

**The Colorado State University
Industrial Assessment Center**

Pollution Prevention Handbook

Pollution Prevention Training Manual For IAC Undergraduate
and Graduate Students

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1.0 GLOSSARY

BDAT	best demonstrated available technology
BDC	business development corporation
BOD	biological oxygen demand
CCP	commercial chemical products
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHMR	Center for Hazardous Materials Research
CRS	central recovery system
DOD	Department of Defense
DOT	Department of Transportation
EDA	Economic Development Administration
EP	extraction procedure
EPCRA	Emergency Planning the Community Right-to- Know Act
FHA	Farmer's Home Administration
HOC	halogenated organic compounds
HSWA	Hazardous and Solid Waste Amendments
IPM	integrated pest management
LEPC	local emergency response commission
MCI	manufacturing chemical intermediates
MSDS	Material Safety Data Sheet
NA	North American
NPDES	National Pollution Discharge Elimination System
NPV	net present value
OPPE	Office of Policy, Planning, and Evaluation (U.S. EPA)
OSHA	Occupational Safety and Health Administration
PBP	payback period
POTW	publicly owned treatment work
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SBA	Small Business Administration
SBIC	small business investment company
SERC	state emergency response commission
SIC	Standard Industrial Classification
SQG	small quantity generator
TPQ	threshold planning quantity
TSCA	Toxic Substances Control Act
UN	United Nations
US EPA	United States Environmental Protection Agency
UST	underground storage tank

2.0 FEDERAL STATUTES AND THE CONTROL OF TOXIC SUBSTANCES

Law	Citation	State Authorization	Section	Key Provisions
Clean Air Act of 1970, as amended 1977	PL 91-604 (42 USC 7401, et seq.)	yes	Sec.109.Ambient Air Quality Standards	· EPA to establish primary and secondary (welfare)
			Sec.112. Emission Standards for hazardous Air Pollutants	· beryllium, asbestos, mercury · vinyl chloride (1976), · radionuclides (1979)
			Sec.111 . New Source Performance Standards	· standards developed for processes · standards being developed for additional processes
Clean Water Act of 1972, as amended 1977	PL 92-500 (1972) and PL 95-217 (1977) (33 USC 1251 et. seq.)	yes	Sec.303. Water Quality Standards	· establish levels of pollutants water can contain and certain uses (i.e., recreational water supply, agriculture)
			Sec. 301. Effluent Limitations	· 65 toxic pollutants list guidelines and pretreatment
			Sec. 307. Toxic and Pretreatment Effluent Standards	· Best Available Technology control required · standards established for toxaphene, benzidine (carcinogenic)
Comprehensive Environmental Responses, Compensation, and Liability Act of 1980	PL 96-510 (42 USC 960 et. seq.)	no	Sec. 311. Oil and Hazardous Substance Liability	· spill cleanup provisions · establish spill quantities to the National Response System
			Sec.102. Reportable Quantities	· spills in excess of specified quantities reported to the National Response System

Law	Citation	State Authorization	Section	Key Provis
			Sec.106. Abatement Action Title II, Sec. 4661 Imposition of Tax	<ul style="list-style-type: none"> · EPA authorized to i · to require responsib · tax imposed on petro · feedstock chemicals · cleanup fund ("Sup
			Sec. 104. Response Authorities	<ul style="list-style-type: none"> · EPA authorized to c
Federal Food Drug, and Cosmetic Act of 1938	PL 717 of 1938 (21 USC 301, et. seq.)	no		<ul style="list-style-type: none"> · food, drug, medical regulated products c · after they are appro · Drug Administrator · adulteration and mis
			Sec. 409	<ul style="list-style-type: none"> · no additive may be · cancer in animals (I · pesticide residues or
Federal Insecticide, Fungicide, and Rodenticide Act of 1972	PL 92-516 (7 USC 136, et. seq.)	partial (States can assume enforcement certification responsibility)	Sec 6. Administrative Review; Suspension	<ul style="list-style-type: none"> · EPA may suspend, c · an existing pesticide · able risk to humans · EPA announces a "r · against registration"
			Sec. 3. Registration of Pesticides	<ul style="list-style-type: none"> · all pesticides sold m · pesticides classified · or restricted use (us · trained applicators)
			Sec. 12. Unlawful Acts	<ul style="list-style-type: none"> · prohibits sale of unr
Hazardous Materials Transportation Act of 1975	PL 93-633 (49 USC 1801, et. seq.)	no	Sec 105. Regulations Governing Transportation of Hazardous Materials	<ul style="list-style-type: none"> · shