not an option.

Disposal: Two types of ballasts were determined to exist and were addressed in the original survey. Ballasts depending on the date of manufacture may contain PCBs. If this is the case, the ballast needs to be treated as hazardous waste. None of the respondents indicated that they treated any ballast differently. All reported ballasts were disposed of in the local landfill. Maintenance electricians need to be made aware of the potential for contamination if the ballast is leaking. If the ballast was manufactured prior to 1980 it most likely contains PCBs and should be handled as hazardous waste.

Tank Preservation. One procedure for tank preservation is the utilization of a rust inhibitor (sodium nitrate) that induces a hard oxidation layer that prevents follow-on corrosion. The tank is filled with a water/sodium nitrate solution, allowed to pickle, then drained. This drained sodium nitrate solution is the tank preservation waste stream.

Reduction: The volume of this waste stream can be significantly reduced by treatment which reduces the level of contaminates to below the PTOW sewer limits.

Reuse: Due to the nature of the waste stream, reuse is not an option.

Reclamation: Due to the nature of the waste stream, reclamation is not an option.

Recycling: Due to the nature of the waste stream, recycling is not an option.

Disposal: One shipyard reported that it disposed of tank preservatives. In the original survey the preservative in question was a sodium nitrate solution that is utilized in order to provide an oxidation layer on the metal surfaces of the tank. It is believed that the data received was in error.

Fluorescent Lights. Fluorescent light tubes are generated when the tube no longer lights when turned on.

Reduction: Installation of natural lighting panels can reduce the time lights are on and hence the amount of tubes required. Additionally, long-life light fixtures and bulbs are currently available that will significantly reduce the number of bulbs required. These lights are energy efficient operating on a fraction of the energy required of a standard fluorescent fixture.

Reuse: Due to the nature of the waste stream, reuse is not an option.

Reclamation: There are currently available companies that will charge you to reclaim the mercury from the tube for its value, however the cost of recycling exceeds the cost of disposal into the landfill.

Recycling: Due to the nature of the waste stream, recycling is not an option.

Disposal: Because of the metals in the tubes (usually mercury) these bulbs can be considered a hazardous material. EPA has issued a guidance paper on disposal of these bulbs in that no more than twenty five tubes per facility per day can be disposed of into the landfill.

Contaminated Rags. Universally utilized for cleaning operations.

Reduction: Procurement of absorbent rags (high percentage of cotton compared to nylon) vice non-absorbent will reduce the number of rags utilized. Additionally, depending on the application, paper wiping rags may be more effective.

Reuse: Due to the nature of the waste stream, reuse is not an option.

Reclamation: One company took the initial expense of buying orange colored rags which stand out. When the recycling crew sorts trash, these rags are easily spotted and recovered. Contaminated rags were collected and sent to a commercial laundry for cleaning and return to the shipyard for reuse. This effort is labor intensive and may not result in a cost savings.

Recycling: Due to the nature of the waste stream, recycling is not an option. Off-site recycling of rags is performed by some companies and typically consists of cleaning and shredding the rags for fiber content. The fiber is then recycled into low-grade usage's, such as making carpet underlayment.

Disposal: The majority of respondents reported disposing of the rags into the landfill. It must be noted that rags which are contaminated by a hazardous material, such as solvents, are hazardous waste, and must be managed as such.

Refrigerants. Refrigerants are derived from equipment involved in space cooling/foodstuff preservation. Additionally refrigerants are utilized in dry air systems. The refrigerants are required to be collected from the equipment systems when the system is to be opened for either maintenance or repair. Venting to the atmosphere is not authorized.

Reduction: Refrigeration equipment manufacturers are currently attempting to develop replacement refrigerants that are not ozone depleting. However, due to the nature of the waste stream, reduction is currently not a viable option.

Reuse: Due to the nature of the waste stream, reuse is currently not a viable option.

Reclamation: Now that regulations prevent the manufacture of certain ozone depleting compounds such as refrigerants, the reclamation industry has built up to the point where refrigerants are reclaimed whenever work with refrigerants is required. These companies evacuate the refrigerant, filter and clean the refrigerant then reinstall the original refrigerant into the equipment being serviced.

Figure 16: Machining fines and metal turnings

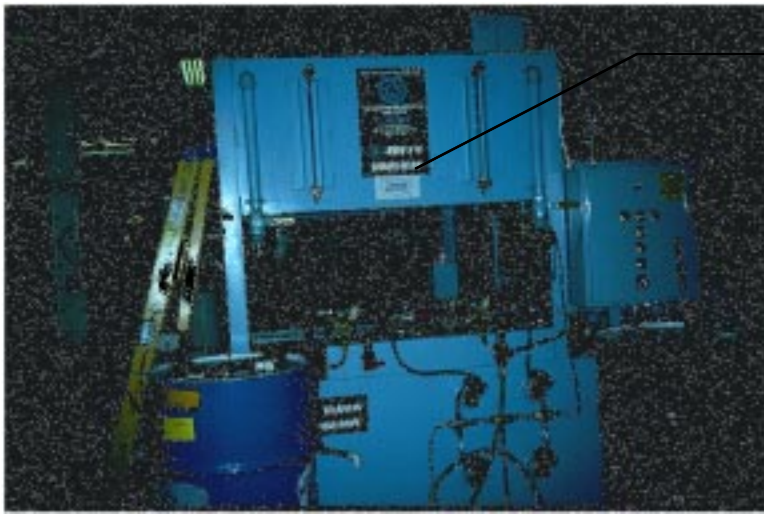


Figure 17: Machine coolant recycling system

Figure 18: Bails of cardboard

Recycling: Due to the nature of the waste stream, recycling is currently not a viable option.

Disposal: EPA regulations prohibit disposal of refrigerants to the atmosphere.

Support, Paper Products. Paper is generated whenever documentation is required in support of a particular effort. Additionally, newspaper, computer paper and disposable plates also contribute to this waste stream.

Reduction: An aggressive effort to reduce the number of persons and departments on the company's routine copy list can reduce paper usage by millions of sheets per year. Printing on both sides of the paper will also significantly reduce the quantity of waste paper generated.

Reuse: Single sided paper can be reused onsite as scratch pads.

Reclamation: Due to the nature of the waste stream, reclamation is not an option.

Recycling: The recycle value of paper fluctuates quite extensively sometimes making the effort cost effective. Very few companies, when investigating the cost associated with paper recycling efforts, include the cost reduction if disposing of the paper products in the landfill.

See Figure 18.

Disposal: Procurement of compactors and bailers significantly decreases the cost of transportation and disposal if tipping fees are based on volume vice weight.

Support, Plastics. Plastic is utilized extensively through out the shipyards for containment, equipment protection, packaging, etc. Various types of plastic are utilized in the shipyard/boatyard environment.

Reduction: Plastic was developed in order to replace (hence reduce) the use of wood, paper, glass, etc. Methods for reduction would depend on the method of determination of cost for disposal. If the landfill cost is based on volume (cubic yard) then compacting may be a method utilized in order to reduce costs.

Reuse: Due to the nature of the waste stream a limited reuse is available. Plastic utilized for equipment protection during shipping (popcorn) can be re-used.

Reclamation: Due to the nature of the waste stream reclamation is not a viable option.

Recycling: The recycle value of plastics fluctuates quite extensively sometimes making the effort cost effective. Very few companies, when investigating the cost associated with plastic recycling efforts, include the cost reduction of disposing of the plastic products in the landfill.

Disposal: Procurement of compactors and bailers significantly decreases the cost of transportation and disposal if tipping fees are based on volume vice weight.

Support, Wood. Wood is utilized extensively as barriers (fall protection) when plastic or paper does not provide the appropriate protection. Additionally wood is utilized in packaging, equipment movement (pallets), docking blocks, etc..

Reduction: In the case of pallets and spools the vender that provided the product will normally accept their return after the product is removed. Additionally some venders charge a reimbursable fee that is provided when the pallet or cable reel is returned. There are venders available that will except these wood products if the supply vender does not accept them.

Reuse: Wood such as pallets and cable reels can be reused as originally designed. Some equipment crates have also been designed to accept the retrograde from a particular repair effort.

Reclamation: Due to the nature of this waste stream, reclamation is not a viable option.

Recycling: Each yard usually has "Do it Yourselfers" that will take any packing crates or scrap wood for home projects or energy recovery (fireplaces). One company that generates a lot of saw dust was utilizing the dust to cover mud and reduce the mud.

Disposal: Wood scrap can be land filled, unless it has been treated with wood preservatives such as creosote. Additionally, untreated and uncoated wood can be chipped and included in mulch.

Metal Fabrication. Metals are utilized extensively in the shipyards. These metals are cut, shaped and formed in order meet the requirements of the customer. Scrap metal waste is generated as the result of these processes.

Reduction: Preplanning and thought given to layout of components to be cut can significantly reduce the metals designated for scrap. Additionally accurate measurement (measure once for the company, measure a second time in order to keep your job) can significantly reduce scrap. Procurement of preshaped metals (I beams, sheets, etc.) can also reduce the scrap.

Reuse: Judicial layout of metals to be cut can leave significant sized metals sheets that can be used in future projects. Smaller sheets can be cut so that they can be utilized as tools such as clamps and wedges.

Reclamation: Due to the nature of the waste stream, reclamation is not an option.

Recycling: All companies that generated any scrap metals utilize recycles in order to recover some of the cost of these metals. Several companies place marked bins throughout the facility that accepted the various types of metals. These metals were then sorted if necessary and consolidated for recycling. Recycled metals, particularly non-ferrous, can have a significant value depending on current conditions of the scrap metal market.

See Figure 20.

Disposal: Due to the recyclable value of scrap metals, these metals are not usually disposed to the landfill.

Bailing contaminated shrink reduces disposal cost

Figure 19: Bails of shrink wrap

Recycling bins encourage recycling and reducing handling

Figure 20: Scrap metal bin

Volume reduction of trash decreases disposal costs

Figure 21: Trash compactor

NSRP

Solid Waste Segregation & Recycling Project

Task Three

Waste Reduction SOP's & Life Cycle Cost Analysis

Justification for Incorporation of Reduction, Reuse or Recycling Steps into Existing Processes

Facility managers in ship and boat building and repair are constantly facing “the bottom line” while balancing budgets. Sometimes it seems like the juggling act is nearly impossible as increasing demands are placed on dwindling budget dollars.

Imagine the following scenario: You report to work on Monday, bright and breezy, ready to slay the dragons of the week and to take the bull by the horns. You start to open your mail. The first letter is from your solid waste hauling company indicating that they “regret to inform you that due to increased operational costs, and decreasing landfill space, your waste hauling rates are going to be increased by 20%, and rates are going to continue to increase in the years to come as landfill space becomes scarce.”

The next letter is from the local solid waste management district indicating that due to the decreasing landfill space, legislated recycling goals are being set, and your institution is expected to comply. The letter indicates that all contributors to the landfill are asked to start recycling, to cut their waste stream by 35% in he next few years, and by the year 2001 to have reduced their contributions by 50%. In addition, effective immediately, and environmental assessment fee will be charged for every ton discarded into the landfill.

The final letter is from the environmental management office for your state, stating that grass clippings and yard waste will no longer be allowed into the landfills. Your yard waste is going to be managed and regulated by the government!

This scenario may sound unrealistic, but organizations throughout the United States are facing these issues daily. The successful ones are facing it head on, by incorporation of reduction, reuse or recycling steps into existing processes. Organizations today must start to reduce the volume of their waste streams. Failure to recycle will cause your organization to spend more and more of your dwindling resources on solid waste hauling. **Failure to comply will mean that you will be throwing your money, literally, into the landfill!**

Potential Savings from Reduction, Reuse or Recycling.

Economic incentives for recycling become clear as landfills close and fees rise. Every ton deferred from the landfill saves you the tipping charges for that ton, in addition to and applicable environmental assessment fees. Thus, by reduction, reuse or recycling initiatives you can start to control your solid waste hauling costs. You can start to control your own destiny rather then have that destiny predetermined for you! If your waste hauling bills are based on a per-ton rate, the more you reduce, reuse or recycle, the lower the cost to you for disposal.

In addition, a careful recycling program can actually generate revenue if you market the recyclable items within your facility.

Harvesting Your Waste Stream

The first step is to analyze your trash flow. In other words, what is in the dumpsters, and how did it become part of your trash? During this first step, clearly identify items that are not trash. Do you find reusable goods? For instance, fasteners, furniture, used equipment, or carpet or other items that can be reused, sold to potential buyers or given to charities? Are the items in the waste stream unused excess materials? Or are they scrap from the building or repair process?

To make a recycling program effective, it is important to identify carefully how much of each material is collected in a given period of time. This information is key if you plan to sell the materials you collect!

Now that you know what is in the waste stream and in what quantities, several pertinent questions need to be asked. Can the items that was thrown away be:

- Reused on site in the building or repair process?
- Used in a different process or by another department?
- Reused by one of your related companies?
- Sold as recycled products to another industry?

Analyzing Results

After identifying products that can be recycled, investigate the potential viability for selling the recycled items. Be realistic. Initially market only those items for which you will receive tangible savings, either by revenues for the product or realized cost savings for diverting the product from the waste stream.

For instance, if your analysis indicates that the largest percentage of your waste stream is plastic, then try to market the plastic. However, if you find out that less then one percent of your waste stream is glass, it may not be practicable or feasible to collect such a small quantity, unless it's recycle value is high.

As you collect information about the categories and quantities that you generate in the waste stream, you should keep good detailed records from the beginning. This will provide invaluable documentation on how you a re handling your waste flow. Good records will demonstrate your efforts toward compliance with regulations and assist in tracking expenses and pay back from your recycling efforts.

As you collect the data, identify a baseline, or your starting point. For instance, you have identified the products in your waste stream, but how many tons does your waste stream represent before a recycling program starts? How much, in percentage or in pounds, do the recycled items represent?

We may be required to divert 35% of the solid waste from the landfill (some locations may be 50% or greater). If you do not know what the baseline of solid waste was at the outset, it is going to be difficult to calculate what percentages are recycled or diverted from the solid waste stream!

The final recourse for your trash should be the landfill. All other cost effective options should be exhausted first. You may ask, "Is recycling worth it?" Well, if you have money to throw away, you may have little concern, but tip charges in many areas over $100 a ton. If you discard 5,000 tons a year, there is a potential for great savings by recycling any percentage of he waste stream!

Collection Systems

Work with plant personnel to develop the simplest system for the collection of items that minimized labor and handling costs. Any way you slice it, recycling involves separation.

You have a fundamental choice at this point. Either handle separations in-house for maximum return, or receive a lower return and put the responsibility on the recycling contractor. If you elect to collect materials commingled, your recycler will be able to pay you little, if anything, because they will in turn have to separate the products they prepare for market.

Individual containers should be made readily available for each material targeted for collection. If you generate glass, drop it into the glass container (some locations may recycle different colors of glass), not into a "catch" container that would be sorted later. Make source separation containers readily available in the area where the item is generated.

The source-separated containers can then be emptied into larger containers on wheels, pallets, etc., that can be readily moved to a central pint for collection, and re-marketing. By using a simple system that generates recyclable items separated at the source, minimal labor is needed in the collection process.

Where does the labor come from? First of all, the recyclable item is "processed" by the generator. If I drink a soda, then it is my responsibility to drop the can in the aluminum recycling bin. The containers can then be removed and processed to the central collection area by plant personnel who would normally pull the trash. Instead of one container of trash, the material is now in two or more separate bags; one for items to be discarded into the dumpster, the other to be recycled. Trash has to be removed one way or the other.

Making Money from Recycled Items

Contact your purchasing or procurement office to ensure that you are complying with company requirements for the resale of items. Another key player would be your risk management or safety officer. One needs to be aware of the potential liability of selling items.

Since you have been keeping thorough records, you know how much you generate. At this point we suggest that you write a request for proposal (RFP) or, in other words, create a means to have people bid on your recyclable trash. Measure the price quotes against realistic market values.

There are several sources for rates, such as *Recycling Times*, or The Official Board market's *Yellow Pages*. The idea is to let the people know what it is you are selling, in what quantities, and that their prices will be compared against some type of standard market index to ensure competitive rates.

After generating the RFP, work with your purchasing agent to discover potential companies that could be buyers, and mail the request to them. Once you receive and thoroughly evaluate all the responses, award the RFP or bid to the company **that best meets your needs.**

The company that's the most flexible and that allows you to market your materials with the least handling and risk, while maximizing your return, is the company that will provide you the best potential for success.

Sell your recyclable items, and watch the revenue flow in while your expenses for disposing of solid waste either decreases of at least remain affordable.

The Cost of Doing Business

In conclusion, an argument that we hear when people say, "Let's start a recycling program!," is that it will be too expensive to recycle and too labor intensive. A well thought-out program can minimize costs while maximizing revenues from the items recycled.

A better question to ask is, "Can we afford *not* to recycle?" As trash handling costs increase and landfills close, what will we do with our garbage?

STANDARD OPERATING PROCEDURE

No. Appendix I	Rev: 0	Date: 5/5/98	Page 1 of 3
Subject: **Environmental Protection and Hazardous Waste Management Program Recycling Definitions**			

Definitions:

Baler: A machine used to compress recyclables into bundles to reduce volume. Balers are used often on newspapers, plastic, corrugated cardboard, and other sorted paper and plastic products.

Compactor: Power driven device used to compress materials to a smaller volume.

Compost: The stable, decomposed organic material resulting from the composting process. Also referred as humus.

Composting: The controlled biological decomposition of organic materials in the presence of oxygen into a stable product that may be sued as a soil amendment or mulch.

Contaminant: Foreign material that makes a recyclable or compostable material impure; for instance, food scraps on paper products.

Hauler: A garbage collection company that offers a complete refuse removable service. Many haulers now offer to serve as collectors of recyclables as well.
Markets: Generally, a recycling business (i.e., a buyer) or municipal recycling facility that accepts recyclable materials for processing and final sale to an end user, either for their own use or for resale.

Materials Exchange: A mutually beneficial relationship whereby two or more organizations exchange materials that otherwise would be thrown away. In some areas, computer and catalog networks are available to match up companies who wish to participate in exchanging their products.

Municipal Solid Waste: For the purposes of this guide, municipal solid waste includes all materials typically disposed of in dumpsters by businesses and removed for offsite disposal by private or municipal haulers. Includes wastes such as durable and nondurable goods, containers and packaging, food scraps, yard trimmings, and miscellaneous inorganic wastes from residential, commercial, institutional, and industrial sources. Municipal solid waste does not include wastes from other sources, such as municipal sludges, combustion ash, and industrial nonhazardous process wastes that might also be disposed of in municipal waste landfills or incinerators.

Pallet: A wooden platform used with a forklift for moving bales or other large items. Also called a skid.

Processing: The operations performed on recycled materials to render them reusable or marketable. Processing can include grinding glass, crushing cans, or baling. Processing has two distinct functions: a separation function and a processing or beneficiation function. Processing generally results in adding value to particular material.

Rebuilding: Modifying a component of municipal solid waste by repairing or replacing certain parts and reusing it again for its original purpose (e.g., refillable or rebuildable toner cartridges, wooden cable reels, or plastic wire reels). Rebuilding of solid waste components is most often done by a middleman.

Recyclables: Materials that still have useful physical or chemical properties after serving their original purpose. (See Appendix IV for a list of common recyclables).

Recycling: The process by which materials are collected and used as raw materials for new products. There are five steps in recycling: collecting waste materials, separating them by type (before or after collection), processing them into reusable forms, marketing the Anew@ products, and purchasing and using the goods made with reprocessed materials.

Reuse: Taking a component of municipal solid waste (possibly with slight modification) and using it again for its original purpose (e.g., refillable beverage bottles, foam peanuts, or pallets).

Solid Waste: According to the Resource Conservation and Recovery Act (RCRA), solid waste is: garbage; refuse; sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility; and other discarded materials, including solid, liquid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities.

Source Separation: Separating waste materials such as paper, metal, and glass by type at the point of discard so that they can be recycled.

Trash: Material often considered worthless, unnecessary, or offensive that is usually thrown away. Generally defined as dry waste material; but in common usage, it is a synonym for garbage, rubbish or refuse.

Waste Prevention: The design, manufacture, purchase or use of materials or products to reduce their amount of toxicity before they enter the municipal solid waste stream. Because it is intended to reduce pollution and conserve resources, waste prevention should not increase the net amount or toxicity of wastes generated throughout the life of a product.

Waste Reduction: Preventing and/or decreasing the amount of waste being generated either through waste prevention, recycling, composting, or buying recycled and reduced-waste products.

Waste Stream: The total flow of solid waste from homes, businesses, institutions, and manufacturing plants that are recycled, burned, or disposed in landfills, or any segment thereof such as the Aresidential waste stream@ or the Arecyclable waste stream.@

STANDARD OPERATING PROCEDURE

No. Appendix II	Rev: 0	Date: 5/5/98	Page 1 of 4
Subject: **Environmental Protection and Hazardous Waste Management Program**			

I. PURPOSE

This Standard Operating Procedure has been provided in order to establish the policy and procedure for control of hazardous and non-hazardous waste.

II. RESPONSIBILITY

The Operations Director is overall responsible for the control of hazardous and non-hazardous waste. Along these lines each department that generates waste is responsible for the implementation of these procedures.

III. REFERENCES

Appendix I Recycling Definitions

a. Appendix II Cost Analysis Procedures
b. Appendix III Metal Recycling Procedures
c. Appendix IV Common Recyclable Materials

IV. Requirements

Reference (a), (c) and (d) provide definitions associated with recycling efforts, some specific recommendations for handling of metal recycling (these same procedures can be adapted to plastic and paper recycling) and some examples of common recyclable materials. Reference (b) provides a quick method to determine if the recycling effort is cost effective.

In order to reduce the waste generated, the following waste minimization and/or recycling procedures should be followed:

Paint Department

Only mix the amount of epoxy based paints required to support painting requirements.

Cleaning solvents utilized for cleaning of paint guns and hoses will be recycled preferably by solvent recovery stills or by utilizing gravity separation procedures.

Paint consumables such as paint brushes, rollers, rags, plastic, cardboard buckets, etc. should be segregated from paint waste. What this will do is reduce the cost of disposal of these paint wastes as well in most localities the consumables can be disposed in the local landfills. (Please verify the rules and regulations of your locality.)

Abrasive Blasting Operations

Metals that require profile and/or coating removals subsequent to recoating/ painting should be blasted in buildings built to recycle the blast medium.

1. It is understood that this is not always feasible. If not then the spent blast medium should be collected and either disposed or handled in accordance with company policies. The following options are available:

   Dispose of as expended abrasive. Depending on local rules and regulations, the expended abrasive may be considered hazardous and therefore can be quiet expensive.

   A. Recycle to cement kiln or asphalt company. The collected abrasive may require some special handling in order to remove shipyard debris (welding rods, fasteners, grinding wheels, etc.). Additionally the accepting companies may require testing to verify the spent abrasive is non-hazardous for metals.

   B. Reuse product after treating. This may require specific permits in order to accomplish. Additionally depending on the process utilized to process the abrasive medium, the resulting product may or may not be within specification.

NSRP Project N1-93-1 provides additional information on the management of spent abrasives.

Metal Fabrication

The recycling of scrap metals can make the difference between profit and loss. Appendix III provides guidance in getting the best dollar per pound of scrap.

1. The mixing of scrap metals can significantly reduce the value of the scrap metals. Therefore, in order to get the maximum, containers (usually skip boxes) need to be marked as to the metals that are to be placed in them. Additionally they need to be placed such that it is convenient for the workers to properly sort the metals.
2. A collection point where the scrap can be consolidated by type should be designated. Final sorting to remove any trash or incorrectly placed metals should be conducted.

Shipping and Receiving

A good Shipping and Receiving person can also make the difference between profit and loss. Because all material entering and leaving the facility goes through Shipping and Receiving, this Department is responsible for the following:

Containers that have a turn-in value need to be tracked and returned to vender when no longer in use. Examples of refundable containers would be:

55 gallon drums
1) Cable spools
2) Pallets
3) Specialized crates

Reuse of packing materials, including popcorn, bubble wrap, paper, etc..

A)Consolidation (and compacting if the necessary equipment is available) of cardboard and paper products.

Administrative Support

Most of the various types of paper that has value are generated from the administrative offices. Containers should be available in the vicinity of these offices for the collection of the various types of paper. See Appendix IV for the various classifications of paper.

Although the value of scrap paper does not usually pay for the cost of this recycling effort, it can make an excellent public relations difference by increasing the corporate image, community relations and recognition of your company.

Tank and Bilge Cleaning

Tank and bilge cleaning generate the largest commodity of waste available for reduction. Large quantities of contaminated water are generated as a result of maintaining these tanks and bilges.

1. Historically, these fluids have gone to the bays and harbors and more recently to sewer systems for disposal. However because of recent evaluation of the contaminants in these fluids, they have come under close scrutiny.

The use of ABaker@ tanks for gravity separation of the fluids (removes oil) have significantly reduced this problem. After the initial cost of the tank there is little expense for the separation of the oils from the water. Additionally the use of inline filters removes the majority of other contaminants (metals) in the water.

Another method for reduction of the of this waste stream is the use of oily water separators. These separators ensure a Acleaner@ water in a much quicker time than the gravity separation method.

Oils extracted from the oily water mixture have a distinct value. These oils can be used in house to provide BTU source for company boilers or can be sold to venders who process the oil for the BTU value. Procedures delineated in Appendix III also apply to this

Machine Shop, Electric Shop, Transportation Department

Parts cleaning will be conducted utilizing biodegradable cleaners. This reduces the amount of hazardous materials stowed thus reducing the possibility of spillage.

If solvent based cleaning required, then solvents will be cleaned periodically in solvent distiller (paint shop).

2. Waste oils (non-automotive) will be placed in the waste oil container for either sale or recycling in boiler.
3. Automotive oils will be kept separated from other oils. These oils will be periodically picked up for processing and reuse.

All Departments

Recycle paper and paper products by placing waste paper into paper product recycling bins located throughout the facility.

2. Scrap metals will be separated and placed into the appropriate scrap metal bins located throughout the facility.

Use this worksheet to evaluate the economic and operational feasibility of the waste reduction options under consideration.

The tables in this worksheet will enable you to examine more closely the potential for waste reductions options. Much of the information requested on this worksheet involves business judgments concerning such factors as the effect each option is likely to have on productivity and the ease of implementation. Certain questions may not be applicable to all waste reduction options.

For the economic evaluation sections of this worksheet, refer to purchasing records, disposal records, waste sort or facility walk-through data, and interviews with company employees. Consult company purchasing officials, financial advisors, or department managers as necessary.

Fill out a separate worksheet for each waste reduction option to be evaluated, copying the forms as needed. Use the last page of this worksheet to summarize the economic, operational, and intangible factors associated with the waste reduction options under evaluation.

Waste Reduction Option

1 Operational Factors

A. Could this option improve or reduce product or service quality? How?

B. Could this option improve or reduce productivity? How?

C. Will additional staff or time be required to implement, operate, or maintain this option? How many? What would additional staff be required to do?

D. Can the option be implemented within the existing facility setup, or are adjustments needed (such as additional space or a change in layout) to accommodate the option? If so, what?

E. Will any new equipment be needed? If so, what?

F. Are there companies willing to purchase collected recyclable materials? List area buyers or haulers willing to collect material.

G. Can reusable materials be donated to local community group or listed with a materials exchange?

2 Economic Factors

A. Capital Costs for This Option

Equipment Purchased (e.g. baler, containers)	
	$
	$
Facility/Storage Preparation (e.g. grading a site for composting)	$
Installation/Utility Connection (for equipment such as compactors)	$
Initial Staff Training	$
Initial Promotional and Educational Materials	$

Other (specify)	$
	$
	$
Total Capital Costs	$

B. Annual Operating Costs for This Option	
Materials and Supplies	$
Operation & Maintenance (e.g. labor, equipment, storage, service contracts, utility charges)	$
Transportation	$
Ongoing Staff Training	$
Ongoing Promotion and Education	$
Other (specify)	$
	$
	$
	$
Total Annual Operating Costs	$

C. Avoided Waste Removal Costs for this Option

Use the table below to calculate the annual avoided removal costs for this waste reduction option. Using data from the waste sort, purchasing records, and interviews with personnel as starting point, estimate the annual amount of waste this option will reduce. An example is provided for replacing single use disposable plates with dishes in the cafeteria.

Waste Reduction Activity	**Waste Material Being Reduced**	**Amount Of Waste Reduced per Time Period**	**Annual Amount of Waste Reduced**	**Waste Removal Cost**	**Annual Avoided Removal Cost**
Replace single-use plates with dishes in cafeteria	Single-use plates	5 cubic yards per week	260 cubic yards per year	$3 per cubic yard	$780

D. Avoided Purchase Costs for this option

If the waste reduction option under consideration will result in the opportunity to purchase fewer supplies or materials, use the formula below to calculate the annual avoided purchase costs for this option.

Type of Material:

	X		=	$
Annual reduction in purchasing [in same unit of measure as the unit price]		Unit Price		**Annual Avoided Purchase Costs**

E. Annual Revenues for this option

Use the formula below to estimate annual revenues for this option (if any).

	+		+		=	$
Sale of recyclable materials		Sale of items in a materials exchange		Sale of others		**Total Annual Revenues**

F. Net Savings for This Option

Use the formula below to estimate annual savings for this option.

[ ]	+	[ ]	+	[ ]	=	$
Annual avoided removal costs [from Step 2-C]		Annual avoided purchase costs [from Step 2-D]		Annual revenues [from Step 2-E]		**Total Annual Savings**

G. Net Annual Cost or Savings for This Option
Subtract the total annual operating costs from the total annual savings to arrive at the net annual cost or savings resulting from this waste reduction option (exclusive of capital costs).

[ ]	-	[ ]	=	$
Total annual savings [from Step 2-E]		Total annual operating costs [from Step 2-B]		**Annual Net Costs or Savings**

H. Interpreting Net Costs

If the figure arrived in 2-F is positive, proceed to 2-I.
If the figure arrived at in 2-F is negative, this option will cost more to implement than it will save. First, review the numbers to ensure you have accounted for all potential costs and savings. If the result is the same, you will need to determine whether this option belongs in your waste reduction program. If this option has other intangible benefits (such as improved public relations and employee morale), you might consider including it. In addition, be sure to consider the program as a whole. This option might make sense if the other components of your program will result in large enough savings to offset the costs of this option, resulting in overall program savings.

If you decide it should not be included in your waste reduction program at this time, you might want to make a note to revisit this option if conditions change. For example, if the market for recyclable material improves significantly or equipment costs decline due to technological advances, this option might become cost-effective.

I. Payback Period for This Option

Payback period is one of many ways of measuring the economic feasibility of the options under consideration. The payback period measures the amount of time needed for the cumulative revenues or savings resulting from the waste reduction program to equal the initial investment. (This calculation is only relevant when annual savings or revenues exceed annual costs.) If your company uses other measures of investment worthiness (internal rate of return, net present value, etc.) you may wish to use one of these methods instead of calculating the payback period.

Calculate the payback period using the formula below.

	–		=	
Total capital costs [from Step 2-A]		Annual net savings [from Step 2-F]		**Payback Period (Years)**

3. Other Factors

Aspects of the options that cannot be expressed using the Economic and Operational Feasibility tables and formulas may be explained below. (These intangible factors include improved working environment, corporate image, employee and customer satisfaction, community relations, and recognition.) List the intangible advantages and drawbacks associated with implementing this option.

4. Summary of Waste Reduction Options

Use this table to summarize the economic and operational feasibility of your waste reduction options.

	Economic			Operational
Option	Projected Amount of Waste Reduced Annually	Annual Net Cost or Savings	Payback Period	Operational and Intangible Advantages and Drawbacks
Recycling office paper	*200 reams of paper*	*$2,000 savings*	*Less than 1 year*	*Strong, local paper recycling market, easy to implement, good for employee involvement*

STANDARD OPERATING PROCEDURE

No. Appendix III	Rev: 0	Date: 5/5/98	Page 1 of 3
Subject: **Environmental Protection and Hazardous Waste Management Program Maximizing Return for Scrap Metals**			

General:

Fix responsibility for scrap program with one person called scrap manager.

1) Use security log on all shipments as double check that you are paid for each load.

2) Ensure that material is sorted so that you get metal price vice mixed metal prices.

Procedures:

FERROUS

1) Weigh all truckloads on a public scale, both empty and loaded, no exceptions. Account for bin weights in your calculations.

2) Have security keep a log or record of each pickup. Double check against security record.

3) Scrap manager shall inspect each load just before it leaves to be sure the material is correct (no Non-Ferrous or garbage). Note anything unusual.

4) Keep a package for each shipment, including weight ticket from public scale, bin weight, notes about contents, if any, and security record of shipment.

5) When settlement received:

5a) Check net weight paid against public weight ticket. (Adjust for bin weight as needed.

5b) Do not accept discrepancies of over 100 pounds unless your note mentioned garbage in the bin.

5c) Check price against vendor’s quote. You can always negotiate a little.

5d) Pass on completed package after approval.

6) Have a double check system to insure that all pick ups noted by security have a settlement package. This can be done by numerical control, or keeping all security records in one spot, and checked.

SPECIAL CONDITIONS - FERROUS:

1) Get current selling price of ship scrap from local sources. It may be worthwhile to truck scrap to remote vender in order to get better value per ton.

NONFERROUS SCRAP

1) Add a “small” bin for “irony or contaminated” (not toxic term) Non-Ferrous metal, and one for monel/cupro nickel as needed.

2) Scrap manager shall continually inspect all bins to insure the correct materials is in place.

3) The clean Non-Ferrous grades should be kept 100% free of iron or non-metallics.

4) If large amounts of one metal are generated (e.g. 70/30 cupro nickel, monel, etc.), they should be identified and kept separate.

5) Provide workers with nitric acid to tell cupro nickel and monel from stainless steel. (Nitric acid does not react with stainless steel, but turns green if any copper is present).

6) Also provide magnets to your employees (cupro nickel and monel are non-magnetic)

7) Weigh all “small” bins on scale and record weights.

8) Weigh all truck on a public scale, both loaded and empty, no exceptions. Count and adjust for individual bin weights as appropriate.

9) Have security log all pick ups, noting date, time, etc.

10) Inspect all bins immediately before shipment to insure the proper quality of the contents. Note any discrepancies.

11) Prepare a package for each shipment as soon as it leaves, including:

11a) Small bin weights and commodity.
11b) Public scale ticket.
11c) Notes on quality, if any
11d) Number of bins on truck.
11e) Security record of shipment.
11f) Check total weight of individual bins and their contents (bin and material) to insure it agrees with the net weight on the public scale ticket. 11g) Note any discrepancies immediately as the small scale are not usually certified.

12) Establish pricing based on date of pick up. Price all brasses and bronzes by individual grade.

13) When you receive a settlement sheet (promptly, at least one per month), the scrap manager shall check each grade and weight shipped (your package) against the grade and weight paid for, they must agree. Sort downgrades on clean material should not be accepted if the above steps were followed and the scrap manager did not see any off grade. Different types of clean grades (e.g. - brasses, bronze, coppers, etc.) are acceptable in settlements, providing they are reasonably close to bin category.

14) Obtain weekly or monthly price sheet to be used as a guide or double check. Check the price against this list. Prices should be within $0.02/pound of the numbers indicated. Occasional variations are normal, but 80% should be in this range.

15) Negotiate any differences not in your favor. The vender will usually raise a price that appears out of line.

16) Double check security log to insure all loads that have left the plant have been paid for.

Please note that Non-Ferrous is normally very valuable. You could easily save or loose a few thousand dollars per month.

Paper

High-Grade Paper

High grade paper is usually generated in office environments and can earn recycling revenues when present in sufficient quantity. Types of high grade paper include:

Computer paper (also known as Computer Print Out or CPO). Can be all white or have a white main fiber with bright green or blue bars.

White ledger. Most white office paper, including white computer paper, copy machine paper, letterhead, white notebook paper, and white envelopes. Common contaminants include glossy paper, wax-coated paper, latex adhesive labels, envelopes with plastic windows, and carbon paper.

Tab cards. Usually manila-colored computer cards; may be other colors but must be separated by color to be valuable as a high grade paper.

Other Papers

These papers are less valuable than high-grade paper in terms of recycling, although they still can be cost effective to recycle in many cases. Examples of other types of paper include:

Colored ledger. Most non-white office paper, including carbonless paper, file folders, tablet paper, colored envelopes, and yellow legal paper.

Corrugated Cardboard (also know as Old Corrugated Cardboard or OCC). Includes unbleached, unwaxed paper with a ruffled (corrugated) inner liner. It usually does not include linerboard or pressboard, such as cereal boxes and shoe boxes. For most businesses, cardboard is a cost effective material to recycle.

Newspaper (also known as Old News Print or ONP). It is most valued when separated from other paper types, but can be recycled as mixed waste paper.

Miscellaneous waste paper. Encompasses most types of clean and dry paper which do not fall into the categories mentioned above, including glossy papers, magazines, catalogs, telephone books, cards laser-printed white ledger, windowed envelopes, paper with adhesive labels, paper bags, wrapping paper, packing paper, sticky-backed notes, and glossy advertising paper. This mixed paper has limited value in existing markets.

Mixed waste paper. Paper that is unsegregated by color, quantity, or grade (e.g., combination of white ledger, newsprint, colored paper, envelopes without windows, computer paper, glossy paper, etc.). Mixed paper generally sells below the price of the least valuable paper in the mix.

Plastic

There are 7 types of plastic which are identified by a Society of Plastics Industry (SPI) code number ranging from 1 to 7. These numbers are usually found on the bottom of plastic containers inside a three-arrow recycling symbol. A description of each kind of plastic is presented below. Also, you may check with the Society of the Plastics Industry at 1-800-2-HELP-90 for information about haulers/recyclers in your area. Some recyclers only accept a sub-category of the ones presented below. For example, a recycler may only accept HDPE milk jugs and not all HDPE products.

PET (SPI=1)

Polyethylene terephthalate (PET) is the most readily recyclable material at this time. It includes 1- and 2- liter clear soda bottles, as well as some bottles containing liquor, liquid cleaners, detergents and antacids.

HDPE (SPI=2)

High-Density Polyethylene (HDPE) is currently recyclable in some areas. This class includes milk, juice, and water jugs, base cups for some plastic soda bottles, as well as bottles for laundry detergent, fabric softener, lotion, motor oil, and antifreeze.

PVC (SPI=3)

Polyvinyl Chloride (PVC, also referred to simply as Avinyl@) includes bottles for cooking oil, salad dressing, floor finish, mouthwash, and liquor, as well as Ablister packs” used for batteries and other hardware and toys.

LDPE (SPI=4)

Low-Density Polyethylene (LDPE) includes grocery bags, bread bags, trash bags, and a variety of other film products. LDPE is currently being recycled by some of the major retail chains.

Polypropylene (SPI=5)

Polypropylene includes a wide variety of packaging such as yogurt containers, shampoo bottles, and margarine tubs. Also cereal box liners, rope and strapping, combs, and battery cases.

Polystyrene (SPI=6)

Polystyrene includes Styrofoam J coffee cups, food trays, and Aclam shell" packaging, as well as some yogurt tubs, clear carryout containers, and plastic cutlery. Foam applications are sometimes called EPS, or Expanded Polystyrene. Some recycling of polystyrene is taking place, but is limited by its low weight-to-volume ratio and it value as a commodity.

Other (SPI=7)

Can refer to applications which use some of the above six resins in combination or to the collection of the individual resins as mixed plastic (e.g., cameral film can include several types of plastic resins). Technology exists to make useful items such as plastic Alumber@ out of mixed plastic resins, but generally the materials are more useful and valuable if separated into the generic resin types described above.

Metals

Aluminum

Included in this category are aluminum beverage cans, as well as clean aluminum scrap and aluminum foil. Currently, aluminum is a highly valued material for recycling.

Tin-Coated Steel Containers

Includes cans used for food packaging (i.e., canned foods). Some local recyclers may require cans to be cleaned and crushed with labels removed.

Bimetal Containers

A typical example includes tin-plated steel cans with aluminum Apop top@ (e.g., peanut cans). These containers can be separated from aluminum cans by using a magnet. (Note: Technically, tin cans are bimetal, but we do not consider them when referring to bimetal cans.) Many recyclers accept bimetal containers with tin-coated steel cans.

Non-Ferrous Metals

Includes most types of scrap metal which do not contain iron (such as copper and brass). This scrap can be a relatively valuable commodity, depending on quantity. It is often recycled through scrap metal dealers, although some general recyclers will handle it with other materials.

Ferrous Metals

Includes iron and iron-containing metal scrap. Ferrous metal is handled in the same manner as non-ferrous metal but generally has lower market value.

Miscellaneous Recyclables

Lead-Acid Batteries

Lead-acid batteries are used in automobiles, back-up lighting systems, lawn mowers, and computers. Lead-acid batteries contain lead, a toxic metal, and sulfuric acid. Many states prohibit disposal of lead-acid batteries in municipal solid waste, and many require either retailers, wholesalers, or distributors to take back batteries. Currently about 90 percent of lead-acid batteries used in automobiles are recycled.

Household Batteries

Household batteries come in a variety of types, including alkaline, carbon-zinc, mercuric-oxide, silver-oxide, zinc-air, and nickel-cadmium. Currently, only button batteries containing mercury and silver or nickel-cadmium batteries can be recycled, often at a net cost.

Introduction To Project Analysis Of Pollution Prevention Projects

PURPOSE OF THIS DOCUMENT

This guidance manual is designed to assist decision makers at shipyard facilities make accurate cost decisions concerning waste reduction and recycling projects by implementing Total Cost Accounting and Life Cycle Analysis when evaluating pollution prevention opportunities. Specifically, this manual introduces and describes several analytical tools that can be used to help users identify and quantify the financial and environmental benefits of pollution prevention projects and alternative opportunities. This information can then be used to evaluate and justify pollution prevention projects.

This manual is written primarily for the individual who makes decisions regarding project funding at the shipyard and for those who recommend and evaluate potential alternatives. However, any shipyard employee involved in the procurement process can use the concepts in this manual to more accurately evaluate the full economic and environmental impacts of projects under consideration.

The information provided in this document will help shipyard managers choose the best pollution prevention practices and support projects amid competing resource demands. The analytical tools to evaluate and support pollution prevention opportunities described in this manual fall into two categories: Economic Analysis and Environmental Analysis. These two categories are discussed separately, but in reality they are two integral components of any project review process.

The financial and environmental techniques discussed in this manual expand upon traditional project analysis to include:

1. Associated direct and indirect cost and environmental impacts;

2. Associated financial and environmental consequences occurring both "upstream" and "downstream;" and

3. The environmental impacts throughout all media (air, water, soil) resulting from competing project alternatives.

Finally, this manual is not intended to be a comprehensive "how-to" text presenting new research on financial and environmental project review concepts. Rather, it provides an introduction and a framework for using these important and evolving tools. Readers who seek more detailed information should refer to the documents listed in Appendix B.

WHAT IS POLLUTION PREVENTION?

Over the past several years, a new environmental protection concept and strategy has been developed that focuses on eliminating or modifying activities that result in adverse environmental impacts. This concept, known as pollution prevention, has gained widespread support as a means to meet or exceed environmental goals and standards and to reduce resources being spent to clean up pollution. Pollution prevention is defined in the Pollution Prevention Act of 1990 as: "...any practice which reduces the amount of a hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, or disposal; and any practice which reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants."

Pollution prevention, referred to here as source reduction, represents the first step in a hierarchy of options for managing waste. Exhibit 1-1 depicts this Environmental Management Hierarchy. Source reduction is assigned the highest priority because it eliminates or reduces wastes at the source of generation. Recycling is the next preferable approach, because it involves the reuse or regeneration of materials that would otherwise become wastes into usable products. Treatment and disposal are viewed as last-resort measures, since they do not involve the reduction or reuse of wastes.

Exhibit 1-1
ENVIRONMENTAL MANAGEMENT HIERARCHY

SOURCE REDUCTION
RECYCLING
TREATMENT
DISPOSAL

Pollution prevention refers to the use of materials, processes, or practices that eliminate or reduce the quantity and/or toxicity of wastes at the source of generation. It includes practices that eliminate the discharge of hazardous or toxic chemicals to the environment and protect natural resources through conservation and improved efficiency. Further, pollution prevention encourages reduction in the use of hazardous materials, energy, and water as the best approach to reducing environmental impacts. Exhibit 1-2 lists the major types of pollution prevention activities.

Exhibit 1-2 POLLUTION PREVENTION ACTIVITES
Process Efficiency Improvements · Perform the same task with less energy or materials by designing new systems or modify existing ones.
Material Substitutions · Replace hazardous chemicals with less toxic alternatives of equal performance
Inventory Control · Improve materials management practices to prevent product expiration or damage.
Preventive Maintenance · Routinely check storage areas and containers for leaks and spills · Maintain equipment in good working order to extend useful life
Housekeeping · Keep work areas neat and organized to reduce the chance of spills or releases or chemicals.
Training · Train employees in pollution prevention techniques.

Pollution prevention differs from the traditional approach to waste management not only because it seeks to avoid the generation of waste or environmental releases, but also because it stresses the relationship between air, land, and water to view the environment as a whole, rather than as individual segments. Within this framework, pollution prevention aims to eliminate or reduce waste released to land, air, and/or water without transferring or shifting pollutants between environmental media.

BENEFITS OF POLLUTION PREVENTION

Practicing pollution prevention may result in a number of economic benefits. These benefits can include fewer Notices of Violation (NOVs) and fewer costs associated with reporting, compliance, penalties, and environmental liability associated with hazardous waste generation and use. Pollution prevention can also reduce the costs associated with waste management. Costs that may be reduced include expenditures for raw materials, waste handling and storage, transportation and disposal, training, management overhead, and emergency response. The likelihood of incurring significant future environmental costs, such as remediation activities, can also be reduced by using pollution prevention approaches.

In addition, pollution prevention can produce positive health and environmental benefits. Minimizing the use of hazardous materials creates a safer work place and reduces the need for expensive health and safety protection devices. A safer work place will also improve employee morale. In addition, the reduction in hazardous materials use can decrease the volume of toxic substances released to the environment from spills, leaks and air emissions that affect human health and the environment. Exhibit 1-3 presents a list of the most significant pollution prevention benefits.

Exhibit 1-3

POLLUTION PREVENTION BENEFITS

Operating Costs

- Reduced waste storage, handling , treatment, and disposal costs.
- Avoided costly alternative treatment technologies.
- Reduced raw material and feedstock purchasing costs.
- Lowered housekeeping costs.
- Reduced operating costs through better management and production efficiencies.
- Reduced usage of energy, water and other resources needed.

Liability/Risk

- Decreased regulatory reporting requirements and compliance costs.
- Reduced liability for environmental problems at both on-site and off-site treatment, storage, and disposal locations.
- Reduced work related injuries and worker exposure to hazardous materials.
- Perceived public health/environmental benefits.

Facility Image

- Improved community relations.
- Perceived public health/environmental benefits.

Although pollution prevention techniques can result in many benefits, many shipyards have not yet embraced pollution prevention projects. This is due, in part, to facility environmental funding historically being focused upon regulatory compliance activities. In addition, traditional governmental economic and environmental analysis tools do not always consider the total costs, savings, and environmental benefits from pollution prevention. In short, these traditional analysis tools often do not provide adequate justification to recommend pollution prevention opportunities. This manual introduces tools for evaluating and justifying pollution prevention projects to overcome this barrier.

HOW DO YOU EVALUATE POLLUTION PREVENTION PROJECTS?

This guidance manual introduces shipyard environmental managers to the tools necessary to more fully evaluate both the environmental effects and economic impacts of current operations, pollution prevention opportunities, and competing project alternatives. Specifically, the manual outlines the key concepts and procedures involved in using economic and environmental project review tools. While these tools can be used to evaluate current operations and virtually any type of project, they are described in this manual in the context of evaluating and supporting pollution prevention projects.

To effectively use the economic and environmental analysis tools described in this document when evaluating pollution prevention opportunities, it is necessary to apply these tools to current operations as well as other project options under consideration. In this way, greater understanding of the financial and the environmental effects can be gained and can be compared on an equal basis.

Estimating Economic Performance

Economic analysis is the most commonly used method to determine how scarce resources should be allocated. An accurate estimate of the costs associated with the development and use of a product or process is central to the internal decision making and strategic planning process. Pollution prevention projects must compete on equal footing with other funding requests.

The easiest and most common economic evaluation is one that compares the up-front purchase price of competing project alternatives. However, the up-front purchase price is typically a poor measure of a project's total cost. Costs such as those associated with maintainability, reliability, disposal/salvage value, and training/education must also be accounted for in the financial decision making process.

This guidance manual provides shipyard decision makers and their advisors with an introduction to the tools to expand upon traditional economic analysis processes to identify more of the costs associated with a particular operation or process at a facility.

The approach discussed in this guidance manual is designed to allow shipyard managers to expand their traditional economic analysis framework by adding new cost elements to existing modeling techniques. This approach gives flexibility to the economic analysis process and allows each analysis to be tailored in scope and detail to reflect both available data and specific project review needs. Further, basic cost data already embedded in existing facility-level models can be used to minimize the effort needed to secure required data.

Estimating Environmental Consequences

In addition to economic performance, the environmental consequences of current practices and alternative opportunities should be factored into project review processes. When environmental consequences are considered, the pollution prevention alternatives can be assigned appropriate weight. Through this process, project opportunities that reduce one type of pollution by transferring the environmental impacts to another media (e.g., from water to atmospheric releases) can be identified and eliminated.

Environmental analyses can be used to examine environmental impacts along various points in the life cycle of the product, process, or activity. This may include extraction and processing of raw materials, manufacturing, transportation and distribution, use/re-use/maintenance, recycling, and final disposal. Environmental analyses, like economic analyses, can be tailored in scope and detail to reflect both available data and specific project review needs.

FORMAT OF THIS GUIDANCE MANUAL

The remainder of this guidance manual provides more specific guidance and application examples using each of the pollution prevention tools discussed above. Chapter 2 presents economic analyses, and Chapter 3 discusses environmental analyses. Both of these chapters provide an introduction to the basic analysis procedure and include worksheets that illustrate how the concepts can be applied. A glossary of terms, a list of additional resources, and a reader response survey are located at the end of the manual in Appendices A, B, and C, respectively.

Chapter 2

TOTAL COST ASSESSMENT FOR POLLUTION PREVENTION

INTRODUCTION

This chapter is designed to assist shipyard managers in identifying a broader and more accurate array of economic costs associated with current operations and with alternative project opportunities. These tools will help uncover areas of cost savings that result from pollution prevention projects that are often overlooked in traditional costing processes. With these tools, managers will be better equipped to answer the questions: "Does pollution prevention pay? And if so, how much?"

The chapter first discusses how traditional project analysis procedures can be expanded upon to more accurately reflect the economic costs and benefits of pollution prevention activities. Next, a worksheet with step-by-step instructions is provided to illustrate how these new concepts can be used. Together, this discussion will provide facility managers with the framework necessary to begin using economic analysis principles to more accurately evaluate the financial viability of pollution prevention projects.

WHAT IS ECONOMIC ANALYSIS?

Economic analysis involves tabulating the financial costs, revenues, and savings that a project is expected to generate. These estimates provide the data necessary to evaluate the economic advantages of competing projects. All Shipyards require some form of financial performance analysis as part of the investment decision making process.

Unfortunately, economic analysis methods historically have minimized or ignored the economic benefits of pollution prevention projects by incorporating too few cost areas in the analysis and by examining costs over too short of a period of time. Not surprisingly, methods to improve economic justification for pollution prevention projects involve addressing these shortcomings.

Definitions And Terms

Over the last few years, researchers and managers working to promote pollution prevention have been developing techniques to evaluate projects that account for the economic benefits of pollution prevention. Several systems and models have been developed, and numerous terms are currently used to define these systems. These systems and models all involve expanding the traditional project evaluation methods to address the issues stated in this chapter. For the sake of clarity, the following section provides a short description of three approaches. These definitions were developed by the United States Environmental Protection Agency (EPA). Many facility managers may be familiar with these approaches, yet call them by a different name.

Total Cost Accounting: Total Cost Accounting, also referred to as Full Cost Environmental Accounting, is used in management accounting to represent the allocation of all direct and indirect costs to specific products, product lives, or operations.

Total Cost Assessment: Total Cost Assessment has come to represent the process of integrating environmental costs into capital budgeting analyses. It has been defined as the long-term, comprehensive financial analysis of the full range of costs and savings of an investment experienced by the organization making the investment.

Life Cycle Cost Assessment: Life Cycle Cost Assessment represents a systematic process for evaluating the life cycle costs of a product, product line, process, system, or facility from raw material acquisition to disposal by identifying environmental consequences and assigning monetary value.

Additional definitions for commonly used terms can be found in Appendix A.

Expanding Cost/Savings Inventories

For pollution prevention projects to compete fairly with pollution control and competing alternatives, more potential costs and savings must be considered. In addition to including direct costs, the cost inventory should also include indirect costs, liability costs, and less tangible benefits. Exhibits 2-1 and 2-2 provide a list of capital and operating costs that environmental managers can use to determine the financial costs and savings associated with a particular project opportunity.

The challenge for any shipyard decision maker or project analyst seeking to use an expanded cost/savings inventory for investment analysis is that some of the cost data associated with a particular piece of equipment or process may be difficult to obtain. Quantifying some of these costs may be a challenge because they may be grouped with other cost items in existing overhead accounts. For example, waste disposal costs for existing processes are often placed into a facility overhead account, whereas an expanded cost inventory would call for these costs to be directly allocated to the product or process that produces them. Consequently, it is not expected that information for all the cost categories will be identified during analyses. Managers and analysts should use the list of categories contained in Exhibits 2-1 and 2-2 to incrementally expand their existing financial analyses whenever possible.

Exhibit 2-1

INVENTORY OF POTENTIAL CAPITAL COSTS

PURCHASED EQUIPMENT

- Equipment
- Delivery
- Sales tax
- Insurance
- Price for initial spare parts

MATERIALS

- Piping
- Electrical
- Instruments
- Structural
- Insulation
- Other materials (e.g., painting, ducting)

UTILITY SYSTEMS AND CONNECTIONS

- General plumbing
- Electricity
- Steam
- Water (e.g., cooling, process)
- Fuel (e.g., gas, oil)
- Plant air
- Inert gas
- Refrigeration
- Sewerage

SITE PERPARATION (LABOR, SUPERVISION, MATERIALS)

- Site studies
- Demolition and clearing
- Old equipment/rubbish disposal
- Grading, landscaping
- Equipment rental

CONSTRUCTION/INSTALLATION (LABOR, SUPERVISION, MATERIALS) · In-house · Contractor/vendor/ consultant fees · Equipment rental
PLANNING/ENGINEERING (LABOR, SUPERVISION, MATERIALS) · In-house planning/engineering (e.g., design, drafting, accounting · Contractor/vendor/ consultant fees · Procurement
STAT-UP/TRAINING (LABOR, SUPERVISION, MATERIALS) · In-house · Contractor/vendor/ consultant fees · Trials/manufacturing variances · Training
REGULATORY/PERMITTING (LABOR, SUPERVISION, MATERIALS) · In-house · Contractor/vendor/ consultant fees · Permit fees
WORKING CAPITAL · Raw materials · Other materials and supplies · Product inventory Protective equipment
CONTINGENCY · Future Compliance Costs · Remediation
BACK-END · Closure/ decommissioning

- Disposal of inventory
- Site survey

Exhibit 2-2

INVENTORY OF POTENTIAL OPERATING COSTS

DIRECT MATERIALS

- Raw materials (e.g., wasted raw materials costs/savings)
- Solvents
- Catalysts
- Transport
- Storage

DIRECT LABOR

- Operating (e.g., worker productivity changes)
- Supervision
- Manufacturing clerical
- Inspection/QA/QC

UTILTIES

- Electricity
- Steam
- Water (e.g., cooling, process)
- Fuel (e.g., gas, oil)
- Plant air
- Inert gas
- Refrigeration
- Sewerage

WASTE MANAGEMENT (LABOR, SUPERVISION, MATERIALS)

- Pre-treatment
- On-site handling
- Storage
- Treatment

- Hauling
- Insurance
- Disposal

REGULATIRY COMPLIANCE (LABOR, SUPERVISION, MATERIALS)

- Permitting
- Training (e.g., Right-To-Know training)
- Monitoring/inspections
- Notifications
- Testing
- Labeling
- Manifesting
- Record keeping
- Reporting
- Generator fees/taxes
- Closure/post-closure care
- Financial Assurance
- Value of marketable pollution permits (e.g., SOx)
- Avoided future regulation (e.g., Clean Air Act amendments)

INSURANCE

- Future Liability
- Fines/penalties
- Cost of legal proceedings (e.g., transaction costs)
- Personal injury
- Property damage
- Natural resource damage
- Superfund

REVENUES

- Sale of product (e.g., from changes in manufacturing throughput,
- market share, corporate image)
- Marketable by-products
- Sale of recyclables

Expanding Time Horizons

Another concept that is helpful in uncovering more of the true economic benefits of pollution prevention projects is to expand the evaluation of costs and savings over a longer time horizon, usually five or more years. This is because many of the costs and savings from pollution prevention take years to materialize, and because the savings from pollution prevention projects often occur every year for an extended period of time. For example, some pollution prevention projects may result in recurrent savings as a result of less waste requiring management and disposal every year. Conventional project analysis, however, often confines costs and savings to a three to five year time period. Often, this time horizon is shorter than the useful life of the item or equipment being evaluated. Using this traditional time frame in project evaluation will exclude some of the areas of savings generated by pollution prevention projects.

Comparing Financial Performance

While expanding cost inventories and time horizons can greatly enhance the ability to accurately portray the economic consequences of a single pollution prevention project, financial performance indicators are needed to allow comparisons to be made between competing project alternatives. Three methods of comparison are currently in widespread use: Payback Period, Net Present Value, and Internal Rate of Return.

The simplest and most common approach is to conduct a payback analysis that estimates the amount of time it will take to recover the capital expenditures. Net present value is also advocated by many economists as a more accurate approach to project evaluation. Both techniques are useful and offer specific advantages/drawbacks for shipyard decision makers. The third approach, Internal Rate of Return, is less common, but is described below for use by readers who encounter it. Analyzing economic impacts using two or more of these approaches will provide even more insight.

Payback Period: Payback period analysis is the investment performance indicator most commonly used by businesses. The purpose of a payback analysis is to determine the length of time it will take before the costs of a new projects are recouped. The formula used to calculate Payback Period is: Payback Period (in years) = start up costs / (annual benefits - annual costs) Payback Period = $800 / ($600 - $400) = 4 years

Those investments that recoup their costs before a set "threshold" period of time (usually 3-5 years) are determined to be projects worth funding. Payback period analysis does not discount costs and savings occurring in future years. In addition, costs and savings are not considered if they occur in years later than the threshold time in which a project must pay back in order to be funded. There are also examples where critical pollution prevention projects may have a payback slightly longer than an established threshold, but have been implemented due to significant intangible benefits.

Net Present Value: The Net Present Value (NPV) method is based upon the concept that a dollar today is worth more than a dollar in the future (commonly referred to as the time value of money). Specifically, this method progressively reduces (discounts) the value of costs and revenues occurring in future years (cash flows). These discounted annual cash flows are then added to calculate the "Net Present Value" of the investment. The higher the NPV, the more attractive the project.

This method is particularly useful when comparing pollution prevention projects against alternatives that result in higher annual waste management and disposal costs. The increased costs of current operations (or of investment options that do not reduce wastes) will tend to lower their net present value. This method easily accommodates the use of an expanded cost inventory when calculating all costs and benefits.

NPV = Initial investment (expressed as a negative number) + discounted net yearly cash flows

Note: Net yearly cash flow = discounted cash inflows - discounted cash outflows

For example:

$100,000 initial investment (-100,000) + $300,000 discounted savings -$100,000 discounted costs = $100,000

Internal Rate of Return: Unlike in NPV calculations, where cash flows are discounted by a rate and then added, the purpose of IRR calculations is to determine the interest rate at which NPV is equal to zero. If that rate exceeds the hurdle rate (defined as the minimum acceptable rate of return on a project), the investment is deemed worthy of funding. Therefore, the IRR equals r in the following equation:

Initial Cost + cash flow year 1/(1+r)1 + cash flow year 2/(1+r)2 + cash flow year 3/(1+r)3... + cash flow year n/(1+r)n = O

In practice, IRR is usually calculated using a process of trial and error, where different interest rates are tried until the correct internal rate of return is found. That rate is then compared to the hurdle rate.

In many instances, decision makers at shipyards may have little choice concerning which of the above methodologies to use. The choice of payback, NPV, or IRR may be dictated by either policy or common practice. Whichever method is used, the challenge for decision makers is to expand the content of their analysis to reflect the true costs and savings as accurately as possible.

GETTING STARTED

The concepts discussed in this chapter can be used to help identify, calculate, and demonstrate the economic benefits that result from pollution prevention projects. They can be used to provide a fair and more complete comparison of two or more competing project alternatives, or can be used to compare proposed projects to the costs of existing operations.

As discussed earlier, managers seeking to expand their existing economic analysis methods to better capture the benefits of pollution prevention should incorporate as many of the concepts discussed in this chapter as practical. Managers who cannot isolate and quantify all of the items they have identified in their expanded cost inventory should nevertheless research and include cost data on all of the items for which they can collect reliable information. Similarly, the time horizon for the analysis should be extended as far as possible, given available data and the type of project evaluation method in use at their facility. Incorporating these concepts is often an incremental process. Even small steps toward expanding inventories and extending time horizons can result in funding approval for pollution prevention projects that would otherwise face rejection.

A worksheet has been provided at the end of this document to illustrate the use of these concepts. This and similar worksheets can help the reader analyze the costs and benefits associated with current operations, pollution prevention projects, and alternative project opportunities. The worksheet demonstrates ways of capturing more cost categories by better allocating costs to specific activities, expanding the cost areas included in the analysis, and expanding the time horizon over which the project is analyzed. Note that the lists of potential costs and revenues have been abbreviated for ease of use. Facility decision makers likely will need to revise this worksheet to include items relevant to their own analysis.

The worksheet also provides for the calculation of two measures of financial performance, a simple payback analysis and a net present value calculation (which incorporates the time value of money). Both of these calculations can help in making comparisons between competing project options or in comparing a proposed project against current operations. IRR calculations are not included on the spreadsheet due to the infrequent use of IRR. Readers wishing to make use of a worksheet incorporating IRR should refer to P2/Finance (see Appendix B).

Chapter 3

ESTIMATING ENVIRONMENTAL CONSEQUENCES

INTRODUCTION

Historically, the project review process has considered only those environmental impacts that could be easily translated into financial terms (e.g., permitting costs and pollution control equipment costs). Consequently, these financially-based budgeting tools often did not fully capture the benefits of pollution prevention opportunities, particularly those that reduce environmental concerns for the present and future. Without the tools to completely document environmental benefits, pollution prevention opportunities have often been difficult to support when competing against more easily-quantified environmental projects such as end-of-pipe controls, and non-environmental investments such as remodeling or plant expansion.

Therefore, managers require analytical tools that accurately and comprehensively account for the environmental consequences and benefits of competing projects. These environmentally-based project review tools must be flexible, easy-to-use, and require limited resources (e.g., staff and funding) so that they can be easily incorporated into the review process.

Many public and private organizations in the United States and abroad actively promote Life Cycle Assessment (LCA) as a means to evaluate environmental consequences and impacts. LCA is a procedure to identify and evaluate cradle-to-grave natural resource requirements and environmental releases associated with processes, products, packaging, and services. LCA concepts can be particularly useful in ensuring that identified pollution prevention opportunities are not causing unwanted secondary impacts by shifting burdens to other places within the life-cycle of a product or process. LCA is an evolving tool undergoing continued development. Nevertheless, LCA concepts can be useful in gaining a broader understanding of the true environmental effects of current practices and of proposed pollution prevention opportunities.

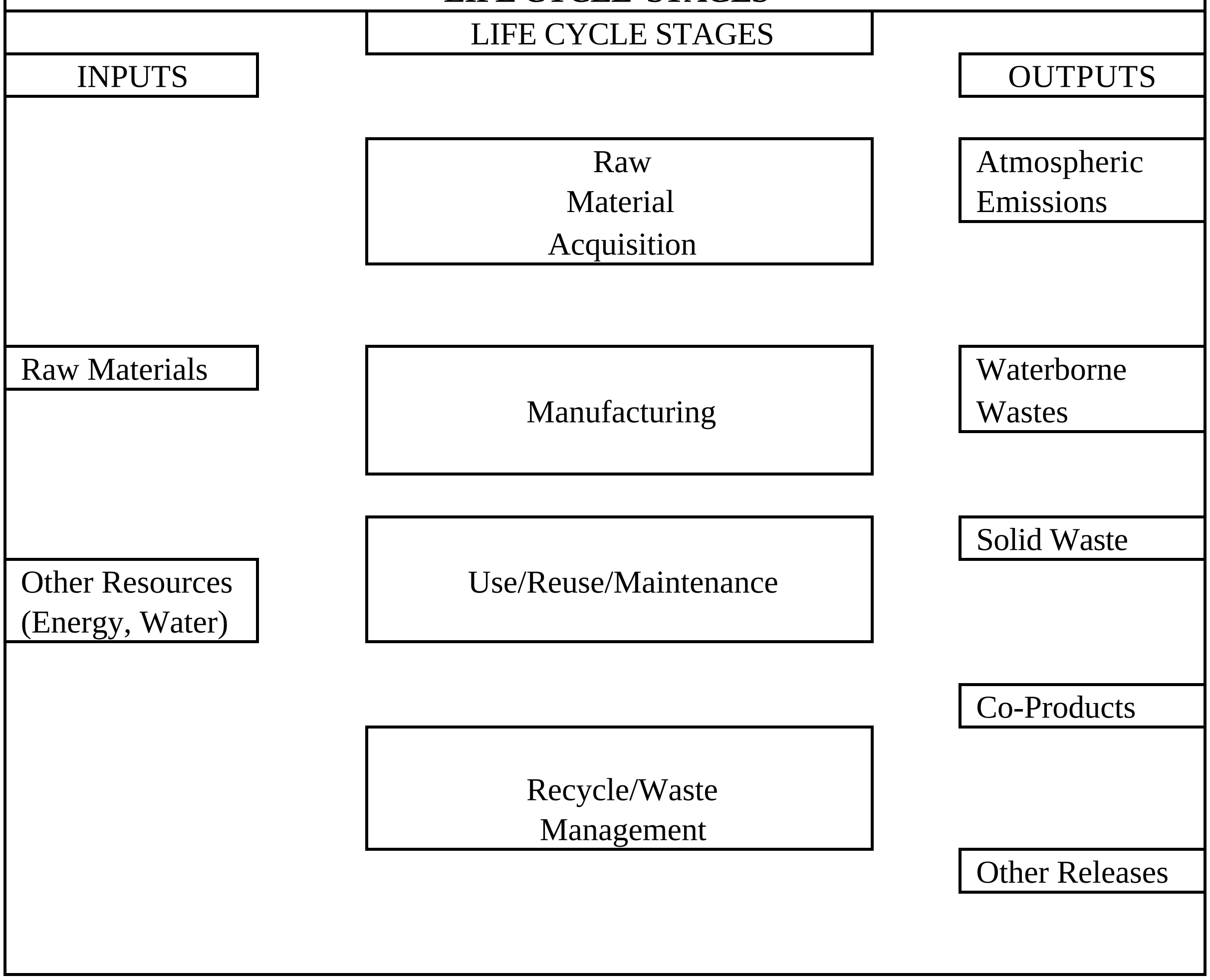
This chapter begins with an introduction to LCA and a discussion of its components. Next, tools are presented to help shipyard decision makers begin to apply LCA concepts to existing and potential projects. The LCA descriptions are adapted from existing LCA reference documents. The abbreviated discussion in this user's manual is intended to provide facility managers with a concise, easy to follow introduction to incorporating environmental considerations into the project review process. For a detailed discussion on conducting a comprehensive life cycle assessment, consult EPA's Life Cycle Assessment: Inventory Guideline and Principles and other LCA reference documents provided in Appendix B.

WHAT IS A LIFE CYCLE ASSESSMENT?

A life cycle assessment (LCA) is a tool to evaluate all environmental effects of a product or process throughout its entire life cycle. This includes identifying and quantifying energy and materials used and wastes released to the environment, assessing their environmental impact, and evaluating opportunities for improvement. Exhibit 3-1 illustrates the possible life stages that can be considered in a LCA and the typical inputs/outputs measured.

Exhibit 3-1

LIFE CYCLE STAGES



The unique feature of this type of assessment is its focus on the entire "life cycle," rather than a single manufacturing step or environmental emission. The theory behind this approach is that operations occurring within a facility can also cause impacts outside the facility's gates that need to be considered when evaluating project alternatives. Examining these "upstream and downstream" impacts can point out benefits or drawbacks to a particular opportunity that otherwise may have been overlooked. For example, examining whether to invest in washable/reusable cloth towels or disposable paper towels in a vehicle maintenance facility should include a comparison of all major impacts, both inside the facility (e.g., disposing of the paper towels) and "outside the gate" (e.g., wastewater discharges from the off-site washing of the reusable towels).

Unlike the financial analysis techniques described in the previous chapter, LCA s provide data on environmental releases and their effects. Some LCA proponents advocate further efforts to assign costs to LCA data. This is often described as a Life Cycle Cost Assessment (LCCA). This chapter will focus on LCA. Those readers interested in finding out more about LCCA should refer to Appendix B.

In general, LCA is a process which includes the following components.

Goal Definition and Scoping: This is a screening process which involves defining and describing the product, process or activity; establishing the context in which the assessment is to be made; and identifying the life cycle stages to be reviewed for the assessment.

Inventory Analysis: This process involves identifying and quantifying energy, water and materials usage, and the environmental releases (e.g., air emissions, solid waste, wastewater discharge) during each life cycle stage.

Impact Assessment: This process is used to assess the human and ecological effects of material consumption and environmental releases identified during the inventory analysis.

Improvement Assessment: This process involves evaluating and implementing opportunities to reduce environmental burdens as well as energy and material consumption associated with a product or process.

APPLICATIONS OF A LIFE CYCLE ASSESSMENT

LCA provides vital information on the environmental consequences associated with pollution prevention projects and competing alternatives. Using LCA can provide decision makers with another ranking criterion to use when evaluating and prioritizing competing project opportunities. For instance, LCA can provide information to assist in addressing decisions, such as:

- Does it make environmental sense to replace a solvent degreaser with a caustic cleaner? Does the elimination of VOC emissions resulting from this change off-set the discharge of heavy-metal laden caustic cleaner to the wastewater treatment plant?

- What are the environmental trade-offs associated with disposable vs. Reusable dinnerware in the cafeteria? How does the solid waste impact of disposable dinnerware compare with the increased water needed to wash reusable plates and utensils?

- Does replacing paper towels in the restrooms with reusable cloth or hand dryers increase or decrease the total impact on the environment?

Facility managers can also use a LCA approach to verify that a project that effectively solves one particular pollution problem does not result in cross-media shifting of pollution to another media (e.g., from waterborne to atmospheric releases). By examining all resource inputs (e.g., energy, materials, water) and environmental releases (e.g., air, water, and solid waste) across the entire life cycle of the product, process, or activity, a LCA can identify cross media transfers and transfers of pollutants to other life cycle stages.

BEGINNING TO APPLY LCA CONCEPTS IN PROJECT ANALYSIS

Gaining a complete understanding of a proposed project's environmental effects requires identifying and analyzing inputs and releases from every life cycle stage. However, securing and analyzing this data can be a daunting task. In many cases shipyard decision makers may not have the time or resources to examine each life cycle stage or to collect all pertinent data.

Therefore, the remainder of this chapter will discuss the steps required to begin applying LCA concepts and principles to project analysis. Examples will demonstrate steps within selected life cycle stages. These stages will generally begin when materials and equipment enter shipyard property, in recognition of the fact that data on materials and releases occurring outside facility fencelines may be difficult to obtain. Tools are presented that will help decision makers with limited resources begin to use LCA concepts.

Before beginning to apply LCA concepts to projects under review, facility managers must first determine the purpose and the scope of the study. In determining the purpose, facility managers should consider the type of information needed from the environmental review (e.g., Does the study require quantitative data or will qualitative information satisfy the requirements?). Once the purpose has been defined, the boundaries or the scope of the study should then be determined. What stages of the life cycle are to be examined? Is data available to study the inputs and outputs for each stage of the life cycle to be reviewed? Is the available data of an acceptable type and quality to meet the objectives of the study? Are adequate staff and resources available to conduct a detailed study? Exhibit 3-2 lists some of the major LCA definitions and scoping issues.

The definition and scoping activity links the purpose and scope of the assessment with available resources and time and allows reviewers to outline what will and will not be included in the study. In some cases, the assessment may be conducted for all stages of the life cycle (i.e., raw materials acquisition, manufacturing, use/reuse/maintenance, and recycling/waste management). In many cases, the analysis may begin at the point where equipment and/or materials enter the facility. In all cases, managers should ensure that the boundaries of the LCA address the purpose for which the assessment is conducted and the realities of resource constraints. Whenever possible, include in the analysis all life-cycle stages in which significant environmental impacts are likely to occur.

Exhibit 3-2 **ISSUES TO BE RESOLVED IN DEFINING AND SCOPING A LIFE CYCLE ASSESSMENT**
Have the boundaries of the assessment been determined (i.e., have the life cycle stages been identified)?
Are data sources available to describe the inputs and outputs for these stages? Is the available data of an acceptable type and quality to meet the objectives of the assessment (e.g., is the data verifiable enough to be used in justifying capital budgeting investments)?
Is a life cycle checklist appropriate for reviewing the project or is a more detailed life cycle assessment needed?
Determining the purpose and scope of the study will help to identify the type of environmental analysis that should be conducted. This chapter provides an introduction to two tools that are useful when applying LCA concepts: 1) Life Cycle Checklist and 2) Life Cycle Assessment Worksheet. For more detailed information on conducting a comprehensive life cycle analysis, consult the reference documents listed in Appendix B.

Exhibit 3-3

SAMPLE LIFE CYCLE CHECKLIST

ISSUE	QUESTION	YES	NO
Material Usage	Does the project minimize use of raw materials?		
Resource Conservation	Does the project minimize energy use?		

	Does the project minimize water usage?		
Local Environmental Impacts	Does the project eliminate or minimize impacts to the local environmental (i.e., air, water, land)?		
Global Environmental Impacts	Does the project eliminate or minimize impacts known to cause global environmental concerns (i.e., global warming, ozone depletion, acid rain)?		
Toxicity Reduction	Does the project improve the management of toxic materials and/or processes which result in human/ecological exposure?		

Life Cycle Checklist

Conducting a LCA that includes all life-cycle stages will provide decision makers with the most complete understanding of environmental consequences. However, if resources are limited and an in-depth, quantitative analysis is not practical, a facility manager may consider using a simple checklist to identify and highlight certain environmental implications associated with competing projects. A checklist using qualitative data instead of quantitative inputs can be very useful when available information is limited or as a first step in conducting a more thorough LCA. In addition, a Life Cycle Checklist should include questions regarding the environmental effects of current operations and/or potential projects in terms of materials and resources consumed and wastes/emissions generated. Exhibit 3-3 provides a sample checklist.

The checklist used by an individual facility can be tailored to emphasize areas of specific concern. For example, a facility in an area of the country where landfill space is limited may want to emphasize the collection and evaluation of solid waste generation data Similarly, a facility located in arid or semi-arid areas may want to collect and evaluate information relating to water consumption.

Using a life cycle checklist has specific advantages and disadvantages when compared to the other forms of life cycle assessment. The principle advantage is that completion of a checklist is relatively easy to perform and requires limited resources. On the other hand, a life cycle checklist does not provide a detailed or complete assessment of the environmental consequences associated with the activity under review. Instead, this method only provides general qualitative data.

Conducting A More Detailed Project Review

If more detailed information concerning the environmental consequences of pollution prevention projects is required, an environmental manager may consider conducting a more in-depth analysis to identify and evaluate the resource and material inputs and the environmental releases associated with each life cycle stage. This is a more resource intensive operation than using a life cycle checklist. Therefore, defining and scoping the analysis to fit available resources while including all significant areas of environmental impact is very important.

The first step in identifying and evaluating the inputs and outputs associated with life cycle stages under review is to describe and understand each step in the process. One common method to do this is to construct a system flow diagram for the product, process, or activity being studied. Each step within the relevant life cycle stages is represented by a box. Each box is connected to other boxes that represent the preceding and succeeding step. A simple example of a process flow diagram is illustrated below. In this example, the life cycle stages covered within the diagram begin at the point a solvent is purchased for use and enters a facility property. Each of these boxes can be further divided into detailed process flow steps.

Purchase Solvent → Use Solvent → Dispose of Solvent

When all relevant steps for each stage of the product, process, or activity under review have been identified, the flow diagram should be expanded to identify the specific energy and material inputs, and the specific environmental releases associated with each box on the diagram. This step is of crucial importance, because data on these identified inputs and releases will be collected later, and will form the basis for all findings and conclusions. The diagram below illustrates the inputs and releases for each step in the sample flow diagram.

Purchase Solvent → Use Solvent → Dispose of Solvent

INPUTS	INPUTS	INPUTS
Solvent	Electricity	Electricity
Packaging		Packaging
OUTPUTS	OUTPUTS	OUTPUTS
Packaging	Air Emissions	Waste Solvent
	Excess Solvent	Air Emissions

Once a flow diagram has been developed, personnel conducting the LCA should identify sources of information that will describe and quantify the material and energy inputs, and the environmental releases associated with each box in the process flow diagram. Possible sources of information for each stage are presented in Exhibit 3-4.

Exhibit 3-4

SOURCES OF INFORMATION

Raw Materials Acquisition

· Data specific to a particular materials processor
· Government, academic, trade association, or industry studies of aggregate data
· Department of Commerce, Census of Manufacturers
· Bureau of Mines, Census of Mineral Industries
· Department of Energy, Monthly Energy Review
· Encyclopedia of Chemical Technology, Kirk-Othmer

Manufacturing

· Data specific to a particular materials processor
· Government, academic, trade association, or industry studies of aggregate data

Use/Reuse/Maintenance

· Engineering studies
· Facility process flow diagrams
· Environmental studies and reports
· Hazardous waste (state Annual reports or Federal biennial reports)
· Toxics Release Inventory reports (as of 1994)
· Compliance assessment reports
· Routine testing and monitoring data (e.g., air emissions, waste water discharge)
· Solid waste disposal records
· Utility bills
· Supply and acquisitions databases of materials used on-site
· Equipment suppliers
· Facility staff or contractors performing maintenance or operations work

Recycle/Waste Management

· Facility staff or responsible contractors, equipment vendors
· Data specific to a particular waste management firm
· Government, academic, trade association, or industry studies of aggregate data
· Although quantitative data are preferable (and are necessary to accurately and completely conduct an impact assessment), qualitative data may be acceptable in cases where quantitative data are lacking.

A worksheet and instructions are provided at the end of this document to help readers complete a sample process flow diagram. The intent of this worksheet is to acquaint shipyard managers with a form that can be completed for each project option or process change under consideration. This life cycle-based worksheet is organized into three sections. The first section asks for a flowchart of the process steps/activities to be included in the analysis. The second section asks for inputs (i.e., raw materials, energy, and water), and the third section asks for outputs (i.e., products, air, water, and land releases). The worksheet provides space for four process steps. If more than four process steps are to be examined, continue the analysis on a copy of the original form.

Using this or any other life cycle worksheet has specific advantages and disadvantages when compared to conducting a complete LCA. The principle advantage is that it provides a more detailed analysis of the process than the checklist, and it is easier to conduct than a complete LCA. On the other hand, it does not encompass the full environmental impacts of a process or activity life cycle stage.

Appendix A

GLOSSARY OF TERMS

Discount Rate: The interest rate (sometimes called the Present Value Factor) used to discount future cash flows to their present values. This represents the rate of return that could be earned by investing in a project with risks comparable to the project being considered. Federal facilities generally use a discount rate determined by the Office of Management and Budget.

Hurdle Rate: In Internal Rate of Return calculations, the minimum rate of return that a project must generate in order to be considered worthy of investment. Federal facilities usually use the discount rate determined by the Office of Management and Budget as the hurdle rate. Projects that provide a rate of return below this rate will not be pursued.

Internal Rate of Return (IRR): The discount rate at which the net savings (or NPV) on a project are equal to zero. The IRR of a project can be compared to the hurdle rate to determine economic attractiveness. The General IRR rule is: If IRR > or = hurdle rate then accept project. If IRR < hurdle rate then reject project.

Life Cycle Assessment: A method to evaluate the environmental effects of a product or process throughout its entire life cycle, from raw material acquisition to disposal. This includes identifying and quantifying energy and materials used and wastes released to the environment, assessing their environmental impact, and evaluating opportunities for improvement.

Life Cycle Costing: A method in which all costs are identified with a product, process, or activity throughout its lifetime, from raw material acquisition to disposal, regardless of whether these costs are borne by the organization making the investment, other organizations, or society as a whole.

Net Present Value (NPV): The present value of the future net revenues of an investment less the investment's current and future cost. An investment is profitable if the NPV of the net revenues it generates in the future exceeds its cost, that is, if the NPV is positive.

Payback Period: The amount of time required for an investment to generate enough net revenues or savings to cover the initial capital outlay for the investment.

Pollution Prevention: Any practice that reduces the amount of environmental and health impacts of any pollutant released into the environment prior to recycling, treatment, or disposal. Pollution prevention includes modifications of equipment and processes; reformulation or redesign of products and processes; substitution of raw materials; and improvements in housekeeping, maintenance, training, or inventory control.

Total Cost Assessment (TCA): A long-term comprehensive financial analysis of the full range of costs and savings of an investment that are or would be experienced directly by the organization making or contemplating the investment.

Appendix B

ADDITIONAL INFORMATION SOURCES

The following government publications are available to assist shipyard environmental managers conduct an investment analysis of pollution prevention projects. Also included is a list of guidance manuals to assist environmental managers identify and develop pollution prevention projects. Finally, a list of various Federal and State agencies which provide direct technical assistance on pollution prevention topics and projects is provided on the pages that follow.

Project Analysis Guidance Documents

1. Total Cost Assessment: Accelerating Industrial Pollution Prevention through Innovative Project Financial Analysis, with applications to the Pulp and Paper Industry
EPA/600-R-92-002
U.S. Environmental Protection Agency
Pollution Prevention Information Clearinghouse (PPIC)
401 M Street, SW
Washington, DC 20460
202-260-1023

This document outlines and justifies a total cost assessment approach to evaluate pollution prevention opportunities. This report applies a TCA method to analyze several actual investments in the pulp and paper industry. It also reviews several TCA methods.

2. Environmental Accounting Resource Listing
EPA/742-F-94-004
U.S. Environmental Protection Agency
Pollution Prevention Information Clearinghouse (PPIC)
401 M Street, SW
Washington, DC 20460
202-260-1023

This resource listing presents selected information sources organized in the following categories (1) Activity-based costing, (2) Bibliographies, curricula, and definition of terms, (3) Corporate environmental accounting, (4) Federal government, military and logistics applications, (7) Pollution prevention, and (8) Quality costs.

3. A Primer for Financial Analysis of Pollution Prevention Projects
EPA/600-R-93-059

The Center for Environmental Research Information (CERI)
26 West Martin Luther King Drive
Cincinnati, OH 45628
513-569-7562

This document introduces the time value of money concept into analysis of pollution prevention investments.

4. Life-Cycle Assessment: Inventory Guidelines and Principles
EPA/600-R-92-245
U.S. Environmental Protection Agency
Office of Research and Development
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7562

This document describes the environmental aspects of a life cycle assessment. The major life cycle stages and data gathering techniques are discussed.

5. A Technical Framework for Life-Cycle Assessment
Society of Environmental Toxicology and Chemistry and SETAC Foundation for Environmental Education, Inc.
1101 14th Street, NW
Suite 1100
Washington, DC 20005

This document provides information about product, process, and activity life-cycle assessments.

6. Life Cycle Assessment
Z760-94
Canadian Standards Association
178 Rexdale Boulevard
Rexdale (Toronto), Ontario
Canada M9W 1R3

This manual provides technical guidance on conducting life cycle assessments and reporting assessment results.

7. Guidelines for Assessing the Quality of Life-Cycle Inventory Analysis
EPA/530-R-95-010
U.S. Environmental Protection Agency
Pollution Prevention Information Clearinghouse (PPIC)
401 M Street, SW
Washington, DC 20460
202-260-1023

This document identifies the issues and challenges confronting LCA practitioners as they seek to gather quality data for Life Cycle Inventories. The document outlines a possible framework for assessing and documenting data quality and discusses specific techniques to support the data quality assessment process.

8. Life Cycle Assessment: Public Data Sources for the LCA Practitioner
EPA/530-R-95-009
U.S. Environmental Protection Agency
Pollution Prevention Information Clearinghouse (PPIC)
401 M Street, SW
Washington, DC 20460
202-260-1023

This document provides LCA practitioners with potentially useful public data sources for preparing LCAs.

9. Development of a Pollution Prevention Factors Methodology Based on Life-Cycle Assessment: Lithographic Printing Case Study
EPA/600-R-94-157
U.S. Environmental Protection Agency
Office of Research and Development
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7562

This report describes a preliminary pollution prevention factors methodology which was developed using a streamlined life-cycle assessment approach. The lithographic printing industry was selected as the test industry.

10. United States Postal Service Hartford Vehicle Maintenance Facility Waste Minimization/Pollution Prevention Study
U.S. Postal Service
Northeast Area Office

This report provides a financial analysis of alternatives to the vehicle painting and oil handling processes used at the Hartford Vehicle Maintenance Facility. Data collection and analysis for the Total Costs Assessment was performed with the use of P2/Finance, a flexible spreadsheet developed by Tellus Institute.

11. Life Cycle Design Guidance Manual: Environmental Requirements and The Product System
EPA/600-R-92-226
U.S. Environmental Protection Agency
Office of Research and Development
26 West Martin Luther King Drive

Cincinnati, OH 45268
513-569-7562

This report promotes the reduction of environmental impacts and health risks through a systems approach to design by integrating environmental, performance, cost, cultural, and legal requirements in effective designs.

12. Federal Agency Environmental Management Program Planning Guidance
EPA/300-B-95-001
U.S. Environmental Protection Agency
Office of Enforcement and Compliance Assurance
401 M Street, SW
Washington, DC 20460
This document discusses the data elements that will be reported to EPA under the A-106 process and provides insight into the rationale underlying those data elements.

13. Survey of Resources Available for Estimating the Environmental Costs of Major Defense
Acquisition Programs
DASW903-94-C-0043
Office of the Director
Program Analysis & Evaluation
1800 Defense Pentagon
Washington, DC 20301-1800

This report is the first from the Survey of Resources Available for Estimating the Environmental Costs of Major Defense Acquisition Programs. It identifies existing environmental management (EM) cost estimating methods, data bases, engineering case studies, and management systems to determine their usefulness for estimating EM costs for major defense acquisition programs.

14. Survey of Resources Available for Estimating the Environmental Costs of Major Defense
Acquisition Programs
DASW903-94-C-0043
Office of the Director
Program Analysis & Evaluation
1800 Defense Pentagon
Washington, DC 20301-1800

This report is the second from the Survey of Resources Available for Estimating the Environmental Costs of Major Defense Acquisition Programs. It presents a cost breakdown structure and a cost driver category structure for environmental management.

15. Evaluation of Environmental Management Cost-Estimating Capabilities for Major Defense
Acquisition Programs
MDA903-94-C-0043
Office of the Director
Program Analysis & Evaluation
1800 Defense Pentagon
Washington, DC 20301-1800

This report, which is the last from the Survey of Resources Available for Estimating the Environmental Costs of Major Defense Acquisition Programs, provides assessments of the most promising cost analysis tools based on testing their capabilities against the cost breakdown structure developed earlier in the project

Pollution Prevention Planning Documents

16. Federal Facility Pollution Prevention: Tools for Compliance
EPA/600-R-94-154
U.S. Environmental Protection Agency
Office of Research and Development
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7562

17. Pollution Prevention in the Federal Government: Guide for Developing Pollution Prevention Strategies for Executive Order 12856 and Beyond
EPA/300-B-94-007
U.S. Environmental Protection Agency
Pollution Prevention Information Clearinghouse
401 M Street, SW
Washington, DC 20460
202-260-1023

18.Federal Facility Pollution Prevention Guide
EPA/300-B-94-013
U.S. Environmental Protection Agency
Pollution Prevention Information Clearinghouse
401 M Street, SW
Washington, DC 20460
202-260-1023

19.Facility Pollution Prevention Guide
EPA/600-R-92-008
U.S. Environmental Protection Agency
Office of Research and Development

26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7562

20. Pollution Prevention Directory
EPA/742-B-94-005
U.S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460
202-260-9801

21. Abstracts of Pollution Prevention Case Study Sources
EPA/742-B-94-001
U.S. Environmental Protection Agency
Pollution Prevention Information Clearinghouse
401 M Street, SW
Washington, DC 20460
202-260-1023

22. Summary of Pollution Prevention Case Studies With Economic Data (By SIC Codes)
EPA/742-S-94-001
U.S. Environmental Protection Agency
Pollution Prevention Information Clearinghouse
401 M Street, SW
Washington, DC 20460
202-260-1023

Agency Guidance Documents

23. Navy Shore Installation Pollution Prevention Planning Guide
Doc. #OPNAV-P45-120-10-94
Office of Chief of Naval Operations
2000 Navy Pentagon
Washington, DC 20350
703-602-5334

24. U.S. Air Force Installation Pollution Prevention Program Manual United States Air Force
Air Force Center for Environmental Excellence (AFCEE)
AFCEE/ESP
8106 Chennault Road
Building 1161
Brooks AFB, TX 78235-5318
1-800-233-4356

25. Army Pollution Prevention Plan Manual: A Guide for Army Installations
Army Environmental Policy Institute
430 10th Street, NW
Suite 5105
Atlanta, GA 30318
404-875-6813

26. Guidance for Preparation of Site Waste Minimization and Pollution Prevention Awareness Plans
Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585
301-427-1570

Technical Assistance Programs

1. Pollution Prevention Information Clearinghouse (PPIC)
U.S. Environmental Protection Agency, PM 211-A
401 M Street, SW
Washington, DC 20460
202-260-1023

The Pollution Prevention Information Clearinghouse (PPIC) is a free, nonregulatory, information and referral service of the U.S. EPA. PPIC includes a repository of pollution prevention information and a telephone reference and referral hotline.

2. Enviro$ense (ES)
EPA Systems Development Center
200 N. Glebe Road
Arlington, VA 22203
703-908-2092 (modem)
http://wastenot.inel.gov/envirosense

ES is a free, 24-hour electronic network accessible by personal computer equipped with a modem or direct connect through Internet WWW. ES consists of message centers, bulletins, electronic documents, technical databases, case studies and issue-specific conference listings.

3.Federal Agency Mini-Exchange (FAME)
EPA Systems Development Center
200 N. Glebe Road
Arlington, VA 22203
703-506-1025 (modem)

FAME is a database on the Pollution Prevention Information Exchange System which provides information on pollution prevention/recycling efforts at Shipyards.

4.Defense Environmental Network and Information Exchange (DENIX)
DECIM Office
Hoffman 2, Room 12S49
200 Stovall Street
Alexandria, VA 22332
1-800-642-3332
703/325-0002

DENIX is a Department of Defense communications platform for the dissemination and exchange of environmental information across all DOD components.

5.PRO-ACT
AFCEE
8106 Chennault Road
Building 1161
Brooks AFB, TX 78235-5318
1-800-233-4356
(210) 536-4214
DSN 240-4214

PRO-ACT is an environmental information clearinghouse and hotline provided by the Air Force Center for Environmental Excellence (AFCEE). PRO-ACT services are provided free of charge to all Air Force personnel.

6.Center for Environmental Research Information (CERI)
Dorothy Williams
U.S. Environmental Protection Agency
Center for Environmental Research Information (CERI)
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7562

CERI serves as the exchange of scientific and technical environmental information produced by EPA in brochures, capsule and summary reports, handbooks, newsletters, project reports, and manuals.

7.Center for Waste Reduction Technologies (CWRT)
American Institute of Chemical Engineers
345 East 47th Street
New York, NY 10017
212-705-7407

CWRT was established in 1989 by the American Institute of Chemical Engineers to support industry efforts in meeting the challenges of waste reduction through a partnership with industry, academia, and government.

8.The National Pollution Prevention Roundtable
David Thomas
218 D Street, SE
Washington, DC 20003
202-543-7272

The Roundtable is a group of pollution prevention program at the State and local level in both the public and academic sectors. The member programs are engaged in activities including multi-audience training and primary to post-secondary pollution prevention education.

9.Northeast States Pollution Prevention Roundtable (NE Roundtable)
Terri Goldberg, Program Manager
Northeast States Pollution Prevention Roundtable / Northeast Waste Management Officials'
Association
85 Merrimac Street
Boston, MA 02114
617-367-8558

The NE Roundtable was initiated in 1989 by the Northeast Waste Management Officials' Association to assist State programs, industry, and the public in implementing effective source reduction programs.

10.Pacific Northwest Pollution Prevention Research Center
Madeline Grulich, Director
Pacific Northwest Pollution Prevention Research Center
411 University Street, Suite 1252
Seattle, WA 98101
206-223-1151

The Pacific Northwest Pollution Prevention Research Center is a non-profit public-private partnership dedicated to the goal of furthering pollution prevention in the Pacific Northwest.

11.Waste Reduction Institute for Training and Applications Research, Inc. (WRITAR)
Terry Foecke
Waste Reduction Institute for Training and Applications Research
1313 5th Street, SE
Minneapolis, MN 55414-4502
612-379-5995

WRITAR is designed to identify waste reduction problems, help find their solutions, and facilitate the dissemination of this information to a variety of public and private organizations.

12.Waste Reduction Resource Center for the Southeast (WRRC)
Gary Hunt
Waste Reduction Center for the Southeast
3825 Barrett Drive
P.O. Box 27687
Raleigh, NC 27611-6787

WRRC was established to provide multimedia waste reduction support for the eight states of U.S. EPA IV (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee).

Federal Facility Pollution Prevention Contacts

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Central Intelligence Agency
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Central Intelligence Agency
Washington, DC 20505
703-482-4533

Coast Guard
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P2 and Recycling Coordinator
U.S. Coast Guard
USCG (G-ECV-1B)
2100 2nd Street, SW
Washington, DC 20593
202-267-1941

Department of Commerce
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U.S. Department of Commerce
Room 6020
14th and Constitution Avenue
Washington, DC 20230
202-482-4115

Department of Energy
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Office of Waste Management (EM-334)
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585
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Department of the Interior
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Department of the Interior, MS 2340-MIB, Room 2349
Office of Environmental Affairs
1849 C Street, NW
Washington, DC 20240
202-208-7554

Department of Justice
Marvin Fink
Safety and Health Manager
Security and Emergency Planning Staff
U.S. Department of Justice, Room 6525
10th and Constitution Avenue, NW
Washington, DC 20530
202-514-5076

Department of Transportation
Janet Krause
Environmental Engineer
Office of the Secretary
Department of Transportation
400 7th Street, SW
Washington, DC 20590
202-366-0038

Department of the Treasury

William McGovern
Chief, Environmental Compliance Division
Department of the Treasury
Treasury Annex
1500 Pennsylvania Avenue, NW
Washington, DC 20220
202-622-0043

Department of Veterans Affairs
John Staudt
Chief, Hazardous Materials Management Division
Department of Veterans Affairs, 138C-4
810 Vermont Avenue, NW
Washington, DC 20420
202-233-7863

Economic Development Administration
Dr. Frank Monteferrante
Senior Environmental Specialist
U.S. Department of Commerce
Herbert C. Hoover Building, Room 7019
Washington, DC 20230
202-482-4208

Federal Aviation Administration
Tom Halloway
Manager of Hazardous Materials and Special Projects Staff
Federal Aviation Administration, AEE-20
800 Independence Avenue, SW
Washington, DC 20591
202-267-8114

Food and Drug Administration
Dr. Naresh K. Chawla
Chief, FDA Safety Office (HFA-205)
Food and Drug Administration
7500 Standish Place
Rockville, MD 20855
301-594-1718

General Services Administration
Karone Peace
Safety and Environmental Division
Environmental Branch (PMS)
General Services Administration, Room 4340

18th and F Streets, NW
Washington, DC 20450
202-501-3518

National Aeronautical Space Administration
Olga Dominguez
Environmental Management Division
National Aeronautics and Space Administration
NASA Headquarters, Code JE
Washington, DC 20546
202-358-1093

National Oceanic and Atmospheric Administration
I. Sam Higuchi, Jr.
Senior Environmental Compliance Officer
National Oceanic and Atmospheric Administration
SSMC-2/OA3X1 Room 4434
1325 East West Highway
Silver Spring, MD 20910
301-713-0845

National Security Agency
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Environmental Service Division
National Security Agency, (APS-13), Room AT200
Department of Defense
9800 Savage Road
Fort Meade, MD 20755-6000
410-684-7305

Postal Service
Bernie Denno
Environmental Specialist
U.S. Postal Service, Room 6830
475 L'Enfant Plaza, SW
Washington, DC 20260-2810
202-268-6014

Tennessee Valley Authority
Paul Schmierbach
Environmental Compliance Department
Tennessee Valley Authority
400 Summit Hill Drive
Knoxville, TN 37902

615-632-6644

State Pollution Prevention Programs

ALABAMA

Alabama Waste Reduction and Technology Transfer (WRATT) Program
Daniel E. Cooper, Chief
Special Projects
Alabama Department of Environmental Management
1751 Congressman William L. Dickinson Drive
Montgomery, AL 36130
205-260-2779

ALASKA

Pollution Prevention Office
David Wigglesworth, Chief
Pollution Prevention Office
Alaska Department of Environmental Conservation
P.O. Box O
Juneau, Alaska 99811-1800
907-465-5275

Waste Reduction Assistance Program (WRAP)
Kristine Benson
Alaska Health Project
1818 West Northern Lights Boulevard
Suite 103
Anchorage, AK 99517
907-276-2864

ARIZONA

Arizona Waste Minimization Program
Sandra Eberhardt, Manager
Pollution Prevention Unit
Arizona Department of Environmental Quality
3033 North Central Avenue, Rm. 558
Phoenix, AZ 85012
602-207-4210

ARKANSAS

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Robert J. Finn

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Arkansas Department of Pollution Prevention and Ecology
P.O. Box 8913
Little Rock, AR 72219-8913
501-570-2861

CALIFORNIA

Department of Toxic Substances Control
Mr. Kim Wilheim
Department of Toxic Substances Control
Pollution Prevention, Public and Regulatory Assistance Division
400 P Street
P.O. Box 806
Sacramento, CA 95812-0806
916-322-3670

Tony Eulo
Local Government Commission
909 12th Street
Suite 205
Sacramento, California 95814
916-448-1198

California Integrated Waste Management Board
8800 Cal Center Drive
Sacramento, California 95826
Recycling Hotline: 800-553-2962
General Public Information: 916-255-2289

COLORADO

Pollution Prevention and Waste Reduction Program
Kate Kramer, Program Manager
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Colorado Department of Health
4300 Cherry Creek Drive South
Denver, CO 80220
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Michael Nemeck
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1724 Gilpin Street
Denver, Colorado 80218
303-355-1861

CONNECTICUT

Connecticut Technical Assistance Program (CONNTAP)
Andrew Vecchio
Connecticut Technical Assistance Program (ConnTAP)
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DISTRICT OF COLUMBIA

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65 K Street, NE
Washington, DC 20002
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George Nichols
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Council of Governments
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202-962-3355

Kenneth Laden
Environmental Policy Division
D.C. Department of Public Works
2000 14th St., NW
Washington, DC 20009
202-939-8115

Ms. Ferial Bishop, Administrator
Environmental Regulation Administration
D.C. Department of Consumer and Regulatory Affairs
2100 MLK Avenue, SE
Suite 203
Washington, DC 20020
202-404-1136

FLORIDA

Waste Reduction Assistance Program (WRAP)
Janeth A. Campbell, Director
Waste Reduction Assistance Program
Florida Department of Environmental Regulation
2600 Blair Stone Road
Tallahassee, Florida 32399-2400
904-488-0300

GEORGIA

Georgia Multimedia Source Reduction and Recycling Program
Susan Hendricks, Program Coordinator
Environmental Protection Division
Georgia Department of Natural Resources
4244 International Parkway, Suite 104
Atlanta, GA 30334
404-362-2537

HAWAII

Hazardous Waste Minimization Program

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John Harder
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IDAHO

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ILLINOIS

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INDIANA

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Instructions For Completing The Project Analysis Worksheet

The following instructions are designed to assist managers in completing the project analysis worksheet. When completing the worksheet, recognize that data might not be available to complete all requested information. By completing only a few sections of the worksheet with data that otherwise would not have been collected, the accuracy in evaluating project opportunities will be enhanced.

Begin by determining the purpose of the analysis, the audience to whom it will be directed, the facility's decision making criteria, and the format in which the analysis must be presented. This information will be critical in ensuring that the scope of the analysis is appropriate, and that the completed analysis will be presented in a readily understood and accepted manner. If these worksheets will be used to compare project alternatives, or to compare a potential project to current operations, a separate worksheet should be completed for each option under consideration.

Sections 1-3 Identify the economic consequences associated with the activity under review. The specific items (i.e., categories of cash outflows) mentioned in the worksheet may not represent a complete list of costs incurred at your facility. If so, add new categories as appropriate. Refer to Exhibits 2-1 and 2-2 for lists of capital and operating cost categories. If you are conducting a payback analysis, completing information for only the initial year is acceptable provided that data is available to describe annual costs and annual savings. If you plan to analyze the financial performance of the investment using a NPV calculation, you need to estimate future costs and benefits.

To allow comparisons with other project options, two measures of economic performance are included in the worksheet. To conduct a payback analysis, refer to section 4. To conduct a net present value analysis, refer to sections 5 through 8.

Section 4: This section calculates the number of years that it will take to recoup the initial capital expenditure. This value is obtained by dividing the initial investment to establish the project by the net annual benefits (obtained by subtracting the expected annual cash outflows from the expected annual cash inflows). If only a payback analysis is needed, skip the following steps.

Section 5: For each year included in the evaluation, calculate the annual net cash flow by subtracting the capital expenditures (Section 1) and annual cash outflows (subtotals from Sections 3,4,5) from the annual cash inflows (Section 2).

Section 6: Calculating the NPV requires determining the value of future cash flows today. To do this, present value factors are used to discount future cash flows. As of January

1995, OMB recommends using a 7.9% nominal discount factor for evaluating performance of 10 year investments. Therefore, the present value (PV) factors assume a 7.9% rate. For more current information, refer to OMB Circular A-94, call OMB at (202) 395-5873, or contact the cost analysis office in your organization. OMB's nominal discount rate for investments of various duration are included in Table 1.

Section 7 Multiply the net cash flows (Section 7) by the PV factors (Section 8) to determine the present value today of the cash flow in each year.

Section 8 Add all the annual discounted cash to determine the Net Present Value of the process. If the value is positive, the project is cost-beneficial. If more than one investment is being analyzed, the project with the greatest NPV is the most cost-beneficial.

Table 1 PRESENT VALUE FACTORS FOR NOMINAL DISCOUNT RATES (OMB JANUARY 1995)

TABLE 1

PRESENT VALUE FACTORS FOR NOMINAL

DISCOUNT RATES (OMB JANUARY 1995)

	7.3%	7.6%	7.7%	7.9%	8.1%
Year 1	0.93197	0.9293	0.92678	0.92678	0.9250
Year 2	0.86856	0.8637	0.86212	0.85893	0.8557
Year 3	0.80947	0.8027	0.80048	0.79604	0.7916
Year 4		0.7460	0.74325	0.73776	0.7323
Year 5		0.6933	0.69012	0.68374	0.6774
Year 6			0.64078	0.63368	0.6266
Year 7			0.59496	0.58729	0.5797
Year 8				0.45529	0.5362
Year 9				0.50444	0.4961
Year 10				0.46750	0.4589
Year 11					0.4245

Year 12					0.3927
Year 13					0.3633
Year 14					0.3360
Year 15					0.3109
Year 16					0.2876
Year 17					0.2660
Year 18					0.2461
Year 19					0.2276
Year 20					0.2106
Year 21					0.1948
Year 22					0.1802
Year 23					0.1667
Year 24					0.1542
Year 25					0.1426
Year 26					0.1319
Year 27					0.1121
Year 28					0.1129
Year 29					0.1044
Year 30					0.0966

After completing the analysis, write a narrative to accompany the analysis that explains the results. Be sure to include a discussion of the economic benefits of the proposed pollution prevention projects that were not able to be quantified, and a discussion of the non-economic benefits that may tip the scales in favor of the pollution prevention project if the economic analysis is too close to call.

Instructions For Completing The Life Cycle Assessment Worksheet

The following instructions are designed to assist managers in completing the life cycle assessment worksheet. The worksheet is intended to help shipyard managers gain a more complete understanding of the life cycle environmental consequences associated with existing processes, potential pollution prevention projects, and competing project alternatives. When completing the worksheet, do not worry if data is not available to complete all requested information. Even by just completing a few sections of the worksheet, the information on each individual line can still be useful in evaluating and comparing the environmental performance of existing processes and potential projects. However, be aware that completing only certain sections of the worksheet may provide misleading results. For example, completing sections on solid wastes and releases to air without entering data on releases to water may bias the analysis toward projects whose primary environmental consequences result from water pollution. Similarly, collecting and analyzing data on a limited number of life cycle stages may bias the analysis toward projects whose primary environmental effects occur upstream or downstream from stages under analysis.

The information requested on the worksheet can be indicated either numerically or by description only. Descriptive information is often the only information available. Specific instructions follow:

Line 1: Indicate the process steps that are to be reviewed. For example, a life cycle analysis of a solvent degreaser tank system might examine the following three activities: acquisition of solvent, use of tank, and disposal/recycling of waste materials.

Line 2a: For each of the process steps indicated in Line 1, identify the raw materials used. Examples of typical materials include chemicals, parts, and minerals. Do not forget to include associated packaging materials such as cans, cardboard, and plastic wrap.

Line 2b: Indicate the energy involved with operating the process activity. Three common energy source categories have been included (i.e., electricity, natural gas, and fuel). Include other categories if needed. If numerical data is available, it is possible to sum together all entries from the same energy source (i.e., electricity usage from each of the process steps examined).

Line 2c: Indicate the quantity of water consumed in each of the process steps being evaluated. Note that water could be coming from surface sources (e.g., pumped in from a nearby river), from a well, or from purchased city water.

Line 2d: Indicate other inputs, as needed. Some process steps that can generate additional inputs include pre-process cleaning, process cleaning and maintenance supplies required in the upkeep of the process.

Line 3a: For each process step, indicate the products that result. Be aware that the products often become the inputs to the next step in the sequence.

Line 3b: Indicate numerically or by description the air releases associated with the process step. Examples of typical releases from an industrial process include particulates/dust and solvent vapors. Numerical records of air emissions can often be found on permitting applications or in engineering records. If numerical data is not available, provide a narrative list of emissions.

Line 3c: Indicate the wastewater discharges and liquid hazardous wastes associated with each process step

Line 3d: Identify the solid waste generated from each process step. If possible list the type/quantity of solid waste and how it is managed (e.g., 10 pounds of cardboard that are recycled or 5 cubic yards of sludge that is sent to a landfill).

PROJECT ANALYSIS WORKSHEET

Section			ESTIMATED CASH FLOW IN EACH YEAR										
			Start-Up	1	2	3	4	5	6	7	8	9	10
CASH OUTFLOWS	1	**CAPITAL COSTS**											
		Equipment											
		Utility Connections											
		Construction											
		Engineering											
		Training											
		Other											
		Subtotal Section 1	0										
	2	**OPERATING COSTS**											
		Materials											
		Labor											
		Utilities											
		Waste Mgmt.											
		Compliance											
		Liability											
		Other											
		Subtotal Section 2		0	0	0	0	0	0	0	0	0	0
CASH INFLOWS	3	**REVENUES**											
		Sale of products											
		Sale of by-products											
		Sale of recyclables											
		Other											
		Subtotal Section 3		0	0	0	0	0	0	0	0	0	0
	4	**PAYBACK**	#DIV/0!	Equals Section 1 divided by (Section 2 - Section 3) NOTE, USE THE VALUES FROM THE SHADED BOXES ABOVE									
	5	**CASHFLOW**	0	0	0	0	0	0	0	0	0	0	0
	6	**PV FACTORS**	1.0000	0.9268	0.8589	0.7960	0.7378	0.6837	0.6337	0.5873	0.5443	0.5044	0.4675
	7	**CFxPV**	0	0	0	0	0	0	0	0	0	0	0
	8	**NET PRESENT VALUE**		0	Equals the sum of all values in Section 7								

Cash flow is calculated by subtracting Cash Outflows from Cash Inflows during each year of the investment (i.e., Sec. 3 minus Sec. 2 minus Sec 1)

Note, the PVs indicated above are for evaluating the performance of 10 year investments.
For investments of other durations, refer to the accompanying text

LIFE CYCLE ASSESSMENT WORKSHEET

I PROCESS STEPS

II INPUTS

2a Raw Materials (units)

2b Energy Usage

Electricity (kW-hr)	______	+	______	+	______	+	______	=	______
Natural Gas (cubic ft.)	______	+	______	+	______	+	______	=	______
Fuel (gallons)	______	+	______	+	______	+	______	=	______
Other	______	+	______	+	______	+	______	=	______

2c Water Usage (gallons) ______ + ______ + ______ + ______ = ______

2d Other Inputs (units)

III OUTPUTS

3a Products, Useful By-Products (item and amount)

3b Releases to the Air (including gaseous wastes)

3c Releases to the Water (including liquid wastes)

3d Solid Wastes

NSRP

Solid Waste Segregation & Recycling Project

Task Four

Methods for Processing Solid Waste

Solid Waste Segregation and Scrap Recycling Project

Methods for Processing Solid Waste

Introduction:

This Task of the Solid Waste Segregation and Scrap Recycling Project consists of two components:

1) Development of "Point of Generation" Standard Operating Procedures for shipyards.
2) Outline the equipment, materials and costs to implement reduction, reuse and/or recycling opportunities identified.

Based on the shipyard waste streams identified in Task Two of this project, Standard Operating Procedures ("SOP") were prepared for standard shipyard craft divisions. Equipment and materials associated with each SOP were developed in a flowchart format. Each SOP has an equipment and materials flowchart attached.

A total of fifteen SOPs and Flowcharts were developed. These fifteen SOPs cover all the shipyard waste streams previously identified. The SOPs and their associated flowcharts were developed to be stand alone documents. Each SOP can customized to the specific departments and processes utilized the shipyard. Each shipyard is encouraged to review the SOPs and prepare versions which conform to its operations. The documents are prepared in Microsoft Word 7.0 for Window95. The flowcharts are prepared in Claris Impact.

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Task One, Methods for Processing Solid Waste

Methods for Processing Solid Waste	Section
Segregation and Recycling	M
Metal Fabrication Point of Generation Reduction, Reuse, Segregation and Recycling	N
Shipping & Receiving Point of Generation Reduction, Reuse, Segregation and Recycling	O

Task Two, Equipment, Materials and Costs to Implement Reduction, Reuse or Recycling Program

STANDARD OPERATING PROCEDURE

Task 4 Tab 1	Rev: 0	Date: 5/11/98	Page 1 of 4
Subject: **Methods for Processing Solid Waste**			

I. PURPOSE

This Standard Operating Procedure has been provided in order to establish the policy and procedure for segregation of hazardous and non-hazardous waste.

II. RESPONSIBILITY

The Operations Director is overall responsible for the control of hazardous and non-hazardous waste. Along these lines each department that generates waste is responsible for the implementation of these procedures.

III. REFERENCES

a. Appendix I Recycling Definitions
b. Appendix II Cost Analysis Procedures
c. Appendix III Metal Recycling Procedures
d. Appendix IV Common Recyclable Materials

IV. Requirements

Reference (a), (c) and (d) provide definitions associated with recycling efforts, some specific recommendations for handling of metal recycling (these same procedures can be adapted to plastic and paper recycling) and some examples of common recyclable materials. Reference (b) provides a quick method to determine if the recycling effort is cost effective.

In order to reduce the waste generated, the following waste minimization and/or recycling procedures should be followed:

Paint Department

1. Only mix the amount of epoxy based paints required to support painting requirements.
2. Cleaning solvents utilized for cleaning of paint guns and hoses will be recycled

preferably by solvent recovery stills or by utilizing gravity separation procedures.

3. Paint consumables such as paint brushes, rollers, rags, plastic, cardboard buckets, etc. should be segregated from paint waste. What this will do is reduce the cost of disposal of these paint wastes as well in most localities the consumables can be disposed in the local landfills. (Please verify the rules and regulations of your locality.)

Abrasive Blasting Operations

1. Metals that require profile and/or coating removals subsequent to recoating/ painting should be blasted in buildings built to recycle the blast medium.
2. It is understood that this is not always feasible. If not then the spent blast medium should be collected and either disposed or handled in accordance with company policies. The following options are available:
   A. Dispose of as expended abrasive. Depending on local rules and regulations, the expended abrasive may be considered hazardous and therefore can be quiet expensive.
   B. Recycle to cement kiln or asphalt company. The collected abrasive may require some special handling in order to remove shipyard debris (welding rods, fasteners, grinding wheels, etc.). Additionally the accepting companies may require testing to verify the spent abrasive is non-hazardous for metals.
   C. Reuse product after treating. This may require specific permits in order to accomplish. Additionally depending on the process utilized to process the abrasive medium, the resulting product may or may not be within specification.
1. NSRP Project N1-93-1 provides additional information on the management of spent abrasives.

Metal Fabrication

1. The recycling of scrap metals can make the difference between profit and loss. Appendix III provides guidance in getting the best dollar per pound of scrap.
2. The mixing of scrap metals can significantly reduce the value of the scrap metals. Therefore, in order to get the maximum, containers (usually skip boxes) need to be marked as to the metals that are to be placed in them. Additionally they need to be

placed such that it is convenient for the workers to properly sort the metals.

3. A collection point where the scrap can be consolidated by type should be designated. Final sorting to remove any trash or incorrectly placed metals should be conducted.

Shipping and Receiving

1. A good Shipping and Receiving person can also make the difference between profit and loss. Because all material entering and leaving the facility goes through Shipping and Receiving, this Department is responsible for the following:
   A. Containers that have a turn-in value need to be tracked and returned to vender when no longer in use. Examples of refundable containers would be:
      1) 55 gallon drums
      2) Cable spools
      3) Pallets
      4) Specialized crates
   A) Reuse of packing materials, including popcorn, bubble wrap, paper, etc..
   B) Consolidation (and compacting if the necessary equipment is available) of cardboard and paper products.

Administrative Support

Most of the various types of paper that has value are generated from the administrative offices. Containers should be available in the vicinity of these offices for the collection of the various types of paper. See Appendix IV for the various classifications of paper.

Although the value of scrap paper does not usually pay for the cost of this recycling effort, it can make an excellent public relations difference by increasing the corporate image, community relations and recognition of your company.

Tank and Bilge Cleaning

1. Tank and bilge cleaning generate the largest commodity of waste available for reduction. Large quantities of contaminated water are generated as a result of maintaining these tanks and bilges.
2. Historically, these fluids have gone to the bays and harbors and more recently to

sewer systems for disposal. However because of recent evaluation of the contaminants in these fluids, they have come under close scrutiny.

3. The use of "Baker" tanks for gravity separation of the fluids (removes oil) have significantly reduced this problem. After the initial cost of the tank there is little expense for the separation of the oils from the water. Additionally the use of inline filters removes the majority of other contaminants (metals) in the water.
4. Another method for reduction of the of this waste stream is the use of oily water separators. These separators ensure a "cleaner" water in a much quicker time than the gravity separation method.
5. Oils extracted from the oily water mixture have a distinct value. These oils can be used in house to provide BTU source for company boilers or can be sold to venders who process the oil for the BTU value. Procedures delineated in Appendix III also apply to this

Machine Shop, Electric Shop, Transportation Department

1. Parts cleaning will be conducted utilizing biodegradable cleaners. This reduces the amount of hazardous materials stowed thus reducing the possibility of spillage.
2. If solvent based cleaning required, then solvents will be cleaned periodically in solvent distiller (paint shop).
3. Waste oils (non-automotive) will be placed in the waste oil container for either sale or recycling in boiler.
4. Automotive oils will be kept separated from other oils. These oils will be periodically picked up for processing and reuse.

All Departments

1. Recycle paper and paper products by placing waste paper into paper product recycling bins located throughout the facility.
2. Scrap metals will be separated and placed into the appropriate scrap metal bins located throughout the facility.

Task 4 Tab 1 Appendix I	Rev: 0	Date: 5/11/98	Page 1 of 3
Subject: **Environmental Protection and Hazardous Waste Management Program Recycling Definitions**			

Definitions:

Baler: A machine used to compress recyclables into bundles to reduce volume. Balers are used often on newspapers, plastic, corrugated cardboard, and other sorted paper and plastic products.

Compactor: Power driven device used to compress materials to a smaller volume.

Compost: The stable, decomposed organic material resulting from the composting process. Also referred as humus.

Composting: The controlled biological decomposition of organic materials in the presence of oxygen into a stable product that may be sued as a soil amendment or mulch.

Contaminant: Foreign material that makes a recyclable or compostable material impure; for instance, food scraps on paper products.

Hauler: A garbage collection company that offers a complete refuse removable service. Many haulers now offer to serve as collectors of recyclables as well.
Markets: Generally, a recycling business (i.e., a buyer) or municipal recycling facility that accepts recyclable materials for processing and final sale to an end user, either for their own use or for resale.

Materials Exchange: A mutually beneficial relationship whereby two or more organizations exchange materials that otherwise would be thrown away. In some areas, computer and catalog networks are available to match up companies who wish to participate in exchanging their products.

Municipal Solid Waste: For the purposes of this guide, municipal solid waste includes all materials typically disposed of in dumpsters by businesses and removed for offsite disposal by private or municipal haulers. Includes wastes such as durable and nondurable goods, containers and packaging, food scraps, yard trimmings, and miscellaneous inorganic wastes from residential, commercial, institutional, and industrial sources. Municipal solid waste does not include wastes from other sources, such as municipal sludges, combustion ash, and industrial nonhazardous process wastes that might also be disposed of in municipal waste landfills or incinerators.

Pallet: A wooden platform used with a forklift for moving bales or other large items. Also called a skid.

Processing: The operations performed on recycled materials to render them reusable or marketable. Processing can include grinding glass, crushing cans, or baling. Processing has two distinct functions: a separation function and a processing or beneficiation function. Processing generally results in adding value to particular material.

Rebuilding: Modifying a component of municipal solid waste by repairing or replacing certain parts and reusing it again for its original purpose (e.g., refillable or rebuildable toner cartridges, wooden cable reels, or plastic wire reels). Rebuilding of solid waste components is most often done by a middleman.

Recyclables: Materials that still have useful physical or chemical properties after serving their original purpose. (See Appendix IV for a list of common recyclables).

Recycling: The process by which materials are collected and used as raw materials for new products. There are five steps in recycling: collecting waste materials, separating them by type (before or after collection), processing them into reusable forms, marketing the “new” products, and purchasing and using the goods made with reprocessed materials.

Reuse: Taking a component of municipal solid waste (possibly with slight modification) and using it again for its original purpose (e.g., refillable beverage bottles, foam peanuts, or pallets).

Solid Waste: According to the Resource Conservation and Recovery Act (RCRA), solid waste is: garbage; refuse; sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility; and other discarded materials, including solid, liquid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities.

Source Separation: Separating waste materials such as paper, metal, and glass by type at the point of discard so that they can be recycled.

Trash: Material often considered worthless, unnecessary, or offensive that is usually thrown away. Generally defined as dry waste material; but in common usage, it is a synonym for garbage, rubbish or refuse.

Waste Prevention: The design, manufacture, purchase or use of materials or products to reduce their amount of toxicity before they enter the municipal solid waste stream. Because it is intended to reduce pollution and conserve resources, waste prevention should not increase the net amount or toxicity of wastes generated throughout the life of a product.

Waste Reduction: Preventing and/or decreasing the amount of waste being generated either through waste prevention, recycling, composting, or buying recycled and reduced-waste products.

Waste Stream: The total flow of solid waste from homes, businesses, institutions, and manufacturing plants that are recycled, burned, or disposed in landfills, or any segment thereof such as the “residential waste stream” or the “recyclable waste stream.”

Use this worksheet to evaluate the economic and operational feasibility of the waste reduction options under consideration.

The tables in this worksheet will enable you to examine more closely the potential for waste reductions options. Much of the information requested on this worksheet involves business judgments concerning such factors as the effect each option is likely to have on productivity and the ease of implementation. Certain questions may not be applicable to all waste reduction options.

For the economic evaluation sections of this worksheet, refer to purchasing records, disposal records, waste sort or facility walk-through data, and interviews with company employees. Consult company purchasing officials, financial advisors, or department managers as necessary.

Fill out a separate worksheet for each waste reduction option to be evaluated, copying the forms as needed. Use the last page of this worksheet to summarize the economic, operational, and intangible factors associated with the waste reduction options under evaluation.

Waste Reduction Option

1 Operational Factors

A. Could this option improve or reduce product or service quality? How?

B. Could this option improve or reduce productivity? How?

C. Will additional staff or time be required to implement, operate, or maintain this option? How many? What would additional staff be required to do?

D. Can the option be implemented within the existing facility setup, or are adjustments needed (such as additional space or a change in layout) to accommodate the option? If so, what?

E. Will any new equipment be needed? If so, what?

F. Are there companies willing to purchase collected recyclable materials? List area buyers or haulers willing to collect material.

G. Can reusable materials be donated to local community group or listed with a materials exchange?

2 Economic Factors

A. Capital Costs for This Option

Equipment Purchased (e.g. baler, containers)	
	$
	$
Facility/Storage Preparation (e.g. grading a site for composting)	$
Installation/Utility Connection (for equipment such as compactors)	$
Initial Staff Training	$
Initial Promotional and Educational Materials	$
Other (specify)	$
	$
	$
Total Capital Costs	$

B. Annual Operating Costs for This Option

Materials and Supplies	$
Operation & Maintenance (e.g. labor, equipment, storage, service contracts, utility charges)	$
Transportation	$
Ongoing Staff Training	$
Ongoing Promotion and Education	$
Other (specify)	$
	$
	$
	$
Total Annual Operating Costs	$

C. Avoided Waste Removal Costs for this Option

Use the table below to calculate the annual avoided removal costs for this waste reduction option. Using data from the waste sort, purchasing records, and interviews with personnel as starting point, estimate the annual amount of waste this option will reduce. An example is provided for replacing single use disposable plates with dishes in the cafeteria.

Waste Reduction Activity	Waste Material Being Reduced	Amount Of Waste Reduced per Time Period	Annual Amount of Waste Reduced	Waste Removal Cost	Annual Avoided Removal Cost
Replace single-use plates with dishes in cafeteria	Single-use plates	5 cubic yards per week	260 cubic yards per year	$3 per cubic yard	$780

D. Avoided Purchase Costs for this option

If the waste reduction option under consideration will result in the opportunity to purchase fewer supplies or materials, use the formula below to calculate the annual avoided purchase costs for this option.

Type of Material:

	X		=	$
Annual reduction in purchasing [in same unit of measure as the unit price]		Unit Price		**Annual Avoided Purchase Costs**

E. Annual Revenues for this option

Use the formula below to estimate annual revenues for this option (if any).

	+		+		=	$
Sale of recyclable materials		Sale of items in a materials exchange		Sale of others		**Total Annual Revenues**

F. Net Savings for This Option

Use the formula below to estimate annual savings for this option.

	+		+		=	$
Annual avoided removal costs [from Step 2-C]		Annual avoided purchase costs [from Step 2-D]		Annual revenues [from Step 2-E]		**Total Annual Savings**

G. Net Annual Cost or Savings for This Option

Subtract the total annual operating costs from the total annual savings to arrive at the net annual cost or savings resulting from this waste reduction option (exclusive of capital costs).

	-		=	$
Total annual savings [from Step 2-E]		Total annual operating costs [from Step 2-B]		**Annual Net Costs or Savings**

H. Interpreting Net Costs

If the figure arrived in 2-F is positive, proceed to 2-I.

If the figure arrived at in 2-F is negative, this option will cost more to implement than it will save. First, review the numbers to ensure you have accounted for all potential costs and savings. If the result is the same, you will need to determine whether this option belongs in your waste reduction program. If this option has other intangible benefits (such as improved public relations and employee morale), you might consider including it. In addition, be sure to consider the program as a whole. This option might make sense if the other components of your program will result in large enough savings to offset the costs of this option, resulting in overall program savings.

If you decide it should not be included in your waste reduction program at this time, you might want to make a note to revisit this option if conditions change. For example, if the market for recyclable material improves significantly or equipment costs decline due to technological advances, this option might become cost-effective.

I. Payback Period for This Option

Payback period is one of many ways of measuring the economic feasibility of the options under consideration. The payback period measures the amount of time needed for the cumulative revenues or savings resulting from the waste reduction program to equal the

initial investment. (This calculation is only relevant when annual savings or revenues exceed annual costs.) If your company uses other measures of investment worthiness (internal rate of return, net present value, etc.) you may wish to use one of these methods instead of calculating the payback period.
Calculate the payback period using the formula below.

	–		=	
Total capital costs [from Step 2-A]		Annual net savings [from Step 2-F]		**Payback Period (Years)**

3. Other Factors

Aspects of the options that cannot be expressed using the Economic and Operational Feasibility tables and formulas may be explained below. (These intangible factors include improved working environment, corporate image, employee and customer satisfaction, community relations, and recognition.) List the intangible advantages and drawbacks associated with implementing this option.

4. Summary of Waste Reduction Options

Use this table to summarize the economic and operational feasibility of your waste reduction options.

	Economic			Operational
Option	Projected Amount of Waste Reduced Annually	Annual Net Cost or Savings	Payback Period	Operational and Intangible Advantages and Drawbacks
Recycling office paper	*200 reams of paper*	*$2,000 savings*	*Less than 1 year*	*Strong, local paper recycling market, easy to implement, good for employee involvement*

Task 4 Tab 1 Appendix III	Rev: 0	Date: 5/11/98	Page 1 of 2
Subject: **Methods for Processing Solid Waste - Maximizing Return for Scrap Metals**			

General:

1. Fix responsibility for scrap program with one person called scrap manager.
2. Use security log on all shipments as double check that you are paid for each load.
3. Ensure that material is sorted so that you get metal price vice mixed metal prices.

Procedures:

FERROUS

1. Weigh all truckloads on a public scale—both empty and loaded—no exceptions. Account for bin weights in your calculations.
2. Have security keep a log or record of each pickup. Double check against security record.
3. Scrap manager shall inspect each load just before it leaves to be sure the material is correct (no Non-Ferrous or garbage). Note anything unusual.
4. Keep a package for each shipment, including weight ticket from public scale, bin weight, notes about contents, if any, and security record of shipment.
5. When settlement received:
   a) Check net weight paid against public weight ticket. (Adjust for bin weight as needed.
   b) Do not accept discrepancies of over 100 pounds unless your note mentioned garbage in the bin.
   c) Check price against vendor's quote. You can always negotiate a little.
   d) Pass on completed package after approval.
1. Have a double check system to insure that all pick ups noted by security have a settlement package. This can be done by numerical control, or keeping all security records in one spot, and checked.

SPECIAL CONDITIONS—FERROUS:

1. Get current selling price of ship scrap from local sources. It may be worthwhile to truck scrap to remote vender in order to get better value per ton.

NON—FERROUS SCRAP

1. Add a "small" bin for "irony or contaminated" (not toxic term) Non-Ferrous metal, and one for monel/cupro nickel as needed.
2. Scrap manager shall continually inspect all bins to insure the correct materials is in place. The clean Non-Ferrous grades should be kept 100% free of iron or non-metallics.

3. If large amounts of one metal are generated (e.g. 70/30 cupro nickel, monel, etc.), they should be identified and kept separate.
4. Provide workers with nitric acid to tell cupro nickel and monel from stainless steel. (Nitric acid does not react with stainless steel, but turns green if any copper is present). Also provide magnets to your employees (cupro nickel and monel are non-magnetic)
5. Weigh all "small" bins on scale and record weights.
6. Weigh all truck on a public scale—both loaded and empty—no exceptions. Count and adjust for individual bin weights as appropriate.
7. Have security log all pick ups, noting date, time, etc.
8. Inspect all bins immediately before shipment to insure the proper quality of the contents. Note any discrepancies.
9. Prepare a package for each shipment as soon as it leaves, including:
   a) Small bin weights and commodity.
   b) Public scale ticket.
   c) Notes on quality, if any
   d) Number of bins on truck.
   e) Security record of shipment.

   Check total weight of individual bins and their contents (bin and material) to insure it agrees with the net weight on the public scale ticket. Note any discrepancies immediately as the small scale are not usually certified.
10. Establish pricing based on date of pick up. Price all brasses and bronzes by individual grade.
11. When you receive a settlement sheet (promptly, at least one per month), the scrap manager shall check each grade and weight shipped (your package) against the grade and weight paid for…they must agree. Sort downgrades on clean material should not be accepted if the above steps were followed and the scrap manager did not see any off grade. Different types of clean grades (e.g. - brasses, bronze, coppers, etc.) are acceptable in settlements, providing they are reasonably close to bin category.
12. Obtain weekly or monthly price sheet to be used as a guide or double check. Check the price against this list. Prices should be within $0.02/pound of the numbers indicated. Occasional variations are normal, but 80% should be in this range. Negotiate any differences not in your favor. The vender will usually raise a price that appears out of line.
13. Double check security log to insure all loads that have left the plant have been paid for.

Please note that Non-Ferrous is normally very valuable. You could easily save or loose a few thousand dollars per month.

Paper

High-Grade Paper

High grade paper is usually generated in office environments and can earn recycling revenues when present in sufficient quantity. Types of high grade paper include:

- Computer paper (also known as Computer Print Out or CPO). Can be all white or have a white main fiber with bright green or blue bars.
- White ledger. Most white office paper, including white computer paper, copy machine paper, letterhead, white notebook paper, and white envelopes. Common contaminants include glossy paper, wax-coated paper, latex adhesive labels, envelopes with plastic windows, and carbon paper.
- Tab cards. Usually manilla-colored computer cards; may be other colors but must be separated by color to be valuable as a high grade paper.

Other Papers

These papers are less valuable than high-grade paper in terms of recycling, although they still can be cost effective to recycle in many cases. Examples of other types of paper include:

- Colored ledger. Most non-white office paper, including carbonless paper, file folders, tablet paper, colored envelopes, and yellow legal paper.
- Corrugated Cardboard (also know as Old Corrugated Cardboard or OCC). Includes unbleached, unwaxed paper with a ruffled (corrugated) inner liner. It usually does not include linerboard or pressboard, such as cereal boxes and shoe boxes. For most businesses, cardboard is a cost effective material to recycle.
- Newspaper (also known as Old News Print or ONP). It is most valued when separated from other paper types, but can be recycled as mixed waste paper.
- Miscellaneous waste paper. Encompasses most types of clean and dry paper which do not fall into the categories mentioned above, including glossy papers, magazines, catalogs, telephone books, cards laser-printed white ledger, windowed envelopes, paper with adhesive labels, paper bags, wrapping paper, packing paper, sticky-backed notes, and glossy advertising paper. This mixed paper has limited value in existing markets.
- Mixed waste paper. Paper that is unsegregated by color, quantity, or grade (e.g., combination of white ledger, newsprint, colored paper, envelopes without windows, computer paper,

glossy paper, etc.). Mixed paper generally sells below the price of the least valuable paper in the mix.

Plastic

There are 7 types of plastic which are identified by a Society of Plastics Industry (SPI) code number ranging from 1 to 7. These numbers are usually found on the bottom of plastic containers inside a three-arrow recycling symbol. A description of each kind of plastic is presented below. Also, you may check with the Society of the Plastics Industry at 1-800-2-HELP-90 for information about haulers/recyclers in your area. Some recyclers only accept a sub-category of the ones presented below. For example, a recycler may only accept HDPE milk jugs and not all HDPE products.

PET (SPI=1)

Polyethylene terephthalate (PET) is the most readily recyclable material at this time. It includes 1- and 2- liter clear soda bottles, as well as some bottles containing liquor, liquid cleaners, detergents and antacids.

HDPE (SPI=2)

High-Density Polyethylene (HDPE) is currently recyclable in some areas. This class includes milk, juice, and water jugs, base cups for some plastic soda bottles, as well as bottles for laundry detergent, fabric softener, lotion, motor oil, and antifreeze.

PVC (SPI=3)

Polyvinyl Chloride (PVC, also referred to simply as “vinyl”) includes bottles for cooking oil, salad dressing, floor finish, mouthwash, and liquor, as well as “blister packs” used for batteries and other hardware and toys.

LDPE (SPI=4)

Low-Density Polyethylene (LDPE) includes grocery bags, bread bags, trash bags, and a variety of other film products. LDPE is currently being recycled by some of the major retail chains.

Polypropylene (SPI=5)

Polypropylene includes a wide variety of packaging such as yogurt containers, shampoo bottles, and margarine tubs. Also cereal box liners, rope and strapping, combs, and battery cases.

Polystyrene (SPI=6)

Polystyrene includes Styrofoam™ coffee cups, food trays, and "clamshell" packaging, as well as some yogurt tubs, clear carryout containers, and plastic cutlery. Foam applications are sometimes called EPS, or Expanded Polystyrene. Some recycling of polystyrene is taking place, but is limited by its low weight-to-volume ratio and it value as a commodity.

Other (SPI=7)

Can refer to applications which use some of the above six resins in combination or to the collection of the individual resins as mixed plastic (e.g., cameral film can include several types of plastic resins). Technology exists to make useful items such as plastic "lumber" out of mixed plastic resins, but generally the materials are more useful and valuable if separated into the generic resin types described above.

Metals

Aluminum

Included in this category are aluminum beverage cans, as well as clean aluminum scrap and aluminum foil. Currently, aluminum is a highly valued material for recycling.

Tin-Coated Steel Containers

Includes cans used for food packaging (i.e., canned foods). Some local recyclers may require cans to be cleaned and crushed with labels removed.

Bimetal Containers

A typical example includes tin-plated steel cans with aluminum "pop top" (e.g., peanut cans). These containers can be separated from aluminum cans by using a magnet. (Note: Technically, tin cans are bimetal, but we do not consider them when referring to bimetal cans.) Many recyclers accept bimetal containers with tin-coated steel cans.

Non-Ferrous Metals

Includes most types of scrap metal which do not contain iron (such as copper and brass). This scrap can be a relatively valuable commodity, depending on quantity. It is often recycled through scrap metal dealers, although some general recyclers will handle it with other materials.

Ferrous Metals

Includes iron and iron-containing metal scrap. Ferrous metal is handled in the same manner as non-ferrous metal but generally has lower market value.

Miscellaneous Recyclables

Lead-Acid Batteries

Lead-acid batteries are used in automobiles, back-up lighting systems, lawn mowers, and computers. Lead-acid batteries contain lead, a toxic metal, and sulfuric acid. Many states prohibit disposal of lead-acid batteries in municipal solid waste, and many require either retailers, wholesalers, or distributors to take back batteries. Currently about 90 percent of lead-acid batteries used in automobiles are recycled.

Household Batteries

Household batteries come in a variety of types, including alkaline, carbon-zinc, mercuric-oxide, silver-oxide, zinc-air, and nickel-cadmium. Currently, only button batteries containing mercury and silver or nickel-cadmium batteries can be recycled, often at a net cost.

Task 4	Rev: 0	Date: 5/6/98	Page 1 of 2
Subject: **VEHICLE MAINTENANCE PROCEDURES**			

I. PURPOSE

This procedure provides guidance to the vehicle maintenance department personnel in the reduction, segregation and recycling of hazardous and non-hazardous waste at the point of generation.

II. RESPONSIBILITY

The Vehicle Maintenance Department Head should ensure that the guidance provided in this document is made available and followed by the maintenance personnel.

III. Requirements

Reduction Procedures

1. Institute a performance standard (chemical testing) to determine when a oil, lubricant or fluid must be changed. This can result in a significant reduction in the volume of these waste streams, in addition to improved maintenance of the rolling stock. Oil testing is available from most distributors of bulk oil.

2. Procurement of oils in bulk will result in substantial reduction in the number of containers required for vehicle maintenance. The cost of bulk oil is less expensive than when procured in quart or gallon quantities.

3. Solvent cleaning of components can result in flammable wastes, depending on the cleaning compound being utilized. Chemical companies have developed non-hazardous cleaners that are as effective as petroleum based cleanup solvents. These cleaners are less hazardous then the petroleum based solvents and may, depending on local regulations and permits, be sewerable.

Reuse Procedures

1. EPA has directed that Ozone Depleting Compounds such as freon not be vented to the atmosphere. Additionally a ban on the manufacturing of these compounds has

made the availability of freons scarce. Industry has made available equipment that will evacuate the freons from air conditioning systems, filter it to remove any contaminants, and store the freon for future use.

2. Antifreeze can be collected during routine maintenance (such as system flushing) and reused. Equipment is available which will filter/process resulting in a clean antifreeze.

3. Petroleum based cleaning solvents utilized for cleaning of equipment and parts can be processed for reuse using solvent recovery stills or utilizing gravity settling procedures.

Segregation Procedures

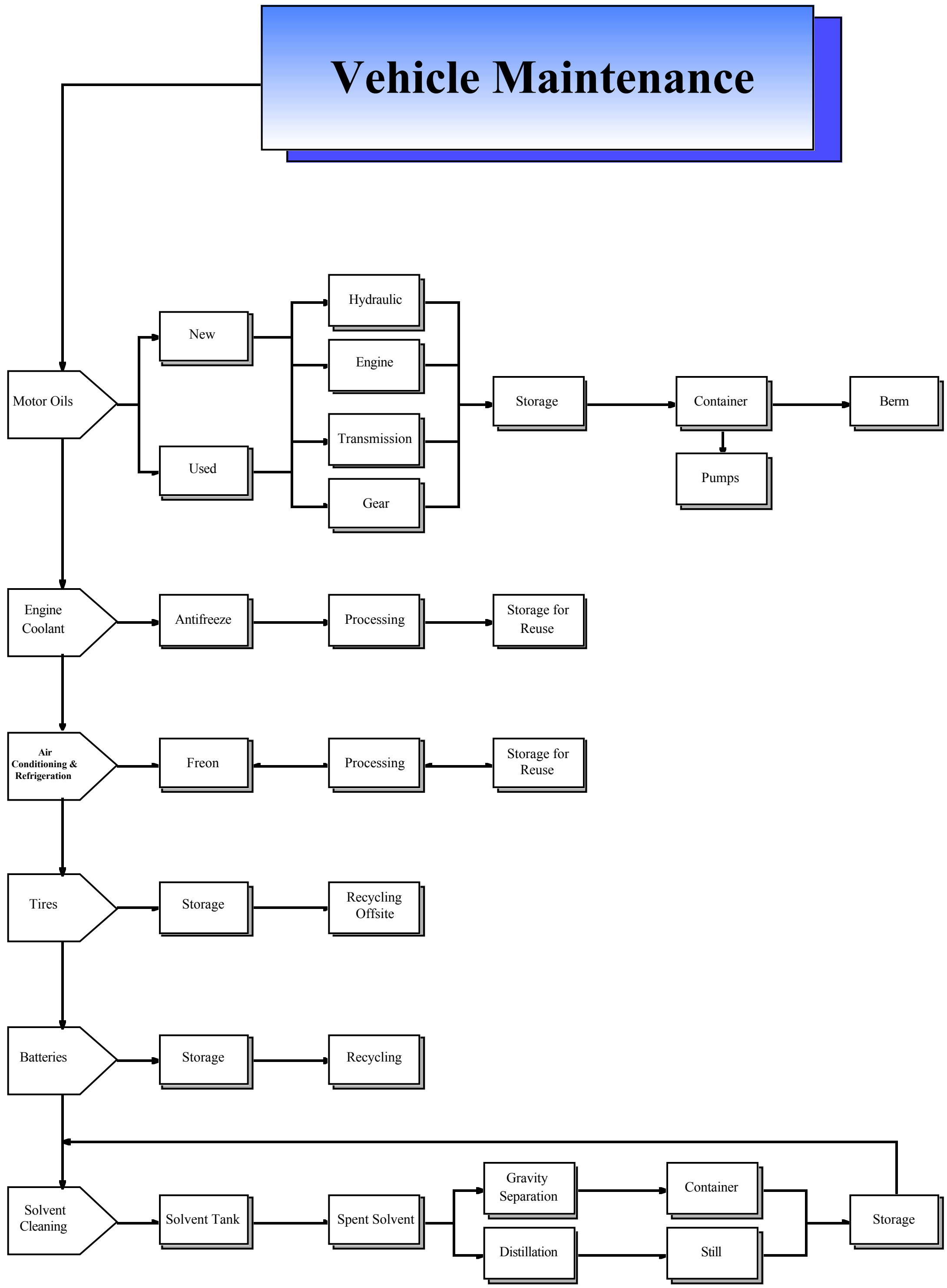
1. Prior to transferring any waste oil to the waste oil bulk storage container, a halogenated solvents test should be utilized. A small amount of halogenated solvents can result in the entire container not being acceptable to the waste oil recycler. Brake and carburetor cleaners normally contain halogenated solvents, and should never be mixed with waste oil.

Recycling Procedures

1. Battery venders will (required by EPA) accept expended batteries on a one for one basis. These batteries are then recycled - either for its components or remanufactured for reuse.

2. Bulk waste oil is usually procured by local recyclers or taken at minimal cost. The waste oil recyclers will normally provide containers for the storage of the waste oil.

3. Turn-in tires to suppliers on a one for one basis. Larger tires that would not normally be accepted can be made available to developers for erosion control.


Vehicle Maintenance
Motor Oils
New
Used
Hydraulic
Engine
Transmission
Gear
Storage
Container
Berm
Pumps
Engine Coolant
Antifreeze
Processing
Storage for Reuse
Air Conditioning & Refrigeration
Freon
Processing
Storage for Reuse
Tires
Storage
Recycling Offsite
Batteries
Storage
Recycling
Solvent Cleaning
Solvent Tank
Spent Solvent
Gravity Separation
Distillation
Container
Still
Storage

Task 4	Rev: 0	Date: 5/11/98	Page 1 of 2
Subject: **PAINTING AND COATING OPERATIONS**			

I. PURPOSE

This procedure provides guidance to the paint department personnel in the reduction, reuse, segregation and recycling of hazardous and non-hazardous waste at the point of generation.

II. RESPONSIBILITY

The Paint Department Head should ensure that the guidance provided in this document is made available and followed by the worker level personnel.

III. Requirements

Reduction Procedures

1. Mix only the amount of epoxy based paints required to support painting requirements for the particular job.

2. Solvent cleaning of components can result in flammable wastes, depending on the cleaning compound being utilized. Chemical companies have developed non-hazardous cleaners that are as effective as petroleum based cleanup solvents. These cleaners are less hazardous then the petroleum based solvents and may, depending on local regulations and permits, be sewerable.

3. Plural component mixing equipment is available if the usage volume can justify the procurement of the equipment and tanks. The result is a significant reduction in material cost per gallon plus the reduction in processing of paint cans that would no longer required.

4. Plastic sheeting utilized to isolate an area of painting operations can be compacted to reduce the volume of waste disposed. Additionally, depending on the quality of the plastic and the current costing available, the plastic maybe sold to venders that accept plastic waste.

Reuse Procedures

1. Petroleum based cleaning solvents utilized for cleaning of equipment and parts can be processed for reuse using solvent recovery stills or utilizing gravity settling procedures.

Segregation Procedures

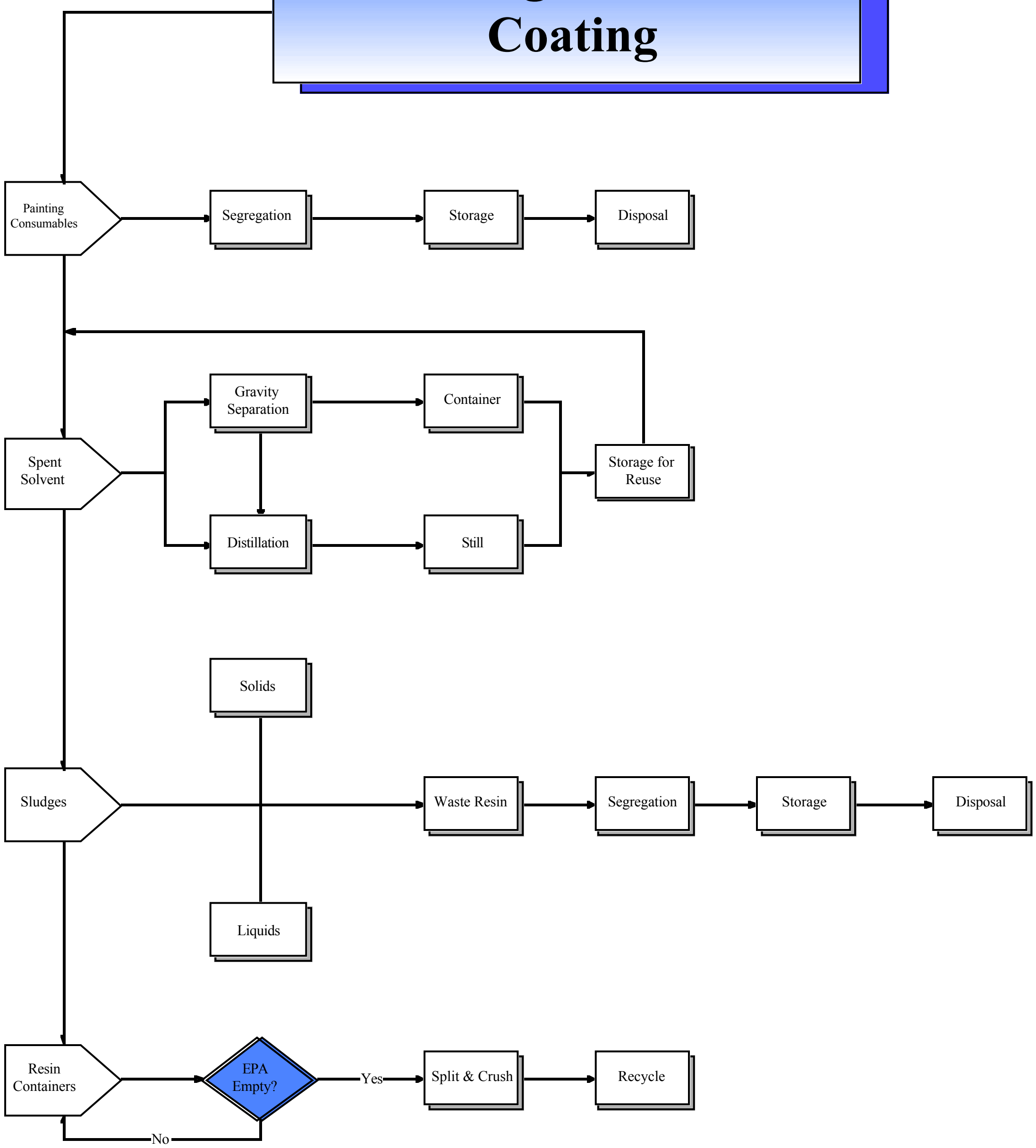
1. Paint consumables such as paint brushes, rollers, rags, plastic, cardboard buckets, etc. should be segregated from paint waste. This will reduce the disposal cost of the paint wastes by reducing their volume. In most localities paint consumables can be disposed in the local landfills. (Local rules and regulations concerning landfill disposal must be consulted.) Additionally the disposal cost of paint and paint consumables can be significantly reduced if the two waste streams are not mixed.

Recycling Procedures

1. Split paint cans and then remove dried and semi-solid paint. Wipe clean the can interior and send the cans to the metal recycling division. The dried and semi-solid paints will be in the appropriate paint waste barrels, prior to disposal.

2. Most paints waste have a high BTU content and can be recycled for their heat value. Contract a fuel blending facility to have the paint waste treated for acceptability.

Painting & Surface Coating



Task 4	Rev: 0	Date: 5/11/98	Page 1 of 2
Subject: **Abrasive Blasting Operations**			

I. PURPOSE

This procedure provides guidance to shipyard personnel involved in abrasive blasting operations in the reduction, segregation and recycling of hazardous and non-hazardous waste at the point of generation.

II. RESPONSIBILITY

The Abrasive Blasting Department Head should ensure that the guidance provided in this document is made available and followed by the worker level personnel.

III. Requirements

Reduction Procedures

1. A training program which provides instruction in the proper procedures for abrasive blasting can significantly reduce the quantity of abrasive blast medium utilized. All blasters must follow correct procedures to minimize the quality of abrasive utilized.

2. A abrasive blasting gun maintenance plan (which includes go/no-go gauges for the air orifices) will result in proper blast medium pressure and flow rates, thus reducing the amount of blast medium required.

3. Solvent cleaning of components can result in flammable wastes, depending on the cleaning compound being utilized. Chemical companies have developed non-hazardous cleaners that are as effective as petroleum based cleanup solvents. These cleaners are less hazardous then the petroleum based solvents and may, depending on local regulations and permits, be sewerable.

Reuse

1. The abrasive media can be reuse after treatment. Treatment may require specific permits to accomplish. Ensure proper permits are in place as required. Additionally, depending on the process utilized to treat the abrasive medium, the

resulting product may or may not be within specification. Ensure all abrasive media reused meets required specifications. Segregation procedures described below as well as mechanical screening will be required.

2. Petroleum based cleaning solvents utilized for cleaning of equipment and parts can be processed for reuse using solvent recovery stills or utilizing gravity settling procedures.

Segregation Procedures

1. Following abrasive blasting, the spent media is usually contaminated with trash and other industrial debris (welding rods, scrap, wood, pallets etc.). Personnel involved in cleanup should, prior to starting, remove any trash or debris that will be entrained with the blast medium during clean-up.
2. Gross trash removal can be accomplished by placing screens over skip boxes/containers in the drydock or abrasive blasting area. Trash and debris will be removed by the screen as the spent media is loaded into skip boxes.

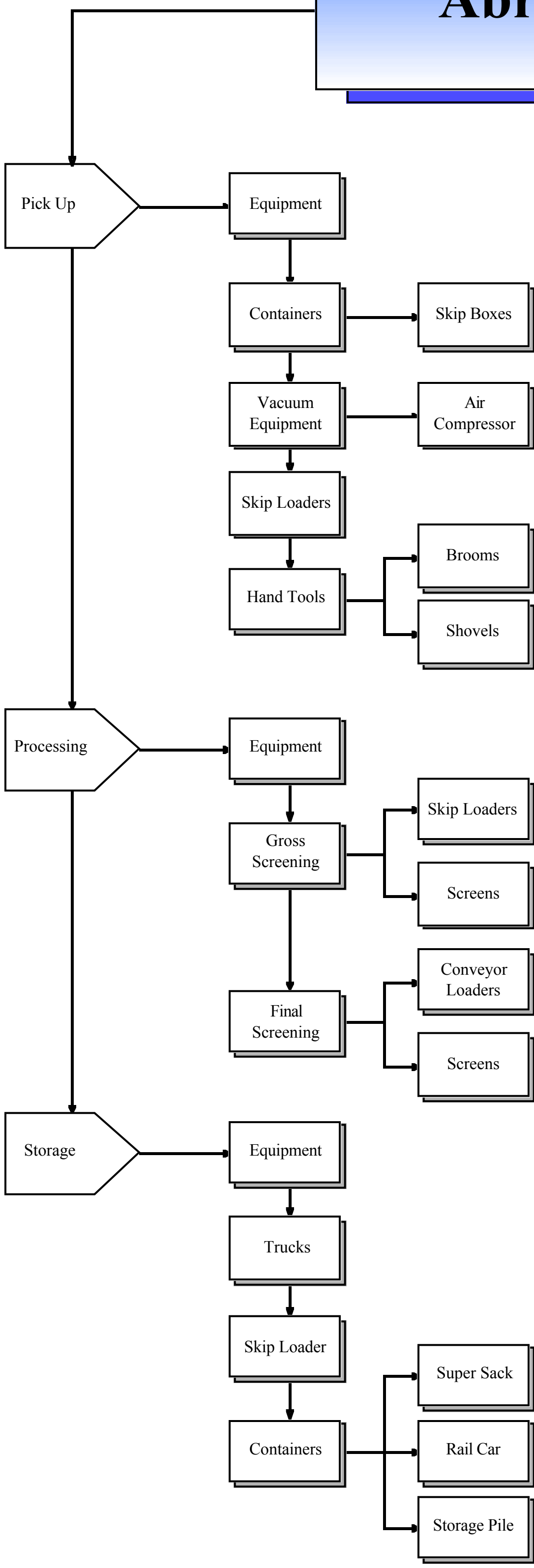
Recycling Procedures

1. *Small metal parts and articles*: that require profile and/or coating removals subsequent to recoating/painting should be blasted in buildings or booths designed to recycle the blast media. Filtering removes dust and contaminants that may become entrained in the blast medium and allows for the reuse of the blast medium.

2. *Open air blasting*: The following recycling options are available.
   Recycle spent media to cement or asphalt manufacturing company. The spent abrasive may require some special handling to remove shipyard debris (welding rods, fasteners, grinding wheels, etc.) prior to shipment. Additionally the accepting company may require testing to verify the spent abrasive is non-hazardous for metals.

3. NSRP Project N1-93-1 provides additional information on the management of spent abrasives.

Abrasive Blasting



Task 4	Rev: 0	Date: 5/11/98	Page 1 of 2
Subject: **MACHINING OPERATIONS PROCEDURES**			

I. PURPOSE

This procedure provides guidance to the machine shop personnel in the reduction, reuse, segregation and recycling of hazardous and non-hazardous waste at the point of generation.

II. RESPONSIBILITY

The Machine Shop Department Supervisor should ensure that the guidance provided in this document is made available and followed by the worker level personnel.

III. Requirements

Reduction Procedures

1. Use of water based cutting fluids and coolants will reduce the potential for generation of hazardous waste.

2. Gross cutting of the component to be machined can reduce the amount of wastage. The gross cuttings can be put into the appropriate metal recycling bin.

3. Solvent cleaning of components can result in flammable wastes, depending on the cleaning compound being utilized. Chemical companies have developed non-hazardous cleaners that are as effective as petroleum based cleanup solvents. These cleaners are less hazardous then the petroleum based solvents and may, depending on local regulations and permits, be sewerable.

Reuse Procedures

1. Periodically clean the screens that filter cutting fluids. Do not let cutting fluids become contaminated with solvents, oils, etc., as the effectiveness of the cutting fluid will be reduced, resulting in premature failure and excess wastage.

2. Petroleum based cleaning solvents utilized for cleaning of equipment and parts can be

processed for reuse using solvent recovery stills or utilizing gravity settling procedures.

Segregation Procedures

1. Separate unusable metal components into the appropriate scrap bins.

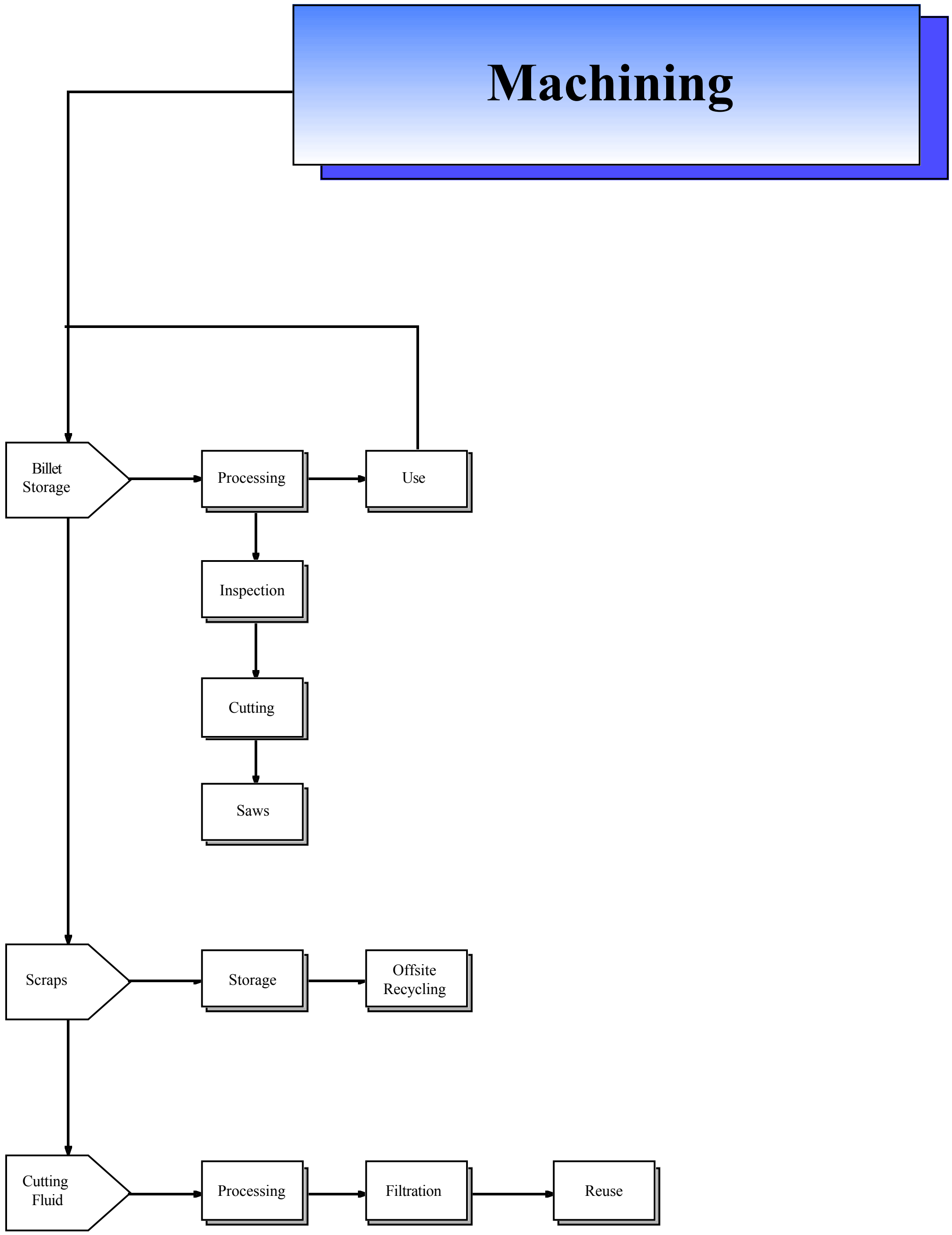
2. Never mix solvents with oils, as this will reduce the recycling value of both waste streams.

3. Ensure solvent wiping rags are kept separate from non-hazardous trash. Mixing of hazardous waste with non-hazardous waste will result in increase waste volume and disposal costs.

Recycling Procedures

1. Place gross cuttings of the various metals in the appropriate metal recycling bins.

2. Recycle metals fines in the appropriate metal recycling bins. Clean fines of solvent and/or oil residue if appropriate.



Machining
Billet Storage
Processing
Use
Inspection
Cutting
Saws
Scraps
Storage
Offsite Recycling
Cutting Fluid
Processing
Filtration
Reuse

I. PURPOSE

This procedure provides guidance to the personnel involved in marine cleaning operations in the reduction, reuse, segregation and recycling of hazardous and non-hazardous waste at the point of generation.

II. RESPONSIBILITY

The Shop Department Head should ensure that the guidance provided in this document is made available and followed by the worker level personnel.

III. Requirements

<u>Reduction Procedures</u>

1. The more water used in cleaning operations, the more costly the processing or the disposal. Only the minimal amount of water necessary to do the job should be utilized.

2. Slight heating of the cleaning water can result in a more effective cleaning, thereby reducing the volume of liquid required to be treated and/or disposed.

3. Pressure washing combined with heating will substantially reduce the volume of tank and bilge cleaning liquids.

<u>Segregation Procedures</u>

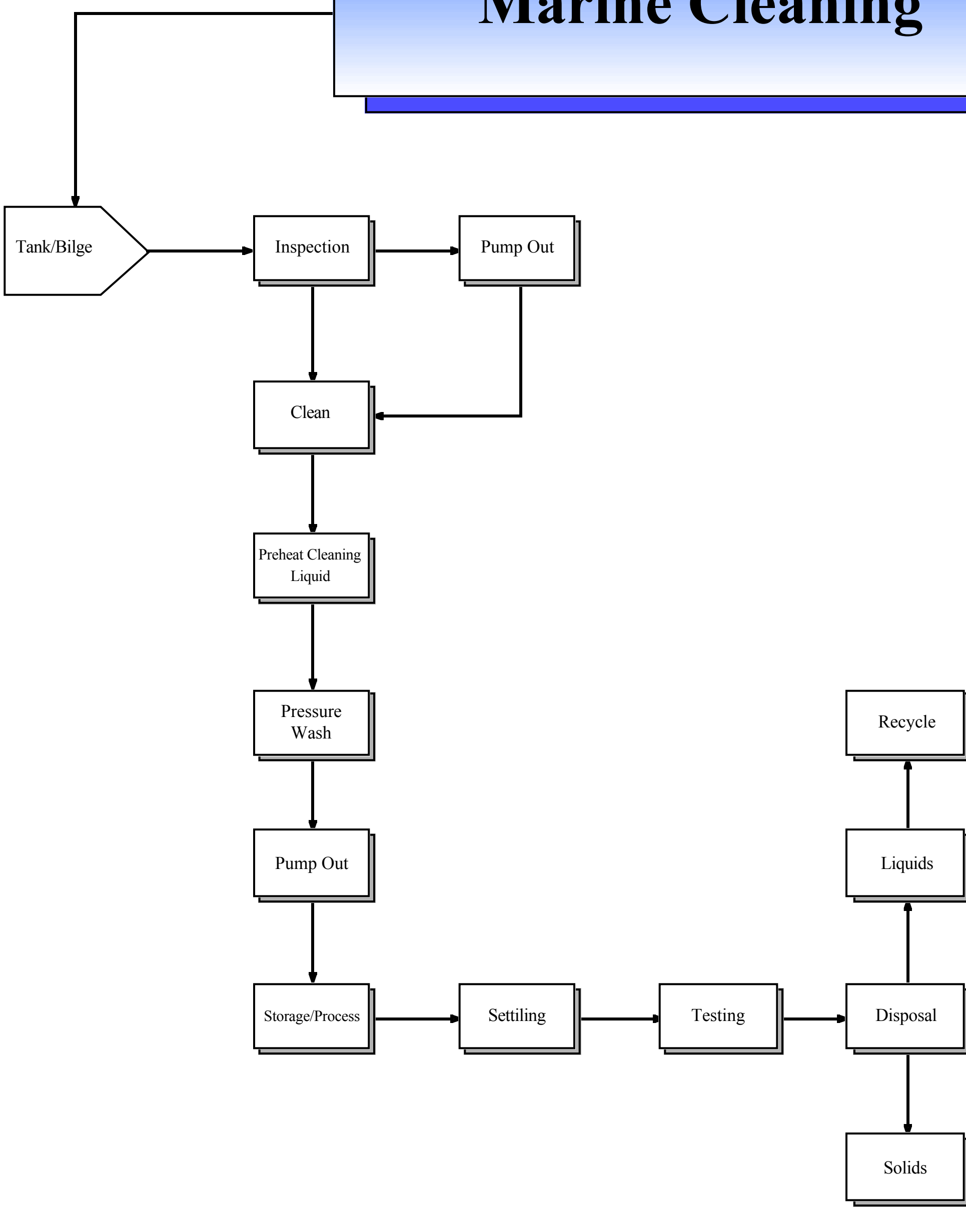
1. When fuel tanks are cleaned, there is always a quantity of fuel that can not be pumped out by operation of the ships systems (fuel below low suction point). This fuel can be pumped out using portable pumps (Sandpipers) and because of the purity of the fuel should be segregated from cleaning fluids/contaminated fuel.

<u>Recycling Procedures</u>

1. *Gravity Separation*: Pump liquids to holding tanks for settling of any dirt and debris, and separation of any fuel from the water. This will allow the disposal of the water to the sewer system (if it meets POTW disposal limits) and recycling of the separated fuel.

2. *Centrifugal Process*: Alternatively process the oily water combination in a oily water separator for the removal of the fuel and diversion of the water to the sewer system.

Marine Cleaning



Task 4	Rev: 0	Date: 5/11/98	Page 1 of 1
Subject: **ELECTRIC MOTOR REPAIR PROCEDURES**			

I. PURPOSE

This procedure provides guidance to the personnel involved in electric motor repair operations in the reduction, reuse, segregation and recycling of hazardous and non-hazardous waste at the point of generation.

II. RESPONSIBILITY

The Electrical Shop Department Supervisor should ensure that the guidance provided in this document is made available and followed by the worker level personnel.

III. Requirements

Reduction Procedures

1. Solvent cleaning of components can result in flammable wastes, depending on the cleaning compound being utilized. Chemical companies have developed non-hazardous cleaners that are as effective as petroleum based cleanup solvents. These cleaners are less hazardous then the petroleum based solvents and may, depending on local regulations and permits, be sewerable.

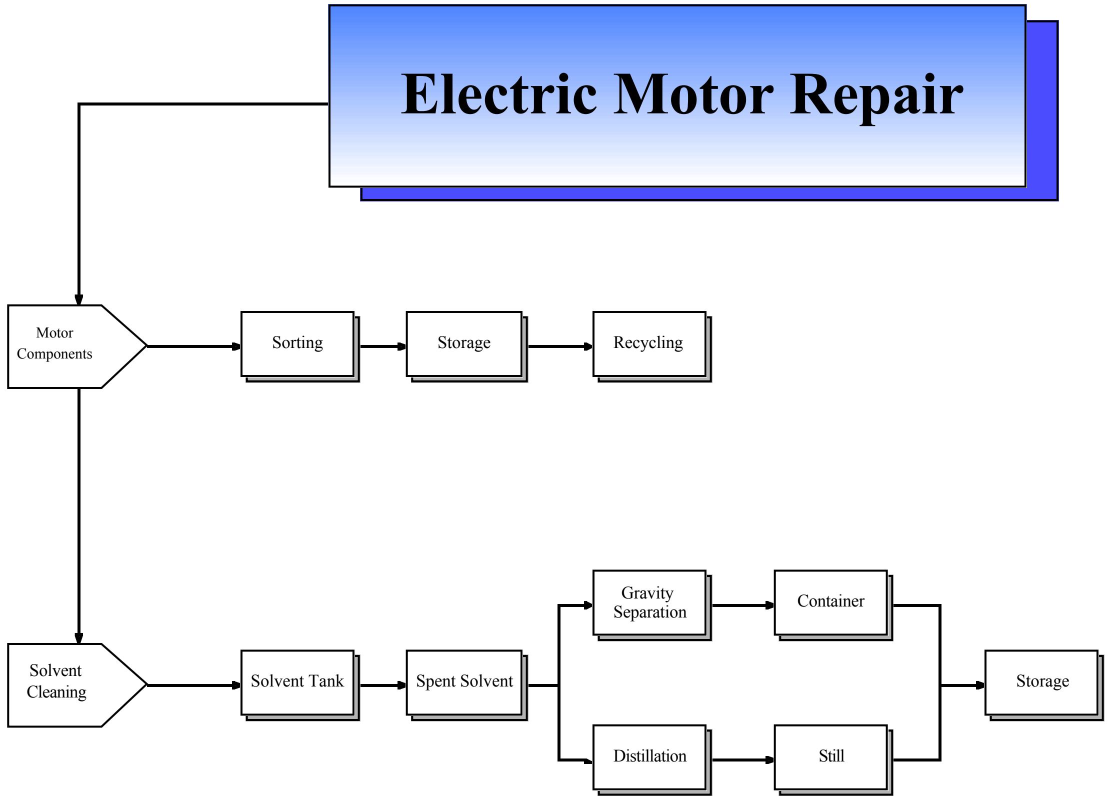
Reuse Procedures

1. Petroleum based cleaning solvents utilized for cleaning of equipment and parts can be processed for reuse using solvent recovery stills or utilizing gravity settling procedures.

Recycling Procedures

1. Remove burnt out stator windings and place in copper metal recycling bin.

2. Sort motor components that are no longer usable - fasteners, bearings, bushings, fans, armatures, etc. - and place these components in the appropriate metal recycling bins.


Electric Motor Repair
Motor Components
Sorting
Storage
Recycling
Solvent Cleaning
Solvent Tank
Spent Solvent
Gravity Separation
Container
Distillation
Still
Storage

Task 4	Rev: 0	Date: 5/11/98	Page 1 of 2
Subject: **BUILDING MAINTENANCE PROCEDURES**			

I. PURPOSE

This procedure provides guidance to the building maintenance department personnel in the reduction, reuse, segregation and recycling of hazardous and non-hazardous waste at the point of generation.

II. RESPONSIBILITY

The Facilities Department Supervisor should ensure that the guidance provided in this document is made available and followed by the worker level personnel.

III. Requirements

Reduction Procedures

1. Install fluorescent lights where possible to reduce electric power usage. Additionally new design lights are available which guarantees minimum of one year on fluorescent tube and five years on ballast.

2. Consolidate number and types of cleaners used into one all purpose cleaner. This will reduce the number of product containers required. Additionally, these general purpose cleaners come in concentrated forms which will reduce the storage required in addition to the quantity cost.

3. Utilization of water based paints will result in the waste as being non-hazardous as opposed to hazardous.

4. Solvent cleaning of components can result in flammable wastes, depending on the cleaning compound being utilized. Chemical companies have developed non-hazardous cleaners that are as effective as petroleum based cleanup solvents. These cleaners are less hazardous then the petroleum based solvents and may, depending on local regulations and permits, be sewerable.

Reuse Procedures

1. The EPA has directed that Ozone Depleting Compounds such as freon not be vented to the atmosphere. Additionally a ban on manufacturing of these compounds has made or will in the future make the availability of freons scarce. Industry has made equipment available that will evacuate freons from air conditioning systems, filter it to remove any contaminants, and store the freon for future use.

2. The use of heavy duty tarps to protect flooring, furniture, equipment, etc. vise plastic sheet when painting will permit the reuse of the tarp as opposed to disposal of the plastic.

3. Petroleum based cleaning solvents utilized for cleaning of equipment and parts can be processed for reuse using solvent recovery stills or utilizing gravity settling procedures.

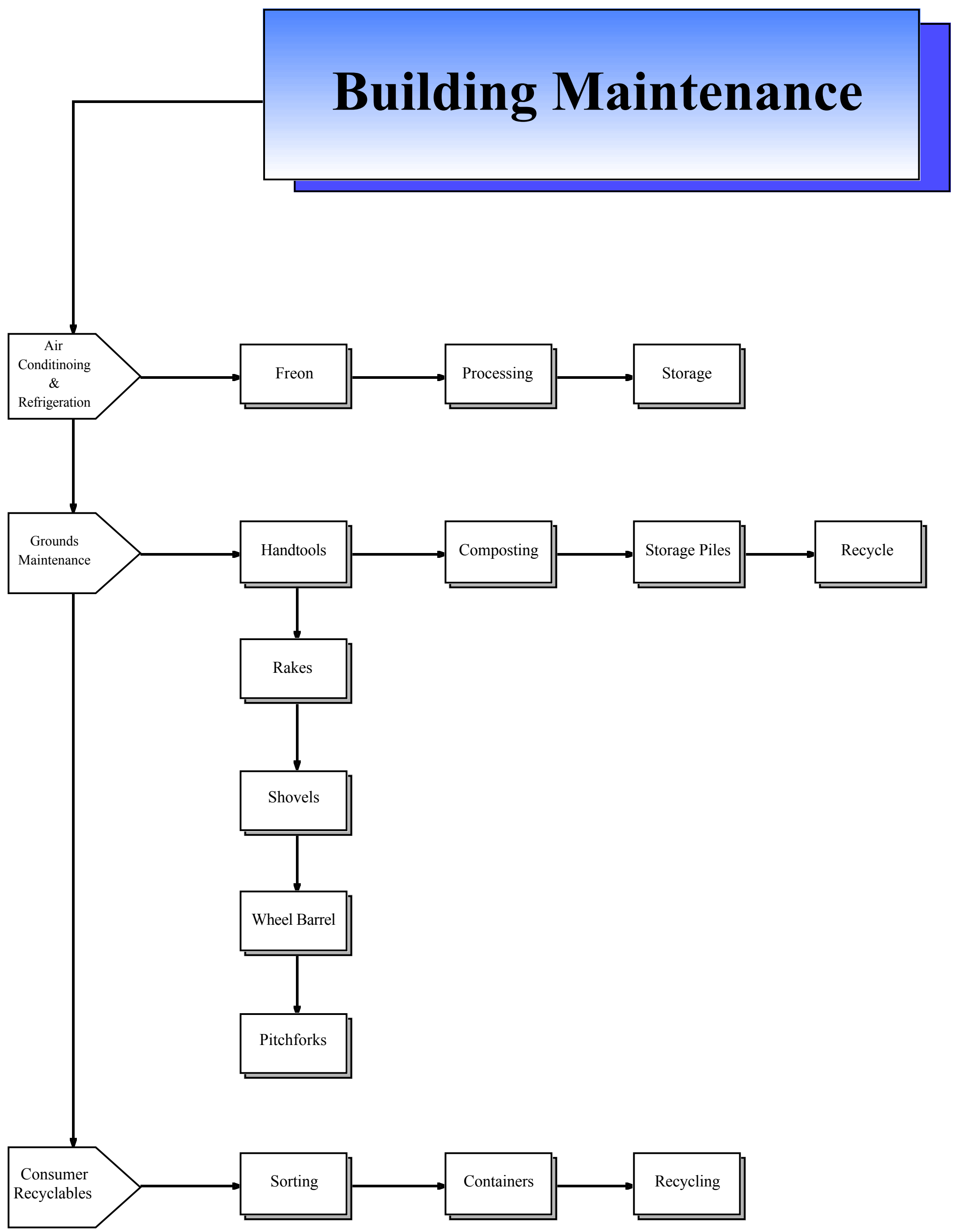
Segregation Procedures

1. Separate any waste/scrap metals into the appropriate scrap metal bin.

Recycling Procedures

1. The establishment of a compost pile for the grounds maintenance waste will result in this waste being recycled into mulch. Additionally sawdust from the carpenter shop can be utilized in the compost pile. However, sawdust should not be added if it was produced from chemically treated woods.

2. Establish collection points throughout the facility for the collection of plastics, glass, paper, soda cans, etc. Although there may be a cost associated with the recycling of some of these waste streams, this cost is usually less than the tipping fee charged by the landfill.


Building Maintenance
Air Conditinoing & Refrigeration
Freon
Processing
Storage
Grounds Maintenance
Handtools
Composting
Storage Piles
Recycle
Rakes
Shovels
Wheel Barrel
Pitchforks
Consumer Recyclables
Sorting
Containers
Recycling

Task 4	Rev: 0	Date: 5/11/98	Page 1 of 2
Subject: **EQUIPMENT MAINTENANCE AND REPAIR PROCEDURES**			

I. PURPOSE

This procedure provides guidance to the maintenance personnel in the reduction, reuse, segregation and recycling of hazardous and non-hazardous waste at the point of generation.

II. RESPONSIBILITY

The Facilities Supervisor should ensure that the guidance provided in this document is made available and followed by the maintenance personnel.

III. Requirements

Reduction Procedures

1. Solvent cleaning of components can result in flammable wastes, depending on the cleaning compound being utilized. Chemical companies have developed non-hazardous cleaners that are as effective as petroleum based cleanup solvents. These cleaners are less hazardous then the petroleum based solvents and may, depending on local regulations and permits, be sewerable.

2. Project the maintenance and repair fluid requirements. If only a quart of a particular fluid is required on an annual basis, ordering a five gallon can or even a gallon can will result in possible wastage of this fluid. Rotate stock to prevent inventory from becoming out of spec due to expiration of shelf life.

3. Diagnostic equipment is available that will identify specific problems with equipment vice conducting an open and inspect of the equipment, resulting in fluid drainage. Conducting specific repairs will reduce the amount of parts and fluids required during the scope of repairs.

Reuse Procedures

1. EPA has directed that Ozone Depleting Compounds such as freon not be vented to

the atmosphere. Additionally a ban on manufacturing of these compounds has made or will in the future make the availability of freons scarce. Industry has made available equipment that will evacuate the freons from air conditioning systems, filter it to remove any contaminants, and store the freon for future use.

2. Antifreeze can be collected during routine maintenance (such as system flushing) and reused. Equipment is available which will filter/process resulting in a clean antifreeze.

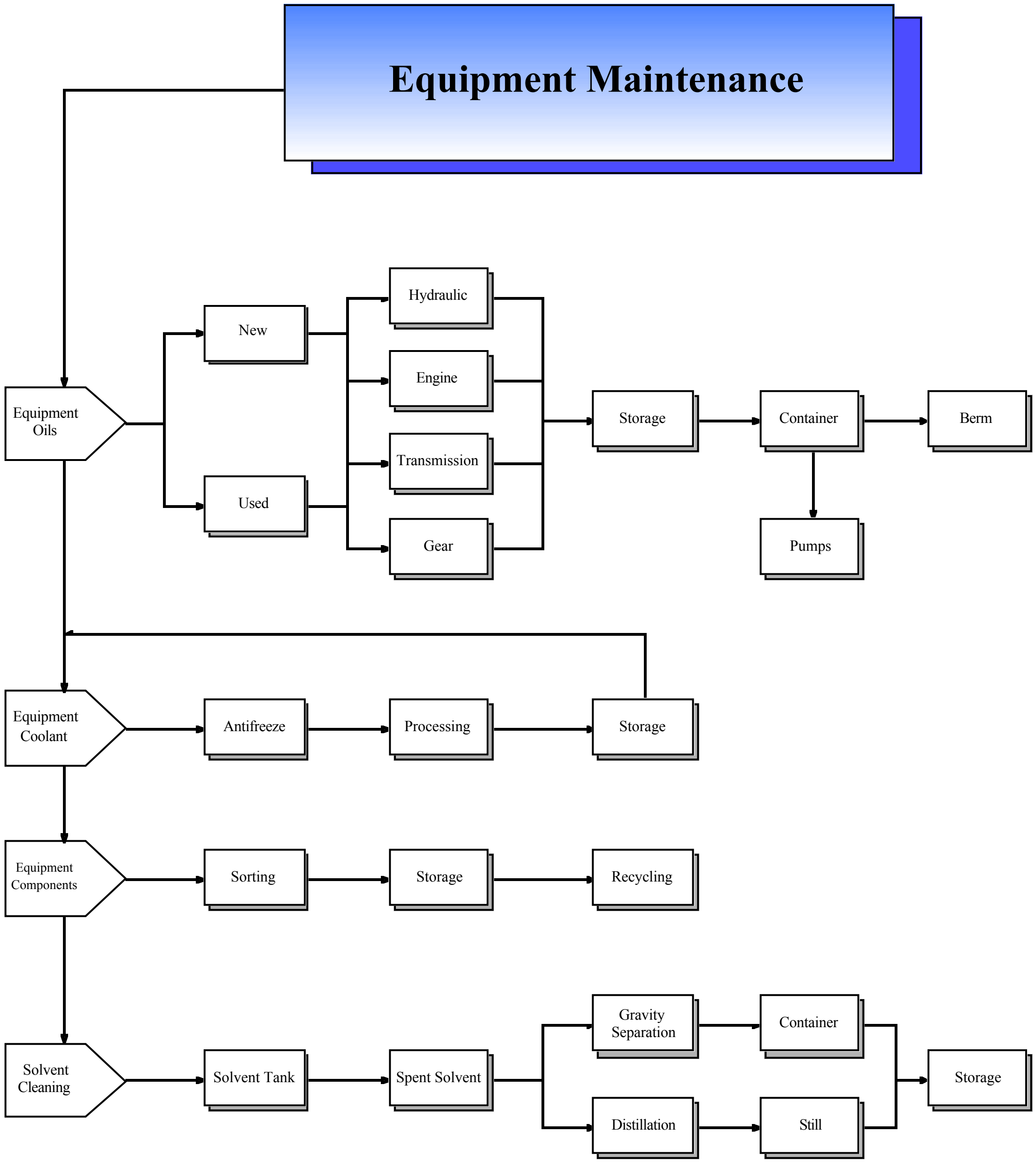
3. Petroleum based cleaning solvents utilized for cleaning of equipment and parts can be processed for reuse using solvent recovery stills or utilizing gravity settling procedures.

Segregation Procedures

1. Separate unusable metal parts and components into the appropriate scrap bin.

2. Never mix cleaning solvents with oils, particularly chlorinated solvents, as this will reduce the recycling value of both waste streams.

3. Ensure solvent wiping rags are kept separate from non-hazardous trash.


Equipment Maintenance
Equipment Oils
New
Used
Hydraulic
Engine
Transmission
Gear
Storage
Container
Berm
Pumps
Equipment Coolant
Antifreeze
Processing
Storage
Equipment Components
Sorting
Storage
Recycling
Solvent Cleaning
Solvent Tank
Spent Solvent
Gravity Separation
Container
Distillation
Still
Storage

Task 4	Rev: 0	Date: 5/11/98	Page 1 of 1
Subject: **WOOD FINISHING AND FABRICATION PROCEDURES**			

I. PURPOSE

This procedure provides guidance to wood finishing and fabrication personnel in the reduction, reuse, segregation and recycling of hazardous and non-hazardous waste at the point of generation.

II. RESPONSIBILITY

The Carpentry Shop Supervisor should ensure that the guidance provided in this document is made available and followed by the worker level personnel.

III. Requirements

Reduction Procedures

1. Wood finishes are currently being developed utilizing a water base as opposed to petroleum based solvent. These finishes are less hazardous and are easier to cleanup.

2. Proper layout of wood to be cut can significantly reduce the wastage on each sheet that is cut. The old adage of “measure once for the company, measure twice to keep your job” will result in reduced wastage as a result of not having to re-cut the pieces.

3. Partial sheets and boards should be stored on racks where they can be easily seen and measured. This will ensure future projects will utilize these sheets and boards.

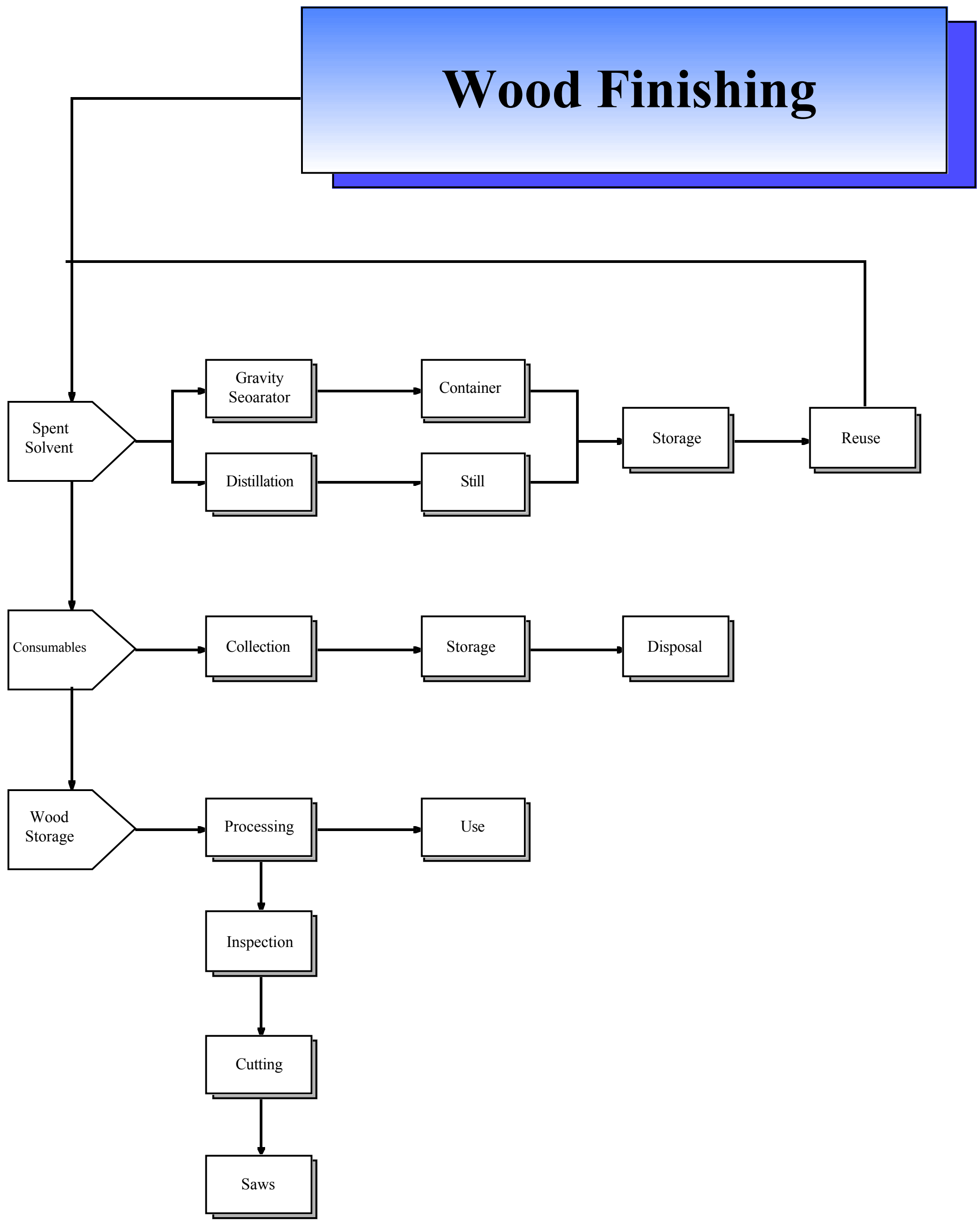
Segregation Procedures

1. Segregate treated and untreated wood waste. Untreated wood can be utilized in compost piles as well as in fireplaces. Treated wood may have special disposal requirements.

Recycling Procedures

1. The establishment of a compost pile for the grounds maintenance waste will result in this waste being recycled into mulch. Sawdust can be utilized in the compost pile. However the sawdust should not be added if it came from treated woods.

2. Untreated scrap wood can either be sold or given to employees for projects or use in fireplaces.


Wood Finishing
Spent Solvent
Gravity Seoarator
Container
Distillation
Still
Storage
Reuse
Consumables
Collection
Storage
Disposal
Wood Storage
Processing
Use
Inspection
Cutting
Saws

Task 4	Rev: 0	Date: 5/11/98	Page 1 of 2
Subject: **FIBERGLASS FABRICATON OPERATIONS**			

I. PURPOSE

This procedure provides guidance to the fiberglass fabrication department personnel in the reduction, reuse, segregation and recycling of hazardous and non-hazardous waste at the point of generation.

II. RESPONSIBILITY

The Fiberglass Fabrication Department Supervisor should ensure that the guidance provided in this document is made available and followed by the worker level personnel.

III. Requirements

Reduction Procedures

1. Only mix the amount of fiberglass resin/catalyst required to support requirements for the particular job.

2. Acetone, which is extremely flammable, is usually utilized as a cleanup solvent during fiberglass fabrication. Industry testing has found that diacetone alcohol can be substituted for acetone, reducing the risk of fire. Additionally, diacetone alcohol is significantly cheaper than acetone.

3. Plural component mixing equipment is available if the usage volume can justify the procurement of the tanks. The result is a significant reduction in material cost per gallon plus reduction in the processing of containers that are no longer required.

4. Plastic sheeting utilized to isolate the area of fiberglassing operations can be compacted in order to reduce the volume of waste disposed. Additionally depending on the quality of the plastic and the current costing available, the plastic maybe recycled to venders that accept plastic waste.

Reuse Procedures

1. Petroleum based cleaning solvents utilized for cleaning of equipment and parts can be processed for reuse using solvent recovery stills or utilizing gravity settling procedures.

2. Solvent cleaning of components can result in flammable wastes, depending on the cleaning compound being utilized. Chemical companies have developed non-hazardous cleaners that are as effective as petroleum based cleanup solvents. These cleaners are less hazardous then the petroleum based solvents and may, depending on local regulations and permits, be sewerable.

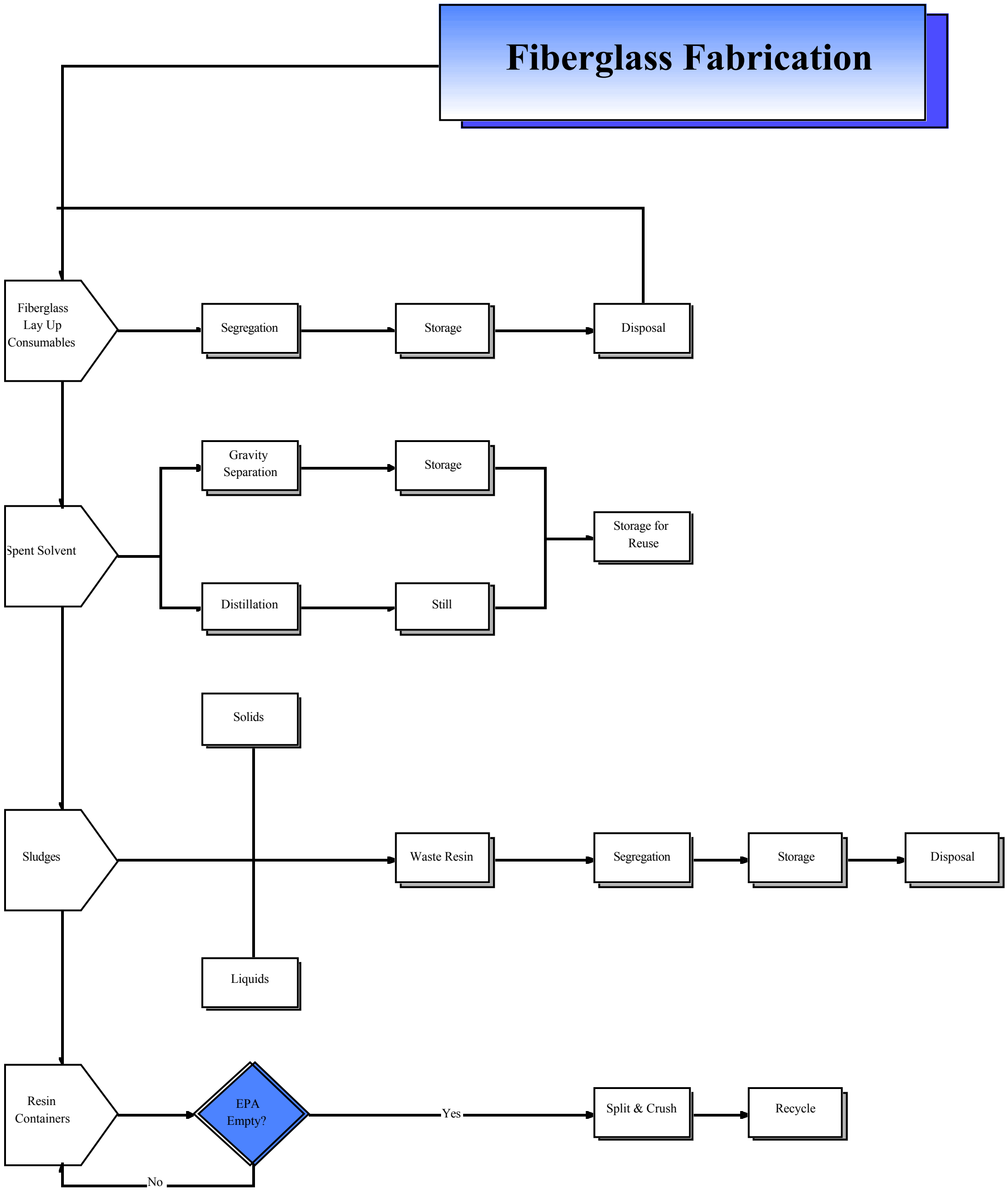
Segregation Procedures

1. Fiberglassing consumables such as brushes, rollers, rags, plastic, cardboard buckets, etc. should be segregated from resin waste. This will reduce the disposal cost of the resin wastes by reducing their volume. In most localities these types of consumables can be disposed in the local landfills. (Local rules and regulations concerning landfill disposal must be consulted.) Additionally the disposal cost of resin and resin contaminated consumables can be significantly reduced if the two waste streams are not mixed.

Recycling Procedures

1. Split resin/catalyst cans and then remove dried and semi-solid resin. Wipe clean the can interior and send the cans to the scrap metal recycler. The dried and semi-solid resins will be placed in the appropriate resin waste barrels, prior to disposal.

2. Most resin waste have a high BTU content and can be recycled for their heat value. Contract a fuel blending facility to have the resin waste tested for acceptability.


Fiberglass Fabrication
Fiberglass Lay Up Consumables
Segregation
Storage
Disposal
Spent Solvent
Gravity Separation
Storage
Storage for Reuse
Distillation
Still
Solids
Sludges
Waste Resin
Segregation
Storage
Disposal
Liquids
Resin Containers
EPA Empty?
Yes
Split & Crush
Recycle
No

Task 4	Rev: 0	Date: 5/11/98	Page 1 of 4
Subject: **METALS PREPARATION AND TREATMENT OPERATIONS**			

I. PURPOSE

This procedure provides guidance to the personnel involved in metals preparation and treatment operations in the reduction, reuse, segregation and recycling of hazardous and non-hazardous waste at the point of generation.

II. RESPONSIBILITY

The Metals Preparation and Treatment Department Supervisor should ensure that the guidance provided in this document is made available and followed by the worker level personnel.

III. Requirements

Treatment and Chemical Recovery Procedures

Optimizing the process followed by the segregation of waste streams and chemical recovery will reduce treatment and disposal costs. Conventional treatment through precipitation generates large amounts of sludge as a hazardous waste. Instead, one of the following procedures can be utilized to reduce waste generation:

1. Evaporation: Rinse water is concentrated by evaporation. This solution can then be returned to the process bath. When evaporated by boiling, steam from the process can be condensed and reused for rinsing.

2. Ion Exchange: Metals are removed from low concentration wastewater by an ion exchange (resin) column. The resin columns can then be regenerated. The metals in the regenerated and the recovered water can then be reused. This is often uses as a final “polish” in water treatment.

3. Electrowinning: (dummy plating) Metals can be plated out of concentrated solutions (e.g. static rinses) by using low plating currents and high surface area substrates. These metals can then be sent to recyclers, or plating solution suppliers.

Increase Rinse Efficiency Procedures

Increasing rinse efficiency will reduce water and sewer bills as well as treatment costs.

1. Rinse tanks should be sized as small as possible depending on the largest part or rack to be immersed. This improves rinse efficiency and reduces water usage.

2. Agitating the rinse can improve the rinse efficiency. This can be done by:
   A. Agitating the rinse bath with either forced air (sparging) or a re-circulating pump.
   B. Agitating the rinse bath with a mechanical mixer.
   C. Agitating the rinse bath with a mechanical mixer.
   D. Agitating the parts by moving them around. This is best done by completely removing the parts and then re-immersing them several times.

1. A “static” or “spill” rinse tank can be used prior to any flowing rinses. This tank is initially filled with “pure” water and slowly builds up a concentration of chemicals from the process bath. This is then used as makeup for the process bath, or for any spray rinsing above the process bath.

2. Counter-current rinsing with multiple tanks can dramatically reduce water usage. The rinse tank furthest from the process bath receives the fresh water, and then the rinse water overflows backwards through the flowing rinses and into the flowing rinse closest to the process bath. From there it can go to any treatment system. Switching from a 1-stage to just a 2-stage counter-current rinse can reduce water usage by up to 90% with the same rinsing effectiveness.

3. Water flow restrictors can be installed to permanently control flow rates. The flow rate can be set as low as possible, based on acceptable concentration levels in the rinse water.

4. Rinses can be turned on and off automatically by using sensors to check concentration levels (e.g. conductivity meters), or to check that the operator is present (e.g. photosensors or pressure plate switches.)

Rinse Water Reuse and Recycling Procedures

Methods to reuse wastes from one process as raw material for another process can reduce costs. The following provides uses for "dirty" rinse water.

1. Used acid cleaning rinse water can be used for rinsing after and alkaline process bath.

2. Use the same rinse tank to rinse parts after both acid and alkaline baths.

3. A water recycling system can be installed to treat the waste water for reuse. In "open loop" recycling systems the final rinse still uses fresh water to ensure good rinsing. A small amount of waste is produced in the form of concentrated wastes, precipitates, or sludges.

4. Install a pollution control device such as a packed-bed scrubber, composite mesh pad system, or fiber-bed mist eliminator. These require strict work practice standards including a formal operation and maintenance plan.

Drag-Out Reduction Procedures

"Drag-out" is the plating solution that "clings" to parts as they are removed from a bath. This solution then either ends up dripping onto the floor or mixing into the next bath or rinse. Reducing drag-out has many benefits, including reduction in expensive bath solutions, reduction in contamination of subsequent baths, reduction in rinse water.

1. Position parts so that fluids will flow together and off the parts by the shortest (quickest) route. Tilt parts to avoid any pockets or flat (table-like) surfaces and don't position parts directly over one another.

2. Remove parts slowly. This allows the solution to flow back into the process tank. For manual operations having hoists overhead can reduce worker fatigue due to slowly taking out heavy racks or parts.

3. Extending drain time can reduce drag-out. For manual operations having hooks to hang the racks or parts on, over the baths, can reduce worker fatigue due to holding heavy racks or parts above baths.

4. Spend more time removing parts slowly, than on draining the parts, for better drag-out reduction.

5. Drain boards can be placed over the lips of two adjacent tanks to catch any drips of drag-out when transferring parts. Slope the boards back to the first tank. This reduces drag-out, and keeps floors clean.

6. Spraying the parts with a fine mist of "pure" or used rinse water above the process bath can "wash" some of the drag-out back into the process bath. These nozzles need to be cleaned periodically. Air knives can also be used, but watch out for spotting due to localized drying effects.

7. Increase the temperature of the plating solution or add surfactants to reduce viscosity and surface tension. NOTE: Do not increase the temperature of cyanide or hexavalent chrome baths.

Rinse Efficiency Improvement Procedues

1. Test bath chemistry regularly. This will help you determine when more chemicals should be added or when impurities should be removed.
2. Lower process bath concentration levels. Sometimes supplier specifications are set high. By experimenting and lowering levels to just above the point where defects start to occur, you can significantly reduce chemical costs.
3. Use high quality raw materials to reduce contamination.
4. Ensure that parts are properly cleaned before entering process baths and properly rinsed of contaminating solutions from previous baths.
5. Quickly remove dropped parts and tools from process baths to reduce contamination. Have rakes handy to remove dropped items.
6. Remove impurities from baths by:
   A. filtration (continuos or batch)
   B. Activated carbon absorption (continuos or batch)
   C. Chemical precipitation (batch)
   D. Low current (dummy) plating (batch)
7. Use "purified" (deionized, distilled, or softened) water instead of tap water for makeup. Contaminants in tap water can foul up chemistry and create extra sludge.
8. Cover the baths with lids when not in use to prevent unwanted materials from entering the baths.

I. PURPOSE

This procedure provides guidance to the personnel involved in metal fabrication burn table operations in the reduction, reuse, segregation and recycling of hazardous and non-hazardous waste at the point of generation.

II. RESPONSIBILITY

The Metal Fabrication Department Supervisor should ensure that the guidance provided in this document is made available and followed by the burn table personnel.

III. Requirements

Reduction Procedures

1. Proper layout of parts to be cut can significantly reduce the wastage on each sheet. The old adage of “measure once for the company, measure twice to keep your job” will result in reduced wastage as a result of not having to re-cut the part(s). Computer controlled equipment is currently available that will automatically layout and cut the metals.

Segregation Procedures

1. Segregate the various types of scrap metals that are cut. The scrap value of mixed metals is considerably less than unmixed. This is especially true if exotic metals (monel, CuNi, etc.) are mixed in with the carbon steels or aluminum. Mark bins or skip boxes (depending on the quantity collected) with the type of metals to be placed in the bins. Do not allow the disposal of trash in these bins.

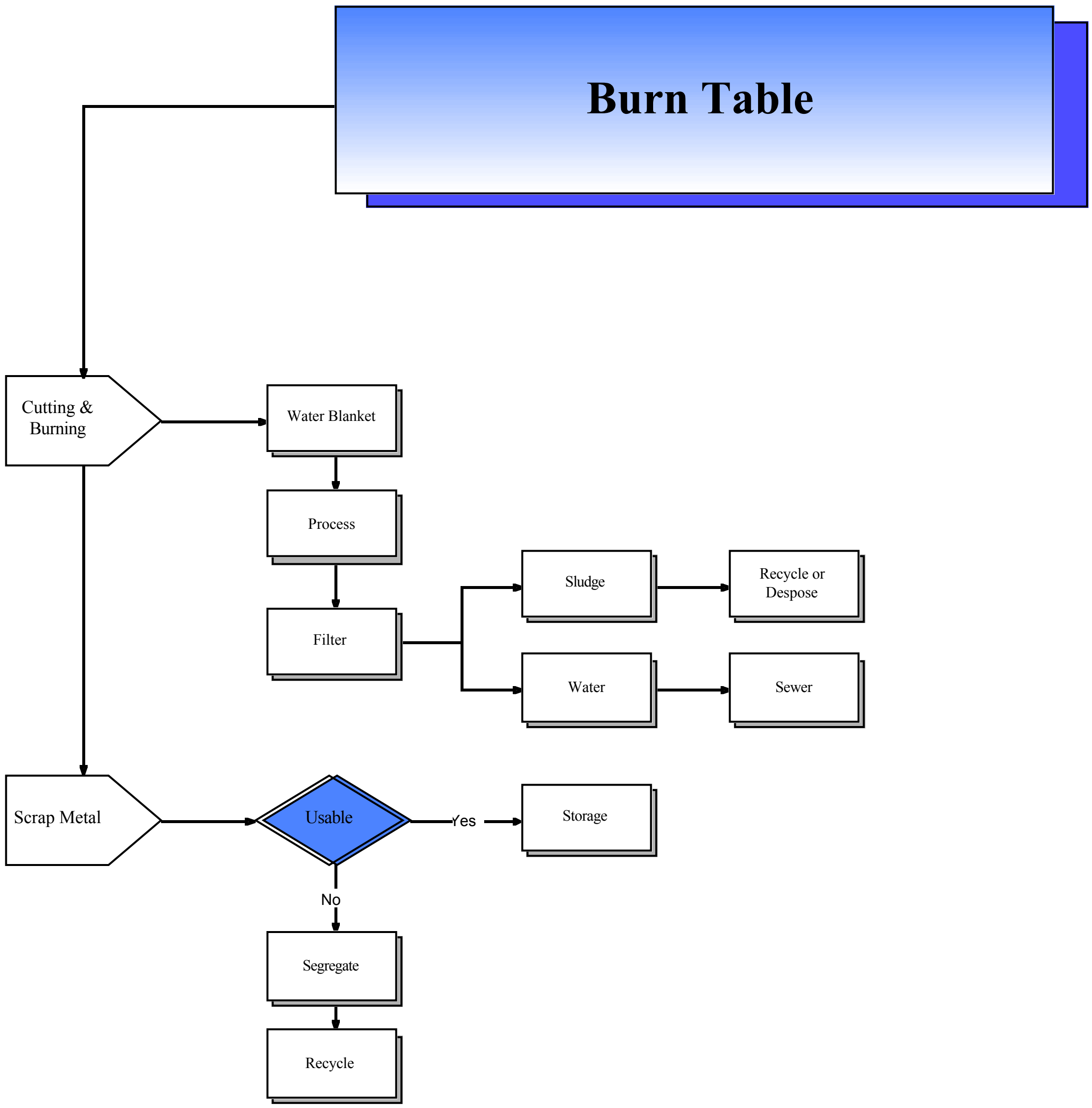
Recycling Procedures

1. Contract with local (or regional if more cost effective) for the recycling of scrap metals. See procedure for obtaining best value for scrap metal recycling. The burn splatter that results from burning operations usually has low or no value to a

metals recycler.

Reuse Procedures

1. Periodically filter water used in the water screen in order to remove contaminants. The filtered water can be reused or disposed to the local POTW.


Burn Table
Cutting & Burning
Water Blanket
Process
Filter
Sludge
Recycle or Despose
Water
Sewer
Scrap Metal
Usable
Yes
Storage
No
Segregate
Recycle

Task 4	Rev: 0	Date: 5/11/98	Page 1 of 1
Subject: **INSULATION AND LAGGING**			

I. PURPOSE

This procedure provides guidance to the insulation and lagging department personnel in the reduction, reuse, segregation and recycling of hazardous and non-hazardous waste at the point of generation.

II. RESPONSIBILITY

The Insulation and Lagging Department Supervisor should ensure that the guidance provided in this document is made available and followed by the worker level personnel.

III. Requirements

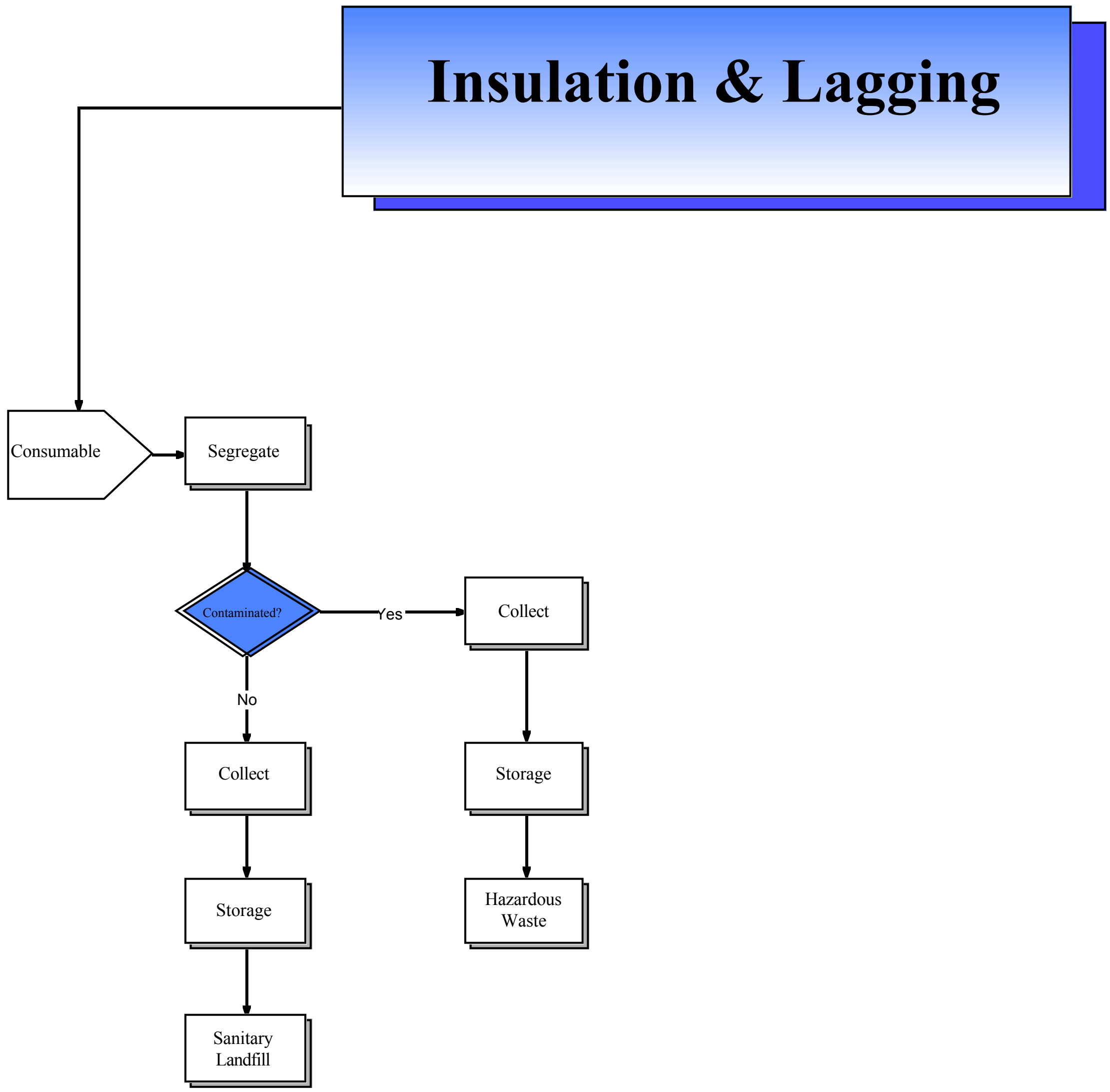
<u>Reduction Procedures</u>

1. Determine the method for used for pricing of waste disposal of asbestos or fiberglass. If the local landfill or hazardous waste disposal company charges by volume, compacting the waste will significantly reduce the volume and allow additional material disposal for a lower cost.

2. Plastic sheeting utilized to isolate the area of insulation and lagging operations can be compacted to reduce the volume of waste disposed. Additionally depending on the quality of the plastic and the current costing available, the plastic maybe sold to venders that accept plastic waste.

<u>Reuse Procedures</u>

1. The use of heavy duty tarps to isolate lagging and insulation operations vise plastic will permit the reuse of the tarp as opposed to disposal of the plastic.


Insulation & Lagging
Consumable
Segregate
Contaminated?
Yes
Collect
Storage
Hazardous Waste
No
Collect
Storage
Sanitary Landfill

I. PURPOSE

This procedure provides guidance to the personnel involved in metal fabrication operations in the reduction, reuse, segregation and recycling of hazardous and non-hazardous waste at the point of generation.

II. RESPONSIBILITY

The Metal Fabrication Department Supervisor should ensure that the guidance provided in this document is made available and followed by the worker level personnel.

III. Requirements

Reduction Procedures

1. Proper layout of parts to be cut can significantly reduce the wastage on each sheet that is cut. The old adage of "measure once for the company, measure twice to keep your job" will result in reduced wastage as a result of not having to re-cut the part(s).

2. Partial sheets should be stored on racks where they can be easily seen and measured. This will ensure future projects will utilize these sheets.

3. Procure only amount required for the job (especially for thickness' not normally utilized).

4. Use stored sheets to make special tools such as wedges, eyelet's and clamps that are utilized in the fabrication process.

Segregation Procedures

1. Segregate the various types of metals. The scrap value of mixed metals is considerably less than unmixed. This is especially true if exotic metals (monel, CuNi, etc.) are mixed in with the carbon steels or aluminum. Mark bins or skip

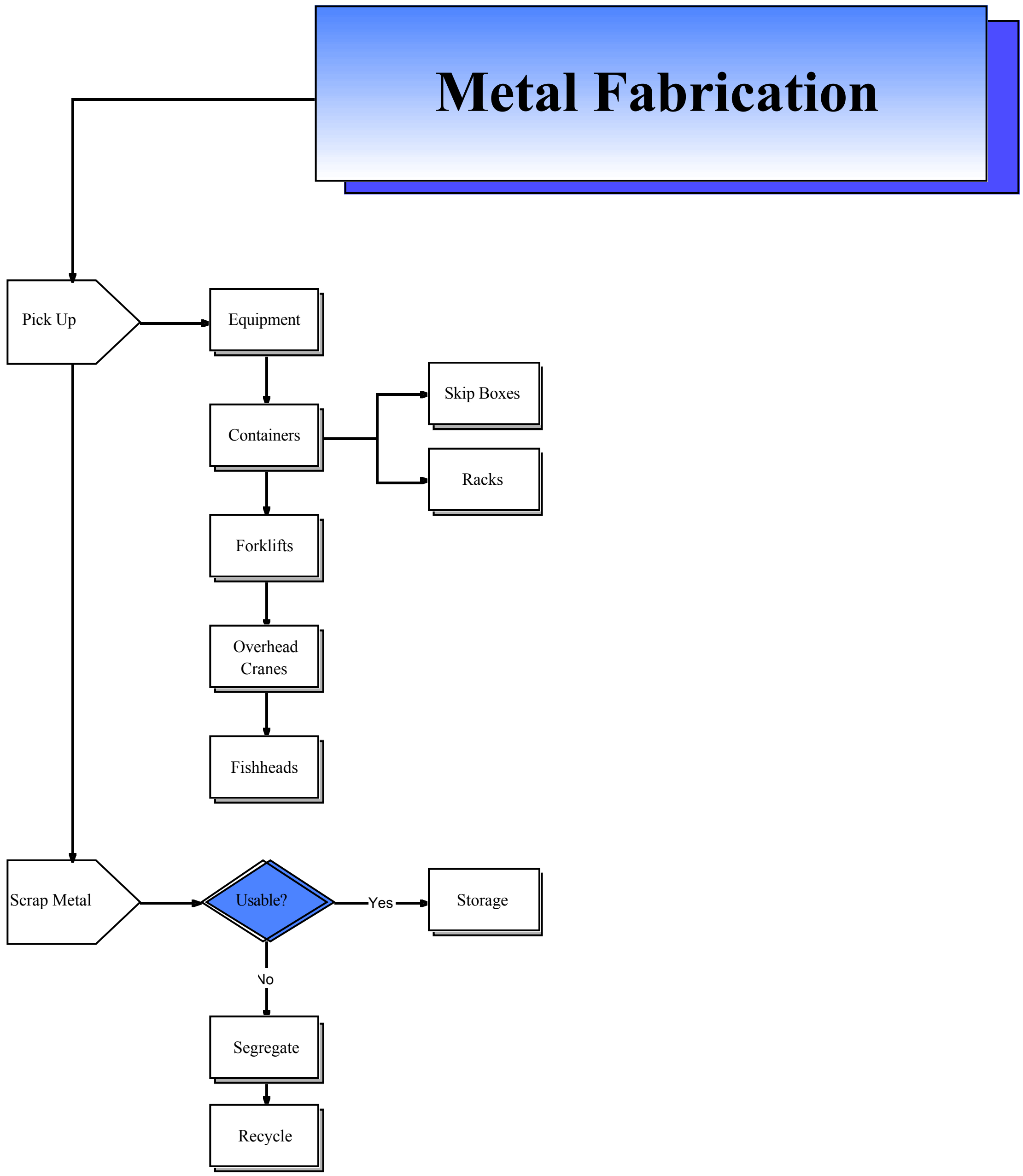
boxes (depending on the quantity collected) with the type of metals to be placed in the bins. Do not allow the disposal of trash in these bins.

Recycling Procedures

1. Contract with local (or regional if cost effective) for the recycling of scrap metals. See procedure for obtaining best value for scrap metal recycling.

Reuse Procedures

1. Previously used uncoated metals can be cut and used for tools during the structural fabrication process.


Metal Fabrication
Pick Up
Equipment
Containers
Skip Boxes
Racks
Forklifts
Overhead Cranes
Fishheads
Scrap Metal
Usable?
Yes
Storage
No
Segregate
Recycle

Task 4	Rev: 0	Date: 5/11/98	Page 1 of 2
Subject: **Shipping & Receiving Operations**			

I. PURPOSE

This procedure provides guidance to the personnel involved in Shipping & Receiving operations in the reduction, segregation, reuse and recycling of hazardous and non-hazardous waste at the point of generation.

II. RESPONSIBILITY

The Shipping & Receiving Section Head should ensure that the guidance provided in this document is made available and followed by the worker level personnel.

III. Requirements

A good Shipping and Receiving person can also make the difference between profit and loss. Because all material entering and leaving the facility goes through Shipping and Receiving, this Department is responsible for the following:

Reduction Procedures

1. Consolidated ordering of parts and supplies (including bulk liquids) will result in reduction of packaging materials required. Multiple orders of the same product can be placed and then distributed by Shipping & Receiving personnel.

2. Discounts could also be available if the consolidated order is significant.

3. Reduction in volume of cardboard can be accomplished by the use of compactors and balers. A side benefit of the compacting is that price received for compacted cardboard is higher than non compacted cardboard.

Segregation Procedures

1. Many containers that have a turn-in value need to be tracked and returned to vender when no longer in use. Document each invoice with the requirement to return the empty container to Shipping & Receiving for turn into the vender.

Examples of refundable containers would be:
A. 55 gallon drums
B. Cable spools
C. Pallets
D. Specialized crates

2. Segregate paper and cardboard by type. Compacting and banding of paper and cardboard can add significantly to this product value.

Recycling Procedures

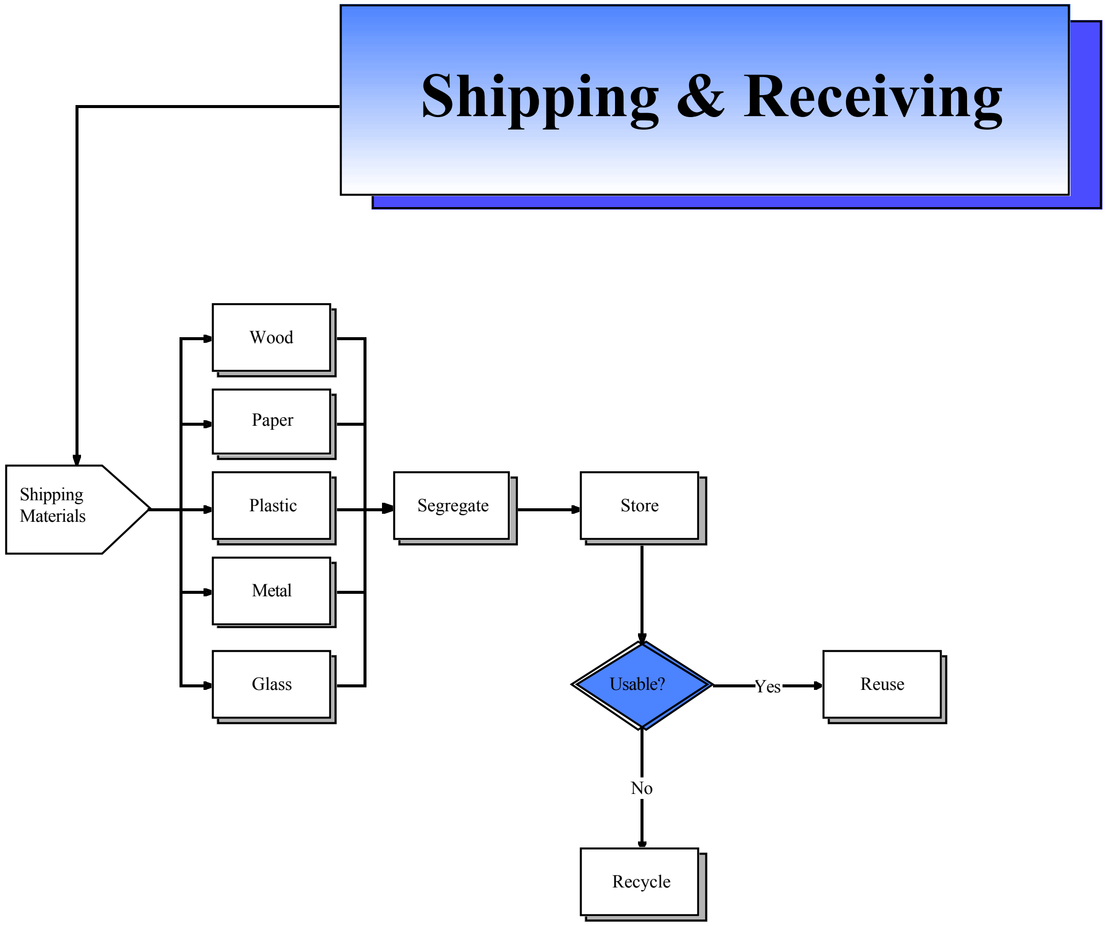
1. Recycle containers for storage (after proper marking) i.e. non returnable open top drums can be used for trash cans. Care must be taken that containers that have held hazardous materials are not utilized unless properly cleaned.

Reuse Procedures

1. Save packaging materials that are received and reuse for outgoing shipments. For instance the popcorn (Styrofoam) utilized for cushioning of supplies and components can be used in outgoing packages.

2. Return retrograde from equipment repairs in the container that the repair parts were received in.

Shipping & Receiving



Equipment, Materials and Costs to Implement Reduction, Reuse or Recycling Program

Task 4 Tab 1 Standard Operating Procedure Appendix II provides format for evaluating the cost effectiveness of implementation of reduction, reuse or recycling efforts for individual waste streams. One of the goals for this project was to conduct the actual analysis for the waste streams; however because of the lack of data returned with the surveys, this effort could not be accomplished.

The major cost with implementation of reduction, reuse or recycling is the management effort necessary to establish this undertaking. Management needs to establish the mind set with the workers that waste management is cost effective and will result in reduced costs. Additionally, someone in management needs to have the authority for the managing of this program throughout the facility.

Companies involved with the pick-up of solid waste from shipyards for recycling will usually provide the necessary containers required to implement the program. These containers include individual skip boxes for the various metals, paper waste containers, bailers and compactors (if enough waste generated), oily waste tanks, etc.. However a cost analysis needs to be done to see what the return would be on procuring these containers.

The following provides a listing of specialized equipment for each waste stream:

SHIPYARD WASTE STREAMS

Steel Shot, Coal Slag, Copper Slag, Garnet, Silica Sand. All these waste streams once utilized in abrasive blasting may or may not be considered hazardous waste, depending on federal and state regulations and material being cleaned.

Reduction: Training of personnel in proper blasting procedures and maintenance of the equipment is required for abrasive blast medium reduction. However, this training would not be above what would normally be done with a new blaster.

Reuse: On-site reuse of spent abrasive is not accomplished without some process *(reclamation)* to remove any wastes that entrained with the spent abrasive during the retrieval process.

Reclamation: Depending on the volume of abrasive blasting being accomplished, it can be cost effective to “reclaim” these blasting mediums. Companies that have found that reclamation is a viable option, process the spent abrasive by essentially straining off the contaminants, through several decreasing in size filters until only the blast medium remains. The equipment utilized to process the spent abrasive would not be much different from what is utilized to pick-up the spent abrasive from dry dock.

Additionally, conveyors and screens would be required to process the medium. See NSRP N1-93-1 Spent Abrasive Management Options.

Figure 1: Spent Coat slag storage area

Figure 2: Spent Coal slag screening facility

Figure 3: Removal of debris after screening

See Figures 1, 2, and 3.

Recycling: Recycling has become a viable option to disposal and is effective (when compared to the cost of disposal). No specialized equipment or costs for implementation are required for processing spent abrasive for recycling.

See Figures 4 - 9.

Cleaning Solutions, Oily Water, and Bilge Water. These waste streams are generated as the result of degreasing and cleaning and emptying ship's bilges, compensating tanks or fuel tanks.

Reduction: No additional equipment, material or costs to implement reduction efforts other than what would normally be accomplished in the cleaning process.

Reclamation: All shipyards reported utilizing a phase or gravity separation method (Baker Tanks) to reduce the volume of these waste streams requiring disposal. This process allows for the disposal of the contaminated water to the sewer system and reclaiming of the oil with the other waste oils**.** The water is usually sewerable, and the oil mixed with the oily waste streams. Periodically test the water in order to ensure that the separated water meets the dump limits of the local municipal sewer district. Two larger facilities had processing equipment (oily-water separators) that separated the oil from the water. No additional equipment, materials or costs to implement reclamation efforts would be required.

See Figures 10, 11 and 12.

Reuse: No reuse of these waste streams was reported.

Recycling: On-site recycling of waste oil as a boiler fuel was reported by one shipyard. Additionally, oil sludge residuals have been recycled for their BTU content in off-site fuel blending facilities. No additional equipment, materials or costs to implement recycling efforts would be required.

Burn Slag. This waste stream is generated as the result of cutting plate on a burn table. Slag from the operation falls to a pan, usually filled with water, underneath the burn table where it is cooled and collected.

Reduction: No methods to reduce this waste stream were identified.

Reuse: No methods to reuse this waste stream was identified.

Reclamation: No methods to reclaim this waste stream was identified.

Figure 4: Spent Abrasive Storage - Copper Slag

Figure 5: Spent abrasive screening and Railcar loading facility

Figure 6: Transport of Spent Abrasive to Cement Kiln

Figure 7: California Portland Cement Company

Figure 8: California Portland Cement Company

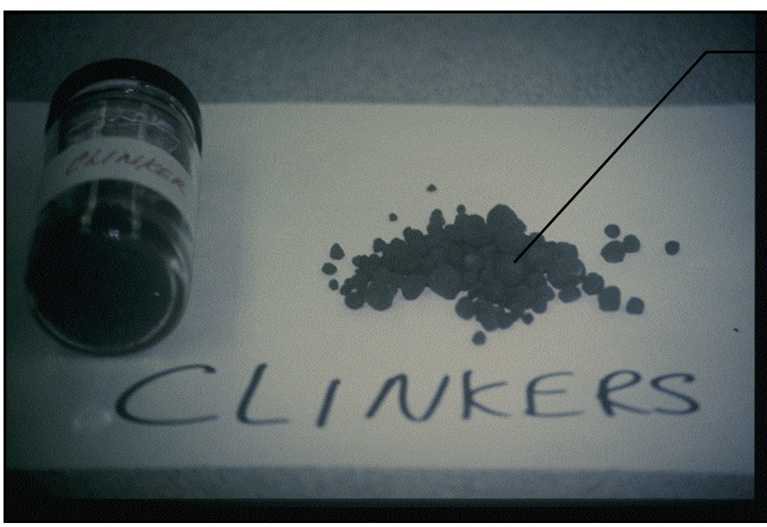


Figure 9: Cement Clinkers

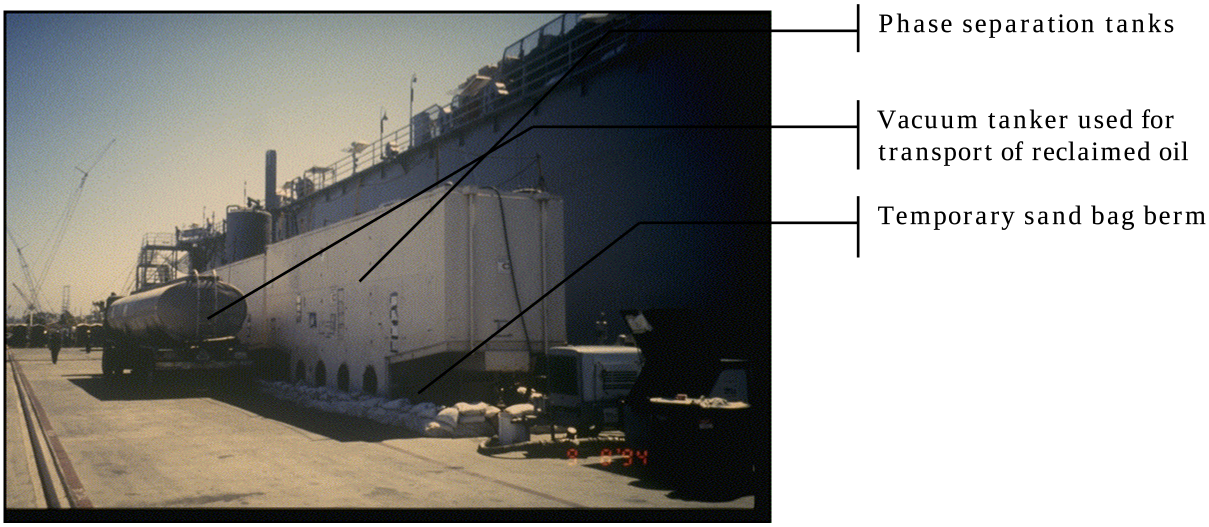


Figure 10: Oil/Separation tank - gravity Separation

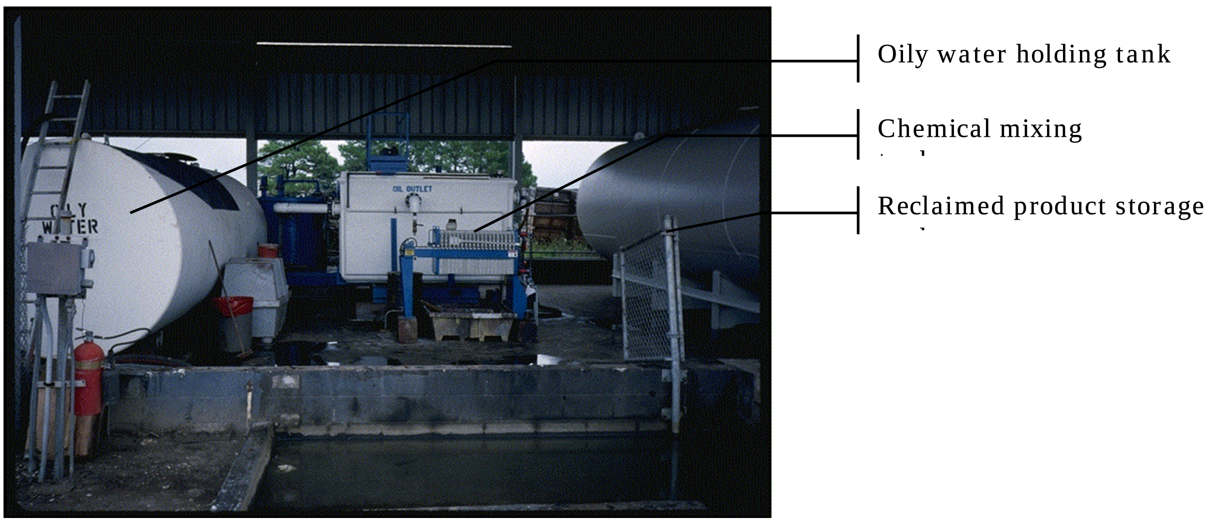


Figure 11: Oily water Separation unit - Air Dissolved Flotation

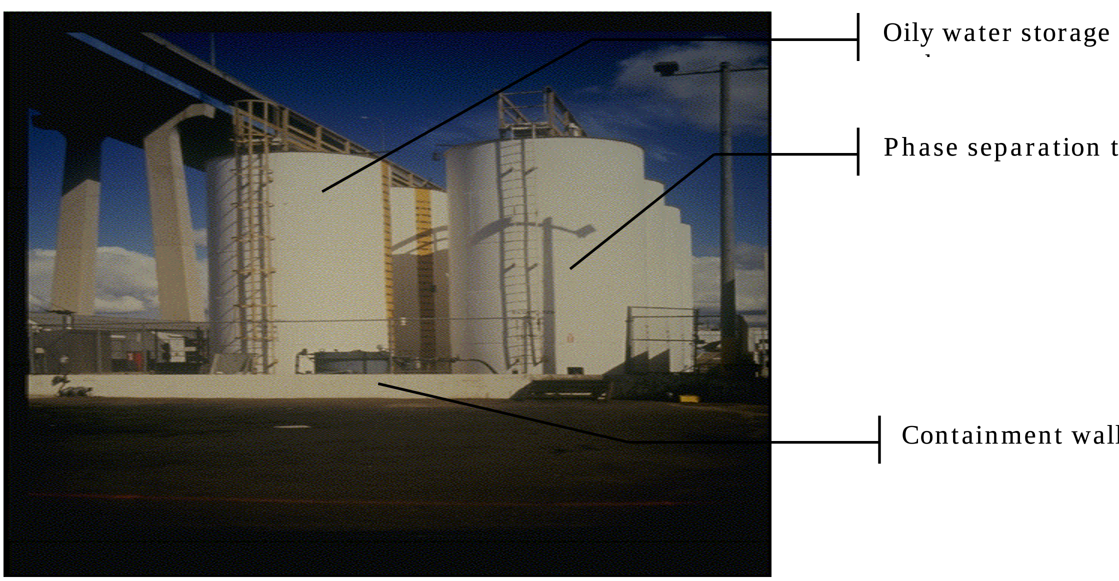


Figure 12: Oily/water storage tanks and treatment facility

Recycling: Several companies reported including this waste stream in the recycled metals.

Fiberglass Insulation. This waste stream is developed as the result of either repairs to structural components or piping systems. The fiberglass insulation is removed in order to work on the structural components or piping systems. Additionally some waste is generated during the re-installation process.

Reduction: If volume reduction is a feasible option, compactors and balers will be required. These same equipments can be utilized in volume reduction of paper, cardboard and plastic sheeting

Reuse: No methods to reuse this waste stream was identified.

Reclamation: No methods of on-site reclamation of this waste stream were identified.

Recycling: No methods to recycle this waste stream was identified.

Waste Oil, Lubricants and Transmission Fluids. This waste stream is generated as result of repairs to shipyard rolling stock (trucks, forklifts, cranes, etc.). Additionally oil is recovered from equipment that utilize oils for lubrication during the repair process. Most companies that were surveyed mixed the various types of oil together.

Reduction: Most of this waste stream is generated during routine maintenance of automobiles, mobile cranes and other shipyard rolling stock. Typically this maintenance is performed on calendar schedule or hours of usage basis. By instituting a performance standard (chemical testing) to determine when an oil, lubricant or fluid must be changed, a significant reduction in the volume of these waste streams can be achieved, in addition to improved maintenance of the rolling stock. No additional equipment, materials or costs to implement reduction efforts would be required.

Reuse: None of the facilities visited or surveyed reused waste oil lubricants or fluids.

Reclamation: No methods of on-site reclamation of waste oil lubricants or fluids were identified.

Recycle: One shipyard uses the oil for fuel (BTU recovery) for a boiler in which steam is produced for use throughout the shipyard. The majority of the survey respondents indicated that the oil was either sold and/or disposed of for a minimal price to local companies that either process the oil for reuse or use if for its BTU recovery value. Storage tanks are required for the waste oil. These tanks are usually available from the company that picks-up the waste oil.

Tank Bottoms Oil, Oil Petroleum/Synthetic. This waste stream is generated as the results or repairs to shipboard fuel or oil tanks. This waste stream is uncontaminated oils and fuels that can not be removed by the use of shipboard piping systems.

Reduction: Ship design and safety requirements (hotwork) prevent utilization of any reduction efforts with this waste stream.

Reuse: These fuels and oils can be reused if the removal process does not contaminate the fuel or oil. However, storage requirements and costs usually result the cost being prohibitive. As a result the oils and fuels are usually immediately transferred or mixed with waste oils.

Reclamation: The oil recovered can be reclaimed and recycled in most instances, unless contaminated with chlorinated solvents. No shipyard reported on-site reclamation of waste oil. Storage tanks are required for the waste oil. Off-site reclamation and recycling facilities are contracted to transport the waste oil to a central processing facility where the waste oil undergoes treatment to produce a refined oil.

Recycling: One shipyard uses the oil for fuel (BTU recovery) for a boiler in which steam is produced for use throughout the shipyard. The majority of the survey respondents indicated that the oil was either sold and/or disposed of for a minimal price to local companies that either process the oil for reuse or use if for its BTU recovery value. Storage tanks are required to store the waste oil. These storage tanks are readily available from the companies reclaiming or recycling waste oil.

Paint Liquids, Paint Solids, Fiberglass Resin, Wood Varnish, Stains, Varnish Insulation (solvent based). This waste stream is generated as a result of coating operations. Most facilities treated the paints as non-hazardous (although the paints may be either flammable or combustible) which allowed disposal in municipal landfill.

Reduction: All respondents reported that procedures have been implemented which reduced the amount of paints and resins mixed to what was required for the process thus reducing the amount requiring disposal. Additionally one yard bought two component paints in large quantity and utilized mixing devices that accurately measured the two parts allowing the mixing of exact quantities. Large procurement (50 gallon bladders) significantly reduced the disposal costs associated with the disposal of paint cans, that is emptying of these cans in order to meet EPA empty requirements with resulting material and labor costs.

See Figures 13 and 14.

Reuse: No reuse of these waste streams was reported.

Reclamation: No methods of on-site reclamation of these coatings waste streams were identified.

Recycling: Solvent based paints can be sold, or disposed of at a reduced price, for their BTU recovery value. The more “pumpable” the waste stream the greater the value because of ease of processing. No additional materials, equipment or costs to implement recycling is required.

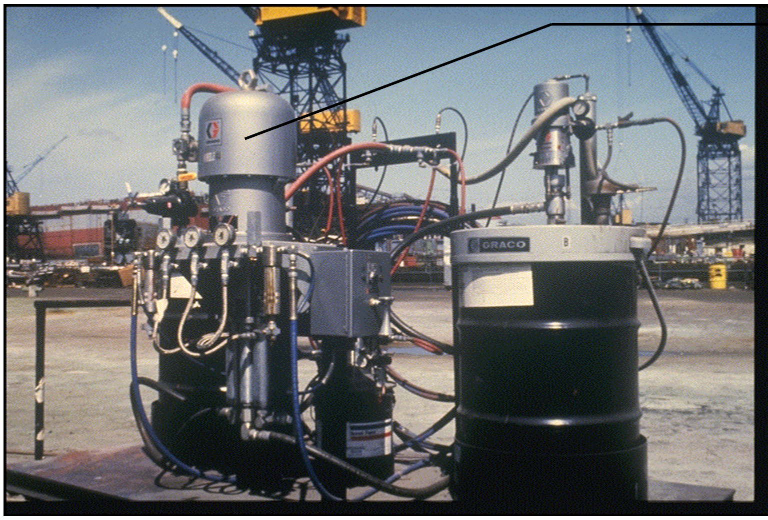


Figure 13: Portable plural component paint mixing system


Figure 14: Stationary plural component paint mixing system

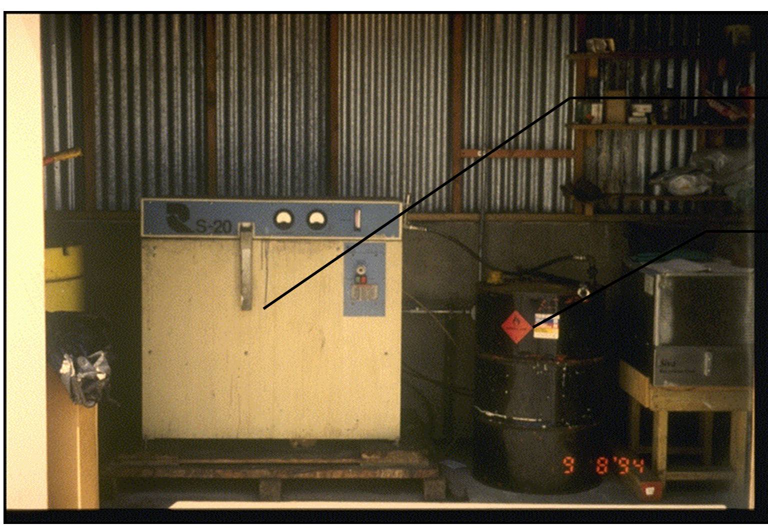


Figure 15: Batch solvent recovery still

Spent Solvent, Fiberglass Solvent, Varnish Solvent. Solvents are used extensively in coating applications for cleanup (and in some cases dilution of the coating system) of residual coatings, equipment utilized in the coating application or overspray.

Reduction: Significant savings in solvent can be realized by conservative utilization of the solvents. Do not allow the utilization of open containers as the solvent will evaporate. No specialized equipment, materials or costs for implementation of reduction efforts is required.

Reuse: Several shipyards reported reuse of spent or out-of-spec solvent for the purpose of spray gun cleaning or other cleaning operations where high purity solvents are not required.

Reclamation: The majority of the yards had solvent recovery stills. Most stills will recover in excess of fifty percent of contaminated solvent. This allows the reuse of the reclaimed solvent and results in significant savings on solvent.

See Figure 15.

Recycling: None of the surveyed facilities reported any type of on-site recycling effort in respect to waste solvents. However the BTU recovery value of the solvent allows for off site recycling at fuel blending facilities.

Asbestos and Asbestos Contaminated Disposables. This waste stream is generated as the result of either repairs to structural components or piping systems. The insulation containing asbestos is removed in order to work on the structural components or piping systems.

Reduction: As all waste asbestos generated in shipyards is derived from removal of interference activities on ships under repair, opportunities for reduction is not possible.

Reuse: Reuse of asbestos waste is not allowed by federal law.

Reclamation: No methods of on-site reclamation of these waste asbestos were identified.

Recycling: Recycling of waste asbestos is not allowed by federal law.

Antifreeze. Antifreeze is removed from water cooled rolling stock (and diesel powered emergency generators) during repairs or as the result of equipment manufacturers recommended periodic replacement.

Reduction: Most of this waste stream is generated during routine maintenance of automobiles, mobile cranes and other shipyard rolling stock. Typically this maintenance is performed on calendar schedule or hours of usage basis. By instituting a performance standard (hygrometer testing) to determine when an antifreeze must be changed, a significant reduction in the volume of this waste stream can be achieved, in addition to improved maintenance of the rolling stock.

Reuse: None of the facilities visited or surveyed reused waste antifreeze.

Reclamation: One facility because of the large number of engines with antifreeze reported filtering and reusing onsite. Commercial machines are readily available for the reclamation of antifreeze. Most other shipyards reported that this waste stream is sent to off-site for reclamation and reuse.

Recycling: No on-site or off-site recycling opportunities for antifreeze were identified.

Cutting Finds. Cutting finds are generated as the result of machining of metals.

Reduction: Procurement of the proper size billets and or precutting can significantly reduce the quantity of metal requiring machining. No specialized equipment, materials or costs for implementation of reduction efforts are required.

Reuse: Due to the nature of the waste stream, reuse is not an option.

Reclamation: Due to the nature of the waste stream, reuse is not an option.

Recycling: All facilities reported that the metal was segregated at point of generation. These metals were combined and sold to recycling venders.

Batteries:. Utilized extensively in rolling stock in order to provide the motive force during the starting process. Additionally batteries are utilized extensively in portable equipment as an electrical source.

Reduction: Proper maintenance of rolling stock significantly increases the life of a battery. Also the use of rechargeable batteries vice single use batteries will substantially reduce the number of disposable batteries required. Subsequent to utilization of rechargeable batteries in test equipment, the manufacturers technical manual needs to be reviewed as some of the materials in the disposable alkaline and nickel cadmium can affect the test results. No specialized equipment, materials or costs for implementation of reduction efforts are required.

Reuse: Other than reuse after re-charging, no opportunities for reuse were reported or identified.

Reclamation: No methods for on-site reclamation were identified.

Recycling: Shipyards universally reported a policy of battery exchange from their supply venders. No specialized equipment, materials or costs for implementation of recycling efforts are required.

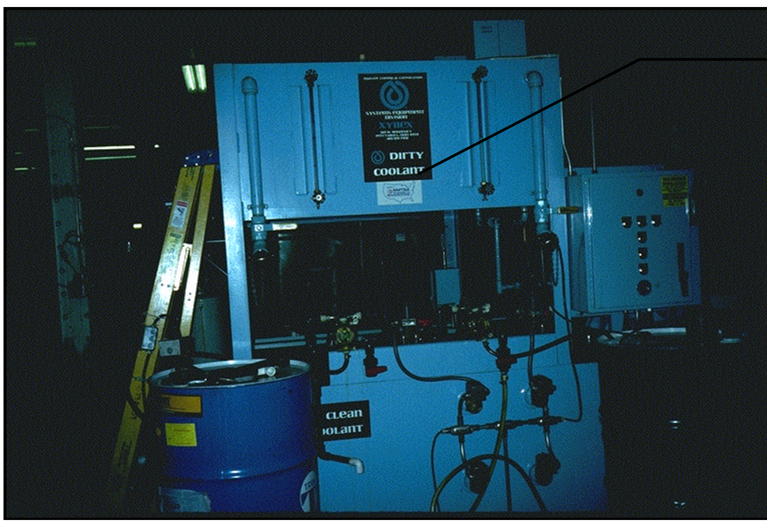
Cutting Fluids. These fluids are utilized in the machining of metals as a cooling medium.

Reduction: In order to reduce the hazardous nature of these fluids, most companies have switched from solvent based to water based fluid. No specialized equipment, materials or costs for implementation of reduction efforts are required.

Reuse: Most machining equipment is designed so that the cutting fluid is reclaimed as part of the machining process. . No specialized equipment, materials or costs for implementation of reuse efforts are required.

Reclamation: One facility utilized a centrifugal filtration process to purify the cutting fluid and keep the fluid clean and usable. Universally loop systems are utilized that "recycle" the cutting fluid. Strainers filter the fluid in order to remove any cutting finds and other contaminants from the fluid. No specialized equipment, materials or costs for implementation of reclamation efforts are required.

See Figure 16.



Recycling coolant reduces costs and machine ware

Figure 16: Machine coolant recycling system

Recycling: Because of the evaporation of the cutting fluid at the site of the cut, recycling is not accomplished. . No specialized equipment, materials or costs for implementation of recycling efforts are required.

Burn Table Coolants. Water is utilized to cool and entrain burn slag and burn gases. Periodically the water is removed in order to remove the burn slag.

Reduction: Procedures need to be established to utilize only the minimal amount of water required to cool and entrain the burn slag and gases. No specialized equipment, materials or costs for implementation of reduction efforts are required.

Reuse: Due to the nature of the waste stream, reuse is not an option.

Reclamation: Due to the nature of the waste stream, reuse is not an option.

Recycling: Due to the nature of the waste stream, reuse is not an option.

Ballasts. Lighting ballasts are generated during the repair process of fluorescent light systems.

Reduction: Due to the nature of the waste stream, reduction is not an option.

Reuse: Due to the nature of the waste stream, reuse is not an option.

Reclamation: Due to the nature of the waste stream, reclamation is not an option.

Recycling: Due to the nature of the waste stream, recycling is not an option.
Tank Preservation. One procedure for tank preservation is the utilization of a rust inhibitor (sodium nitrate) that provides a hard oxidation layer that prevents follow-on corrosion. The tank is filled with a water and sodium nitrate then drained. This drained sodium nitrate is the waste.

Reduction: The water should be tested to ascertain that it could meet the POTW sewer limits. If not, the water can be treated in order to precipitate the metals which with filtering will result in a liquid that is sewerable. If it meets the sewerable limits, it can be pumped to the sewer system. Local and state regulations need to be verified to ascertain if permit required for treatment. . No specialized equipment, materials or costs for implementation of reduction efforts are required.

Reuse: Due to the nature of the waste stream, reuse is not an option.

Reclamation: Due to the nature of the waste stream, reclamation is not an option.

Recycling: Due to the nature of the waste stream, recycling is not an option.

Fluorescent Lights. Fluorescent light tubes are generated when the tube no longer lights when turned on.

Reduction: Installation of natural lighting panels can reduce the time lights are on and hence the amount of tubes required. Additionally, long-life light fixtures and bulbs are currently available that will significantly reduce the number of bulbs required. These lights are energy efficient operating on a fraction of the energy required of a standard fluorescent fixture. A cost analysis utilizing procedures outlined in Task 4 Tab 1 Appendix II will determine the recovery time for new lighting systems. . No additional specialized equipment, materials or costs for implementation of reduction efforts are required.

Reuse: Due to the nature of the waste stream, reuse is not an option.

Reclamation: Due to the nature of the waste stream, reuse is not an option.

Recycling: There are currently available, companies that will recycle (remove the mercury for its value), however the cost of recycling exceeds the cost of disposal into the landfill. . No specialized equipment, materials or costs for implementation of reduction efforts are required.

Contaminated Rags. Universally utilized for cleaning operations.

Reduction: Procurement of absorbent rags (high percentage of cotton compared to nylon) vice non-absorbent will reduce the number of rags utilized. Additionally, depending on the application, paper wiping rags may be more effective. . No specialized equipment, materials or costs for implementation of reduction efforts are required.

Reuse: Due to the nature of the waste stream, reuse is not an option.

Reclamation: One company took the initial expense of buying orange colored rags that stand out. When the recycling crew sorts trash, these rags are easily spotted and recovered. Contaminated rags were collected and sent to a commercial laundry for cleaning and return to the shipyard for reuse. This effort is labor intensive and may not result in a cost savings. Cost analysis utilizing procedures outlined in Task 4 Tab 1 Appendix II should be conducted to determine if the use of special designated rags for cleaning is cost effective. No specialized equipment, materials or costs for implementation of reduction efforts are required.

Recycling: Due to the nature of the waste stream, recycling is not an option.

Refrigerants. Refrigerants are derived from equipment involved in cooling either a room or food. Additionally refrigerants are utilized in dry air systems. The refrigerants are required to be collected from the equipment systems when the system is to be opened for either maintenance or repair. Venting to the atmosphere is not authorized.

Reduction: Refrigeration equipment manufacturers are currently attempting to develop replacement refrigerants that are not ozone depleting. However due to the nature of the waste stream, reduction is currently not a viable option.

Reuse: Due to the nature of the waste stream, reuse is currently not a viable option.

Reclamation: Now that regulations prevent the manufacture of certain ozone depleting compounds such as refrigerants, the reclamation industry has built up to the point where refrigerants are reclaimed whenever work with refrigerants is required. These companies evacuate the refrigerant, filter and clean the refrigerant then reinstall the original refrigerant into the equipment being serviced. These equipments are commercially available.

Recycling: Due to the nature of the waste stream, recycling is currently not a viable option.

Support, Paper Products. Paper is generated whenever documentation is required in support of a particular effort. Additionally, newspaper, computer paper, plates also contribute to this waste stream.

Reduction: An aggressive effort to reduce the number of persons and departments on the routine copy list can reduce paper usage by millions of sheets per year. Use of two sided paper would significantly reduce the quantity generated. . No specialized equipment, materials or costs for implementation of reduction efforts are required.

Reuse: Single sided paper can be reused onsite as scratch pads.

Reclamation: Due to the nature of the waste stream, reuse is not an option.

Recycling: The recycle value of paper fluctuates quite extensively sometimes making the effort cost effective. Very few companies when investigating the cost associated with paper recycling efforts include the cost reduction if disposing of the paper products in the landfill. No specialized equipment, materials or costs for implementation of recycling efforts are required.

Support, Plastics. Plastic is utilized extensively through out the shipyards for containment, equipment protection, packaging, etc. Various types of plastic are utilized in the shipyard and boatyard environment.

Reduction: Plastic was developed in order to replace (hence reduce) the use of wood, paper, glass, etc. Methods for reduction would depend on the method of determination of cost for disposal. If the landfill cost is based on volume (cubic yard) then compacting may be a method utilized in order to reduce costs. Compacting and baling equipment would be required in order to effect this type of volume reduction. The same equipment could be utilized in paper, cardboard, plastic, etc. compacting and baling. . No additional specialized equipment, materials or costs for implementation of reduction efforts is required.

Reuse: Due to the nature of the waste stream a limited reuse is available. Plastic utilized for equipment protection during shipping (popcorn) can be re-used. . No specialized equipment, materials or costs for implementation of reuse efforts are required.

Reclamation: Due to the nature of the waste stream reclamation is not a viable option.

Recycling: The recycle value of plastics fluctuates quite extensively sometimes making the effort cost effective. Very few companies when investigating the cost associated with plastic recycling efforts include the cost reduction of disposing of the plastic products in the landfill.

Support, Wood. Wood is utilized extensively as barriers (fall protection prevention) when plastic or paper does not provide the appropriate protection. Additionally wood is utilized in packaging, equipment movement (pallets), docking blocks, etc..

Reduction: In the case of pallets and spools the vender that provided the product will normally accept their return after the product is removed. Additionally some venders charge a reimbursable fee that is provided when the pallet or cable reel is returned. There are venders available that will except these wood products if the supply vender does not accept them. No specialized equipment, materials or costs for implementation of reduction efforts are required.

Reuse: Wood such as pallets and cable reels can be reused as originally designed. Some equipment crates have also been designed to accept the retrograde from a particular repair effort. . No specialized equipment, materials or costs for implementation of reuse efforts are required.

Reclamation: Due to the nature of this waste stream, reclamation is not a viable option.

Recycling: Each yard usually has "Do it Yourselfers" that will take any packing crates or scrap wood for home projects or fireplaces. One company that generates a lot of saw dust was utilizing the dust to cover mud and reduce the mud. No specialized equipment, materials or costs for implementation of recycling efforts are required.

Metal Fabrication. Metals are utilized extensively in the shipyards. These metals are cut, shaped and formed in order meet the requirements of the customer. Scrap metal waste is generated as the result of these processes.

Reduction: Preplanning and thought given to layout of components to be cut can significantly reduce the metals designated for scrap. Additionally accurate measurement (measure once for the company, measure a second time in order to keep your job) can significantly reduce scrap. Procurement of preshaped metals (I beams, sheets, can also reduce the scrap. No specialized equipment, materials or costs for implementation of reduction efforts are required.

Reuse: Judicious layout of metals to be cut can leave significant sized metals sheets that can be used in future projects. Smaller sheets can be cut so that they can be utilized as tools such as clamps and wedges. Storage racks for segregation of the scrap available for use would be required. No specialized equipment, materials or costs for implementation of reuse efforts are required.

Reclamation: Due to the nature of the waste stream, reclamation is not an option.

Recycling: All companies that generated any scrap metals recycle in order to recover some of the cost of these metals. Several place marked bins throughout the facility that accepted the various types of metals. These metals were then sorted if necessary and consolidated for disposal. Significant savings are generated as the result of recycling metals. Usually the recycler will provide the appropriate containers required for this effort. . No additional specialized equipment, materials or costs for implementation of recycling efforts is required.

See Figure 17.

Recycling bins encourage recycling and reducing

Figure 17: Scrap metal bin

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Solid Waste Segregation & Recycling Project

Task Five

Waste & Scrap Processing Equipment

Reuse, Recycling and Reduction Equipment Requirement Matrix

Using the survey and site visit data presented previously, a detailed equipment requirement list was developed. This list contains equipment currently utilized in shipyards that are necessary to implement the reuse, recycling and reduction methods, and procedures.

The information is presented as an equipment requirement matrix, by process and waste stream. Shipyard processes that generate waste which are included in the matrix consist of:

1. Vehicle Maintenance
2. Painting and Surface Coating
3. Abrasive Blasting Operations
4. Machining Operations
5. Marine Cleaning and Fluid Removal
6. Metal Preparation and Treatment
7. Electric Motor Repair
8. Building Maintenance
9. Wood Fabrication
10. Fiberglass Fabrication
11. Burn Table Operations
12. Insulation and Lagging
13. Support Operation

The required equipment portion of the matrix is divided into two sections.

1. Storage equipment or methods
2. Processing equipment or methods

By comparing the process waste streams to the equipment requirement list the shipyard can determine what equipment is currently in use.

Waste Segregation and Recycling Equipment

	STORAGE								PROCESSING										
	40 CUYD BIN	6 CUYD BIN	SUPER SACK	55 GAL DRUM	3 CUYD BOX	TANKS	RACKS	MISC CNTR	COMPACTOR	BALER	CONVEYOR	SCREEN	FILTER	PUMPS	FORK TRUCK	SOLVENT DISTILLER	NEUTRALIZE	FREON RECOVERY	ANTIFREEZE RECOVERY
Vehicle Maintenance																			
Antifreeze																			X
Batteries Each							X												
Auto Waste Oil						X													
Transmission Fluid						X													
Painting and Surface Coating																			
Paint Solids					X														
Paint Liquids				X															
Paint Sludges				X															
Spent Solvent																X			
Paint Disposables	X				X														
Abrasive Blasting Operations																			
Spent Medium			X								X	X			X				
Machining Operations																			
Cutting Fluids													X						
Cutting Finds		X																	
Marine Cleaning and Fluid Removal																			
Rinsate						X							X	X					
Tank Bottoms Chemical						X							X	X					
Cleaning Solutions						X							X	X					
Tank Bottoms Oil						X							X	X					
Waste Oil						X							X	X					
Bilge Water						X							X	X					
Oily Water						X							X	X					
Oil Petroleum						X							X	X					
Oil Synthetic						X							X	X					
Metal Preparation and Treatment																			
Plating Solutions																	X		
Rinsate Electroplating																	X		
Tank Bottoms Electroplating																	X		
Cleaning Solutions Electroplating																	X		
Electric Motor Repair																			
Varnish Insulation					X														
Varnish Drippings				X															
Varnish Cleaning Solvent																X			
Building Maintenance																			
Ballasts								X											
Fluorescent Lights								X											
Lubricants						X													
Refrigerants																		X	

Waste Segregation and Recycling Equipment

	STORAGE								PROCESSING										
	40 CUYD BIN	6 CUYD BIN	SUPER SACK	55 GAL DRUM	3 CUYD BOX	TANKS	RACKS	MISC CNTR	COMPACTOR	BALER	CONVEYOR	SCREEN	FILTER	PUMPS	FORK TRUCK	SOLVENT DISTILLER	NEUTRALIZE	FREON RECOVERY	ANTIFREEZE RECOVERY
Wood Fabrication																			
Stains				X															
Wood Varnish				X															
Scrap Wood							X												
Fiberglass Fabrication																			
Fiberglass Solvent																X			
Fiberglass Resin				X															
Burn Table Operatons																			
Burn Table Coolant													X						
Burn Slag		X																	
Insulation and Lagging																			
Asbestos	X																		
Fiberglass Insualtion	X								X	X									
Support																			
Paper									X	X									
Plastics									X	X									
Wood							X												

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Solid Waste Segregation & Recycling Project

Task Six

Application of Solid Waste Processing Equipment to Shipyards

Shipyard and Solid Waste Processing Equipment Matrix

Equipment that is seen in the typical shipyard and/or boatyard are also seen in a commercial recycling facility. The equipment that are utilized in the recycling facility and shipyard are for dissimilar functions. Some of the shipyard equipment can be utilized as is, modified or is not physically functional for the use that the recycling facilities uses the equipment.

Collection: In the shipyard industry, containers are utilized for the temporary storage of waste awaiting pickup. Whereas in the recycling facility large quantities of low value material is collected, processed then shipped to a receiving site. Since the material is low value, there needs to be sufficient quantity of the materials in place before it becomes cost effective to process. Therefore, large storage areas (mounds) are utilized while awaiting sufficient quantities to arrive. Smaller containers are not normally seen except for the storage of metals.

Handling:

Cranes: Cranes are utilized in both industries for moving heavy items. Because of the weight and size of material moved in of shipyards, a larger crane is seen in the shipyard.

Crane Attachments: The type of material moved by cranes in shipyards and recycling facilities are dissimilar. Therefore the type of attachments for movement are dissimilar. In the shipyard heavy or voluminous items are moved. In the recycling facility quantities of heavy items (scrap metal) are moved which require “grappling” or the use of “magnetic”. These attachments are not readily available in shipyards.

Front End Loaders: Front-end loaders are utilized in the shipyards primarily for the cleanup and processing of spent abrasive blast. Therefore the front-end loader is not normally seen in the smaller shipyards and boatyards. In the recycling facilities the loaders are utilized for the movement of the large volumes of waste for processing.

Conveyors: Conveyors are used in the recycling facility to aid the processing (sorting) of waste types. Conveyors are not normally utilized in the shipyard industry.

Forklifts: Forklifts are used extensively in both industries however for different purposes. Shipyard forklifts can be provided with attachments to aid in the sorting of trash.

Weight Scales: Scales are used in the shipyard industry but not for the volume/weight that scrap/recycling facilities utilize. Commercial scales are available if required by the shipyards.

Processing: Trash is not normally processed in shipyards although there are similar equipment in the shipyards similar to the equipment in the recycling facilities.

Drop-Ball Breakage: Not seen in the shipyards however could be fabricated with scrap metals.

Cutting Equipment: Utilized extensively in the shipyards. No modification would be required.

Shears: Ferrous shears are utilized extensively in the shipyards. Non-ferrous shears not normally required by shipyard industry.

Balers: Balers are utilized in some yards in conjunction with the compactors for paper, cardboard and visqueen compaction. Commercial buyers of used paper and plastic usually require paper and plastic to be in five cubic yard bales. Shipyard compactors usually compact on a cubic yard or smaller cube. These cubes are usually unbaled and recompacted into five cubic yard cubes.

Magnetic Separators: Not normally utilized in the shipyards.

Screens: Not normally utilized in shipyards except in the processing of spent abrasive blast medium or filtering of liquids. These screens are readily modifiable for use as seen in recycling facility.

Mills: Not normally utilized in shipyards except in the machining of metals.

Grinders: Not normally utilized in the shipyards.

Shredders: Not normally utilized in the shipyards.

Air Classifiers: Not normally utilized in the shipyards.

Eddy Current Separators: Not normally utilized in the shipyards.

The attached matrix identifies that the equipment utilized in the solid waste and recycling industry and compares it to common shipyard equipment used for material reuse, reclamation and recycling.

Recyling Facility Equipment	COLLECTION											HANDLING													PROCESSING													
	MOUNDS	40 CUYD BIN	6 CUYD BIN	SUPER SACK	55 GAL DRUM	3 CUYD BOX	TANKS	RACKS	MISC CNTR	COMPACTOR	BALER	*CRANES*	PEDESTAL	RAIL-MOUNTED	LOCOMOTIVE	TRACK MOUNTED	TIRE MOUNTED	*CRANE ATTACHMENTS*	MAGNETIC	GRAPPLE	FRONTEND LOADER	FORK TRUCK	SHEAR	CONVEYOR	*CUTTING TORCHES*	GAS	PLASMA	WATER-JET	ABRASIVE DISK	POWDER	SCREEN	FILTER	PUMPS	SOLVENT DISTILLER	NEUTRALIZE	FREON RECOVERY	ANTIFREEZE RECOVERY	NON SHIPYARD EQUIPMENT
COLLECTION																																						
MOUNDS	=																																					
40 CUYD BIN		=																																				
COMPACTORS										X																												
HANDLING																																						
CRANES																																						
PEDESTAL													O																									
RAIL-MOUNTED														=																								
LOCOMOTIVE															=																							
TRACK MOUNTED																=																						
TIRE MOUNTED																	=																					
CRANE ATTACHMENTS																																						
MAGNETIC																			O																			X
GRAPPLE																				O																		X
SHEAR																																						X
FRONT END LOADERS																					=																	
CONVEYORS																																						X
FORKLIFTS																						O																
WEIGHT SCALES																																						X
PROCESSING																																						
DROP-BALL BREAKAGE																																						X
CUTTING TORCHES																																						
GAS																										=												
PLASMA																											=											
POWDER																														=								
WATER-JET																												=										
ABRASIVE DISK																													=									
SHEARS																																						
FERROUS																							=															
NON-FERROUS																																						X
BALERS																																						
VERTICAL																																						X
HORIZONTAL																																						X
MAGNETIC SEPARATORS																																						
SUSPENDED BELTS																																						X
DRUMS																																						X
SOLID WASTE																																						X
SCREENS																																						
VIBRATORY DECK																																						X
TROMMELS																																						X
MILLS																																						
HORIZONTAL SHAFT																																						X
VERTICAL SHAFT																																						X
FLAIL																																						X
GRINDERS																																						
VERTICAL SHAFT																																						X
GLASS PULVERIZERS																																						X
GRANULATORS																																						X
SHREDDERS																																						
KNIFE																																						X
ROTARY SHEAR																																						X
AIR CLASSIFIERS																																						
HORIZONTAL																																						X
ZIGZAG																																						X
ROTARY DRUM																																						X
ASPIRATORS																																						X
VIBROELUTRIATORS																																						X
EDDY CURRENT SEPARATORS																																						
LINEAR MOTOR																																						X
PULSORT																																						X
SLIDING RAMP																																						X
ROTATING DRUM																																						X

KEY
IDENTICAL =
DISSIMILAR X
MODIFIABLE O

Waste Segregation and Recycling Equipment

Shipyard Equipment in Common Usage

Solid Waste Management and Recycling Equipment		STORAGE								PROCESSING										
		40 CUYD BIN	6 CUYD BIN	SUPER SACK	55 GAL DRUM	3 CUYD BOX	TANKS	RACKS	MISC CNTR	COMPACTOR	BALER	CONVEYOR	SCREEN	FILTER	PUMPS	FORK TRUCK	SOLVENT DISTILLER	NEUTRALIZE	FREON RECOVERY	ANTIFREEZE RECOVERY
Collection																				
Transportation																				
Handling																				
Cranes	Pedestal																			
	Rail-mounted																			
	Locomotive																			
	Track Mounted																			
	Tire-mounted																			
Crane Attachments	Magnetic																			
	Grapple																			
	Shear																			
Front End Loaders																				
Conveyors																				
Forklifts																				
Weight Scales																				
Processing																				
Drop-ball Breakage																				
Cutting Torches	Gas																			
	Plasma																			
	Powder																			
	Laser																			
	Water-jet																			
	Abrasive disk																			
Shears	Ferrous																			
	Nonferrous																			
Balers	Vertical																			
	Horizontal																			
Magnetic Separators	Suspended Belt																			
	Head Pulley																			
	Drums																			
	Solid Waste																			
Screens	Vibratory Deck																			

Waste Segregation and Recycling Equipment

Solid Waste Management and Recycling Equipment		STORAGE								PROCESSING											
		40 CUYD BIN	6 CUYD BIN	SUPER SACK	55 GAL DRUM	3 CUYD BOX	TANKS	RACKS	MISC CNTR	COMPACTOR	BALER	CONVEYOR	SCREEN	FILTER	PUMPS	FORK TRUCK	SOLVENT DISTILLER	NEUTRALIZE	FREON RECOVERY	ANTIFREEZE RECOVERY
	Trommels																			
Mills	Horizontal Shaft																			
	Vertical Shaft																			
	Flail																			
Grinders	Vertical Shaft																			
	Glass pulverizers																			
	Granulators																			
Shredders	Knife																			
	Rotary Shear																			
Air Classifiers	Horizontal																			
	Zigzag																			
	Rotary Drum																			
	Aspirators																			
	Vibroelutriators																			
Eddy Current Separators	Linear motor																			
	Pulsort																			
	Sliding Ramp																			
	Rotating Drum																			
Storing																				
Shipping																				

Key

Identical	=
Dissimilar	**X**
Modifiable	**O**

Solid Waste Processing Equipment - Applicability to Shipyard Facilities

Introduction. One of the conclusions of this study of shipyard solid waste management and recycling is that the solid waste stream generated in shipyards is more similar to those waste streams generated in residential communities vs. heavy industry waste streams. Certainly, one of the principal reasons for this similarity to residential waste is that the ships in shipyards often support a special type of residential community, i.e. the ship's crew. Indeed, it is often the case that the majority of waste disposed of from the shipyard is the "residential waste" derived from ships. In terms of solid waste management and recycling, this provides a parallel set of management, equipment and process experiences that the shipyard may draw upon in determining how to accomplish the following:

1) reduce solid waste management and disposal costs;
2) increase the value for recovered recyclables; and
3) decrease the liability for inadvertent disposal of hazardous waste.

There are already existing techniques for estimating the cost disposal of waste or the value of recyclables. The decrease in liability for the prevention of improper disposal of hazardous waste cannot be definitely appraised. However, we do know that in the past, shipyards have been fined enormous amounts of money, as well as barred from receiving government contracts for improper disposal of hazardous waste. While it can be the most difficult to quantify, the prevention of inadvertent disposal of hazardous waste may be the most important aspect of the shipyard's solid waste management program.

In the past twenty years, many states, municipalities and waste management companies have been grappling with the issues of managing the cost of solid waste disposal, meeting government mandated waste reduction and recycling goals, and protecting the environment. The results of these experiences have clearly been mixed. While some solid waste disposal and/or recovery facilities built by cities or other municipalities have prospered, others have never been able to pay their own way. In many cases, taxpayer support has been required to makeup the deficient of operating expenses. While the public's support for recycling and recovery facilities may allow these facilities to operate at a deficit, the shipyard must, like any other business, meet the demands of financial necessity to remain solvent and competitive.

Solid Waste Management Facilities. Several types of waste management facilities are currently in use throughout the United States in order to centralize the collection, transfer, recovery and disposal of this material. These facilities can be analogized to the waste management options available to shipyards. The following table provides a description of each type of facility:

Facility Type	Facility Purpose	Shipyard Equivalent
Transfer Facility	Centralized station to receive waste collected from an extended area, such as residences and businesses within a city or county. Waste brought to the transfer facility is usually temporarily deposited on the ground or floor until reloaded onto trucks or rail cars for transfer to a landfill or other disposal facility.	Shipyard waste collection area, where skip boxes or other small collection boxes are transferred into 40 cubic yards bins to be transported to a landfill or other disposal site. The shipyard waste collection area may also include some hazardous waste processing and segregation of recyclables.
Material Recovery Facility ("MRF")	Materials Recovery Facilities primarily accept recyclables from sources, such as residences and businesses where the materials are segregated at the point of generation, i.e. curbside recycling programs. The MRF processes the material to increase its value and sells the recyclables on the open market.	The shipyard equivalent of a materials recovery facility is that area of the shipyard where scrap metal is recovered and stored prior to transfer to a scrap metal dealer. A similar analogy exists for the process of point of generation segregation (curb side recycling programs) in that the shipyard crafts which generate scrap metal will collect and segregate the material prior to transport to the collection area.
Combination Material Recovery Facility	Combination Material Recovery Facilities (also referred to as "dirty MRFs") accept waste which has received little or no segregation of recyclables prior to transfer to the facility. Using a combination of manual labor and waste processing equipment, recyclable materials are recovered from the waste stream. The value of the recyclables are enhanced by processing, and remaining	A large percentage of the waste accepted into the shipyard's waste processing area is un-segregated. Waste materials of obvious value are often removed manually by waste yard personnel. Scrap metal, electrical cable, corrugated cardboard, and other types of materials which are both easily recognizable and removable from the waste stream are pulled out and segregated for their recyclable value. The

	waste is loaded into trucks or rail cars for transfer to a landfill or other disposal site.	remainder (and typically vast majority) of the waste is transferred to a landfill or other disposal site.

Each of the above types of waste processing facilities has its economic advantages and disadvantages. In the case of transfer facilities, the volume of the waste is maximized (and therefore the cost of disposal) because recyclable materials are not removed prior to disposal. However, equipment and labor costs are minimized due to the fact that the waste is handled only once, using available equipment, such as skip boxes and forklifts. In the case of MRFs, the recyclables are removed from the waste stream using point of generation segregation. This does not reduce the labor cost of segregating the waste, but does transfer the cost to the waste generator. The total volume of waste is decreased, thereby reducing disposal costs. Additionally the market value of the recyclables provides some increase in income.

In the case of the combined MRF, the labor and equipment costs to segregate the recyclables are returned to the receiving facility. Total labor costs are typically reduced because of the increased efficiency with which the waste can be processes. However, this segregation efficiency is achieved through the use of specialized and often expensive waste processing equipment. The total volume of waste is decreased, thereby reducing disposal costs. In addition, the market value of the recyclables provides some increase in income.

Shipyard Material Recover Facilities

Shipyards that are generating a large enough volume of “high” value waste may decide to site a dedicated Material Recover Facility (“MRF”) on site to prepare recyclable materials for market, reduce their disposal volume and remove hazardous waste which has been inadvertently placed in the solid waste collection containers.

Many different processing schemes can be devised to segregate and process recyclable materials. The selection of a particular system may depend on the size of the shipyard, the various materials which are collected and the form in which they are received, and the personnel or vendor that will operate the facility. Processing preferences and technology depend upon the design engineer or the system vendor selected to design, build, and/or operate the given recycling facility. Further, the ideal system for a given shipyard will depend greatly on locality particular factors such as site, markets, collection practices, alternative methods of handling recyclables, traffic, transportation. applicable building regulations, codes, etc.

This section gives an overview of the types of systems available for processing source-separated recyclables, commingled recyclables, and mixed waste. General guidelines are provided for the design of these systems.

Processing of Source-Separated recyclables. Processing systems for household separated recyclables are much the same whether the recyclables are collected by means of:

- Return of bottles and containers to the waste as part of a shipyard mandated waste reduction program;
- Employee recycling through use of drop boxes, drop-off centers, or buy-back centers; or
- Area collection of craft specific separated materials, i.e. weld shop, pipefitters, structural shop, etc.

In all three of these cases, a glass bottle, for example, is collected with other glass bottles and not mixed with paper, cans, and plastic containers. However, the glass bottles are not just glass. They may have aluminum or plastic caps still on them. They may have paper or plastic labels. Further, the glass may or may not be separated by color into clear (flint), brown (amber), or green (emerald).

Normally, the separated recyclables are taken to a central collection or consolidation center. In some cases, materials are simply consolidated into larger containers and sold "as is." Little or no processing is performed. Efforts may be made to separate the glass by color if not collected already color separated. Some quality control may be employed when separation at the source has not been properly carried out. However, little effort is made to remove labels, take off caps, crush bottles, or flatten cans. Paper is not baled but is loose. In larger facilities, source-separated containers could be processed through crushing, flattening, baling, and label and/or cap separation operations. In either case, storage is needed for each incoming material. The storage needs must be calculated based on the overall design requirements and markets. The tipping floor, bunkers, and/or storage containers must be large enough to store at least 1 day's incoming material and keep it segregated from the other materials received. A weigh scale is desirable to weigh both incoming and outgoing products. Product weights can also be determined off site or by the end market purchaser.

Processing a material may not be necessary to increase density provided a lower price can be accepted and transportation distances are not great, but some sort of consolidation is almost always required. When processing is required as well as consolidation, processing system space requirements as well as product storage must be considered. Output product storage may have to accommodate more than 1 day's supply, since it may take time to accumulate truckload quantities of some products such as aluminum or plastic. The equipment and systems utilized for the consolidation and processing of source-separated materials-glass, metal, plastic, and paper-are described in the following sections.

Glass Processing. Glass bottles are typically received in loose form directly from collection bins. They may be stored in intermediate holding containers or in gaylords. When enough glass has been received to begin processing, the material is removed from the storage containers and placed on the tipping floor. If not already accomplished, the glass may be color separated manually on the tipping floor. Care should be taken to avoid excessive breakage of the glass prior to color separation. Breakage after color separation is not a problem. While on the floor, the glass is also inspected for contaminants such as plate glass, ceramics, rocks, and/or stone which would cause impurities in the finished glass product and therefore must be removed prior to processing. In large facilities, a front-end loader is usually used for moving material. Care must be taken to avoid picking up contaminants from the floor with the loader bucket.

The glass is crushed using a pulverizer or shredder. Following crushing, small vibrating screens or trommels are used to screen away bottle caps as oversize material from the smaller pulverized glass. Labels are also largely removed by screening, or, alternatively, air classifiers can be employed. This process is repeated for each color of glass. Normally the same equipment can be utilized on a rotating basis for all three colors of glass. In higher-capacity systems, multiple parallel processing systems are installed for each color of glass. Noise and dust control are important environmental considerations which must be addressed during installation of a glass crushing and processing system. Also, the proper design of feed conveyors and the interface to the feed hopper and dribble chutes require experienced design knowledge.

While the glass is stored prior to shipment to market, a manual inspection should be conducted as a final quality control measure to remove any obvious unwanted contamination. A small amount of color contamination does not present a significant reduction in market value or market demand. Glass is expensive to ship relative to its market value, which is on the order of $15 to $60 per ton depending on color, cleanliness, and market conditions. Selection of the final shipping container or vehicle must be coordinated with the glass buyer. If the glass is to be used locally as an aggregate or as part of a paving mix, shipping in open dump trucks may be adequate. However, rail shipment is an important consideration if the glass is to be used as cullet in the manufacture of glass bottles and the distance to the nearest glass bottle producer exceeds 100 miles. Glass can be shipped in enclosed rail hopper cars or in roll-off containers.

Can and Metal Processing. Generally speaking, the metal cans received from a source-separation program are of three different types: all ferrous (including tin-coated); bimetal (ferrous metal cans with aluminum "pop top" lids); and all aluminum. Collection of aluminum plate, castings, and foils may also be included within various collection programs. Normally. magnetic separators are not utilized in source-separated materials processing centers. It is relatively easy to visually identify aluminum cans and hand sort them from cans containing ferrous metal before baling or flattening.

Aluminum companies, such as Alcoa and Reynolds, often provide the recycler with a can flattener and trailer. This equipment is provided either under a lease arrangement or as a price reduction in the finished product in exchange for a long-term purchase agreement. The aluminum buyer will normally stage the trailer on the site and replace a full trailer with an empty one as needed. The markets for steel can scrap are often more difficult than the markets for aluminum simply because the value of the finished product is so much lower. Flattening or low-density baling makes sense only if the market is a local scrap dealer rather than a steel mill or end user. The finished product most often is baled or briquetted in order to find a strong market and achieve reasonable transportation economics. Rail shipment may be a market requirement.

It is not necessary to provide strapping for high-density bales. Also, the market is sufficiently strong for this material so that it is not necessary to remove labels from the steel cans. When can scrap is shredded, the shredder automatically removes the labels. The shredded material can be stored and shipped loose because it typically has a density of 40 to 50 lb/ft^3. In some shredders, densities of 60 to 80 lb/ft^3 can be achieved by balling the product. Balled material is not suitable for detinning because the detinning reagent cannot easily penetrate the metal ball. However, baling is desirable for steel making applications owing to the improved density and cleanliness of the material.
Aluminum contamination of steel cans is not a problem in steel making applications or markets because aluminum is a valuable deoxidant for steel making. However, aluminum contamination can be a problem in detinning because it consumes detinning reagent. Thus, for detinning, separation of bimetal cans from tin cans may be important. It is not important to a minimill or steel making customer. The aluminum lost to the tin can scrap, however, will only be valued at steel prices.

*Plastics Processing***.**

PET (Soda) Bottles. PET is separated by color into clear and green or alternatively, it can be sold as mixed color. It should not be granulated unless directed by the end market buyer, the problem being that once the product is granulated, it is not possible to inspect for contamination. Technology does not yet exist to remove small particles of PVC from PET practically and efficiently, at commercial throughput rates, although some promising development programs are underway. Some end market buyers furnish granulators in exchange for long-term supply contracts once the supplier has been certified for quality control.

PET can sometimes be sold as whole bottles without baling or granulation provided the transportation distance to the end user is quite short. Material is collected in large, reusable bags. These bags are emptied, and the contents segregated by color and then granulated by the end user. The bags are returned to the supplier when a new shipment is received. PET bottles can be sold "as is." Automated processing systems are in place to remove caps, bottom cups, and labels, producing a high-quality finished product that can be recycled into new PET bottles.

Homopolymer (Natural) HDPE. Homopolymer or natural HDPE consists primarily of milk and water bottles. There is a strong market demand for this product, although price may be low at times. Natural HDPE may be processed simply by baling or granulating. The impurity issues are not as stringent for HDPE as for PET and thus granulation is often acceptable, but it should be verified by the end user. Also, granulating may be less expensive than baling and may contribute to the market value, since granulation must eventually be done by the end purchaser at a cost of about $0.05 per lb.

The market for natural HDPE is higher and the demand greater when caps are removed because the finished product can meet more stringent color specifications. However, cap removal requires added labor cost. Care should be taken not to contaminate the product by other plastics and to keep it clean during this processing step. Care must be taken to avoid processing materials that look like HDPE milk bottles but are not. Many forms of polypropylene look just like homopolymer HDPE. A small amount of PP can be tolerated by HDPE processors, normally less than 3 percent. If large quantities of PP are contained in the HDPE material, the finished product may not be marketable.

Mixed Color HDPE. Mixed color HDPE comprises laundry detergent bottles, bleach bottles, dishwashing detergent bottles, and the like. Even though homopolymer HDPE milk bottles are composed of the same polymer as mixed color HDPE, the two are incompatible The reasons for this are quite complex but in essence can be explained by the term "melt index." Homopolymer HDPE has a low melt index (sometimes described as having a "fractional melt index") because it is less than 1, while mixed HDPE has a melt index which is greater than 1 and typically in the high 20s or low 30s. The higher the melt index, the more the polymer flows when melted. Mixing high melt index HDPE with fractional melt index HDPE is like mixing tar with water. It doesn't mix. For that reason, even though both polymers are HDPE, the markets for each are different. Thus they must be processed separately and stored separately as if they were different polymers. Mixed HDPE is also hard to granulate and requires more frequent granulator maintenance than does homopolymer HDPE granulation. A heavy-duty, wide-mouth granulator is desirable. HDPE should not be stored outside in sunlight for prolonged periods of time because the material is photodegradable. The market value of the finished product may be destroyed.

Paper. Paper is received in many different forms including old newspaper (ONP), old corrugated containers (OCC), mixed paper, and high grades such as computer printout (CPO). ONP may be sold loose or baled. If the market for the product is overseas, a high-density baler is required. Low-density bales, whose ultimate market is overseas, are frequently "broken" and rebaled in high-density balers. Thus the money and effort invested in baling the finished product may not contribute value to the recycling facility where it does not contribute value to the end user. OCC must be baled. This material is of too low a bulk density to be shipped loose more than a few miles. High-grade paper such as CPO is usually baled, but may be marketed loose to local paper recyclers.

One must ensure that a market exists for mixed paper before it is collected or "produced" through the improper segregation of incoming materials. Hand or automated separation of mixed paper into various paper grades is not economically viable.

Enriched corrugated loads can be separated from other paper, plastics, and contaminants on a tipping floor. However, this is backbreaking work and requires significant storage and working area. A separate sorting line with a large (minimum 5-ft-wide) conveyor is desirable. The width of this conveyor makes the sorting of other containers such as glass, metals, and plastic difficult because the operator needs to reach out such long distances across the conveyor belt.

A number of layout and design considerations are to be taken into account if corrugated is separated from other paper or wastes on a conveyor belt. First, these materials tend to be presented in surges or lumps. A variable-speed conveyor should be used and the lead (front) picker should have easy access to the speed control to slow down the conveyor when needed and speed it up when necessary. Second, it is difficult to throw material forward off the picking conveyor. It is easier to pull it towards oneself, swing it around, and throw it off the back of the conveyor. (This is just the opposite of bottles and cans, which are easier to throw forward.) The conveyor should therefore be high off the ground, or a takeaway conveyor should be utilized, so material separated does not interfere with the hand picking operation. Piles can be built from the floor without requiring constant front-end loader attention to remove the high volume of material being picked out for later baling. Obstructions should be kept to a minimum. Hand pickers should be spaced far enough apart so that the momentum when pulling cardboard from the pile can be used to throw the material off the conveyor.

Central Processing of Mixed Recyclables. The term "material recovery facility," or MRF, is one of the more ill-defined terms used in recycling. For some, it includes drop-off centers, processing plants that accept only source-separated materials, paper stock operations, and scrap yards. However, for others, to be an MRF, a facility must process commingled residential recyclables. The industry definition of an MRF is a "central operation where commingled recyclables, at least a portion of which come from the residential sector, are sorted and processed for market." In the case of the shipyard, the source of the residential recycables would be derived from ship's force living aboard the vessel.The MRF, as defined, is also often referred to as an "intermediate processing center" (IPC).

In its simplest form, a "low-tech" MRF consists of not much more than a linear picking conveyor on which a number of workers pick out recyclable materials from a commingled stream and throw them into bins for shipment to customers. In its more complicated form, the "high-tech" MRF, handpicking is assisted through machine separation operations utilizing magnets, eddy-current separators, air classifiers, screens, and other devices. No fully automated MRF existing today is capable of receiving a stream of commingled recyclables and converting those materials into salable end products without some handpicking and manual quality control steps. In some cases, unique separation equipment has been developed by various system vendors to aid in the necessary separations.

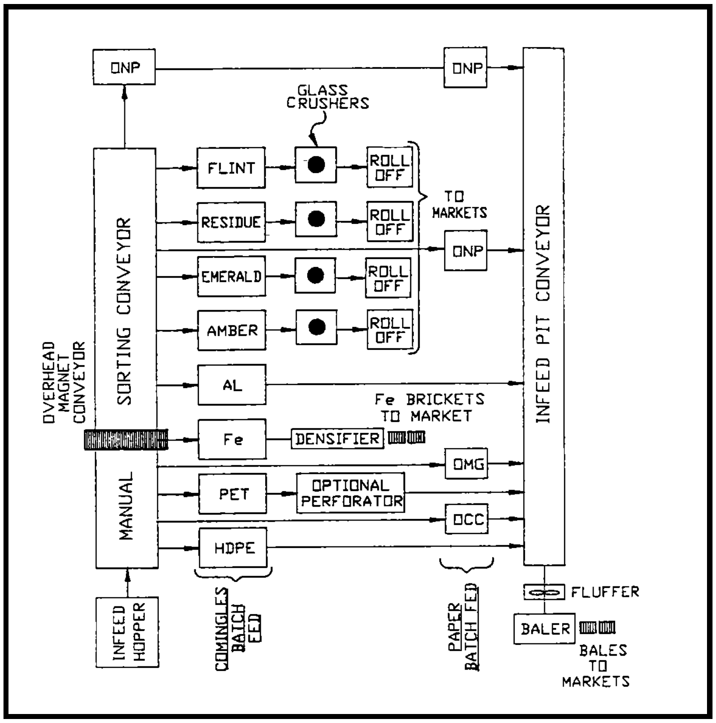
The design of an MRF depends upon many factors such as site constraints, vendor or licensed technology, methods-of collection, delivery schedules, raw materials, and markets. However, all MRFs normally depend upon the delivery of two separate feed streams: (I) commingled recyclables and (2) paper products. The commingled recyclables stream could include three colors of glass, tin cans and aluminum cans, foils, and plastics such as HDPE and PET. The paper products stream could be one grade of paper or several.

MRF buildings must be designed to various code requirements. Particular attention must be given to sprinklers which must be designed to meet "high-hazard" code requirements, at least where bales of paper and plastic are stored. High hazard also is often the basis of design for tipping and processing areas. Floor drains and oil-water separation systems are frequently required. Loading docks and loading dock doors should be assumed for transferring bales from intermediate storage into transfer vehicles or rail cars. At least 1 day's storage of infeed material should be provided assuming same-day processing. At least one day's storage should be provided for output products.

Small-scale (up to 100 tons per day) and large-scale (100 to 200 tons per day) MRF processing systems are discussed in the following sections. Incoming materials received at the MRFs are assumed to be a combination of source-separated materials delivered in multi-compartment trucks, drop-off containers, or skip-tubs and also commingled in refuse packer vehicles which deliver either bagged or unbagged mixed material.

Small-Scale, Low-Tech MRFs. As a rule of thumb, when the volume of material to be recycled is less than 25 tons per day, it should be collected in a multi-compartment container, tipped into roll-off containers and transported to either a scrap or paper broker, or a centralized, regional MRF. On-site processing is not cost-effective and is not recommended for such very small quantities.

A flow diagram for a 25 to 100 tons per day MRF is provided below. The system only requires a feed hopper, band sorting platform, product bunkers under the conveyor and/or roll-off storage containers, and a baler. Commingled recyclables are first fed into an infeed hopper set into the floor below grade. The feed hopper contains a cleated rubber belt conveyor which inclines up to the picking platform. Rubber cleats avoid the unwanted breakage of glass which can occur with metal cleats. The feed conveyor conveys the commingled material up the incline onto a picking conveyor (may be the same conveyor) with a platform for hand pickers along its side. The conveyor should not be more than 48 inches wide. It should be flat and should have side skirts to prevent spillage. Operators stand on one side of the belt and throw handpicked recyclables forward into hoppers on the opposite side of the conveyor. The hoppers have "backstops" behind the opening and are at least 36 inches wide. The hoppers may be lined with rubber or wood, at least for glass products, to reduce noise. Each product is positively sorted, i.e., picked off the belt. The residue remains behind as the last "product" which is "negatively sorted" and which will contain nonmarketable materials, broken glass, etc. If the products are very clean coming into the plant, it may be possible to positively pick off the residue and leave another product, say mixed color cullet, as the negatively sorted finished product coming off the end of the conveyor. However, generally, the objective here is to produce high-grade products, and thus each product is "positively" sorted.



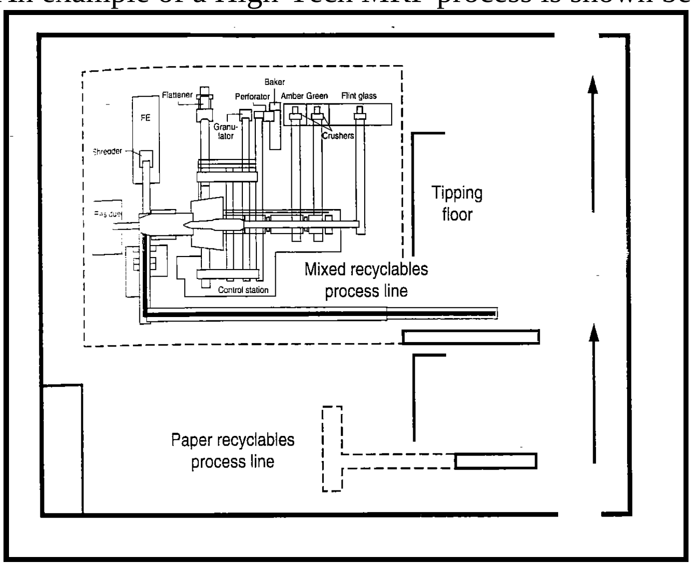
HDPE and PET are picked off the belt first (i.e., positively sorted). These materials tend to be on top of the commingled stream because they are light in weight. They also represent a high volume of the infeed material. Plastics are stored separately in bunkers or large containers and then fed to the baler or granulator when sufficient quantities have been accumulated to make a whole bale or to operate the granulator near capacity for a continuous period of time. HDPE and PET are baled separately. PET is baled as mixed green and clear; HDPE is natural only. A horizontal automatic tie baler is recommended. The ferrous metals are removed magnetically using a cross-belt magnet or can also be separated by hand. Aluminum cans and aluminum food trays are then picked off. Some bimetal cans may be included with the aluminum. The MRF operator should verify that this is acceptable to the product customer. If not, a small magnet should be placed under the aluminum chute to drop bimetal cans into a separate hopper from the all-aluminum cans. If a ferrous magnet is utilized, the bimetal cans will automatically be sorted to go with the ferrous metal, since they will behave as magnetics. Finally, glass is sorted by color into flint, amber, and emerald green. The glass is stored in separate roll-off containers for each color. The glass may optionally be pulverized, one color at a time, followed by screening before final loading onto rolloffs. The screen oversize, consisting mostly of caps and labels, is discarded as residue. The residue is discarded in a roll-off container or is placed in a stationary compactor if the quantities are large.

Old newspaper and corrugated containers should be tipped on a separate area on the tipping floor. The tipping floor should be large enough to leave adequate room for storage, working area, and interim storage while waiting for baling of each separate paper product as well as baling of other containers once separated. Walls in the tipping area should have backstops to push and pile the paper and corrugated cardboard against so that these materials can be piled up to 12 ft high. Sorters, standing on the floor, pull the corrugated from the other ONP and throw it aside temporarily. Paper bags are removed from the ONP as are any plastic bags and string. These materials are discarded as residue. The corrugated cardboard is thrown to one side while the heavier newspaper is fed into the baler. The baler is fed from a loading conveyor which is slightly, about 1 or 2 ft, below floor grade. If possible, a paper picker is stationed on a platform next to the feed conveyor to positively sort out residue and contaminants from the baler feedstock just before material is fed into the baler feed hopper. It is critical that unwanted material is removed from the bale. Whole bales of paper are produced and tied off. When enough corrugated cardboard has been accumulated for a whole bale, feeding of newspaper ceases and a bale of corrugated cardboard is produced. Intermittently, the baler can be utilized to make a bale of PET, HDPE, aluminum, or ferrous metals.

Bales are picked up by a forklift, weighed, marked with weights and numbered, and stacked for later loading into transfer trailers. A digital weigh scale is recommended. The bale size should allow full utilization of standard-sized enclosed trailers. Adequate space should be provided in the plant or under shelter to store between one and two trailers worth of each product. Truck drivers delivering each product to market will not be kept waiting while the operator tries to produce the product needed to fill the truck, since it is too costly to ship a partially filled truck. Shipping mixed loads is not practical in most instances unless both products are going to the same broker or mill.

For the smaller range facilities, closer to 25 to 50 tons per day, a "bobcat" loader may be adequate for both product and infeed materials. However, it is wise to either maintain a second standby unit or have rapid access to a rental unit. It is also wise to have a backup forklift. For facilities in the 50 to 100 ton range, a small articulated frame loader such as a small Caterpillar is a better option than a bobcat because it is capable of heavier service, has higher lifting capacity, and can push larger loads, especially of corrugated cardboard and paper, on the floor. It has a frame which provides greater clearance from the floor, thus avoiding wrapping of wire and strapping around the axles and various other undercarriage parts of the machine. Further, the radiator is designed to withstand heavier-duty service in high-dust areas. A swing-out radiator which can be periodically blown out with an air gun is highly desirable. Foam-filled tires are also advantageous.

High-Tech MRFs. MRFs employing a highly mechanized process line have been developed for processing large quantities of recyclables from commingled feed streams. An example of a High-Tech MRF process is shown below. This facility was designed to process 130 tons per day of commingled recyclables received in co-collected, separate fractions of mixed paper (ONP and OCC) and mixed containers (ferrous, HDPE, PET, three colors of glass, and aluminum).

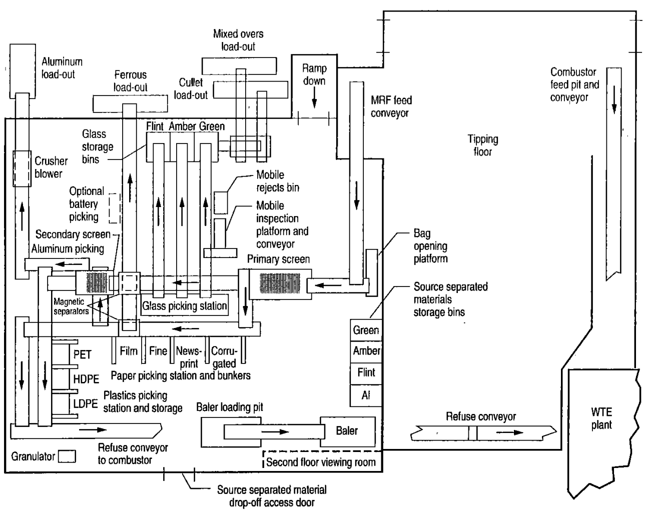


Mixed paper is removed from the tip floor and manually sorted on conveyors prior to baling into its constituent fractions. Commingled containers are loaded onto a computer-regulated conveyor that senses the quantity of materials fed per lineal foot in order to maintain a steady feed rate. Ascending to elevated separation stations, material is initially visually inspected for gross contaminants and hazardous materials, which are removed manually. After magnetic belts separate ferrous materials, the remaining fraction cascades downward on the conveyor and through a series of suspended metal bars that, relying on the weight. particle size, and aerodynamic differences of aluminum and plastic containers, separate them from glass. Also, because of gravity, glass continues down the line with other containers diverted to either side. Glass is screened, with the overs manually sorted by color and the unders remaining as mixed cullet. Clear glass overs are negatively sorted and visually inspected to assure high quality of this most valuable glass color. Containers on the diverted line pass through an eddy-current separator to remove aluminum, and plastics are manually sorted by resin type.

Materials are prepared for market as follows. Ferrous is shredded in a flail mill This (which also removes and separates the aluminum tops of bimetal cans) and is containerized in loose form. Aluminum is shipped similarly after passing through a can flattener. Glass is crushed and boxed or shipped loose in truckload quantities. PET is perforated and baled, while HDPE is shredded and shipped in gaylord-style boxes. Papers are baled. Residue, primarily mixed glass cullet from the screen unders, is estimated to be 10 percent of the daily throughput.

Processing of Mixed Waste for Recovery of Recyclables. In a mixed waste processing program, only one trash can per collection is required. The recyclables are mixed in with all the other "municipal" solid waste and delivered to a mixed waste processing facility. Mixed waste processing systems are often termed "front-end processing systems" or "refuse-derived fuel (RDF) processing systems. The processing technology can involve either mechanically assisted band separation of mixed MSW or fully automated processing of mixed MSW.

An example of a mixed waste or front-end processing system co-located with a waste-to-energy facility is shown below. This facility features a relatively low technology process that relies on manual inspection and picking of recyclable products from conveyors. It is supplemented by two-stage screening for size classification and magnetic separation of ferrous metals. Materials to be recovered from the solid waste stream include ferrous metals and aluminum; HDPE, PET, and mixed film plastics; amber, green, and flint glass; and corrugated, newsprint, and fine paper.



Mixed waste processing center (3500 tons per week).

Solid Waste Statutes and Regulations.   Regulation of non-hazardous waste is the responsibility of the states pursuant to Subtitle D of the Resource Conservation and Recovery Act ("RCRA"). The federal involvement is limited to establishing minimum criteria that prescribe the best practicable controls and monitoring requirements for solid waste disposal facilities. Additionally, Subtitle D required the EPA to issue guidelines to assist states in developing and carrying out solid waste management plans . The intent of the guidelines was that by creating solid waste management plans, states could identify a overall strategy of protecting human health and environment. States were not required submit plans under Subtitle D however, and as a result not all state have EPA-approved solid waste management plans.

Many of the state's integrated waste management plans have been incorporated into both state law and regulation. These statutes and regulations provide the basis for waste management of solid waste disposal facilities (i.e. landfills and other types of disposal plants), solid waste transporters, waste transfer facilities, material recovery facilities and scrap recyclers. These requirements vary greatly from state to state. It is important for any shipyard contemplating a solid waste management program within their facility to understand the applicability of their state's requirements to their program.

California Solid Waste Management Requirements. As any example of how a state's solid waste management requirements can effect a shipyard's waste management program, the applicability of California's statutes and regulation were analyzed given a hypothetical shipyard solid waste fact case, given below.

Solid Waste Management Scenario

1. A privately owned shipyard conducts new construction and repair operations in California.
2. On site waste collection performed using approximately 100 small (3 cubic yard) "skip tubs." The skip tubs are transported by forklifts to a central collection area, by company employees.
3. Daily average waste collection is 125 cubic yards.
4. Incoming waste is deposited on the ground and hand sorted by company employees to locate recyclable materials.
5. Recyclable materials are removed and segregated in to bins, including scrap metal and cardboard.
6. Remaining trash is loaded into 40 yard bins and compacted to maximize loading capacity.
7. The 40 yard bins are removed from the site by a contracted solid waste transporter and hauled to a local landfill.

Given the above facts, is this facility subject to the California solid waste management requirements, and if so, what requirements apply?

Statutory and Regulatory Analysis

Statutory Applicability. The applicable statutes for solid waste management in California are contained in the Public Resources Code, Section 40000. Section 40194 defines a "Solid Waste Facility" to include a solid waste transfer or processing station, a composing facility, a transformation facility and a disposal facility. Section 40200 (a) defines a "Transfer or processing station" or "station" to include those facilities utilized to receive solid wastes (2), temporarily store (5), separate (4), convert, or otherwise process (6) the materials in the solid wastes, or to transfer the solid wastes directly from smaller to larger vehicles for transport (7), and those facilities utilized for transformation. *(The numbers in parenthesis refer to that element of the hypothetical above which may trigger the applicability in the definition).*

Analysis. The shipyard is clearly used to receive, temporary store, separate and otherwise process the materials in the solid waste. Additionally, the shipyard may be transferring the solid waste directly from smaller to larger vehicles for transport. California law does not define the term "facility." This implies that the law does not recognize a distinction between companies that receive wastes from homes and business and processes those wastes to remove recyclables, and those companies that receive and process the waste generated on-site. Therefore, given the facts in the hypothetical above the shipyard would be defined as a Transfer or Processing Station, and therefore a Solid Waste Facility.

Requirements. The Public Resources Code provides requirements for Solid Waste Facilities.

> Sections 44001- 44018 requires that any person who proposes to become an operator shall file for and obtain a permit to operate the facility. Additionally, this Section requires that no person shall operate a facility without a permit.
>
> Section 44100- 44106 provides for inspections of a solid waste facility by the enforcement agency.
>
> Section 43020 - 43035 establish requirements for minimum standards for solid waste handling, transfer, composing, transforming and disposal.
>
> Section 43040 provides that the solid waste facility must provide assurance of adequate financial ability to respond to personal injury claims and public and private property damage claims resulting from operations of the facility.

Therefore, in the case of our hypothetical shipyard, before it could begin processing solid waste as described above it must first apply for a receive a permit to operate, it must design and build the facility to meet the minimum standards and it must allow the local enforcement agency to inspect the operations on a on-going basis. Additionally, a adequate form of financial assurance must be provided. These state requirements will place a substantial burden on the facility. The value of this burden should be integrated into the overall cost analysis of operating a solid waste facility within the shipyard in California.

The requirements in other states will differ from California. Before any shipyard considers conducting solid waste operations which may be affected by their state's solid waste statutes or regulations, a thorough statutory applicability analysis must be performed.

Solid Waste Process Equipment. This section describes the technology and systems utilized to process recyclables once they are collected. When materials are collected and fully separated at curbside (after initial separation by the resident), they still may have too low a density to be sold directly to an end user. Bottles may need to be crushed, metals flattened or baled, plastics granulated or baled, and waste paper baled.

For commingled recyclables, not fully separated before collection, more complex separation and processing systems are employed to first separate the commingled recyclables into their component materials, remove impurities from them, and then densify them or otherwise prepare them for shipment to the end user. Commingled processing facilities, called materials recycling facilities or MRFs, are typically of larger volume or tonnage than the systems required to process source separated materials. MRF equipment is also normally of larger capacity and more rugged. Very complex, heavy-duty, capital-intensive processing systems are required for mixed waste processing facilities which must recover materials from the entire solid waste stream.

Unit Operations and Equipment

The basic process system unit operations are similar regardless of whether the materials to be processed or separated are obtained from source separation, commingled collection, or mixed waste collection programs. The unit operations employed in processing recyclable materials include baling, magnetic separation, screening, size reduction, air classification, eddy current separation, and can flattening and densification. The intent of this section is to familiarize the shipyard with the various unit operations, provide an overview of the type of equipment available, and present some guidelines regarding the selection and operation of these unit operations and associated equipment as they particularly pertain to the business of waste processing.

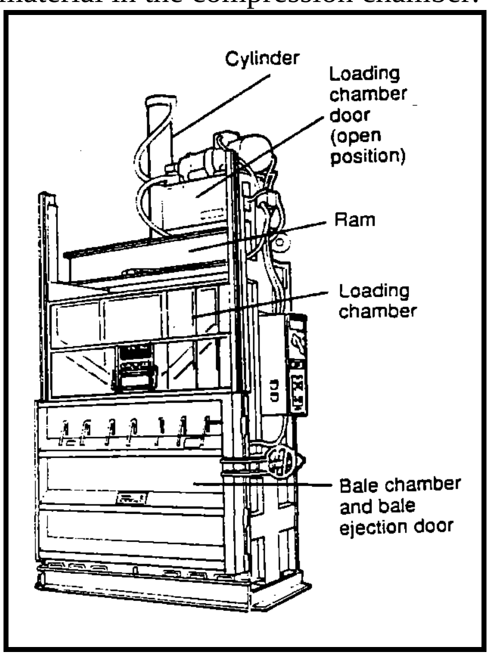
Baling. Most waste processing facilities employ at least one baler. In addition to the traditional function of baling paper and corrugated cardboard, the baler can also serve to densify ferrous metals, aluminum, and plastics. Furthermore, it can be an efficient means of reducing the volume, and thus the disposal cost, of residues or rejects from various recycling operations. Balers can be categorized into two main types: (1) vertical balers and (2) horizontal balers. All balers have the following features:

1. Feed hopper or area into which the recyclables are fed;
2. One or more hydraulic or mechanically driven rams which compress the material fed;
3. Compression area where the materials are densified; and
4. Discharge area opening from which the completed bales are ejected.

Wire ties are normally utilized in either a manual or automatic configuration to wrap wire around the bale and tie it off, so that on ejection from the compression chamber, the bale does not expand or break apart.

Vertical Baler. Vertical balers are an integral part of many commercial and industrial scrap operations and are used for baling waste paper, corrugated cardboard, ferrous and nonferrous metals, steel scrap of light gauge, foam scraps, and plastic containers and bottles. (It should be noted that when baling plastic bottles, caps should be removed to release entrapped air.)

A diagram of a vertical baler is provided below. The operator feeds material into the feed hopper and closes the hopper door, locking the material in the compression chamber. The hydraulic ram compresses the material with a downward stroke. The procedure is repeated until a sufficiently large and dense bale has been formed. The entire bale is then bound with wire strapping (plastic strapping may also be used). Tying is accomplished manually while the ram is in the down position. The process of loading, compressing, wrapping and tying the wire, and ejecting the bale takes about 20 to 30 minutes per bale. Thus, two or three bales per hour can be produced. Bale sizes can range in length from 18 to 72 in. The standard mill size, 30 by 48 by 60 in, is the most prevalent.

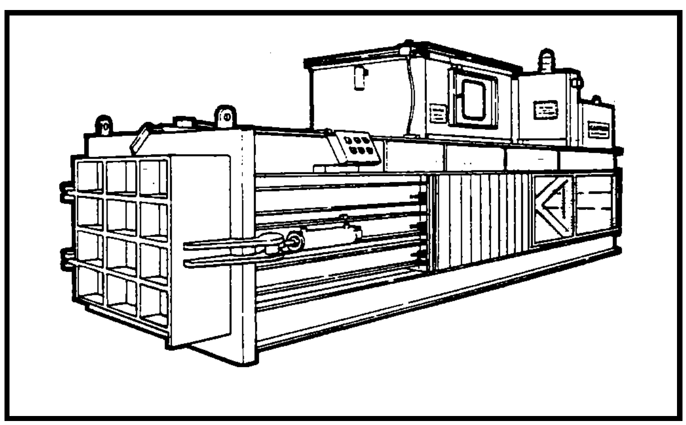


The cost of a vertical baler ranges from $4000 to $30,000. The price is a function of unit size, motor horsepower and hydraulic pressure. Motor sizes range from 1 to 30 hp, but are typically 10 hp. The unit is self-contained and easily transportable, although vertical balers do require about 13 to 15 ft of vertical clearance for installation and operation. These units are inexpensive, require low power consumption, and are versatile. However, they are slow, must be hand-fed, and cannot be automated for wire tying. They have the lowest overall production output of all balers, and are thus appropriate for only small-sized operations.

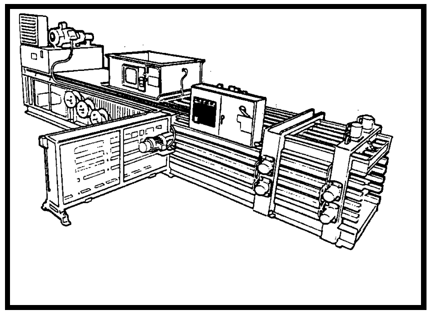
Similar to the vertical baler is the upstroke baler, except that the compression chamber is below grade, or underground. Installation requires foundations and structure about 12 to 18 ft deep. Motor sizes range from 10 to 25 hp; the 25hp unit is considered a high-density baler. These units utilize mechanical, chain-driven densification rams rather than the hydraulic rams of the vertical baler. Although upstroke balers continue to be produced in limited quantities, they are, for the most part, available on the used market. They are no longer in widespread use, primarily because of the high construction cost inherent in their permanent installation.

Horizontal Baler. Horizontal balers are fed from the top through a feed chute. The hydraulic ram is arranged in a horizontal configuration, resulting in the ability to operate with lower roof heights than the vertical baler. Motor sizes range from 5 to 150 hp. The cost of a horizontal unit can range from $7000 to $500,000. The most expensive units are high-volume units which incorporate continuous feed and automatic tying mechanisms. "Fluffers" are frequently used on horizontal balers to loosen incoming newsprint prior to baling, thus improving the stability and integrity of the bales.

CLOSED-DOOR, MANUAL-TIE HORIZONTAL BALER. This type of bailer operates similarly to the vertical baler. However, it can be hand-fed or conveyor-fed into a charging hopper rather than into the baling chamber itself. It can also be fed continuously; the ram can be in a compression cycle while material is being fed into the charging hopper on top of the ram itself during the compression stroke. Bale size is from 42 to 72 in. in length. Cross sections are normally square and range in size from 24 by 24 in to 48 by 48 in. Cost is in the $12,000 to $60,000 range. Motor size is typically 5 to 50 hp. The advantages of this baler are that it is relatively low in cost, can be fed by conveyor, and requires low headroom, little electrical power, and relatively low maintenance. The disadvantage is that while it is faster than the vertical baler, it is still relatively slow because of the manual-tie feature.



OPEN-END, AUTOMATIC-TIE HORIZONTAL BALER. The open-end automatic-tie horizontal baler is similar to the horizontal unit above but is constructed on a much larger scale and operates at much higher throughput rates. Material is continuously extruded from the baler rather than manual ejection of one bale at a time from a closed door. The open-end baling chamber incorporates tension cylinders which apply varying degrees of pressure against the baling chamber walls. These tension cylinders are extended during the bale compression until the correct bale density is determined by the unit's pressure setting. At this point, the tension cylinders ease their pressure, allowing the compressed formation to move forward. An automatic tying mechanism wraps and ties wire around the emerging bale. Motors range in horsepower from 20 to 150 hp. Maintenance is higher owing to the degree of sophistication in these units. Feed openings from the hopper can be as large as 48 by 72 in. Thus the unit can handle large cardboard boxes. A conditioning unit can also be installed ahead of the feed hopper to puncture bottles so air can be easily released on compression, thus eliminating the need to remove caps prior to baling.



These balers are particularly suited for large-scale MRF operations. They are capable of producing bales of variable lengths such that "short bales" of various materials can be produced and the operation changed over from one material to another. Thus a good-quality bale can be produced even though there may not be enough material available to produce a "whole" bale.

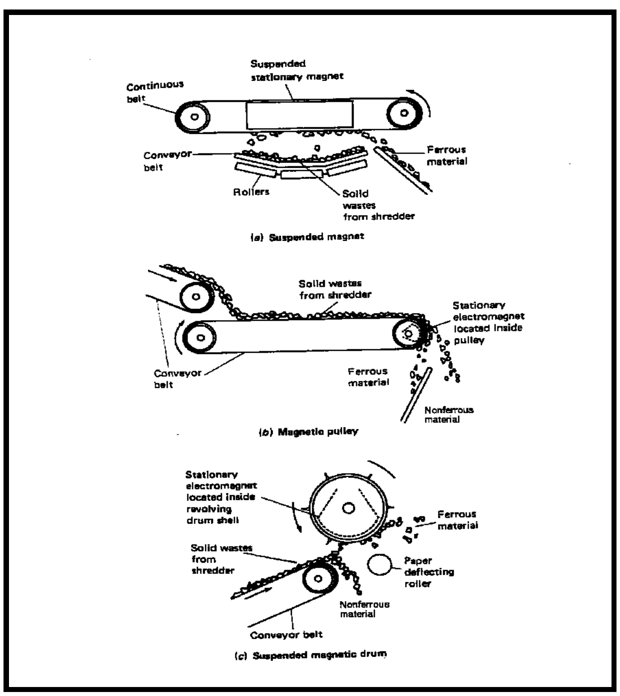
TWO-RAM HORIZONTAL, AUTOMATIC-TIE BALER. Two-ram horizontal balers are high-capacity, high-density balers. One ram is used to compress the material which is continuously fed into the feed hopper, and the second is used to eject the bale after it has been tied off. The bale ejection ram is situated at right angles to the compression stroke ram. These balers range in cost from $120,000 to $500,000 and are expensive to run and maintain. They are excellent units for high-volume paper and corrugated operations. Motor sizes range from 50 to 300 hp. Feed openings from the hopper are quite large, sometimes as much as 5 ft wide and 10 ft long. The major disadvantage to using the two-ram baler for high-volume operations is that it produces whole bales only; the second ram cannot eject a half-size bale.

Baler Selection Considerations. Vertical balers are often the choice of very small recycling operations because of their low purchase price. They are much slower and operations costs are higher than for horizontal balers. Larger recycling operations and MRFs normally employ horizontal balers. The size and baling densities vary depending upon the size of the unit selected. The price increases as the capability for higher bale density is increased.

High-density, automatic-tie horizontal balers are preferred when it is necessary to generate export bales. The added density is important, especially in baling plastics (which are very difficult to bale) because high density is required to hold the bale together. High density is also desirable for improving the value of corrugated and paper bales. The labor savings and improved shipping densities for materials offset the capital costs incurred.

An MRF which has a processing line that processes only paper and corrugated cardboard, or a high-volume, paper-only facility, may best utilize a two-ram baler. However, this baler can only make whole bales. When changing over from one material to another, a mixed bale is produced. Typically, an open-end, horizontal baler is preferable to the two-ram baler when there are frequent changeovers from one type of material or one grade of paper to another. These in-line balers can make short bales and full bales of high density. They are often more appropriate for recycling operations, while the two-ram units are best for high-volume, paper-only processing facilities or lines.

Magnetic Separation. The most common method for removing ferrous metals from commingled recyclables involves the use of magnetic separation systems. Magnets can be classified as either (1) electromagnets which use electricity to magnetize or polarize an iron core or (2) permanent magnets which utilize permanently magnetized materials to create a magnetic field.



Various types of magnet configurations have been used in recycling applications. The most common, shown in the diagram below, are the suspended belt magnet, the magnetic head pulley, and the suspended magnetic drum. In addition, specialized solid waste magnets have been designed which involve multiple stages of magnetic separation to shake contamination loose from tin cans while they are being separated.

Suspended Belt Magnets. Suspended belt magnets can be of the cross-belt or inline configuration. Cross-belt magnets are most often used in MRF operations, especially where the magnetic materials that are separated from the commingled recyclables are to be lifted off the belt, much as a handpicker would do, and conveyed at a 90^{o} angle from the primary feed conveyor into a bin or downstream item of processing equipment such as a can flattener. The in-line suspended belt magnet is discussed below together with in-line suspended magnetic drums.

The "strength" of a magnet at any location is a product of the magnetic flux density and the magnetic flux gradient. Because the magnetic core is normally smaller than the width of the feed conveyor belt, and because the flux density and flux gradient will vary at various locations across the feed conveyor, the magnetic strength will also vary. The ability to lift cans off the belt will vary accordingly. This is the reason why a lightweight, inexpensive magnet will fail to pick up ferrous metals and cans at the edges of the belt. Another reason may be that the side skirting is made of ferrous metal which may become magnetized, presenting a counteractive magnetic force. Thus, in utilizing such magnets, caution should be applied to evaluate the magnetic flux and flux gradient at various locations across the feed belt to be sure that the magnetic field strength does not fall off at the edges of the belt. Further, materials of construction in the vicinity of the magnetic field must be non-magnetic if the magnet is to work properly. It is important to recognize that magnets not only pick up the ferrous metals, but they also magnetize the ferrous metal support structure, conveyor support structure, and chutes and hoppers which are located within the field, unless these items are made of non-magnetic materials such as non-magnetic stainless steel, wood, plastic, etc. If magnetic materials are used and they become magnetized, they will inhibit the separation.

Cross-belt magnets lift the material to be separated. The magnet must be positioned above the feed conveyor at least twice the distance away from the belt as the dimension of the largest materials carried on the belt. Otherwise, materials on the belt and materials on the magnet will see mechanical or physical interference which will hinder the efficiency of separation. Moreover, magnetic metals are often covered with a burden of non-magnetic material. This overburden can also be lifted up by the strength of force exerted between the magnetic material and the magnet itself. The entrained burden of non-magnetics can thus be lifted and held to the magnetic belt, resulting in contamination of the magnetic product. Because of the lifting action carrying material through the air, the potential for entrapment of paper and plastic is less than for the head pulley magnet described below.

Head Pulley Magnets. The head pulley magnet is installed as an integral part of a belt conveyor. However, owing to the need for the magnet to be installed into the head pulley, the diameter of the head pulley is often much larger than the diameter of the normal conveyor head pulley used in recycling operations. Magnetic head pulleys are typically between 24 and 36 inches in diameter, but can be as small as 18 inches and as large as 60 inches. As material falls off the end of the conveyor, the head pulley magnetic forces hold magnetics to the belt, attracting the magnetic materials and changing their trajectory as they fall off the end of the belt. The advantage of head pulley magnets is that they are inexpensive and take up little space. The disadvantage is that they do not "lift" or tumble, thus liberating the magnetic product from contaminants. Underburden material, such as paper or plastic, which is entrapped under the magnetic metal, will be held onto the belt by the magnetic material above it and carried over into the magnetic product, causing contamination. This is more of a problem in solid waste applications than in MRF applications.

In-Line Suspended Magnetic Drums. When the magnetic product is to be conveyed parallel to the direction of the feed conveyor or lifted off the end of a conveyor (while the non-magnetic material drops to a conveyor or bin below), an "in-line" magnetic drum separator is often used. Alternatively, an in-line suspended magnetic belt can be used. This type of magnet can produce a higher-quality finished product than the cross-belt or head pulley magnet because the separation occurs while the feed stream is suspended in air and acted upon simultaneously by momentum, gravitational forces, and magnetic forces. Since separation takes place while fully suspended in the air, the potential for entrapment of non-magnetics is reduced. The magnet must be fed at a belt speed of about 400 ft/min. Thus, this type of magnet should not be fed directly by the main conveyor belt because it moves at too slow a speed. The feed stream is actually “thrown" at the magnet. The "gap" between the magnetic material and the magnet itself is low compared with the cross-belt suspended magnet described above, where the feed material just lies on the belt below the magnet. This effectively increases the strength of the magnet because the field gradient and field strength are higher near the surface of the magnet than on a belt some distance away (ex. 24 in) from the magnet surface. Efficiency of separation is increased accordingly.

Solid Waste Magnets. In applications where cans and paper are combined on the feed conveyor, and where there is a burden of contamination carried along with the magnetic product, it is desirable to "shake loose" this material from the magnetics. A special solid waste magnet has been designed to meet this need. The magnet is actually a combination of either two or three magnets. As the magnetic product is lifted to the first magnet, it is carried along the belt. As the magnetic force falls off near the end of the core, the magnetics are dropped from the first magnet. However, their forward momentum carries them into an area of space where they are then affected by the magnetic field of the second magnet and again attracted to the magnetic field. The same principle occurs a third time where there is a third magnet. Moreover, since the core of the magnet is one polarity and the box which holds the core serves as the return path for the magnetic flux field and thus, is of opposite polarity, the material tends to flip-flop while it is being transported across the three magnets. As the material moves along this series of magnets, the metal is both dropped and flip-flopped, which tends to shake off any entrapped material, making the finished product cleaner.

Magnet Selection Considerations. The following factors should be taken into consideration in the selection of either permanent or electromagnets, and in choosing the type and configuration of the magnetic installation:

1. The physical relationship between the feed conveyor and the discharge conveyor, and whether the magnetic product is to be conveyed in-line or at 90^{o} to the infeed material;
2. The width of the feed conveyor and the size weight, and cost of magnet required to effectively cover the entire conveyor width with an adequate magnetic field strength;
3. The largest size of materials on the belt and/or the tendency of the feed conveyor to encounter piling and surges of flow which could affect the physical mounting arrangement and the distance of the magnet from the feed conveyor;
4. The amount of contamination and the shape of contaminants which are intermixed with the magnetic product; and
5. Operating requirements such as electrical consumption, space requirements, structural support requirements, conveyor speeds, conveyor widths, type of magnetic cooling systems required, magnetic strength, materials of construction, maintenance, and physical access.

A head pulley magnet is typically used where low-cost separation is required to remove small amounts of "tramp" magnetic particles from materials being processed. Where large quantities of highly magnetic materials are involved, permanent magnetic separators are usually employed. These can be either drum magnets or overhead suspended belts, depending on the space requirements and personal preference. For more weakly magnetic materials, electromagnetic separators can be used. These can also be selected as drum magnets or overhead suspended belts, again depending on the space requirements and personal preference. In-line magnetic separation tends to provide a higher recovery efficiency for separation of magnetic materials; however, space constraints frequently dictate the need for cross-belt magnets. In considering whether to use a belt magnet versus a drum magnet, care should be taken to identify the potential for belt damage that can result from nails, wire, and other sharp objects. Drum magnets employ a metal surface which is more resistant to damage from projectiles.

Magnetic separators can typically accomplish a recovery efficiency of 95 to 99 percent for magnetic materials, depending on the application and burden depth of the materials being processed. The contamination level of the recovered magnetic fraction varies depending on the particle size and characteristics of the feed stream. Purities of 95 to 98 percent for the recovered magnetic fraction are considered typical. In mixed waste processing systems, recovery efficiencies of only 80 percent are typical, and the grade or purity of the magnetic product can be as low as 60 to 80 percent ferrous metal. Mixed waste magnetic material often requires reprocessing before it can be sold to a steel maker.

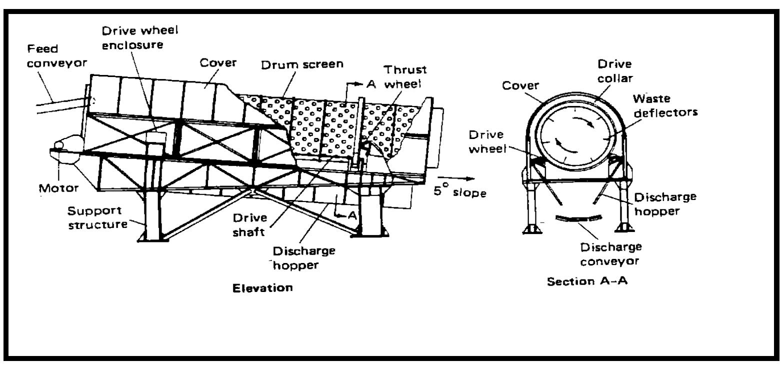
Screening. The most common types of screens in recycling applications are the vibrating screen, the rotary drum screen or trommel, and the disc screen.

Vibratory Deck Screens. Vibrating screens typically have flat decks and are mounted on an incline to assist in material movement. The screens may be designed with one deck to make a bimodal product, or may have multiple decks, but normally not more than two, in which three different-sized products can be produced.

The screen "cloth," which is often a wire mesh but can also be a solid metal plate with holes punched into it (a "punch plate"), is powered by an electric motor and drive mechanism which vibrates the material and "throws" it up and down on the screen so the that the material impinges many times on the deck, providing numerous opportunities to pass through an opening. The gyratory motion can often be adjusted to change the throw and alter the extent of upward travel versus horizontal travel down the length of the screen. The screen is often supported on springs and a motor turns an eccentric weight which imparts motion to the material which sits on the screen deck. The throw or length of stroke, the inclination of the screen, its overall length, and its vibration frequency are selected to handle the throughput and screening efficiency.

Although vibrating screens are very efficient and cost-effective for screening fine particles such as glass, they are not very efficient for separation of large materials such as paper which tend to blind over the screen openings. The disc screen and trommel offer much better performance for these types of materials.

Rotary Screen or Trommel. A rotary screen, also called a trommel, is shown in the diagram below. The screen is normally set at a downward slope on the order of 5^o so that material will flow down the screen as it is dropped and tumbled. Lifters are sometimes placed within the screen to increase the degree of lifting and dropping of material,



enhancing tumbling action and thus liberation. Trommel screens can use various types of screen "cloth" and materials of construction. Both wire-type screens and punch plate screens are in use. Rubber cloth with punched holes has also been used. Wire-type screens can be troublesome in screening material which contains cloth, wire and stringy materials because they hang across the wire screen and plug the openings. For these stringy materials, punch plate screens are the better choice. The punch plates can be removed in sections and replaced as needed to change the size of the opening.

It is important in a rotary screen operation to avoid operating the screen at too high a rotation velocity which can centrifuge the material within the screen, drastically reducing screen efficiency. Screening should be performed at about 50 percent below this "critical velocity." Maintenance requirements for trommels normally include lubrication of bearings and removal of wire, ribbon, and cloth which wrap around the trommel periodically. In mixed waste processing, this may be required on a daily basis. Generally, however, trommels require less cleaning than any other type of screen. Screen plates normally only need to be replaced every 5 years or so depending on the materials processed and the severity of application.

Disc Screens. Disc screens look very much like horizontal screens except that in place of screen cloth, there are several horizontal bars or shafts which run across the screen's width arranged perpendicular to the material flow. On each shaft are several serrated or star-shaped discs spaced evenly across the width of the screen. As the shaft turns, it carries material across the discs and bounces it into the air. The action is not as aggressive as the trommel where the material is actually lifted and dropped, but it is much more aggressive than the horizontal vibratory screen. Long stringy objects tend to flow across the bars, while smaller objects such as glass, grit, bottles, and cans tend to fall between the discs, normally onto a take-away conveyor below, depending on the size of the spacings. In spite of the fact that these screens were designed to deal with stringy items such as wood bark, which would normally blind a vibrating screen, these items can sometimes wrap around the discs. This wrapping can eventually blind the screen and entirely block the openings, especially when the opening size is set to a coarse opening of 3 to 4 in. and above. This is not a very large problem when the spacing is set to remove items of a 2- to 3-in. size range.

Maintenance for disc screens includes periodic unwrapping of cloth and stringy materials from around the discs. This may be required on a single-shift basis in the case of mixed waste processing. Another maintenance requirement is the periodic replacement of the discs that wear down. It is important to ensure that such replacement has been designed to be performed easily, as many of these screens use a welded construction which makes disc replacement very difficult and costly in both time and materials. Disc screens are employed in applications similar to those of trommels. The principal reasons for their acceptance are that they occupy less space and can be purchased for less total cost than a similar sized trommel. The trade-off is that operations and maintenance costs are higher and efficiency is lower.

Screen Selection Considerations. Factors to be considered in selection of screening equipment include:

1. Particle size, particle size distribution, bulk density, moisture content, particle shape, and potential for the material to stick together or entangle;
2. Screen design characteristics including materials of construction, size of screen openings. shape of screen openings, total surface screening area, rotational speed for

rotary drum screens and oscillation rate for vibrating screens, length and width for vibrating screens, or length and diameter for rotary screens;

3. Separation efficiency and overall effectiveness; and
4. Operational characteristics such as energy requirements, routine maintenance, simplicity of operation, reliability, noise and vibration, and potential for plugging.

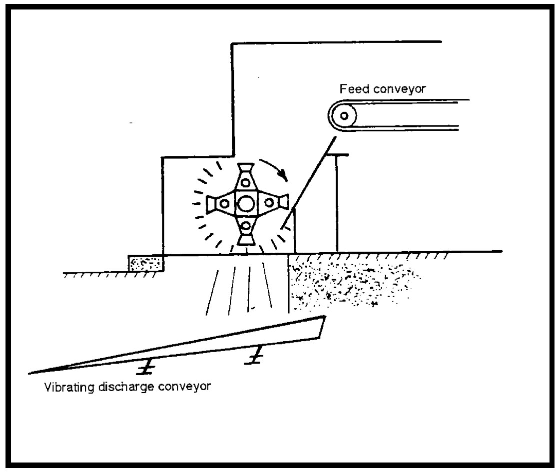
Thus the selection of screens for a given application requires considerable attention to the characteristics of the materials being processed. Vibrating screens offer inexpensive sizing for free-flowing granular materials such as glass that do not tend to blind the screen or become entrapped with other materials. Trommel screens are better suited for large-particle applications where blinding is anticipated or where materials become entrapped and require tumbling to free them for removal by the screen. The performance of disc screens lies between that of vibratory screens and trommels, as does the cost and size of the equipment. Typically, disc screens are utilized in applications where rigid materials such as wood chips are being screened to remove the grit and dirt. Disc screens are prone to wrapping (and thus higher maintenance) when long flexible items such as wire, rope, and textiles are present in the feed stream.

Size Reduction. Several types of size-reduction equipment are utilized to rip, cut, tear, and pulverize commingled recyclables, liberating materials that are bound together so they can be separated from each other in downstream unit operations. This equipment is also utilized to densify materials prior to shipping to reduce storage, handling, and transportation costs.

Types of size-reduction equipment include:

1. Horizontal shaft hammermill;
2. Vertical shaft hammermill;
3. Vertical shaft ring grinder;
4. Flail mill;
5. Glass crusher and pulverizer;
6. Granulator and knife shredder; and
7. Rotary shear shredder.

Horizontal Shaft Hammermill. The downrunning horizontal shaft hammermill (shown below) is the most common type of shredder utilized in recycling operations. It is also the unit most typically utilized in automobile shredding operations, composting operations, and mixed waste processing plants. Material is fed through a feed hopper, falling into a "hammer circle." The hammers, which are attached to a rotor or shaft, impact the infeed material, crushing it, pulverizing it, and tearing it into smaller pieces. Below the hammer circle are a series of cast grates which are similar to a screen with very wide openings which may range in size from 3 by 6 to 14 by 20 in. The material remains inside the hammermill and is crushed and torn between the hammers and the grates, until its size is sufficiently reduced to pass through the grates, where it is discharged onto a belt or vibrating pan conveyor below.



Downrunning shredders require hammer changes frequently, or alternatively, the hammers must be welded up by adding welding material onto the hammer itself to replace the metal which is worn off during operations. For example, a shredder having 4 rows of hammers of 9 hammers each would require welding on 36 hammers. The frequency of hammer replacement depends on the maintenance procedures employed, the tonnage of material processed per week, and the type of material processed.
A center feed reversible horizontal shaft hammermill is similar to a downrunning hammermill, except the feed material is fed directly down on top of the hammer circle. The feed hopper tends to be higher in height to reduce the potential for material being "baseballed" out of the feed opening of the mill. One of the advantages of a center feed mill is that the direction of shaft rotation can be reversed. The hammermill can be kept running without having to weld up the hammer faces or reverse the hammers themselves to keep the hard or sharp face of the hammers working on the feed material. Thus the operating time between scheduled maintenance can be twice as long. A disadvantage of these mills is that they tend to have a lower throughput for similar size machines than the downrunning mills, sometimes as much as 25 percent lower, especially when operated in the reverse rotation direction. They also tend to exhibit a greater tendency for "blowback," dusting, and ejection of feed material out of the feed hopper. They are also more expensive.

A center feed mill characteristically has an impact breaker, which is sometimes adjustable either mechanically or hydraulically to allow large items to pass. It also serves as an impact plate on which materials are pulverized. This type of shredder is similar in design to a pulverizer, except that it has grates installed in the bottom to control the particle size of tough-to-shred items.

Vertical Shaft Hammermill. A vertical shaft hammermill differs from the horizontal mill in that there is no grate. Instead, the discharge material passes through an annulus which controls the exit particle size. This shredder tends to offer less control over maximum particle size than the horizontal shaft hammermills discussed above. The infeed material is fed into the top of a chute which feeds into a breaker plate and hammer area. As the material is beat and hammered, it works its way down the cone-shaped machine. The distance between the hammers and the breaker plate constantly decreases, thus continuously working to reduce particle size.

Maintenance tends to be lower for the vertical mill than for the horizontal mills. However, both types are very reliable and can handle a large range of massive materials. In a vertical shaft mill, all the hammers are not changed at once. Rather, new hammers are replaced on the shorter arms located at the bottom of the mill and the worn hammers are then moved up to a higher location where sharpness is not so critical. Finally, when they are moved to the top position, they must be either replaced or rewelded. Most installations utilizing vertical shaft hammermills replace the hammers rather than retip or weld the hammers when they become dull.

Vertical Shaft Ring Grinder. A vertical shaft ring grinder appears externally similar to a vertical shaft hammermill. However, internally, rather than having hammers pinned to the end of each rotor disc on the shaft, a gear-type device is positioned in place of a hammer. These mills provide more of a mashing and grinding action rather than the tearing, pulverizing, and ripping action of the horizontal and vertical shaft hammermills. This grinding action is particularly good in densifying materials such as metal cans, and tends to produce a nuggetized metal product of quite high density. Although vertical ring grinders saw significant use in early solid waste operations, to-date, they have not been applied very much in recycling operations.

Flail Mill. A flail mill is somewhat like a hammermill, but without grates. There are several types of flail mills including single and double shaft, and horizontal fed. Material is fed into the top of the single and double shaft mills through a feed chute. Horizontal fed mills are fed from a conveyor into the front of the hammer circle. The flails are attached to a rotating shaft function as knives. These knives can cut open bags, liberating the contents. Paper is torn and ripped. Cans pass through the mill relatively unaffected while glass is pulverized into very fine sizes. Because the flail mill does not have grates, it is not a good device for controlling particle size - especially the particle size of rags and other similar material which is very hard to shred.

Pulverizer and Glass Crusher. A pulverizer is much like a flail mill but utilizes a breaker plate and hammers rather than knives. These machines have impact bars and impact plates which assist in the pulverization of glass and other friable materials. As these materials fall into the mill, glass is struck by the hammers and thrown against the impact blocks where it is again smashed into smaller pieces. Pulverizers tend to be much smaller in size than hammermills, and normally they do not have grates. There are many different types of glass crushing and pulverizing equipment. Noise control and dust control are important environmental mental considerations which must be addressed during installation of a glass processing system. The design of feed conveyors and the interface to the feed hopper and dribble chutes require experienced design knowledge if they are to be done properly.

Granulator and Knife Shredder. A granulator or knife shredder employs very sharp, long knives for cutting materials such as rags and plastic bottles into small pieces for later separation. The knives are attached to a rotor and are positioned horizontally across the entire width of the shredder. As the shredder rotor rotates, the knives pass by an impact or cutting block at high speeds. Material caught between the impact block and the knife is cut. The cutting action is such that the material which is being size reduced is cut into particles on the order of 1/4 to 3/4 in. in size. It is important to note that hard materials such as glass and metal should not be fed into this type of equipment, as they would damage the knives. Granulators are typically used in plastics processing operations to reduce the particle size of bottles and increase density. They can also be used on paper products or rags.

Rotary Shear Shredder. The rotary shear shredder is essentially a continuous rotary shear or scissors. Two counterrotating shafts rotate in opposite directions with very close spacings between the cutters which are placed on each shaft. This type of shredder tends to cut feed material into strips which are the same dimension as the cutter width or spacing. Since the cutters tend to be not less than 1 in. in size, this would be the smallest cutting dimension. Cutters have also been configured up to 6 or even 8 in. in size either by making larger cutters (normally not larger than 4 in) or by stacking cutters next to each other such that three 2-in. cutters would produce a 6-in. total cutter spacing.

The cutters are oblong rather than circular. Material passes down through openings which form between the top of opposing cutters from opposite shafts. The rotary shear shredder offers one significant advantage over the higher-speed mills discussed above and that is a much lower potential for explosions and dust generation from processing waste materials. Hooks are positioned on each cutter to grab material which enters the mill and pull it into the shear where it is cut. These mills are capable of cutting whole truck tires. They are also used in some solid waste shredding operations to open bags and liberate their contents.

Unlike the hammermills described above, the shear shredder operates at very slow speeds and does not pulverize glass or significantly reduce the size of cans, many of which, depending upon the size of the cutters, can actually pass through the machine unaffected for a machine having 4-in. cutters.

Size Reduction Equipment Selection Considerations. The selection of size reduction equipment is dependent primarily on the characteristics of the feed stream and the process needs of the size-reduced materials. Pulverizers and crushers are preferred where friable materials are being processed and size reduction can be accomplished by impact alone. Flail mills are used when materials require only coarse shredding, and reduction to a specific particle size is not a factor. Hammermills are normally employed where coarse size reduction via cutting is required and a wide-ranging particle size can be accepted, with a controlled maximum particle size passing through the grate. Vertical shaft hammermills are typically applied in place of a horizontal hammermill when the maximum particle size passing through the grate is not critical.

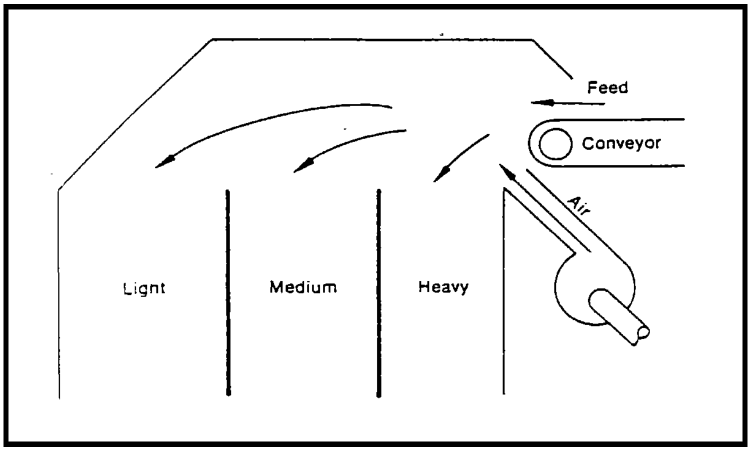
Pulverizers, flail mills, and hammermills tend to be noisy and are likely to generate dust during operations. They are also susceptible to explosions due to the presence of flammable materials and pressurized containers (e.g., aerosol cans, gas canisters, propane cylinders). Shear shredders are selected where the potential for explosions is high and the need to minimize dust generation is important. Because of its lower operating rotation speed, abrasion on the cutters of the shear shredder is less and the horsepower requirement is typically lower than for a hammermill. Knife mills are employed where fine particle-sized discharge is required and tight control over size distribution is important. Care must be taken to ensure that difficult-to-shred items (metals, rocks, etc.) are removed prior to entering a knife mill to prevent damage to the knives.

Air Classification**.** Air classification has many applications in the processing of recyclable materials. Among many other applications, air classifiers are used to separate the following: (1) labels from granulated plastic bottles, (2) lighter plastic bottles and cans from heavier glass bottles, (3) paper and plastic films from bottles and cans once these materials are liberated, and (4) fine glass and dirt from coarse glass.

Air classifiers are categorized into the following general types:

1. Horizontal air classifier and air knife;
2. Vertical column;
3. Zigzag;
4. Rotary drum;
5. Multiple-stage aspirators; and
6. Vibroeluriators.

Horizontal Air Classifier and Air Knife. A horizontal air classifier is shown in the figure below. Material is fed by conveyor and dropped into the airstream over an air blower.



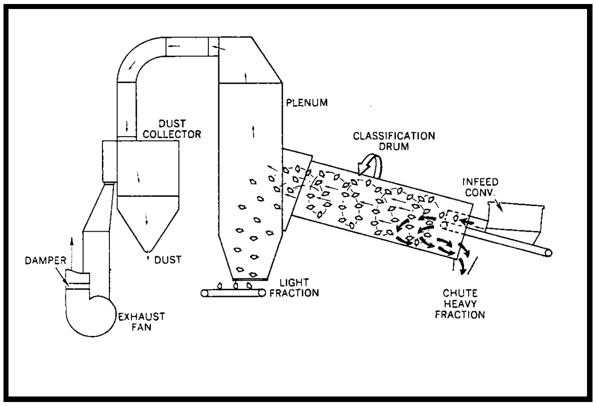
Heavy objects which are more affected by gravitational force than by the pneumatic forces of the air current drop quickly through the air current while lighter more air buoyant objects are carried by the airstream farther distances or are carried away with the airstream into a cyclone which acts to separate the light entrained matter from the airstream itself. (Material which is not dropped out of the airstream by the cyclone mechanical separator is later separated from the airstream using either a bag filter or a wet scrubber.)

An air knife is similar in concept to a horizontal air classifier. Here the mixed waste sees an air separation step as it is being fed onto a disc screen. The air knife removes some of the very light paper and plastic material along with very fine glass particles which will also fly just before it is being dropped onto a screen for size separation.

Vertical Column. The vertical column air classifier acts much like the horizontal air classifier or air knife except that the material which is fed is dropped straight down through the air column which is a vertical chamber. The separation is bimodal in that material is either heavy or light (goes up or down), whereas in some horizontal air classifier systems, many different fractions can be recovered depending upon the trajectory of the products across the horizontal distance of the air classifier. Vertical column air classifiers have been utilized at high capacities in the solid waste and composting industries.

Zigzag. The zigzag air classifier was developed to allow multiple stages of classification to occur in order to improve the quality of separation. This type of air classifier is similar to the vertical air classifier except that material tumbles as it drops through the air current falling from one shelf onto the next. While in principle this multiple action appears to offer great benefit, in practice much of the separation takes place in the first stage or on the first zig. Material which is liberated or separated in later stages of the air classifier must pass through the burden above before it can be separated and reclaimed as a "light." This is a very tortuous path from the lower stages to the upper stages of the air classifier and thus, unless the unit is lightly loaded, the burden falling from above will tend to take light materials freed in lower stages out with the "heavy" fraction.

Rotary Drum. A rotary drum air classifier resembles a slightly inclined large barrel on its side which rotates slowly while a gentle airstream passes through it (see diagram below). The rotary drum air classifier characteristically performs its separation at much lower air velocities than other air classifiers. In essence, it acts much like the horizontal air classifier except the separation is performed many times and at lower velocities. The material to be separated is introduced near the upper end of the drum. The drum normally has lifters inside of it which lift the waste and drop it repeatedly as air is being drawn up the inclined drum and while the drum turns. The heavy material, which is more affected by gravitational forces than by the pneumatic forces, "walks" down the incline and out the bottom of the drum while the lighter material either is entrained in the air current and flies up the drum or alternatively "walks" up the drum, after repeated drops in the airstream.



Experience has shown the rotary drum air classifier to be the most efficient type of air classifier available in terms of making a high-quality separation. It also has the advantage of being able to separate materials of large particle size. The major disadvantage is its large physical size and mechanical complexity which make it more expensive to purchase and maintain than other air classifiers of similar capacity. Thus, if critical separation efficiency is important, the rotary drum is an ideal candidate for selection, but if very rough separation is all that is required, then other types of air classifiers offer a lower-cost alternative.

Multiple-Stage Aspirator. This air classifier employs an upward flow of air to lift lighter materials away from heavier materials. The multiple-stage aspirator has openings along its vertical length which allow outside air to "sweep" through the cascading infeed materials at various points to lift materials away into the airstream. Heavy materials fall through the air classifier and exit via gravity at the bottom.

Vibroelutriator. The vibroelutriator has the characteristics of both an air classifier and a vibratory screen. Material to be separated is introduced at the upper end of a device somewhat resembling a horizontal inclined vibrating screen which has a device resembling a fume hood above it. As the material is vibrated down the screen deck, air is sucked up the hood both from the bottom discharge area and from under the screen cloth. Light material such as labels and other fine particles are lifted by the air currents and drawn up the feed hood where they removed from the airstream by cyclones and bag filters. The heavier materials travel down the screen cloth and are discharged at the lower end. This separator has the advantage of long residence times in the separation zone and vibrating the material to provide tumbling action. The device is better for small particle sizes rather than large particle sizes because the tumbling action would not be sufficiently aggressive for large particle sizes on the order of 2 inches and above.

Air Classifier Selection Considerations. The selection of an air classifier for a particular application is dependent primarily on the separation efficiency required and the money and facility space that can be committed. The least expensive equipment is a vertical column which requires a minimum of space but is the least efficient type of air classifier. The zigzag air classifier is slightly taller than a vertical column unit and has internal veins which add to the purchase price. The zigzag offers a higher separation efficiency than the vertical column but is sensitive to the infeed particle size.

The horizontal air classifier can process materials having a larger particle size than a zigzag unit; however, it requires a considerable amount of floor space. The vibroelutriator provides a higher efficiency than the horizontal air classifier because the materials are spread uniformly and the vibration tends to stratify the lighter materials on top for easy retrieval. The vibroelutriator is considerably higher in cost than the horizontal air classifier. The rotary drum air classifier is the most efficient of all air classifiers and can accommodate a wide range of particle sizes. Materials are repeatedly tumbled and have multiple opportunities for separation. However, the rotary drum is the highest in cost and requires the greatest amount of floor space.

Eddy-Current Separation. Eddy-current separation is utilized to separate conductors from nonconductors. The principle of separation relies upon Faraday's law of electro-magnetic induction. In essence, when a magnetic field passes through a conductor (e.g., when a conductor experiences a change in an applied magnetic field), it induces in that conductor, or generates in the conductor, an electric current. That electric current also has associated with it a secondary magnetic field which always opposes the primary magnetic field.

If the conductor is in the shape of a ring, current flows in one direction and can easily be measured. If the conductor is a solid piece of metal, current is more difficult to observe and measure, owing to the complex current path, but the current is there just the same. Such currents which are closed within more or less solid pieces of metal are known as eddy currents, because they resemble eddies observed in liquids. Eddy currents give rise to a physical force that is the basis of a separation process. In general, all conductors resist changes in magnetic field strength. It has been established that the repulsive force set up by eddy currents is a function of particle size, particle geometry, and the ratio of conductivity to mass density, in addition to such factors as magnetic field strength and frequency. The opposing forces between the primary and secondary magnetic fields are utilized in eddy-current separators to make a separation between materials. The principal criteria used to make the separation have to do with conductivity and mass. Aluminum has a lower conductivity than copper but also has lower mass. Aluminum has the lower mass-conductivity ratio and thus is more affected by an eddy-current separator; that is, aluminum sees a greater trajectory than copper when subjected to an eddy-current separator. The force exerted on a particle increases with the fourth power of the radius, and thus bigger particles are much more affected than small particles. Shape and thickness can also be factors in such separations.

Eddy-current separators create forces on conductors but not on nonconductors. Thus non-magnetic metals may be separated from plastics, wood, rubber, etc., using this principle.

There are four principal types of eddy-current separators:

1. "Linear motor" separator;
2. "Popper" or "Pulsort" separator;
3. Stationary permanent magnet or sliding ramp separator; and
4. Active permanent magnet or rotating drum separator

In the linear motor separator, a traveling magnetic field is generated by an electromagnet energized by an electromagnetic field. In essence, this separator works like an induction motor in which the rotor has been removed and the stator has been opened up and is lying flat. The forces exerted by the stator which would normally rotate the armature or rotor are instead utilized to move conductors which pass over the flat, or linear, induction motor. The metal particles are moved laterally across the belt and roll off of one side or the other.

In the Popper separator, particles are passed over a rapidly changing magnetic induction coil capable of generating very high currents through the use of large capacitor banks which are discharged intermittently. The conductors which are over the coil when it discharges see very high forces and are "popped" off of the belt. When the popper is set for small particles and sees a large particle, very high forces (which can be dangerous) can be generated because the separation force increases to the fourth order of the particle size. Large particles can be ejected from these separators at bullet speeds.

In the sliding ramp separator, permanent magnets are used to make the separation, and thus this is called a passive separator while the others which use a change in an electromagnetic field are termed "active." In this type of separator, magnets of alternating polarity are arranged in stripes on a flat, inclined board, or ramp. The materials to be separated are conveyed to the top of the ramp and slide down using gravitational force. As the conductors slide over the top of the magnets, they see an oscillating magnetic field similar to the active field which is generated in the stator of an electric motor. Much like the linear motor separator the conductors see a force that moves them over to one side while the nonconductors slide down the ramp unaffected by the oscillating magnetic field. In this case, the work is done by gravity and there are no capacitors or any moving parts.

Furthermore, the forces are never very high because large particles cannot experience forces which exceed their own gravitational force. The drum-type eddy-current separator is much like the ramp-type separator except that the magnets are attached to a drum which is in essence a continuous ramp. The permanent magnets are rotated under an outer shell or under a belt. The conductors are then moved by the eddy-current forces.

Solid waste processing equipment is available from numerous suppliers through-out the United States. An extensive listing of MSW companies, their products and services are provided in Appendix B of this Task. This listing was previously published in MSW Management, and is reprinted here with their permission.

Application of Solid Waste Processing Equipment to Shipyards. Many municipal waste processing facilities have been built which do not generate a positive cash flow due to the vagaries in the waste disposal and recycling markets. Some of these facilities have been sold to private waste management companies, exist on taxpayer subsidies, or have been closed completely. Can a shipyard take advantage of lessons learned from municipal and private waste management experiences to both reduce cost and increase income from their shipyard/ship derived waste streams? In an attempt to answer that question and to identify which type of waste management facility would be best suited to shipyard operations, a waste allocation study was performed on the waste derived from two shipyards. One shipyard, National Steel & Shipbuilding Company ("NASSCO") engages in mostly new construction and major ship conversion work. The second shipyard, Southwest Marine, Inc. - San Diego Division ("SWM") engages in mostly ship repair operations. A waste allocation study was performed on both of these facilities to empirically determine if there was a qualitative difference in their respective waste.

Shipyard Waste Allocation Study. AEI contracted with EDCO Disposal Corporation, located in Lemon Grove, California to conduct the waste allocation study of shipyard waste stream. EDCO has successfully operated both a MRF and a Transfer Facility in San Diego County for twelve years and was uniquely qualified to conduct this study. EDCO agreed to receive waste from both shipyards at their MRF, manually segregate the waste load into various components, then dispose of any remaining waste which did not have a recyclable value. Additionally, EDCO provided estimates of the labor effort required to segregate the waste and the current value of recovered materials.

NASSCO and SWM were asked to fill waste containers with un-segregated loads of waste from cross sections of work areas within the shipyards, including solid waste generated from ship's force aboard vessels within their facilities. When the waste containers were full, EDCO transported the waste to their MRF, where it was deposited on the floor and sorted by experienced waste segregation personnel. EDCO then reported their findings to AEI. The results of these waste allocation studies are presented as Case Studies, below.

NASSCO Case Study. NASSCO provided a total of 60 cubic yards of non-segregated waste to EDCO for this study. NASSCO estimates its current annual generation of solid waste to be 50,000 cubic yards (approx. 16,000 skip tubs). Therefore, the study volume represents approximately 0.12 percent of NASSCO's annual waste volume. This value for annual waste volume does not include special or hazardous waste, which is managed separately. The EDCO allocation study of NASSCO's waste yielded the following data:

Incoming waste:

Weight (lbs)	Volume (cubic yards)	Lbs/cubic yard
21,400	60	357.3

Segregation Efficiency

Volume (cubic yards)	Man-hours	Cubic Yards/hour
60	6.75	8.89

Allocation Fractions:

Waste Fraction	Weight (lbs)	Percent of Total (%)
Wood	506	2.36
Corrugated Cardboard	442	2.06
Plastics	30	0.14
Scrap Metal	684	3.19
Concrete (1 piece)	2,300	10.72
Trash	16,298	76.01
Uncounted	1,140	5.32
Totals	21,400	99.8

AEI believes that the disposal of concrete on a regular basis from the shipyard is an unlikely possibility. Therefore, an adjusted table of allocation fractions was derived by removing the weight of the concrete from the total weight and recalculating the percent of total values of each waste fraction. The adjusted table of allocation fractions is presented below:

Adjusted Allocation Fractions:

Waste Fraction	Weight (lbs)	Percent of Total (%)
Wood	506	2.64
OCC	442	2.31

Plastics	30	0.18
Scrap Metal	684	3.58
Trash	16,298	85.32
Uncounted	1,140	5.96
Totals	19,100	99.99

Based on the above percentages of each waste fraction, annualized amounts of each waste were projected below:

Projected Annual Waste Allocation:

Waste Fraction	Weight (lbs)	Percent of Total (%)
Wood	434,280	2.64
OCC	379,995	2.31
Plastics	29,610	0.18
Scrap Metal	588,910	3.58
Trash	14,035,140	85.32
Uncounted	980,420	5.96
Totals	16,448,355	99.99

The current estimated value (income or cost) of the projected annual waste allocation fractions is presented in the table below:

Waste Fraction	Value ($/lbs)	Annual Value ($)
Wood	0.00	0.00
OCC	0.02	8,205
Plastics	0.40	11,844
Scrap Metal	0.10	58,891
Trash	(0.0625)	(877,196.25)
Uncounted	0.00	0.00
Totals		(789,256.25)

Southwest Marine Case Study. SWM provided a total of 20 cubic yards of non-segregated waste to EDCO for this study. SWM estimates its current annual generation of solid waste to be 10,000 cubic yards (approx. 3,400 skip tubs). Therefore, the study volume represents approximately 0.2 percent of SWM's annual waste volume. This value for annual waste volume does not include special or hazardous waste, which is managed separately. The EDCO allocation study of SWM's waste yielded the following data:

Incoming waste:

Weight (lbs)	Volume (cubic yards)	Lbs/cubic yard
2,500	20	125

Segregation Efficiency:

Volume (cubic yards)	Man-hours	Cubic Yards/hour
20	2.25	8.89

Allocation Fractions:

Waste Fraction	Weight (lbs)	Percent of Total (%)
Wood	0	0.00
Corrugated Cardboard	128	5.12
Plastics	6	0.24
Scrap Metal	4	0.16
Trash	2,352.6	94.30
Uncounted	4.5	0.18
Totals	2,495.1	100

Based on above percentages of each waste fraction, annualized amounts of each waste were projected below:

Projected Annual Waste Allocation:

Waste Fraction	Weight (lbs)	Percent of Total (%)
Wood	0.00	0.00
Corrugated Cardboard	64,000	5.12
Plastics	3,000	0.24
Scrap Metal	2,000	0.16
Trash	1,178,750	94.30
Uncounted	2,250	0.18
Totals	1,250,000	100.0

The current estimated value (income or cost) of the projected annual waste allocation fractions is presented in the table below:

Waste Fraction	Value ($/lbs)	Annual Value ($)
Wood	0.00	0.00

OCC	0.02	1,280
Plastics	0.40	1,280
Scrap Metal	.1	200
Trash	(0.0625)	(73,671.88)
Uncounted	0.00	0.00
Totals		70,911.88

Solid Waste Value Analysis. This value analysis is used to determined two key parameters: the annual net difference in disposal cost, and the value of "Liability Avoidance" ("LA") factor, resulting from manual segregation of waste in the shipyard.

The annual net difference in disposal cost determines if the process of manually segregating waste into recyclables (which can be sold) and sanitary waste (which costs money to dispose of) results in an overall increase or decrease of cost to the shipyard.

The LA factor is defined as the net annual difference in disposal costs, divided by the total annual disposal in tons. This value represents the value (income or loss) difference to the shipyard to discover and remove hazardous waste inadvertently disposed of in the solid waste system. A positive LA indicates that reduction in cost for disposal of waste after segregation, plus the value of the recyclables, results in lower overall cost to process and dispose of solid waste. In essence the cost of searching for and removal of hazardous waste is subsidized by the value of the recyclables, plus lower disposal cost resulting from reduced disposal volume. A negative LA indicates that the costs of searching for and removing hazardous waste cost the shipyard more than mere disposal of the solid waste stream along with recovery of recyclable materials.

The LA factor is not intended to indicate whether complete removal of hazardous waste from the solid waste stream is cost effective. The liability of inadvertent disposal of hazardous waste cannot be accurately quantified monetarily. The LA factor merely provides information cost per ton to manually segregate and reclaim recyclables as well as hazardous waste. In this manner, the shipyard can obtain the necessary data to perform a complete life cycle cost analysis of its solid waste process program.

Using the data derived from the allocation analysis performed on NASSCO and SWM, a Solid Waste Value Analysis ("SWVA") was performed (see Appendix A for complete data form). A data summary for both cases histories is provided below.

Analysis Parameter	New Construction	Repair
Net Annual Difference ($/year)	$139,776.25	($10,925.25)
Liability Avoidance ($/ton)	$15.65	($17.48)

The data analysis indicates a tremendous difference in economics between a new construction shipyard and a repair facility. By implementing a manual waste segregation program in the new construction yard, the total overall cost of processing and disposal of solid waste could be reduced by nearly one hundred and fifty thousand dollars ($150,000.00) and while paying for a hazardous waste identification and removal program at the same time. Both cost and liability are greatly reduced. However in the case of the repair facility, the cost of implementing a manual segregation program would result in net increase in costs of ten thousand nine hundred twenty five dollars and twenty five cents ($10,925.25). This increase in cost to the shipyard is the value require to implement a hazardous waste identification and removal program for its solid waste stream.

For both types of facilities, i.e. new construction and repair, the most important variable in reducing the overall cost of the solid management program was not the added income from recovering recyclables, but cost avoidance in reducing the gross disposal volume. For example, for the new construction facility, 65.6 % of the total cost reduction was achieved by avoiding the disposal of the recovered materials, whereas the current value of the recovered materials was merely 34.35 % of the cost avoidance.

This difference in cost savings achieved from disposal avoidance versus the income from the value of the recyclables is a strong indication that an in-plant materials recover program is less driven by the value of the recyclables than the cost of disposal. For example, if the value of the recyclables is reduced by 50 % the overall cost savings is only reduced by 17.17 %. However, if the cost of disposal is reduced by 50%, the overall cost savings is reduced by 32.8%. This same relationship holds true of increases in recyclable value and disposal costs.

Conclusions. The result of the case studies and SWVA presented above indicate the following general conclusions:

1. A significant difference in the waste streams exists between new construction and repair shipyards, mostly due to the presence of a greater percentage of scrap metal in new construction waste streams. The presence of a larger percentage of metals in the waste both increases the value of the material recovered during segregation, and also has the greatest impact in reducing the tonnage of material disposed, thereby significantly reducing the cost of disposal.

2. A manual waste segregation program in new construction yards is likely to more than pay for itself in reduced disposal fees and income from recovered recyclables. A waste segregation program in a repair facility will mostly likely result in an increase in overall costs, but achieve a significant reduction in liability associated with inadvertent hazardous waste disposal.

Those factors that have the greatest impact on the overall cost of the solid waste management program are the cost of disposal, density of the waste steam, segregation efficiency and the labor rate. Of these four variables, the shipyard has the greatest opportunity to improve overall value of the waste segregation program by increasing the segregation efficiency through employment of waste segregation equipment, rather than manual labor.

Appendix A

Manual Segregation of Waste Cost Analysis

Manual Segregation of Waste Cost Analysis - New Construction

Item or Element	Input	Calculated
Disposal Cost ($/ton)	$ 125.00	
Annual Waste Volume (cubic yards)	50,000	
Average Waste Density (lbs/cubic yard)	357.3	
Annual Waste Tonnage (tons)		8,932.50
Annual Disposal Cost ($/year)		$ 1,116,562.50
Segregation Efficiency (yards/hour)	8.89	
Segregation Labor Rate ($/hour)	$ 16.00	
Segregation Cost ($/yard)		$ 1.80
Annual Segregation Cost ($/year)		$ 89,988.75
Annual Tonnage of Recyclables (tons)	1,206.60	
Annual Value of Recyclables ($/year)	$ 78,940.00	
Annual Tonnage Disposed after Segregation		7,725.90
Annual Disposal Cost ($/year)		$ 965,737.50
Net annual difference in cost (income or loss)		$ 139,776.25
Liability Avoidance ($/ton)		$ 15.65

Manual Segregation of Waste Cost Analysis - Repair

Item or Element	Input	Calculated
Disposal Cost ($/ton)	$ 125.00	
Annual Waste Volume (cubic yards)	10,000	
Average Waste Density (lbs/cubic yard)	125	
Annual Waste Tonnage (tons)		625.00
Annual Disposal Cost		$ 78,125.00
Segregation Efficiency (yards/hour)	8.89	
Segregation Labor Rate ($/hour)	$ 16.00	
Segregation Cost ($/yard)		$ 1.80
Annual Segregation Cost ($/year)		$ 17,997.75
Annual Tonnage of Recyclables (tons)	34.50	
Annual Value of Recyclables ($/year)	$ 2,760.00	
Annual Tonnage Disposed after Segregation		590.50
Annual Disposal Cost ($/year)		$ 73,812.50
Net annual difference in cost (income or loss)		$ (10,925.25)
Liability Avoidance ($/ton)		$ (17.48)

Appendix B
MSW Company Products and Services

Collection Equipment, Products and Services

The Following companies offer products and services pertaining to MSW collection and activities

A&L Systems, Livonia, MI, Art Lake, (313) 513-7100, daytime lights, automatic lubrication
A-I Produces, Brampton. ON, Cathy Tedesco, (905) 451-4800, plastic recycling containers
Abbott Tachograph, Inc., Pine Bluff, AR, John Ware, (501) 535-4973, vehicle and collection system activity recorders
Accurate Industries, Inc., Erial, NJ, Seth Weingarten, (800) 220-2228, compactors, balers, roll-offs, containers
Advantage Lift Systems, Inc., San Diego, CA, Clay Carlay. (619) 453-2841, heavy duty vehicle lifts
Air-Weigh Scales, Eugene, OR, Sales Director, (503) 342-1521, on-board truck and trailer scales
Alloy Trailers, Inc., Spokane, WA, Richard Peirone, (509) 455-8650, live floor refuse trailers, container chassis, steel rail containers
American Isuzu Motors, Inc., Whittier, CA, Dan Cutler, (310) 699-0500, truck cabs/chassis
American Rolloff, Trenton, NJ, Fred Fisher, (609) 588-5400, rolloff trucks and trailers
Automated Waste Equipment Co., Inc., Trenton, NJ, Fred Fisher, (609) 588-5400, rolloff and solid waste collection equipment
B.A.G. Corporation, Dallas, TK Cindy Finley. (214) 340-7060, fabric bags for collection and material handling
Bailey Manufacturing Corporation, Knoxville, TN, John Sprouse. (423) 588-4010, custom hydraulic cylinders
Barker Products, Greenville, SC, Bob Wyman, (803) 288-7384, hydraulic lift units for semi-automated rollout containers
BenLee, Romulus, Ml, Steve Doughty, (313) 722-8100, scrap, waste, and sludge containers
Bes-Pac, Easley, SC, Danny James, (864) 859-6030, compactors, rear-loaders, side containers, vehicles
Best Litter Receptacle, Inc., Florance, SC, Carol Doty, (803) 667-8188, concrete trash, recycling and liter receptacles
Bonar Plastics, Lindsay, ON. Susan Burns, (705) 324-6701. recycling related products
Bouldin & Lawson, McMinnville, TN, Wade Sparkman, (615) 668-4090, compost baggers
Bridgeport Refuse Trucks, Bridgeport, TX, Trey Stamps, (817) 683-5477, refuse vehicles
Bruce Mooney Associates, Inc., Allison Park, PA, Bruce Mooney, (800) 454-2686, recycling systems and equipment
Cascade Engineering, Grand Rapids, MI, Don HoIm, (800) 968-2278, containers
Clement Industries, Minden, LA, Bill Garrison, (318) 377-2776, roll-off and dump trailers
Columbian Steel Tank Co., Kansas City, KS, Pat Wilson, (913) 621-3700, belted and steel tanks
Consolidated Fabricators Corporation, Vernon, CA, Barbara Ross, (800) 339-8335, front/'rear-load containers, roll-offs, hoppers
Continental Manufacturing Co., Earth City, MO, Jack Benninghofen, (314) 770-9949, truck containers, collection containers

Crane Carrier Co., Tulsa, OK, Rueben Brown, (918) 836-1651, collection vehicles, products, services
Crane Equipment Manufacturing Corporation, Eugene, OR, Mike Kogutkiewicz, (503) 746-9681, grapples and knuckleboom cranes
Creative Information Systems. Inc., Manchester, NH, Kevin St. John, (603) 627-4144, waste and recycling software
Dempster, Toccoa, GA, Pete Van Tholen, (706) 886-2327, waste and recycling handling equipment
Detroit Diesel Corporation, Detroit, MI, Mark Tiedens, (313) 592-5000, engines for truck manufacturers
Donovan, Stuart, FL, Max Owens, (407) 286-3350, tarps, automatic covering systems for containers/roll-off trucks
Dryden Oil Co., Inc., Baltimore, MD. David Perry, (800) 777-1466, oil and lubricants
Eaton Corporation, Clemmons, NC, Sales Department, (910) 712-2043, onboard logistics management system
El Monte Plastics, Tustin, CA, Glen Sanders, (714) 544~ 9599, automated and semi-automated plastic refuse containers
Elgin Sweeper Co., Elgin, IL Annette Adams, (847) 741-5370, sweepers
Epoleon Corporation, Torrance, CA, Kit Hammond, (310) 782-0190, odor neutralizing chemicals
Fabrex, Trois Rivieres, OR. Jean Loisel, (819) 379-3738, transfer and dump trailers
Fibrex, Chesapeake, VA, Ruben Leenders, (804) 487-5744, recycling containers
Fikes Plastics, Inc., Angola. IN, Wayne or Pete, (219) 665-7715, plastic lids/locks, truck fenders **Galbreath, Inc.**, Winamac, IN, Keven Crawford, (800) 285-0666, roll-offs, hoists, compactors, containers, trailers
Gensco Equipment Co., Toronto, ON, David Zelunka, (416) 465-7521, grapples, buckets, material handling equipment
GIRO Enterprises, Montreal, 0N, Marc Dupont (514) 383-0404, route optimization software
Global Sensor Systems, Inc., Mississauga, ON, Ray Glenn, (905) 507-0007, infrared rear search sensor systems
Greg Markim, Inc., Milwaukee, WI, Kim Schiedermayer, (414) 453-1480, school training programs, community education programs
Hardy Instruments, San Diego, CA, Dave Ness, (519) 278-2900, scales, collection management systems
Harris Group, Peachtree City, GA, Coleen Helland, (770) 631-7290, balers, conveyers, shears, cranes
Haul-All Equipment, Lethbridge, AB, Robert Niven, (403) 328-7719, waste and recycling containers and equipment
Hawk Bulky Waste Cranes, Trenton, NJ, Fred Fisher, (609) 588-5400, waste collection cranes and bodies
Hail Environmental Industries, Ltd., Chattanooga, TN, Larry Stone, (423) 899-9100, waste and recycling collection bodies
Hesco Sales, Inc., Miami, FL, Sam Eissen, (305) 597-0243, refuse/recycling/roll-off containers

Hi-Rise Recycling Systems, Inc., Miami, FL. Robert Runge, (305) 624-9222. automated recycling systems for multi-story buildings
Highway Equipment Co., Cedar Rapids, IA, Bill Stamats, (319) 363-8281, lift truck scales
HQN Industrial Fabrics, Sarnia, ON, Paul Hardy, (519) 344-9050, waste container liners
Imperial, Green Bay, WI, Lynn Podoski, (414) 497-5422, waste fleet maintenance products
Intec Video System, Inc., Laguna Hills, CA, David Nama, (714) 859-3800, rear- and side-vision camera systems
International Compactor. Inc., Hilton Head Island, SC, Michael Pierson, (803) 686-5503, compactors, crushers
IPL, Inc., St. Damien, QB, Gartan Boldue, (418) 789-2880, trash cans, plastic wheeled carts
J.V. Manufacturing, Inc., Springdale, AR, Keith Pinson, (501) 751-7320, containers, compactors, recycling containers
Jacobs Vehicle Systems, Hayward, CA, Harrie Valec, (510) 888-1449, engine retarders, exhaust brakes, electromagnetic retarders
Karl W. Schmict & Associates, Inc., Commerce City, CO, Bill Ranger, (303) 287-7400, conveyors/conveying systems
Kewanna Screen Printing, Inc., Kewanna, IN, Wiladean DeWitt, (800) 348-2454, decals for refuse and recycling containers
KG Rear Vision, Arlington Heights, IL, David Gaul, (800) 543-9312, rear- and side-vision camera systems
Landa Water Cleaning Systems, Portland, OR, Crismon Lewis, (800) 547-8672, cleaning equipment
Leach, Oshkosh, WI, Tim Inglese, (414) 231-2770, refuse collection bodies
Logemann Brothers, Milwaukee, WI, Philip Johnson, (414) 445-3005,2-ram automatic-tie balers
Lubriquip, Inc., Cleveland, OH, Blake Beharry, (800) 872-5823, automatic lubrication systems
Mac Equipment Inc., Kansas City, MO, Stacy Shaleen, (816) 891-9300, dust collection equipment
Marathon Equipment Co., Vernon, AL, Christina Harris, (205) 695-8517, compactors, containers, rolloff hoists
Marrel Corporation, Hendersonville, TN, Hans Vooys, (615) 822-3536, container handling systems
McClain Group Sales, Galion, OH, David Johnson, (419) 468-2120, truck bodies, refuse vehicles
McNeilus, Dodge Center, MN, Dennis Hansen, (507) 374-6321, trucks, rolloffs, parts
Melroe Co., Fargo, ND, Wanda Roath, (701) 241-8700, skid-steer loaders and compact hydraulic excavators
Michelin North America, Greenville, SC, Lisa Breazeale, (803) 458-5000, tires
Midwest Power, W. Chicago, IL, Justin Avey, (800) 635-2023, truck renovation
Mitsubishi/Fuso Truck of America, Bridgeport NI, Sales Department, (609) 467-4500, medium duty, diesel-powered, cab-over trucks
Modem Manufacturing, Beaumont, TX, Will Crenshaw, (409) 833-2665, containers, boxes, trailers

Moto Mirror, Grand Prairie, TX, Ann Gordon, (800) 433-6686, motorized and heated mirrors
Multiforce Systems Corporation, Princeton, NI, Dave Alampi, (609) 683-4242, cardless/keyless fuel management systems
Munice Power Products, Munice, IN, George Halleck, (317) 284-284-7721, power take-offs, hydraulic pumps, motors, valves
National Manufacturing/Geneva Products, Valley City, ND, Joel Strom, (701) 845-1017, rolloff drop boxes, recycling trailers, rear-load containers
National Recycling Equipment Co., Georgetown., MA, Fred Warrender, (401) 245-0002, roll-off hoists, containers, compactors
Nautical Paint Industries, New Brunswick, NJ, Doug Holmberg, (908) 821-3200, industrial and fleet coatings
Navistar International, Chicago, IL, Mike Briggs, (312) 836-3686, medium- and heavy-duty truck chassis and diesel engines
North American Business Technology, Cockeysville, MD, Robert Sima, (800) 666-6570, refuse management systems
O'Brian Manufacturing, Wilson, NC, Joyce Upchurch, (800) 334-8277, automated tarping systems, tarps for open top containers
Oregon Western Industries, Tualatin, OR, Julien Birkey, (503) 624-6403, cranes, skid-loading refuse bodies, compactors, rolloff hoists
Pactec, Inc., Clinton, LA, Charles Moore, (800) 272-2832, liners, tarps, bags
Pak-Mor Manufacturing, San Antonio, TX, John Bastian, (210) 923-4317, truck-mounted refuse equipment
Panasonic Industrial Camera Division, Secaucus, NJ, Bob Schindler, (201) 358-1801, rear- and side-vision camera systems
Pemberton, Inc., Longwood, FL, Todd Pemberton, (407) 831-6688, attachments for excavators grapples, large equipment
Permco, Inc., Streetsboro, OH, Rick Olszewski, (330) 626-2801, dry valve gear pumps
Petersen Industries, Inc., Lake Wales, IL, Bruce McGill, (941) 676-1493, knuckleboom loaders, dump bodies
Philippi-Hagenbuch. Inc., Peoria, IL, LeRoy G. Hagenbuch, (309) 697-9200, refuse dump body mounts
Plastican, Inc., Leominster, MA, Barbara Vosburgh, (508) 537-4911, curbside recycling bins and cans
Plastopan North America, Inc., Los Angeles, CA, Catherine Bump, (213) 231-2225, wheeled automated refuse and recycling rafts, crates
Precision Loads, Seattle, WA, Thomas Kendall, (206) 783-4430, onboard scales for collection vehicles and transfer trailers
Pulltarps Manufacturing, El Cajon, CA, Sales Department, (619) 449-8860, tarp systems
Recycled Plastics Marketing, Redmond, WA, Tony Viscosi, (206) 867-3200, compost bins, recycled plastic products
Recycling Insights, Shakopee, MN, Mark Banwart, (612) 445-6992, environmental software, solid waste planning management
Rehrig Pacific, Los Angeles, CA, William Block, (213) 262-5145, trash cans, recycling

containers, green waste cart
Rexworks, Inc., Milwaukee, WI, Chris Klinck/Dave Ross, (414) 747-7200, recycling grinders, landfill compactors
Richard Serlen-Gaylord Boxes, Elkins Park, PA, Richard Serlen, (215) 635-7277, recycling boxes
Ridewell Suspensions, Springfield, MO, Jerry Steele, (417) 833-4565, suspensions and height control valves
Roto Industries, Inc., Anaheim, CA, Nikki Stuil (714) 630-0272, automated refuse containers and bin lids
Rotobec, Inc., Ste. Justine, QB, Jubal Frost, (418) 383-3002, knuckleboom loaders, material handling grapples
Roura Iron Works, Inc., Clinton Township, MI, Sales Department, (800) 968-9070, self-dumping hoppers
Routesmart Technologies, Columbia, MD, Chris Walz, (800) 977-7284, vehicle routing/scheduling/mapping software
Royal Basket Trucks, Inc., Darien, WI, Stephanie Prater, (414) 728-1227, recycling containers
Ruckstell California Sales, Inc., Fresno, CA. Dick Townly, (209) 233-3277, dual automated container and split-body automated collection vehicles
Safety Vision. Inc., Houston, TX, Bruce Smith, (713) 589-7400, vehicle back-up systems distributor
Schaefer Systems International Inc., Charlotte, NC, Corinne Higdon, (704) 588-2150, waste/recycling containers
Scranton Manufacturing, Scranton, IA, Mike McLaughlin, (712) 652-3396, rear-loader/side-loader/satellite manufacturer
Screentech Products, South Holland, IL, Robert Roeda, (708) 333-3021, container and equipment decals
Setco, Idabel, OK, Scot Sellers, (800) 634-2381, custom solid fires and rims for loaders and heavy equipment
Shu-Fak Equipment Inc., Woodstock, ON, Ben Cannella, (519) 539-7461, side-loading refuse collection vehicles
Solid Waste Equipment Co. of Virginia, Ashland, VA, Cary V. Hall, (804) 752-677I, collection and recycling truck, carts
Sony, Montvile, NI, Bill Yan, (201) 358-4919, rear- and side-vision camera systems
SP Industries, Inc., Hopkins, Ml, Steve Burk, (616) 793-3232, compactors, containers, balers, container dumpers
Special Trucks, Inc., Fort Wayne, IN, Tim Lowden, Mike Baum, (219) 493-1100, truck componentry and systems
Steco, Enid, OK, Michael Turley, (405) 237-7433, live-floor and push-out transfer trailers
Stellar Industries, Inc., Garner, IA, David Zrostlik, (800) 321-3741, truck-mounted hook lift loaders
Structural Instrumentation, Inc., Tukwila, WA, Customer Service, (206) 244-6100, truck scales
Swaploader USA, Ltd., Des Moines, IA, JeanAnn Rodibaugh, (888) 767-8000, hook-lift hoists

Tecnomen Data Collection, Inc., Atlanta, GA, Chris Ronnblad, (770) 512-5130, onboard data collection and reporting systems

The Bag Company, Kennesaw, CA, Katherine Remick, (404) 422-4187, recycling bags

The Turtle Group, Cleveland, OH, Tom Norton, (216) 791-2100, mats and matting for MRFs and service garages

TMT Software, Chapel Hill, NC, Rick Rosenberg, (919) 493-4700, maintenance management software

Top Hand Glove, McCaysville, GA, Sales Staff, (704) 274-2900, work gloves, safety glasses, tarps, straps, back supports, safely supplies

Toro-Recycling Equipment Division, Bloomington, MN, Neil Berenstein, (612) 887-7214, tub grinders, road debris retrieval Systems

Toter, Statesville, NC, Inside Sales, (704) 872-8171, recycling carts, hydraulic lifting devices

Travis Body and Trailer, Houston, TX, Bud Hughes, (713) 466-5888, aluminum live-floors

Tri-Rinse, St. Louis, MO, Jim Waldren, (314) 647-8338, mobile shredding plastic recycling product recovery

Triple E Co., Cedar Falls, IA, Floyd R. Swanson, (319) 266-4723, MRF and recycling-related produces and services

Tulip Corporation, City of Industry, CA, Bryan Walker, (81 8) 968-0044, home and office recycling containers

UD Trucks, Irving, TX, Bill Snyder, (214) 756-5500, light-and medium-duty truck chassis

Union Camp Corporation, Wayne, NI, Diane Schroeder, (201) 628-2505, compostable collection bags

Vital Visions Manufacturing Corporation, Freeport, FL, Carol Wood, (904) 835-2121, waste/recycling/used oil containers

Volvo Trucks, Greensboro, NC, Frank Bio, (910) 393-2000, collection vehicles

Vulcan On-Board Scales, Kent, WA, Fred Houghton, (800) 237-0022, on-board scale systems

Walinga, Inc., Ontario, ON, Terry Medenblik, (519) 824-8520, recycling collection vehicles

WARM, Reno, NV, Sales Department, (702) 322-7331, software for haulers, landfills, MRFs, transfer stations

Wastequip, Beachwood, OH, Rich Garcia, (216) 292-2554, commercial containers, compactors, rolloff hoists, trailers

Wayne Engineering, Cedar Falls, IA, Sherry Benak, (319) 266-1721, recycling collection vehicles

Wheatec, Wheaton, IL, Charles R. Stack, (630) 682-3024, odor control products

Windsor Barrel Works, Kempton, PA Beverly Brolost, (610) 756-4344, recyclable collection containers

Zarn, Inc., Reidsville, NC, Mel Paterline, (910) 349-3323, waste and recycling carts and hydraulic lifters

ZF Industries, Inc., Vernon Hills, IL, Mark Johns, (847) 634-3500, transmissions

Landfill Equipment, Products and Services

The following companies offer products and services pertaining to MSW landfilling and disposal activities

A&L Systems, Livonia, MI, Art Lake, (313) 513-7100, daytime lights, automatic lubrication system

A.O. Smith Harvestore Products, DeKaIb, IL Mike Poole, (815) 756-1551, water/wastewater storage tanks

Aardvark Corporation, Puyallup, WA, Ed Foy, (206) 927-4321, gas and leachate collection pipes, quick-conned fittings

Advanced Aquaculture Systems, Inc., Brandon,. FL, Dana Kent (813) 653-2823, aeration/nitrification/degassing systems

Advanced Drainage Systems, Columbus, OH, Tony Radoszewski. (800) 733-7473, corrugated polyethylene pipes and manholes

Aeromix Systems, Minneapolis, MN, Linda MacFrarland, (612) 521-8519, leachate aerator equipment

Agru/America, Inc., Salem, NH, Bob Pelletier, (603) 890-6160, geomembrane liners/pipes

Air-weigh Scales, Eugene. OR, Sales Director, (503) 342-1521, on-board truck and trailer scales

Alfa Laval Separation, Inc., Warminster, PA, Charles Ehne, (215) 443-4222, centrifuge and sludge equipment

Allegany Technology, Inc., Cumberland, MD, John Riley, (301) 722-6000, lift truck scale

Alliance Environmental, Marietta, OH, Rudolph Lehman, (614) 373-2190, landfill geotechnical and drilling services

American Excelsior, Arlington, TX, John Tengvall, (817) 640-1555, erosion control produces

American Rolloff, Trenton, NJ, Fred Fisher, (609) 588-5400, rolloff trucks and trailers

Amoco Fabrics, Atlanta, CA, Janice Duncan, (770) 984-4444, geotextiles

Aqua Treatment Systems, Inc., Seattle, WA, Paul Geisert (206) 343-5221, stormwater and wastewater treatment products

Aqua-Shed, Inc., Florence, SC, Fritz Kramer, (803) 661-7444, ADC

Atlantic Construction Fabrics, Inc., Richmond, VA, Sean Simonpietri, (804) 271-2363, geomembrane lining estimating/installation

Atlantic Screen, Inc., Milton, DE, Pat Lawson, (302) 684-3197, slotted, perforated, threaded pipes, manholes, sampling pumps

Atlas Copco Wagner, Inc., Portland, OR, Harold Kammerzell, (503) 255-2863, 6x6 articulated dump trucks

Automated Waste Equipment Co., Inc., Trenton, NJ, Fred Fisher, (609) 588-5400, rolloff and collection equipment

Bandit Industries, Inc., Remus, MI, Regional Managers, (517) 561-2270, woodwaste chippers, tub grinders, hogs

Bascom-Turner Instruments, Norwood, MA, Dennis Crouse, (617) 769-9660, landfill gas detectors

Belton Industries, Inc., Atlanta, GA, Bob Moran, (800) 225-409S, geotextiles and biodegradable fabrics, ADC

Bentonite Corp., Denver, CO, Many Steinmeyer, (303) 291-2946, bentonite landfill liners
Bird-X Inc., Chicago, IL, Mike Schless, (312) 226-2473, bird and pest control products
Blue Ridge Solid Waste Consulting, Bozeman, MT, Neal Bolton, (406) 587-8771, consulting/training/engineering consultants
Bomag/Compaction America, Kewanee, IL, Tom Mertz, (309) 853-3571, landfill compaction equipment
Bridgestone Firestone Off Road Tire Co., Nashville, TN, Joe Rayna, (615) 231-5700, tires for off-road applications
Brown, Vence & Associates, San Francisco, CA, Lauren Snell, (415) 434-0900, landfill planning and engineering consultants
Bryan A. Stirrat & Associates, Diamond Bar, CA, Fred Guido, (909) 860-7777, landfill, leachate, and LFG consultants
C.H. Hanson Company, Franklin Park, IL, Larry Krull, (800) 837-3398, landfill covers, liners, and cap systems
Canadian Forest Products, Ltd., New Westminister, BC, Joe Hargitt, (604) 520-9327, mulch and bonded fiber matrix for erosion control
Carolina Software, Wilmington, NC, Larry Blanton, (910) 799-6767, software ticketing for landfills, transfer stations, WTE
Caron Compactor Company, Modesto, CA, Lesley Bailey, (209) 578-9514, landfill compactors and crawlers and attachments
CEA Instruments, Inc., Emerson, NJ, Steven Adelman, (201) 967-5660, personal, portable, and fated gas monitors
Central Fiber Corporation, Wellsville, KS, Gregg Krause, (800) 654-6117, ADC and bonded erosion fibers
Central Plastics, Shawnee, OK, Tammy Jones, (800) 654-3872, gas recovery and leachate systems
CETCO, Arlington Heights, IL, Richard Carriker, (847) 392-5800, geosynthetic day liners, soil sealants, Bentonite
Chapman, Inc., Atlantic Highlands, NJ, James Nash, (908) 291-7773, wastewater treatment facility operation
Clean Environment Equipment, Inc., Oakland. CA, Michael L. Fass, (510) 891-0880, controllerless pneumatic leachate and condensate pumps
Columbian Steel Tank, Kansas City, KS, Debbie DressIer, (913) 621-3700, steel tanks for leachate storage
Cooley Engineered Membranes, Pawtucket, RI, Dick Cunningham, (401) 724-9000, geomembranes, polypropylene landfill liners
Creative Information Systems, Inc., Manchester, NH, Kevin St. John, (603) 627-4144, waste management software
Deitering Landscaping, Inc., Leipsic, OH. Ken Deitering, (800) 622-4733, seeding/erosion control for landfill closure
Dumpstat, Chicago, IL, Robert Gibbons, (312) 413-7755, groundwater monitoring software
E Products, Vadnais Heights, MN. Stephen Hirt, (612) 490-9690, thermal oxidizers and enclosed flares

Ecolo Worldwide, Mississauga, ON, Ian Howard, (905) 625-8664,odor control
Ecolotree, Iowa City, IA, (319) 35B-9753, tree plantings for water contaminant uptake and removal
EG&G Rotron Industrial Division, Saugerties, NY, Vince Conte, (914) 246-3401, corrosion-resistant and explosion-proof blowers
Engineered Textile Products, Inc., Mobile, AL, Ken Robinson. (334) 476-8001, geomembranes, landfill tarps, ADC
Environmental Liners, Inc., Cortez, CO, Lynette Durham, (970) 565-9540, geomembrane liner fabrication/installation
EPG Companies, Rogers, MN, Duncan Bosley, (612) 424-2613, leachate collection, vapor extraction, flares
EPI Environmental Products, Inc., Conroe, TX, David Deeds, (409) 788-2998, degradable ADC plastic film and systems
Epoleon Corporation, Torrance, CA, Kit Hammond, (310) 782-0190, odor neutralizing chemicals
Erin Screens, Portland. ME, David Miley, (207) 878-3661, screens for MSW and C&D
ERRCO, Epping, NH, Matthew Senior, (603) 679-2626, woodchips, aggregate
Fabrene. Inc., Mississauga, ON, Darlene Broderick, (905) 567-2850, ADC
Fabric Building Systems, Inc.. Sarasota, FL, Tom Ruprecht, (941) 351-6096, pre-engineered tension fabric structures
Finn Corporation, Fairfield, OH, Don Sharp, (513) 874-2818, hydroseeding equipment, erosion control/cover
Flexxaire Manufacturing, Edmonton, AB, Hugh Williams, (403) 483-3257, reversible engine fan for heavy equipment
Fluid Controls, Inc., Huntsville, AL, Alan Deriax, (205) 851-6000, perforated pipe to remove liquids
Forestry Suppliers, Inc., Jackson, MS, Jerry Pelly, (601) 354-3565, soil/water/gas sampling and monitoring equipment
Forrer Supply Company, Inc., Germantown, WI, Larry Wood, (414) 255-3030, HDPE/PVC pipes & fittings, valves, geotexiles
Fuller-Kovako, Bethlehem, PA, Tony Dwyer. (610) 264-6055, LFG compressors
Fuss & O'Neill, Manchester, CT, Diane Cedar. (860) 646-2469, landfill design consultants/engineers
Geosyntec Consultants, Atlanta, GA, Tom Sargeant Sr., (404) 705-9500, geotextiles geogrids, pond liners, materials testing lab
Golder Associates Corporation, Atlanta, GA, Kristin Thomas, (770) 496-1893, landfill design/permit/closure, consulting engineers
Groundwater Control, Inc., Jacksonville, FL, Steve Blume, (800) 843-6133, groundwater control
Grundfos Pumps Corporation, Clovis, CA, Cynthia Hamilton, (209) 292-8000, centrifugal pumps
GSE Lining Technology, Inc., Houston, TX, Sales Department, (800) 435-2008, HDPE/VFPE liners, drainage nets, and composites

Guardian, New Baltimore, Ml, Craig Szachta, (810) 725-1235, double-contained piping systems and leak detectors
Holmes & Narver, Orange, CA, Steve Galloway, (714) 567-2500, consulting engineers
Information Systems, Inc., Baltimore, MD, James Manley, (410) 769-9800, automated weighing systems
Integra Plastics, Inc., Madison, SD, Kent Metzger, (800) 578-5257, ADC, interim covers, leachate pond covers
Intelligent Decision Technologies, Ltd., Longmont CO. Melinda Cross, (303) 652-0332, groundwater/RCRA statistical software products
J&L Engineering, Inc., Canonsburg, PA, Dr. Mahiru Shettima, (412) 746-4441, geosynthetic testing, consulting, site assessment
John Deere, Moline, IL, Joe Hayward, (319) 388-4610, crawler dozers/loaders, excavators, scrapers, motor graders, backhoes
John Zink Company, Tulsa, OK, Tim Locke, (913) 234-2783, LFG flare systems
Joyce Engineering, Richmond, VA, Deborah Kirk, (804) 355-4520, landfill, groundwater, closure consulting engineers
Kuma Corporation, Grass Valley, CA, Jim Ippolito, (916) 268-7070, odor control chemicals
Landfill Energy Systems, Wixom, MI, Scott Salisbury, (810) 380-3920, LFG collection and energy systems
Landfill Gas & Environmental, Inc., Santee, CA, Manuel Palma, (888) 533-5343, LFG pneumatic pumps, flow meters, seals, connectors, recovery equipment
Landfill Technologies, Inc., Sand Lake, NV, George Nealon, (518) 674-8694, solar ignited LFG flares, ADC cover systems
Landtec, Commerce, CA, Alex Roqueta, (800) 821-0496, leachate and LEG collection/control, and instrumentation
Leak Location Services, Inc., San Antonio, TX, Daren Laine, (210) 408-1241, electrical leak location survey services
LFG Specialties, New Concord, OH, Ray Nardelli, (614) 826-7686, LFG flares, blowers, and LFG recovery packages
Littleford Day, Florence, KY, Bill Barker, (606) 525-7600, composting equipment mixers
Loegering Manufacturing, Inc., Casselton, ND, Bill Borkowski, (701) 347-5441, extra traction items for all rubber-tired equipment
Met-Pro Corporation, Harleysville, PA, Tom Edwards, (215) 723-6751, leachate and wastewater treatment systems
Midwest Environmental Consultants, Jefferson City, MO, Anthony Starns, (314) 636-9454, landfill/transfer station services
Modular Gabions/C.E. Shepherd, Houston, TX, Kiran Jagad, (713) 928-3763, gabions for erosion control
Montell Polyolefins, Wilmington, DE, Nick Nagurny, (302) 996-6063, geotextiles, geomembranes
Montgomery Watson, Inc., Boulder, CO, Dan Viste, (603) 231-4747, engineering consultant services
Moretrench Environmental Services, Tampa, FL, Carl Asprinio, (813) 331-1371, LFG

recovery systems, flaring, leachate and condensate collection
MPC Containment Systems, Chicago, IL, Dennis O'Brien, (312) 927-4120, landfill/pond/lagoon liners, geomembranes
National Foam, Exton, PA, Ron Correia, (610) 363-1400, ADC foam
National Seal Company, Aurora, IL, Larry Lidick, (630) 898-1161, geosynthetic liners, composites, covers, nets, and structures
Neotronics of North America, Inc., Flowery Branch, GA, Carol Dellinger, (770) 967-2196, portable gas detectors
New Waste Concepts, Erie, MI, Tom Nachtrnan, (313) 847-8997, foam and foam systems for ADC
North American Green, Evansville, IN, Randy Schmitt, (800) 772-2040, erosion control products
O&E Machine, Greenbay, WI, Dennis Jeanquart (414) 437-6537, solid waste shredders, grinders, and custom machinery
Organic Waste Technologies, Inc., Middleburg Heights, OH, Vince Little, (216) 891-0300, landfill operation, methane recovery, leachate control
PC Automation, Waterloo, ON. Mark Wills, (519) 888-9304, waste management automation systems
PC Scale, Oxford, PA, Don Tefft, (610) 932-4006, PC-based software for landfill operations
Pepcon Systems, Inc., Las Vegas, NV, Glen Smith, (702) 735-2324, electrochlorination equipment
Plastic Fusion Fabricators, Inc., Huntsville, AL, Anissa Morton, (800) 356-1480, geomembranes, geotextiles, geonets, geogrids, geocomposites, HDPE pipes
Plexco, Bensenville, IL, Jim Stilling, (630) 350-3700, pipes
Pneumatech, Kenosha, WI, Titus Mathews, (414) 658-4300, LFG dryers/regulators
Polly-Flex, Grand Prairie, TX, Tom Boothe, (972) 647-4374, HDPE and LLDPE geomembrane liners
Presto Products, Appleton, WI, Dan Senf, (414) 739-9471, landfill erosion control systems
PRS Materials, Inc., West Chester, PA, Gina Marie D'Ginto, (610) 430-3960, enriched mulch/compost
QED Ground Water Specialists, Ann Arbor, MI, Sales Department, (313) 995-2547, leachate pumps, groundwater sampling and LFG condensate collection systems
R.E. Wright Environmental, Inc., Middletown, PA, Stephen Snyder, (717) 944-5501, landfill remediation
Raven Industries, Sioux Falls, SD, Tom Stoebner, (605) 336-2750, temporary landfill covers
Re-Tech, Myerstown, PA, Peter Logan, (717) 866-2357, material processing, composting, landfill trommels
Reef Industries, Houston, TX, Lynn Ciolli, (713) 507-4200, HDPE daily covers
Rexius, Eugene, OR, Dan Sutton, (800) 285-7227, hydroseeding vehicles, products, services
RT Environmental Services, Inc., King of Prussia, PA, Gary Brown, (610) 265-1510, landfill design/construction, capping. and leachate treatment
Rusmar, Inc., West Chester, PA, Laura White, (800) 733-3626, ADC foam to cover landfills
Scansys Corporation, Jacksonville, FL. Sharon Rock, (904) 771-6060, accounting and

management information systems

Scicorp Systems, Barrie, ON, (705) 733-2626, anaerobic bacteria for odor control and waste decomposition

Serrot Corporation, Henderson, NV, R.A. Otto, (702) 566-8600, geomembrane liners/materials and installation

Setco, Idabel, OK, Scot Sellers, (800) 634-2331, solid tires and rims for loaders and heavy equipment

Solid Waste Equipment Co. of Virginia, Ashland, VA, Cary V. Hall, (804) 752-6771, shredders, balers, sorters, trucks, and carts

Solid Waste Technologies, Inc., Jamesburg, NJ, Jerome Prevete, (609) 860-0900, landfill consulting

Solinst Canada, Ltd., Georgetown, ON, Jim Pianos, (905) 873-2255, landfill groundwater monitoring equipment

Solomat, Norwalk, CT 06850, Helen Rosselli, (201) 849-3111, portable water quality monitoring instruments and dataloggers

Sterling Bag & Supply Co., Inc., Lackawanna, NY, Richard Konefke, (716) 826-1990, geotextiles, filter bags, silt fencing

Structural Instrumentation, Inc., Tukwila, WA, Customer Service, (206) 244-6100, truck scales

Sur-Lite, Santa Fe Springs, CA, Wanda Cudmore, (310) 693-0796, LFG flares

Tensar Earth Technologies, Inc., Atlanta, GA, Ron Johnson, (800) 836-7271, landfill capacity improvement systems

Total Energy Technologies, Inc., Westlake, OH, James Hiendlemayr, (216) 899-0057, modular LFGTE engines/generator and processing systems

TQM Engineering, Northridge, CA, Stuart Tays, (818) 880-8010, LFG to compressed natural gas systems

U.S. Filter/Zimpro, Rothschild, UW, Jim Force, (800) 338-7226, groundwater and leachate management equipment

United Linings, Inc., Phoenix, AZ, John Ramos, (502) 243-9211, flexible membrane liners for ponds, landfills, barriers, and trenches

Vector Engineering, Inc., Grass Valley, CA, Scott Purdy, (916) 272-2448, consulting engineers, landfill and liner systems

Vermeer, Pella, IA, Doug Hundt, (515) 628-3141, grinders, chippers, directional boring machines

Waste Energy Technology, Ft. Walton Beach, FL, Terry Peterson, (904) 243-0033, LFC design, engineering and operations

Watersaver/Western Allied Systems, Denver, CO, Stan Slifer, (303) 289-1318, geomembranes

Weigh Right, S. Hutchinson, KS, Lori Dorman, (316) 665-1123, on-board truck scales

Western Industries, Miles City, MT, Stacy Coffin, (406) 232-1680, landfill covers, tarps, HDPE liners

Weyerhaeuser, Tacoma, WA, Donna LeBlanc, (206) 924-2551, erosion control mulch, tackifier, and bonded fiber matrix

Wire Rope Specialists, Prairieville, LA, Marlon Yarboraugh, (800) 694-5515, ADC tarps,

tarpaulins
Zahren Alternative Power Corporation, Avon, CT, Martin Laughlin, (286) 678-7537, LFGTE project management and financing
Zep Manufacturing Company, Atlanta, GA, Tobie Kranitz, (404) 352-1680, odor control products

Processing Equipment Services

The following companies offer products and services pertaining to MSW transfer and processing activities

A&A Magnetics, Woodstock, IL, Ron Harrelson, (888) 605-6054, overhead magnets for MRFs, recycling

ABC Bailing Wire Supply Co., Inc., Weehawken, NJ, Marie Morney, (201) 866-7799, baling wire

Accurate Industries, Inc., Erial, NJ, Seth Weingarten, (800) 220-2228, compactors**,** loaders, roll-offs, containers

Ag-Bag Compost Technology International, Warrenton, OR, Angela Grote, (800) 334-7432, low-tech, in-vessel composting systems

Ajax Corporation, Rochester, NY, Doug Mattice, (716) 240-1077, electric motors for waste processing

Allegheny Paper Shredders, Delmont, PA, Robert Wagner, (800) 245-2497, paper shredding and baling equipment

Allied-Gator, Inc., Youngstown, OH, Jack Stewart, (330) 744-0308, mobile shears, grapples

Amadas Industries, Suffolk, VA, Tiny Andrews, (804) 539-0231, recycling and composting equipment conveyors

American Baler Co., Bellevue, OH, Richard Harris, (419) 485-5790, balers, high-density, no-shred conveyors

American Pulverizer, St. Louis, MO, Skip Anthony, (314) 731-6100, fire shredders, trommel screens, hammenmills, ring mills, shredders

Andela Tool & Machine, Inc., Richfield Springs, NY, Cynthia Andela, (315) 858-4055, glass, CRT, and gypsum recycling systems

Arch Environmental Equipment, Inc., Paducah, KY, Lori Hyde, (502) 898-6821, belt cleaning systems, idlers

Athey Products, Raleigh, NC, Jim Perry, (919) 556-5171, compost tumers

Bailey Manufacturing Corporation, Knoxville, TN, John Sprouse, (423) 538-6010, custom hydraulic cylinders

Balemaster, Crown Point, IN, Sam Finlay, (219) 663-4525, horizontal balers

Bandit Industries, Inc., Remus, MI, Regional Managers, (517) 561-2270, tree and brush chippers, tub grinders, hogs

Barker Products, Greenville, SC, Bob Wyman, (803) 288-7384, hydraulic lift units for semi-automated roll-out containers

Bes-Pac, Easley, SC, Danny James, (864) 859-6030, compactors, rear-loaders, side containers, vehicles

Best Litter Receptacle, Inc., Florence, SC, Carol Doty, (803) 667-8188, concrete trash, recycling and litter receptacles

Blower Application Co., Germantown, WI, Lawrence Brenner, (414) 255-5580, pneumatic scrap-handling and shredding systems

Bouldin & Lawson, McMinnville, TN, Wade Sparkman, (615) 663-4090. compost baggers, MSW consulting

Brothers Industries, Inc., Morris, MN, David Sterek, (320) 539-1971, trarsfer and recycling trailers and truck bodies

Bruce Mooney Associates, Inc., Allison Park, PA, Bruce Mooney, (800) 454-2686, recycling systems and equipment

Bulk Handling Systems, Inc., Eugene, OR, Sean Austin, (541) 485-0999, MRFs, paper separators, screens, hag breakers, screens

C.S. Bell, Trifin, OH, Ronald White, (419) 448-00791, custom conveyors, crushers, and separators

Carolina Software, Wilmington, NC, Larry Blanton, (910) 799-6767, software ticketing for landfills, transfer stations, WTE

Carpco, Jacksonville, FL Robert Carver. (904) 353-3631, electrostatic separation equipment

Caterpillar, Inc., Peoria, IL, Local Caterpillar Dealer, (309) 675-4486, material handlers

Central Manufacturing Co., Inc., Peoria, IL, Mike McLemore, (309) 387-6591, trommel screens and conveyor systems

Columbus McKinnon, Amherst, NY, Charles Astafan, (941) 755-2621, tire shredders

Connecticut Metal Industries, Inc., Monroe, CT, Tom Mele, (203) 268-5509, recycling/recovery of nonferrous metals MRF

Consolidated Fabricators Corporation, Vernon, CA, Barbara Ross, (800) 339-8335, front-/rear-loaders, roll-offs. hoppers, and containers

Consolidated Resource Recovery, Sarasota, FL, Dee Steverson, (813) 756-0977, woodwaste grinders, screens

Continental Biomass Industries, Newton, NH, Ted Cook, (603) 382-0556, composting equipment, wood chippers

Continental Manufacturing Co., Earth City, MO, Jack Benninghofen, (314) 770-9949, recycling containers

Countec Recycling Systems/Portec, Des Moines, IA, Andy Andrews, (515) 246-1709, MRF equipment balers, glass sorters

CP Manufacturing, National City, CA, John Willis, (619) 477-3175, can flatteners, densifiers, crushers, sorters

Crane Equipment Manufacturing Corporation, Eugene, OR, Mike Kogutkiewicz, (503) 746-9681, grapples and knuckleboom cranes

Cranston Machinery Co., Inc., Oak Grove, OR, Paul Morrissey, (503) 654-7751. wire strappers, coilers, cutters

Creative Information Systems, Inc., Manchester, NH, Kevin St. John, (603) 627-4144, waste and recycling software

CW Manufacturing, Sabetha, KS, Tim Wenger, (913) 284-3454, tub grinders

Delta Pacific Builders, Inc., Huntington Beach, CA, Jim Andrews, (714) 891-9080, MRF and tipping floor maintenance/'restoration

Dempster, Toccoa, GA, Pete Van Tholen, (706) 886-2327, waste and recycling handling equipment

Diamond Z Manufacturing, Nampa, ID, Sam Ozuna, (208) 467-6229, industrial tub grinders

Dings Company Magnetic Group, Milwaukee, WI, Harry Bolstad, (414) 672-7630, magnetic separators for ferrous and nonferrous metals

Double T Equipment Manufacturing, Ltd., Airdrie, AB, Rey Rawlins, (403) 948-5618, windrow turners, tunnel composting, conveyors and conveyor systems
Douglas Manufacturing, Inc., Pell City, AL, Doug Ross, (205) 884-1200, MRF equipment and components. conveyors, separators
Dover Conveyor, Midvale. OH, Joe Coniglio, (614) 922-9390, bulk materials handling equipment
Duratech Industries, Jamestown, ND, Bruce Leiseth, (701) 252-4601, grinders for yardwaste
Eagle Crusher Co./Cobey Composter, Galion, OH, Team Eagle Sales, (614) 891-1558, C&D crushers and screens
Ecolo Worldwide, Mississauga, ON, Ian Howard, (905) 625-8664, odor control
Endura-Max, Alpena, MI, Julie Cordes, (517) 356-1593, shredders, conveyers, and related products
Enterprise Baler Co., Santa Ana, CA, Orval Gould, (714) 835-0551, balers, compactors, complete MRF systems
Epoleon Corporation, Torrance, CA, Kit Hammond, (310) 782-0190, odor neutralizing chemicals
Eriez Magnetics, Erie, PA, Al Cegaudas, (814) 835-6000, magnetic and eddy-current separators, vibratory feeders, conveyers. screens
Erin Screens, Portland, ME, David Miley, (207) 878-3661, screens for MSW, compost, C&D
ERRCO, Epping, NH, Matthew Senior, (603) 679-2626, wood chips. aggregate
ESP Corporation, Arlington, TX, Terry Merrill, (817) 275-5533, bioremediation microbes, enzymes, odor control suifactant
Excel Manufacturing, St. Charles, MN, Michael Forsythe, (507) 932-4680, horizontal and vertical balers, conveyors
Extec of North America, Lester, PA, Colon Douglas, (757) 564-3920, screening/crushing/shredding/blending/conveying systems
Fecon, Inc., Cincinnati, OH, John Heekin, (513) 956-5700, mobile shredders/composters and windrow turners
Flexible Steel Lacing Co., Downers Grove, IL, Jayne Dore, (630) 971-0150, belt conveyor products, tools, and accessories
Foster Wheeler Corporation, Clinton, NI, Hank Somerville, (908) 730-1000, MRFs and cogeneration facilities installation and operation
Frontier Manufacturing Co., Brooks, OR, Ken Warner, (503) 792-3737, windrow turners, automatic watering systems
Fuel Harvesters Equipment, Inc., Midland, TX, Mike Byford, (915) 694-9988, tub grinders, compost turners, separators. trammel screens
Galbreath, Inc., Winamac, IN, Keven Crawford, (800) 285-0666, roll-offs, hoists, compactors, balers, containers, trailers, hoppers
Gardner Equipment Co., Inc., Juneau, WI, Daryl Benson, (800) 393-0333, backyard composters, oil filter crushers
GDS Screens, Inc., Riviera Beach, FL, Ginger Olson, (561) 840-8481, portable trommels
Geisert Plastics, Inc., Seattle, WA, Paul Geisen, (206) 343-7965, thermoplastic recycling sourcing, and supply

General Kinematics Corporation, Barrington, IL, Bill Guptail, (847)381-2240, vibrating processing for separation and classification

Gensco Equipment Co., Toronto, ON, David Zelunka, (416) 465-7521, grapples, buckets, material handling equipment

Global Equipment Marketing, Inc., Boca Raton, FL, Marshall Gralnick, (561) 750-8662, magnets/eddy-current separators

GPI Division Harmony Enterprises, Harmony, MN, Stephen Kingety, (507) 886-6656, vertical balers and compactors

Green Mountain Technologies, Seattle, WA, Tim O'Neill, (206) 634-1308, containerized compost systems, aeration systems

Hagglunds Drives, Columbus OH, Kevin Kennedy, (614) 527-7400, hydraulic motors used in shredders, conveyors

Harmonious Technologies, Sebastopol, CA, John Roulac, (707) 823-8030, backyard composting products and consulting services

Harris Group, Peachtree City, GA, Coleen Helland, (770) 631-7290, balers, conveyors. shears, cranes

Haul-All Equipment, Lethbridge, AB, Robert Niven, (403) 328-7719, waste and recycling containers and equipment

Haz-Waste, Inc., St. Louis, MO, Pat Harper, (314) 842-8383, environmental, waste management. and safety services

Hesco Sales, Inc., Miami, FL, Sam Eissen, (305) 597-0243, roll-oft hoists and containers

HQN Industrial Fabrics, Sarnia, ON, Paul Hardy, (519) 344-9050, waste container liners, oil spill products

Hustler Conveyor Co., St. Louis, MO, Dave Guyton, (314) 352-6000, conveyors and complete MRF systems

Industrial Paper Shredders, Salem, OH, DeeDee Thomas, (330) 332-0024, paper shredders

Information Systems, Inc., Baltimore, MD, James Manley, (410) 769-9800, automated weighing systems

International Baler, Inc., Jacksonville, FL, Jerry Wise, (904)358-3812, vertical/horizontal/auto-tie/2-ram balers

International Compactor, Inc., Hilton Head Island, SC, Michael Pierson, (803)686-5503. Compactors, crushers

J.V. Manufacturing, Inc., Springdale, AR, Keith Pinson, (501) 751-7320, balers, containers, compactors. recycling containers

Jeffrey, Woodruff, SC, John Blake, (864) 476-7523, hammermill-type shredders, vibrating feeders

John Deere, Moline, IL, Joe Hayward, (319) 388-4610, crawler dozers/loaders, excavators, 4WD loaders, scrapers, motor graders, backhoes

Jones Manufacturing Co., Beemer, NE, Don Reis, (402) 528-3861. tub grinders

Jorgensen Conveyors, Inc., Mequon, WI, Mark Presti, (414) 242-3069, hinged steel belt conveyors for bulk scrap waste handling

K-F Environmental Technologies, Inc., Pompton Plains, NJ, Emil Kneis, (201) 616-0700, sludge management services

Karl W. Schmidt & Associates, Inc., Commerce City, CO, Bi11 Ranger, (303) 287-7400, conveyors/conveying systems
Knight Manufacturing, Brodhead, WI, Steve Pesik, (608) 897-2131, sludge and compost mixers, trommels, spreaders
Komar Industries, Inc., Groveport, OH, Kelly Eley, (614) 836-2366, compactors, shredders, waste processing equipment
Kubota Tractor Corporation, Torrance, CA, Dealer Referral, (310) 570-3370, articulated wheel loader
Kuma Corporation, Grass Valley, CA Jim Ippolito. (916) 268-7070, odor control chemicals
Kurtz Brothers, Inc., Cleveland, OH, Greg Rondy, (216) 641-7000, wood mulch coloring machines, coloring
KW Plastics Recycling Division, Troy, AL, J. Scott Saunders, (334) 566-1563, postconsumer plastics recyclers/MRFs
LaBounty Manufacturing, Two Harbors, MN, Matt Mahoney, (218) 834-2123, hydraulic tools **Lester Building Systems**, Lester Prairie, MN, Janell Koch, (320)395-2531, pre-engineered wood frame structures
LH Resource Management, Inc., Walton, ON, Chris Lee, (519) 867-9378, composting plant process design, equipment, and services
Lindemann Recycling Equipment, Inc., Charlotte, NC, Joe Szany, (704) 332-5004, balers, eddy-current separators
Lindig Corporation, Lexington, MN, John Lindig, (612) 633-3072, shredders, chippers, and grinders
Littleford Day, Florence, KY, Bill Barker, (606)525-7600, composting equipment, mixers
Loegering Manufacturing, Inc., Casselton, ND, Bill Borkowski, (701) 347-5441, extra traction items for all rubber-bred equipment
Logemann Brothers, Milwaukee, WI, Philip Johnson, (414) 445-3005, 2-ram automatic-tie balers
Lubriquip, Inc., Cleveland, OH, Blake Beharry, (800) 872-5823, automatic lubrication systems
Mac Equipment, Inc., Kansas City, MO, Stacy Shaleen, (816) 891-9300, dust collection equipment
Marathon Equipment Co., Vernon, AL, Christina Harris, (205) 695-8517, compactors, containers, balers, roll-off hoist
Marcom Industries, Inc., Greensburg, PA, Michael Scott, (412) 832-0140, compost aerators, control systems
Maren Engineering Corporation, South Holland, IL, Chuck Brown, (708) 333-6250, balers, shredders
Marrel Corporation, Hendersonville, TN, Hans Vooys, (615) 822-3536, container handling systems
Mayne Machinery Co., Inc., Waco, TX, John Mayne, (817) 772-2033, sorting systems, balers and conveyors
McLanahan Corporation, Hollidaysburg, PA, Sales, (814)695-9807, rotary trommel screens, pug mill mixers
Melroe Co., Fargo, ND, Wanda Roath, (701) 241-8700, skid-steer loaders and compact

hydraulic excavators
Mi-jack Products, Hazel Crest, IL, John Troop, (708) 596-5200, lift equipment container opening services for intermodal terminals
Mid-Atlantic Plastic Systems, Inc., Roselle, NJ, Craig Rogers, (908) 241-9333, plastic recycling systems
Mid-Atlantic Waste Systems, Easton, MD, Susie Newcomb, (410)820-7188, reusable recycling bag pans, equipment
Mid-States Recycling Systems, Inc., Bridgeview, IL, Tom Ellis, (800) 235-8351, balers, conveyors, sorting systems
Midwest Environmental Consultants, Jefferson City, MO, Anthony Starns, (314) 636-9454, landfill/transfer station services
Modern Manufacturing, Beaumont, TX, Will Crenshaw, (409) 833-2665, containers, boxes, trailers
Montenay Power, New York, NY, Paul Alderdice, (212) 826-7051, waste-to-energy facilities
Morbark, Winn, Ml, Sales Department, (517) 866-2381, tub grinders, hogs, screens, chippers
N-Viro Energy Systems, Ltd., Toledo, OH, Chris Mahoney, (419) 535-7008, biosolids and waste disinfection and reuse technology
National Ecology Co., Timonium, MD, John Berry, (410) 252-5666, waste processing system design/operation
National Manufacturing/Geneva Products, Valley City, ND, Joel Strom, (701) 815-1017, roll-off drop boxes, recycling trailers, rear-load containers
National Recycling Equipment Co., Georgetown, MA, Fred Warrender, (401) 245-0002, roll-off hoists, containers, compactors, transfer stations
Nature Plus, New Canaan, CT, Shave Sexon. (203) 972-1100, odor management formulations and dispensers
Naturtech Composting Systems, Inc., Saint Cloud, MN, Jim McNelly, (320) 253-6255, containerized in-vessel composting equipment
Nordberg Sales Corporation, Milwaukee, WI, David van Driel, (414) 723-4447, crushers, screens, conveyors
Norseman Plastics, Rexdale, ON, Herb Noseworthy, (416) 745-6980, composters
Northshore Manufacturing, Two Harbors, MN, John Anderson, (218) 834-5555, material handling equipment, transfer station cranes and grapples
Norton Environmental, Independence, OH, Louis Perez. (216) 447-0070, MRF operator/builder/design
O&E Machine, Greenbay, WI, Dennis Jeanquart, (414) 437-6587, solid waste shredders, grinders, and custom machine design and building
Oliver Manufacturing Co., Inc., Rocky Ford, CO, Tom Helman, (719) 254-7814, density separation equipment for purification
Oregon Western Industries, Tualatin, OR, Julien Birkey, (503) 624-6403, cranes. portable satellite compactors, roll-off hoists
Owark USA, Inc., Minneapolis, MN, Anders Carlegren, (612) 881-9200, midsize compacting balers
Pacific Shredder Technologies, Inc., Portland, OR, Jay Randall, (503) 223-4980, slow-speed

shredders
Peerless Corporation, Paragould, AR, Phil Williams, (501) 236-7753, shuttle trailers, refuse trailers
Pemberton, Inc., Longwood, FL, Todd Pemberton, (407) 831-6688, attachments for excavators grapples, large equipment
Permco, Inc., Streetsboro, OH, Rick Olszewski, (330) 626-2801, dry valve gear pumps
Peterson Pacific Corporation, Eugene, OR, Jack Nantz, (503) 689-6520, yardwaste grindesr, composters
Plastopan North America, Inc., Los Angeles, CA, Catherine Bump, (213) 231-2225 backyard composters
Pneumatech, Inc., Kenosha, WI, Joe Fresh, (414) 658-4300, compressors, air dryers, and compressed air management systems
Presona, Inc., Waco, TX, Buddy Himes, (800) 577-3766, horizontal balers for recyclables and waste
Processing Technologies, Inc., St. Charles, IL, Sue Bullock, (630) 443-3000, extrusion systems for plastics industry
Prodeva, Inc., Jackson Center, OH, Steve Bunke, (800) 999-3271, recycling equipment conveyors
PRS Materials, Inc., West Chester, PA, Gina Marie D'Ginto, (610) 430-3960, enriched mulch/compost
Quality Recycling Equipment, Horse Shoe, NC, Doug King, (704) 696-2111, recycling equipment distributors
R.M. Johnson Co., Inc., Annandale, MN, Kirsty Harren, (320) 274-3594, crushers, shredders, balers, tire cutters
Rader Resource Recovery, Inc., Memphis, TN, Steve Jones, (901) 795-7722, screens and bag breaker, conveyors
Rain for Rent, Bakersfield, CA, Tom Pruitt, (800) 742-7246, liquid storage containment systems
Rainbow Environmental Products, Fairfield, NJ, Jeff Brown, (800) 842-0527, custom imprintable educational products
Re-Tech, Myerstown, PA, Peter Logan, (717) 866-2357, material processing, composting, landfill trommels
Recovery Systems Technology, Inc., Seattle, WA, Bob Schloredt, (206) 542-9347, trommel and disk screens, picking belts and conveyors
Recycling Equipment Corporation, Souderton, PA, Bud Etzler, (215) 721-6464, new/used/reconditioned balers, shredders, and conveyors
Resource Recovery Systems of Nebraska, Sterling, CO, Lester Kuhlman, (970) 522-0663, self-propelled windrow composters
Resource Recycling Systems, Ann Arbor, MI, James Frey, (313) 996-1361, composting systems
Rexnord Conveyor Equipment Division, Milwaukee, WI, Richard Skroski, (414) 643-3743, heavy-duty apron pan convevors, drag and flight conveyors, bucket elevators
Rexworks, Inc., Milwaukee, WI, Chris Klinck/'Dave Ross, (414) 747-7200, recycling grinders

Riede Systems, Inc., St. Paul, MN, Tom Bowen, (800) 486-5426, MRF and processing equipment
Rigo & Rigo Associates, Inc., Berea, OH, Greg Rigo, (216) 243-5544, consulting engineering for permitting and waste processing/recovery
Rotobec, Inc., St. .Justine, QB, Jubal Frost, (418)383-3002. knuckleboom loaders, material handling grapples
Rotochopper, Coon Valley, WI, Vince Hundt, (608) 452-3651, wood grinders for pallets, slab wood, and greenwaste
Roura Iron Works, Inc., Clinton Township, Ml, Sales Department, (800) 968-9070, self-dumping hoppers
Royal Basket Trucks, Inc., Darien, WI, Stephanie Prater, (414) 728-1227, recycling containers
Rubb Building Systems, Sanford Airport, ME, John Poulin, (800) 289-7822, prefabricated, relocatable containment structures, tank covers
Saturn Shredders Division of Mac Corporation, Grand Prairie, TX, Sales Staff, (612) 754-5089, shredders
Scarab Manufacturing & Leasing, White Deer, TX, Michael Hill, (806) 883-7621, self-propelled windrow composting machines
SCAT Engineering, Delhi, IA, Wayne Heitshusen, (319) 922-2230, composting equipment windrow turners
Scicorp Systems, Barrie, ON, (705) 733-2626, odor-producing anaerobic bacteria inhibitors
Screw Conveyor, Hammond, IN, Randy Block, (219) 931-1450, bulk material handling conveyors and equipment
Seppi Division of CT&E Co., Rosemount. MN, Jim Ochetti, (612) 423-2222, wood waste volume reduction equipment
Setco, Idabel, OK, Scot Sellers, (800) 634-2381, custom solid tires and rims for loaders and heavy equipment
Shred-Tech, Ltd., Cambridge, ON, Rob Glass, (800) 465-3214, shredding and reduction systems
Sizing Technology Engineering, La Porte, TX, Doug Lattimer III, (713) 471-1061, shredders
Smalis, New Stanton, PA, Doug Smalis, (412) 925-8500, conveyors, screw conveyors, bucket elevators
Smith & Hawken, Mill Valley, CA, Jim Downing, (415) 383-4415, backyard compost bins
Solid Waste Equipment Co. of Virginia, Ashland, VA, Cary V. Hall, (804) 752-677!, balers, shredders, trucks, carts
SP Industries, Inc., Hopkins, Ml, Steve Burk, (616) 793-3232, compactors, containers, balers, container dumpers
SSI Shredding Systems, Wilsonville, OR, Terri Ward, (503) 682-3633, reduction equipment shredders, compactors, granulator systems
Structural Instrumentation, Inc., Tukwila, WA, Customer Service, (206) 244-6100, truck scales
Sundance, Greeley, CO, Ralph O'Donnell, (970) 339-9322, waste grinders
Svedala Industries, Inc., Waukesha, WI, James Kidd, (414) 798-6341, grinders, screens, and sorters for MRFs/tire grinders

Svedala/Universal Engineering, Cedars Rapids, IA, Kelly Archer, (319) 365-0411, concrete/asphalt recycling equipment shredders
Tenax Corporation, Baltimore, MD, Brian Duncan, (800) 356-8495, geocomposites, erosion control
Texel, Inc., St. Elzear, QB, Sylvain Helie, (418) 387-5910, nonwoven needlepunched synthetic fiber compost covers
Texmarc Conveyor Co., Houston, TX, Ronald Smith, (713) 466-0426, portable screening plants, conveyors, stackers
The Newark Group, Inc., Cranford, NJ, Moe Banville, (908) 276-4000, MRF and recycling-related products and services
The Read Corporation, Middleboro, MA, William Tryder III, (508) 946-1200, portable screen plant
The Turtle Group, Cleveland, OH, Tom Norton, (216) 791-2100, malts and matting for MRFs and service garages
Thermo Tech Technologies, Inc., Langley, BC, Rene Branconnier, (604) 534-5085, bioconversion processor
Tink, Durham, CA, Roy Farrel, (916) 895-0897, roll-out bucket, hydraulic attachments for wheel loaders
Tire Resource Systems, Inc., Sioux City, IA, Les Pederson, (712) 255-5701, scrap fire cutters, tire balers, fire de-beaders, fire de-rimmers
Titan Industries, New London, WI, Harris Tofte, (414) 982-6600, conveyors for MRFs
Top Hand Glove, McCaysville, CA, Sales Staff, (704) 274-2900, work gloves, safety glasses, tams, straps, back supports, safety supplies
Toro-Recycling Equipment Division, Bloomington, MN, Neil Berenstein, (612) 887-7214, tub grinders, road debris retrieval systems
Tri-Rinse, St. Louis, MO, Jim Waldren, (314) 647-8338, mobile shredding, plastic recycling, product recovery
Triple E Co., Cedar Falls, IA, Floyd Swanson, (319) 266-4723, MRF and recycling-related products and services
Tryco International, Decatur, IL, Robert West, (217) 428-0901, fire grinders
Universal Refiner Corporation, Montesano, WA, Gerald Schaefer, (800) 277-8068, grinders
Valoraction, Inc., Sherbrooke, QB, Francois Courdeau, (819) 829-2818, tractor-tow composters, turners
Van Dyk Baler Corporation, Stamford, CT, Peter Bond, (203) 967-1100, balers, shredders, conveyors, sorting systems, composting equipment
Vermeer, Pella, IA, Doug Hundt, (515) 628-3141, tub grinders, brush chippers, directional boring machines
VME Composting, Syracuse, NY, Thomas Roach, (315) 422-7663, outdoor vermicomposting systems
Vulcan On-Board Scales, Kent, WA, Fred Houghten, (800) 237-0022, on-board scales and computers, transfer station weighing systems
Walker Magnetics Group, Worcester, MA, Don Morgan, (508) 853-3232. magnetic separators
WAM, Reno, NV, Sales Department, (702) 322-7331, software for haulers, landfills, MRFs,

transfer stations
Warren & Baerg Manufacturing, Inc., Dinuba, CA, Randy Baerg, (209)591-6790, baler/cuber/densifier of biomass for burning fuel
Wastequip, Beachwood, OH, Rich Garcia, (216) 292-2554, commercial containers, compactors, balers, roll-off hoists, trailers
Webb-Materials Handling Equipment, Marietta, GA, Barry Straus, (770) 426-3900, screw conveyors, feeders, bucket elevators
Wheatec, Wheaton, IL, Charles R. Stack, (630) 682-3024, odor control products

Diversion Equipment, Products and Services

The following companies offer products and services pertaining to waste diversion and recycling activities

3M personal Safety Products, St. Paul, MN, Joanne Johnson. (800) 328-7098, safety products. Reflective material

A&A Magnetics, Woodstock, IL, Ron Harrelson, (888) 605-6054, overhead magnets for MRFs, recycling

A-1 Products, Brampton, ON, Cathy Tedesco, (905) 451-4800, curbside, home/office plastic recycling containers

ABC Railing Wire Supply Co., Inc., Weehawken, NJ, Marie Morney, (201) 866-7799, baling wire

Accurate Industries, Inc., Erial, NJ, Seth Weingarten, (800)220-2228, compactors, balers, roll-offs, containers

Ag-Bag Compost Technology International, Warrenton, OR, Angela Grote, (800) 334-7432, low-tech. in-vessel composting systems

Allegheny Paper Shredders, Delmont, PA, Robert Wagner, (800) 245-2497, paper shredding and baling equipment

Allied-Gator, Inc., Youngstown, OH, Jack Stewart (330) 744-0808, mobile shears, grapples

Amadas Industries, Suffolk, VA, Tiny Andrews, (804) 539-0231, recycling equipment, composting/organic recovery technologies, conveyors

American Baler Co., Bellevue, OH, Richard Harris, (800) 843-7512, balers, high-density, no-shred conveyors

American Pulverizer, St. Louis, MO, Skip Anthony, (314) 781-6100, tire shredders, trommel screens, hammermills, ring milk, shredders

Andela Tool & Machine, Inc., Richfield Springs, NY, Cynthia Andela, (315) 850-0055, glass, CRT, and gypsum recycling systems

Arch Environmental Equipment, Inc., Paducah, KY. Lori Hyde, (502) 898-6821, belt cleaning systems, idlers

Arrowwood Associates, LLC, Noblesville, IN, Cynthia Lamberth, (317) 773-1603, environmental consulting training and software

Athey Products, Raleigh, NC, Jim Perry, (919) 556-5171, compost turners

Bailey Manufacturing Corporation, Knoxville, TN, John Sprouse, (800) 800-1830, custom hydraulic cylinders

Balemaster, Crown Point, IN, Sam Finlay, (219) 663-4525, horizontal balers

Bandit Industries, Inc., Remus, MI, Jerry Morey, (800) 952-0178, chippers, tub grinders, hogs

Banner Environmental, Germantown, VA, Paul Treiber, (414) 253-2900, shredders, grinders

Becker-Underwood, Inc., Ames, IA, Brent Lester, (515) 232-5907, colorants for turf

BenLee, Romulus, Ml, Steve Doughty, (313) 722-8100, scrap, waste, and sludge containers

Bes-Pac, Easley, SC, Danny James, (864) 859-6030, compactors, rear-loaders, side containers, vehicles

Best Litter Receptacle, Inc., Florence, SC, Carol Doty, (800) 526-1322, concrete trash, recycling and liner receptacles

Black & Veatch, Kansas City, MO, Jerry Novacek (913) 458-2222, consultants/engineers
Blower Application Co., Germantown, WI, Lawrence Brenner, (414) 255-5580, pneumatic scrap-handling and shredding systems
Blue Ridge Solid Waste Consulting, Bozeman, MT, Neal Bolton, (406) 587-8771, consulting/training/engineering
Bonar Plastics, Lindsay, ON, Susan Burns, (705) 324-6701, recycling-related products
Bouldin & Lawson, McMinnville, TN, Wade Sparkman, (615) 668-4090, compost baggers, MSW consulting
Brown & Caldwell, Pleasant Hill, CA, Margaret Coles, (800) 727-2224, engineering and WTE services
Bruce Mooney Associates, Inc., Allison Park, PA, Bruce Mooney, (800) 454-2686, recycling systems and equipment
C.S. Bell, Tiffin, OH, Ronald White, (419) 448-0791, custom conveyors, crushers, and separators
Calrecovery, Inc., Hercules, CA, George M. Savage, (510) 724-0220, solid waste consultants
Camp Dresser & McKee, Tampa. FL, Tammy Hayes, (813) 281-2900, consulting engineers
Cascade Engineering, Grand Rapids, MI, Don HoIm, (800) 968-2278, containers
Caterpillar, Inc., Peoria, IL, Local Caterpillar Dealer, (309) 675-4486, material handlers, compactors, loaders
Celdex Environmental Technology, Sainte-Foy, Quebec, Anne-Marie Tommasel, (514) 449-1234, solid waste management
CH2M Hill, Englewood, CO, Local Office, (303) 771-0900, consulting engineers
City Management Corporation, Detroit Ml, Thomas Horton, (313) 567-4700, waste management company
Colella & Associates, S. Daytona, FL, Jim Colella, (904) 522-9080, full-service consulting
Connecticut Metal Industries, Inc., Monroe, CT, Tom Mele, (203) 268-5909, recycling/recovery of nonferrous metals, MRF
Consolidated Fabricators Corporation, Vernon, CA,, Barbara Ross, (213) 586-4545, front-/rear-load containers, roll-offs, hoppers
Consolidated Resource Recovery, Sarasota, FL, Dee Steverson, (813) 756-0977, wood-waste grinding, screening disposal
Continental Biomass Industries, Newton, NH. Ted Cook (603) 382-0556, composting equipment wood chippers
Continental Manufacturing Co., Earth City, MO. Jack Benninghofen, (314)770-9949, recycling products, collection container
Countec Recycling Systems/Ponec, Des Moines, IA, Andy Andrews, (515) 246-1709, MRF, recycling, balers, glass, sorters
CP Manufacturing, National City, CA,, John Willis, (619) 477-3175. can flatteners, densifiers, crushers, sorters
Crane Equipment Manufacturing Corporation, Eugene, OR, Mike Kogukiewia, (503) 740-6981, grapples and knuckleboom cranes
Cranston Machinery Co., Inc., Oak Grove, OR, Paul Morrissey, (503) 654-7751, wire strappers, coilers, cutters

Creative Information Systems, Inc., Manchester, NH, Kevin St. John, (603) 627-4144, waste and recycling software
CW Manufacturing, Sabetha, KS, Tim Wenger, (800) 743-3491, tub grinders
Dempster, Toccoa, GA, Pete Van Tholen, (706) 886-2327, waste and recycling handling equipment
Diamond Z Manufacturing, Nampa, ID, Sam Ozuna, (208) 467-6229, industrial tub grinders
Dings Co. Magnetic Group, Milwaukee, WI, Harry Bolstad, (414) 672-7830, magnetic separators for ferrous and nonferrous metals
Double T Equipment Manufacturing, Ltd., Airdrie, AB, Rey Rawlins, (403) 948-5618, windrow turners, tunnel composting, conveyors, and conveyor systems
Douglas Manufacturing, Inc., Pell City, AL, Doug Ross, (205) 884-1200, MRF equipment, conveyors. separators, components
Dover Conveyor, Midvale, OH, Joe Coniglio, (614) 922-9390, bulk materials handling equipment apron feeders, conveyors, bucket elevators, screw conveyors
Duraquip, Tualatin, OR, Larry Gilmore, (800) 486-5320, separation systems, conveyors, shredders
Duratech Industries, Jamestown, ND, Bruce Leiseth, (701) 252-4601, grinders for yardwaste
Eagle Crusher Co./'Cobey Composter, Galion, OH, Team Eagle Sales, (419) 468-2288, portable crushers and screeners for C&D
EBA Wastechnologies, Santa Rosa, CA, Duane Butler, (707) 544-0784, consulting engineers
Ecolo Worldwide, Mississauga, ON, Ian Howard, (905) 625-8664, odor control products
Educational Development Specialists, Lakewood, CA, Ann Crafton, (310) 420-6814, environmental education programs for schools
El Monte Plastics, Tustin, CA, Glen Sanders, (714) 544-9599, automated and semi-automated plastic refuse containers
Endura-Max, Alpena, MI, Julie Cordes, (800) 356-1593, shredders, conveyors, and related products
Enterprise Baler Co., Santa Ana, CA, Orval Gould, (714) 835-0551, balers, compactors, complete MIF systems
Environmental Risk Ltd., Bloomfield, CT, Richard Atkins, (203) 242-9933, environmental consulting/engineering
Environmental Waste Management Corporation, Ajax, ON, Tom Fairfull, (800) 399-2366, tire and medical waste systems
EPI Environmental Products, Inc., Conroe, TX, David Deeds, (409) 768-2998, degradable plastic film and compostable bags
Epoleon Corporation, Torrance, CA, Kit Hammond, (800) 376-5366, odor neutralizing chemicals
Eriez Magnetics, Erie, PA, Al Gegaudas, (800) 345-4946, magnetic and eddy-current separators, vibratory feeders, conveyors, screens
Erin Screens, Portland, ME, David Miley, (800) 789-3746, screens for MSW, compost, C&D
ERM Group, Exton, PA, Mary Beth Clay, (610) 524-3500, environmental engineers/consultants
ERRCO, Epping, NH, Matthew Senior, (603) 679-2526, woodchips, aggregate
ESP Corporation, Arlington, TX, Terry Merrill, (817) 275-5533, bioremediation microbes,

enzymes, odor control surfactant
Excel Manufacturing, St. Charles, MN, Michael Forsythe, (800) 475-8812, horizontal and vertical balers, conveyors
Extec of North America, Lester, PA, Colin Douglas, (610) 521-6344, screening, crushing, shredding, blending, conveying systems
Fecon, Inc., Cincinnati, OH, John Heekin, (513) 956-5700, mobile yardwaste shredders/composters and windrow turners
Fibrex, Chesapeake, VA, Ruben Leenders, (804) 487-5744, recycling containers
Flexible Steel Lacing Co., Downers Grove, IL, Jayne Dore, (630) 971-0150, belt conveyor products
Frontier Research, Sterling, VA, Sales Department, (703) 478-0181, software for data analysis
Foster Wheeler Corporation, Clinton, NJ, Hank Somerville, (908) 730-4000, MRFs and cogeneration facilities
Freese & Nichols, Inc., Fort Worth, TX, William C. Allanach, (817) 735-7300, consulting engineers
Frontier Manufacturing Co., Brooks, OR, Ken Warner, (503)792-3737, windrow turners, automatic watering systems
Fuel Harvesters Equipment Inc., Midland, TX, Mike Byford, (915) 694-99B8, tub grinders, compost turners, separators, trammel screens
Galbreath, Inc., Winamac, IN, Keven Crawford, (219) 946-4631, roll-offs, hoists, compactors, balers, containers, trailers, hoppers
Gardner Equipment Co., Inc., Juneau, WI, Darryl Benson, (800) 393-0333, backyard composter, oil filter crushers
GDS Screens, Inc., Riviera Beach, FL, Ginger Olson, (561) 840-8481, portable trammels
Geisert Plastics, Inc., Seattle, WA, Paul Geisert, (206) 343-7965, thermoplastic recycling sourcing and supply
General Kinematics Corporation, Barrington, IL, Bill Guptail, (847) 381-2240, vibrating processing for separation and classification
Gensco Equipment Co., Toronto, ON, David Zelunka, (416) 465-7521, grapples, buckets, material handling equipment
Geosoft, Inc., Toronto, ON, Angela Lennox, (800) 363-6277, environmental data management processing, and analysis software
Gershman, Brickner & Bratton, Inc., Falls Church, VA, Harvey Gershman, (703) 573-5800, solid waste management consultants
Global Equipment Marketing, Inc., Boca Ratan, FL, Marshall Gralnick. (561) 750-8662, magnets/eddy-current separators
Golder Associates Corporation, Atlanta, GA, Kristin Thomas, (770) 496-1893, consultant engineers
GPI Division Harmony Enterprises, Harmony, MN, Stephen Kingety, (507) 886-6666, vertical balers and compactors
Green Mountain Technologies, Seattle, WA, Tim O'Neill, (206) 634-1308, containerized compost systems, aeration systems
Greg Markim, Inc., Milwaukee, WI, Kim Schiedermayer, (800) 453-1485, school training

programs, community education programs
Hagglunds Drives, Columbus, OH, Kevin Kennedy, (614) 527-7400, hydraulic motors for shredders and conveyors
Harding Lawson Associates, Novato, CA, Joseph Petrillo, (415) 892-0821, consulting engineers
Harmonious Technologies, Sebastopol, CA, John Roulac, (707) 823-1999, backyard composting products and consulting services
Harris Group, Peachtree City, GA, Coleen Helland, (770) 631-7290, balers, conveyers/shears/cranes
Haul-All Equipment, Lethbridge, AB, Robert Niven, (403) 328-7719, waste and recycling containers and equipment
HDR Engineering, Omaha, NE, John Williams, (914) 328-8505, consulting engineers
Heil Environmental Industries, Ltd., Chattanooga, TN, Larry Stone, (423) 899-9100, waste and recycling collection bodies
Hesco Sales, Inc., Miami, FL, Sam Eissen, (305) 597-0243, balers, roll-offs, hoists, and recycling containers
Hi-Rise Recycling Systems, Inc., Miami, FL, Robert Runge, (305) 624-9222, automated recycling Systems for multistory buildings
Holmes & Narver, Orange, CA, Steve Galloway. (714) 567-2500, consulting engineers
Hustler Conveyor Co., St. Louis, MO, Dave Guytan, (314) 352-4000, conveyors for MRFs and complete MRF Systems
Hydrometrics, Helena, MT, Bob Braico, (406) 443-4150, full-service environmental analysis and permitting
Industrial Paper Shredders, Salem, OH, DeeDee Thomas, (216) 332-0024, paper shredders
Information Systems, Inc., Baltimore, MD, James Manley, (410) 769-9800, automated weighing systems
Integrated Waste Services Association, Washington, DC. Maria Zannes, (202) 467-6240, national WTE trade group
International Baler, Inc., Jacksonville, FL, Jerry Wise, (904) 358-3812, vertical, horizontal, auto-tie, and 2-ram balers
International Compactor, Inc., Hilton Head Island, SC, Michael Pierson, (803) 686-5503, compactors, crushers
IPL, Inc., St. Damien, QB, Gartan Boldue, (418) 789-2880, trash cans, plastic-wheeled carts
J.V. Manufacturing Inc., Springdale, AR, Keith Pinson, (501) 751-7320, balers, containers, compactors, recycling containers
Jeffrey, Woodruff, SC, John Blake, (864) 476-7523, hammermill-type shredders, vibrating feeders
Jones Manufacturing Co., Beemer, NE, Don Reis, (402) 528-3861, tub grinders
K-F Environmental Technologies, Inc., Pompton Plains, NJ, Emil Kneis, (201) 616-0700, sludge management services
Karl W Schmidt & Associates, Inc., Commerce City, CO, Bill Ranger, (303) 287-7400, conveyors/conveying systems
Kewanna Screen Printing, Inc., Kewanna, IN, Wiladean DeWitt, (800) 348-2454, decals for refuse and recycling containers

Knight Manufacturing, Brodhead, WI, Steve Pesik (608) 897-2131, sludge and compost mixers, trammels, spreaders
Komar Industries, Inc., Groveport, OH, Kelly Eley, (614) 836-2366, compactors, shredders, waste processing equipment
Kuma Corporation, Grass Valley, CA, Jim Ippolito, (916) 268-7070, odor control chemicals for landfills, composting and transfer stations
Kurtz Brothers, Inc., Cleveland, OH, Greg Rondy, (216) 641-7000, wood mulch coloring machines, coloring and consultation
KW Plastics Recycling Division, Troy, AL, J. Scott Saunders, (334) 566-1563, postconsumer plastics recycler/MRF
LaBounty Manufacturing, Two Harbors, MN, Man Mahoney, (218) 834-2123, hydraulic tools **Laidlaw Waste Systems, Ltd.**, Budington, ON, Mike Bracagn/US, (817) 485-9950, full service waste management company
LH Resource Management Inc., Walton, ON, Chris Lee, (800) 265-9682, composting plant design, equipment and services
Lindemann Recycling Equipment Inc., Charlotte, NC, Joe Szany, (800) 995-9149, balers, eddy-current separators
Lindig Corporation, Lexington, MN, John Lindig, (612) 633-3072, shredders, chippers, and grinders
Liquid Waste Technology, Inc., Somerset, WI, Don Mueller, (715) 247-5464, dredging equipment and service
Littleford Day, Florence, KY, Bill Barker, (606) 525-7600, composting equipment mixers
Logemann Brothers, Milwaukee, WI, Philip Johnson, (414) 445-3005, manufacturer of 2-ram automatic-tie balers
Lubriquip, Inc., Cleveland, OH, Blake Beharry, (800) 872-5823, automatic lubrication systems for mobile and stationary equipment
Mac Equipment, Inc., Kansas City, MO, Stacy Shaleen, (816) 891-9300 dust collection
Marathon Equipment Co., Vernon, AL, Christina Harris, (205) 695-8517, compactors, containers, balers, roll-off hoists
Marcom Industries, Inc., Greensburg, PA, Michael Scott, (412) 832-0140, compost aerators, control systems
Maren Engineering Corporation, South Holland, IL, Chuck Brown, (708) 333-6250, balers, shredders
Marrel Corporation, Hendersonville, TN, Hans Vooys, (615) 822-3536, container handling systems
Mayne Machinery Co., Inc., Waco, TX, John Mayne, (817) 772-2033, sorting systems, new and used balers and conveyors
Melroe Co., Fargo, ND, Wanda Roath, (701)241-8700, skid-steer loaders and compact hydraulic excavators
Mi-Jack Products, Hazel Crest, IL, John Troop, (708) 596-5200, intermodal container equipment and services
Mid-Atlantic Plastic Systems, Inc., Roselle, NJ, Craig Rogers, (908) 241-9333. plastic recycling systems, recycled plastic lumber

Mid-Atlantic Waste Systems, Easton, MD, Susie Newcomb, (410) 820-7188, reusable recycling bag parts and equipment
Mid-States Recycling Systems, Inc., Bridgeview, IL, Tom Ellis, (800) 235-8351, balers, conveyors, and sorting systems
Midwest Environmental Consultants, Jefferson City, MO, Anthony Starns, (314) 636-9454, landfill/transfer station services
Modern Manufacturing, Beaumont, TX, Will Crenshaw, (409) 833-2665, containers, boxes, and trailers
Modular Gabions/C.E Shepherd, Houston, TX, Kiran Jagad, (713) 928-3763, home composters
Montenay Power, New York, NY, Paul Alderdice, (212) 826-7054, WTE facilities
Morbark, Winn, Ml, Sales Department, (517) 866-2381, organic and woodwaste recycling/processing equipment
N-Viro Energy Systems, Ltd., Toledo, OH, Chris Mahoney, (419) 535-7008, biosolids and waste disinfection and reuse technology
National Ecology Co., Timonium, MD, John Berry, (410) 252-5666, waste processing system design, operation, and consulting
National Manufacturing/Geneva Products, Valley City, ND, Joel Strom, (701) 8451017, roll-off drop boxes, recycling trailers, rear-load containers
National Recycling Equipment Co., Georgetown, MA, Fred Warrender, (401) 245-0002, recycling collection equipment transfer stations
Nature Plus, New Canaan, a, Shave Sexon, (203) 972-1100, odor management formulations and dispensers
Naturtech Composting Systems, Inc., Saint Cloud, MN, Jim McNelly, (320) 253-6255, containerized in-vessel composting equipment
Nordberg Sales Corporation, Milwaukee, WI, David van Driel, (414) 7694381, crushers, screens, conveyors
Norseman Plastics, Rexdale, ON, Herb Noseworthy, (416) 745-6980, composters
Norton Environmental, Independence, OH, Louis Perez, (216) 447-0070, MRF operator/builder/design
O&E Machine, Greenbay, WI, Dennis Jeanquart (414) 437-6587, custom-built solid waste shredders, grinders
O'Brien & Gere Engineers, Inc., Syracuse, NY, Gary N. Kirsche P.E., (315) 437-6100, full-service consulting engineers
Ogden Projects, Inc., Fairfield, NJ, Gloria Mills, (201) 882-9000, waste management consulting, WTE
Oliver Manufacturing Co., Inc., Rocky Ford, CO, Tom Helman, (719) 254-7814,density separation equipment
Orix Credit Alliance, Inc., Rolling Meadows, IL, Nick Jones, (847) 593-5580, equipment financing
Orwak USA, Inc., Minneapolis, MN, Anders Carlegren, (612) 881-9200, midsize compacting balers
F.L. Lamoreaux, Tuscaloosa, AL, Jim LaMoreaux, (205) 752-5543, environmental consulting

Pacific Shredder Technologies, Inc., Portland, OR, Jay Randall, (503) 223-4980, slow-speed shredders
Pactec, Inc., Clinton, IA, Charles Moore, (800) 272-2832, liners, tarps, bags
Parametrix Kirkland, WA, Dwight E. Miller, (206) 822-8880, environmental and engineering consultants
PC Scale, Oxford, PA, Don Tefft, (610) 932-4006, PC-based environmental software
Pemberton, Inc., Longwood, FL, Todd Pemberton, (800) 393-6688, attachments for excavators grapples, large equipment
Permco, Inc., Streetsboro, OH, Rick Olszewski, (330) 626-2801, dry valve gear pumps
Peterson Pacific Corporation, Eugene, OR, Jack Nantz, (503) 689-6520, yardwaste, grinder, compost, wood processing equipment
Plastican, Inc., Leominster, MA, Barbara Vosburgh, (508) 537-4911, curbside recycling bins and cans
Plastopan North America, Inc., Los Angeles, CA, Catherine Bump, (213) 231-2225, wheeled automated refuse and recycling carts, crates, backyard composters
Post, Buckley, Schuh & Jernigan, Inc., Winterpark, FL, Sam Levin, (407) 647-7275, environmental and engineering consultants
Presona, Inc., Waco, TX, Ruddy Himes, (800) 577-3766, horizontal balers for paper, OCC, UBC, plastics, and solid waste
Processing Technologies, Inc., St. Charles, IL, Sue Bullock, (630) 443-3000, extrusion systems for plastics industry
Prodeva, Inc., Jackson Center, OH, Steve Bunke, (800) 999-3271. recycling equipment, conveyors
PRS Materials, Inc., West Chester, PA, Gina Marie D'Ginto, (610) 430-3960, enriched mulch/compost
Quality Recycling Equipment, Horse Shoe, NC, Doug King, (704) 696-2111, new and used recycling equipment
R.M. Johnson Co., Inc., Annandale, MN, Kristy Harren, (320) 274-3594, crushers, shredders, balers, tire cutters
Rader Resource Recovery, Inc., Memphis, TN, Steve Jones. (901) 795-7722, screens and bag breakers, conveyors
Recovery Systems Technology. Inc., Seattle, WA, Bob Schloredt, (206) 542-9347, trommel and disk screens, picking belts and conveyors
Recycled Plastics Marketing Redmond, WA, Tony Viscosi, (206) 867-3200, compost bins, recycled plastic products
Recycling Insights, Shakopee, MN, Mark Banwart, (612) 445-6992, environmental software, solid waste planning/management
Regional Disposal Co./Rabanco, Bellevue, WA, Warren Razore, (206) 646-2400, full-service waste management
Rehrig Pacific, Los Angles, CA, William Block, (213) 262-5145, trash cans, recycling containers, greenwaste carts
Reotemp Instrument Corporation, San Diego, CA, Bob Riker, (619) 481-7737, compost thermometers

Resource Recovery Systems of Nebraska, Sterling, CO, Lester Kuhlman, (970) 522-0663, self-propelled windrow composters

Resource Recycling Systems, Ann Arbor, Ml, James Frey, (313) 996-1361, consulting engineers

Rexius, Eugene, OR, Dan Sutton, (800) 285-7227, hydroseeding vehicles, products, services

Rexnord Conveyor Equipment Division, Milwaukee, WI, Richard Skroski, (414) 643-3743, heavy-duty conveyors, bucket elevators

Rexworks, Inc., Milwaukee, WI, Chris Klinck/Dave Ross, (414) 747-7200, recycling grinders

Richard Serlen/Gaylord Boxes, EIkins Park, PA, Richard Serlen, (215) 635-7277, recycling boxes

Riede Systems, Inc., St. Paul, MN, Tom Bowen, (800) 486-5426, MRF and processing equipment

Rigo & Rigo Associates, Inc., Berea, OH, Greg Rigo, (216) 243-5544, consulting engineering for waste processing/recovery

Rotobec, Inc., Ste. Justine, QB, .Jubal Frost, (418) 383-3002, knuckleboom loaders, material handling grapples

Rotochopper, Coon Valley, WI, Vince Hundt, (608) 452-3651, wood grinders for pallets, slab wood, and greenwaste

Roura Iron Works, Inc., Clinton Township, Ml, Sales Department, (800) 968-9070, self-dumping hoppers

Roy F. Weston. Inc., West Chester, PA, Bruce Gledhill, (610) 701-3000, environmental consulting

Royal Basket Trucks, Inc., Darien, WI, Stephanie Prater, (414) 728-1227, recycling containers

Ruckstell California Sales, Inc., Fresno, CA, Dick Townly, (209) 233-3277, dual automated container recycling system

Rust Environmental & Infrastructure, Greenville, SC, Walt Studabaker, (800) 868-0373, full-service consulting engineers

Saturn Shredders Division of Mac Corporation, Grand Prairie, TX, Sales Staff, (972) 790-7800, shredders

Scansys Corporation, Jacksonville, II, Sharon Rocks, (904) 771-6060, accounting and management hardware and software

Scarab Manufacturing & Leasing, White Deer, TX, Michael Hill, (806) 883-7621, self-propelled windrow composting machines

SCAT Engineering, Delhi, IA, Wayne Heitshusen, (319) 922-2230, composting equipment, windrow turners

Schaefer Systems International. Inc., Charlotte, NC, Corinne Higdon, (704) 588-2150, waste/'recycling containers

Scicorp Systems, Barrie, ON, Sales Department (705) 733-2626, odor-inhibiting systems

Screentech Products, South Holland, IL, Robert Roeda, (708) 333-3021, container and equipment decals, banners

Screw Conveyor, Hammond, IN, Randy Block, (219) 931-1450, bulk material handling conveyors and equipment

SCS Engineers, Long Beach, CA, James M. Gittelson, (310) 426-9544, consulting engineers

Seppi Division of Ct&E Company, Rosemount, MN, Jim Ochetti, (612) 423-2222, woodwaste volume-reduction equipment

Setco, Idabel, OK, Scot Sellers, (800) 634-2381, custom solid tire and rims

Shred-Tech, Ltd., Cambridge, ON, Rob Glass, (800) 465-3214, shredding and reduction systems

Smalis, New Stanton, PA, Doug Smalis, (412) 925-8500, conveyors, screw conveyors, bucket elevators

Smith & Hawken, Mill Valley, CA, Jim Downing, (415) 383-4415, backyard compost bins

Solid Waste Equipment Co. of Virginia, Ashland, VA, Cary V. Hall, (804) 752-6771, balers, shredders, trucks, carts

SP Industries, Inc., Hopkins, Ml, Steve Burk, (616) 793-3232, compactors, containers, balers, container dumpers

SSI Shredding Systems, Wilsonville, OR, Terrri Ward, (503) 682-3633, reduction equipment, shredders, compactors, granulator systems

Statsoft, Tulsa, OK, Sales, (918) 749-1119, statistical software

Stearns & Wheler, Cazenovia, NY, Howard La Fever, (315) 655-8161, consulting engineers

Steco, Enid, OK, Michael Turley, (405) 237-7433, live-floor and push-out transfer trailers

Steel Recycling Institute, Pittsburgh, PA, Greg Crawford, (800) 876-7274, association

Sterling Bag & Supply Co., Inc., Lackawanna, NY, Richard Konefke, (800) 515-1990, geotextiles, filter bags, silt fending

STS Consultants, Ltd., Deerfield, IL, Andrew Hanbert, (847) 267-8010, environmental engineers

Sundance, Greeley, CO, Ralph O'Donnell, (970) 339-9322, waste grinders

Svedala Industries, Inc., Waukesha, WI, James Kidd, (414) 798-6341, grinders, screens, and sorters for MRFs/tire grinders

Svedala/Universal Engineering, Cedars Rapids, IA, Kelly Archer, (319) 365-0441, concrete/asphalt recycling equipment/shredders

Tecnomen Data Collection, Inc., Atlanta, GA, Chris Ronnblad, (770) 512-5130, onboard data collection equipment waste management and reporting software

Texel, Inc., St. Elzear, QB, Sylvian Helie, (418) 387-5910, nonwoven needlepunched synthetic fiber compost covers

The Newark Group, Inc., Cranford, NJ, Moe Banville, (908) 276-4000, MRF and recycling-related products and services

The Read Corporation, Middleboro, MA, William Tryder III, (508) 946-1200, portable screen plant

The Turtle Group, Cleveland, OH, Tom Norton, (216) 791-2100, mats and matting for MRFs and service garages

Thermo Tech Technologies, Inc., Langley, BC, Rene Branconnier, (800) 377-5085, bioconversion for livestock feed/fertilizer

Tink, Durham, CA, Roy Farrel, (916) 895-4897, roll-out bucket, hydraulic attachments for wheel loaders

Tire Resource Systems, Inc., Sioux City, IA, Les Pederson, (712) 255-5701, scrap tire cutter, tire balers, tire debeader, tire de-rimmer

Top Hand Glove, McCaysville, GA, Sales Staff, (800) 241-7001, work gloves, safety glasses, taros, straps, back supports, safety supplies

Toro -Recycling Equipment Division, Bloomington, MN, Neil Berenstein, (800) 525-0059, tub grinders. road debris retrieval system

Toter, Statesville, NC, Inside Sales, (704) 872-8171, waste and recycling carts, hydraulic lifting devices

Tri-Rinse, St. Louis, MO, Jim Waldren, (314) 647-8338, mobile shredding, plastic recycling, product recovery

Tribble & Richardson, Inc., Macon, GA, Joan P. Kirby, (912) 474-6100, consulting engineers

Triple H Co., Cedar Fails, IA, Floyd R. Swanson, (319) 266-4723, MRF and recycling-related products and services

Triple/S Co., Dallas, TX, Jay Sullivan. (800) 527-2116, granulators, shredders, trommels, separators, conveyors

Tryco International, Decatur, IL, Robert West, (217) 428-0901, tire grinders

Tulip Corporation, City of Industry, CA, Bryan Walker, (818) 968-0044, single-/multifamily/office recycling containers

Union Camp Corporation, Wayne, NJ, Diane Schroeder, (201) 628-2505, compostable collection bags

URS Consultants, New York, NY, Robert W. Karn, (212) 736-4444, consulting/architects/developers/engineers

Valoraction, Inc., Sherbrooke, QB, Francois Gourdeau, (819) 829-2818, tractor-tow composters, turners

Van Dyk Baler Corporation, Stamford, CT, Peter Bond, (203) 967-1100, balers, shredders, conveyors, sorting systems, composting equipment

Vermeer, Pella, IA, Doug Hundt, (515) 628-3141, tub grinders, brush chippers

Vital Visions Manufacturing Corp., Freeport, FL, Carol Wood, (904) 835-2121, containers for waste, recycling, used oil

VME Composting, Syracuse, NY, Thomas Roach, (315) 422-7663, outdoor vermicomposting system

Vulcan On-Board Scales, Kent, WA Fred Houghton, (800) 237-0022, on-board scale systems

Walker Magnetics Group, Worcester, MA, Don Morgan, (508) 853-3232, magnetic separators

WAM, Reno, NV, Sales Department, (800) 282-8229, software for haulers, landfills, MRFs, transfer stations

Warren & Baerg Manufacturing, Inc., Dinuba, CA, Randy Baerg, (209) 591-6790, baler/cuber/densifier of biomass for burning fuel

Wastequip, Beachwood, OH, Rich Garcia, (216) 292-2554, commercial containers, compactors, balers, roll-off hoists, trailers

Webb-Materials Handling Equipment, Marietta, GA, Barry Straus, (770) 426-3900, screw conveyors, feeders, bucket elevators

Wheatec, Wheaton, IL, Charles R. Stack, (630) 682-3024, odor control products

Willis Corroon Recyclers Insurance, Rochester, NH, Brooks W. Chase, (888) 225-4725, insurance and environmental risk management programs for recyclers

Windsor Barrel Works, Kempton, PA, Beverly Brolost, (610) 756-4344, recyclables collection

containers
WMX, Inc., Oak Brook, IL, Laura Field, (708) 572-2956, full-service waste management
Woodward Clyde Group, Inc., Denver, CO, Sales Department, (303) 740-2600, consulting engineers
Zarn, Inc., Reidsville, NC, Mel Paterline, (910) 349-3323, collection containers, waste and recycling carts, and hydraulic lifters

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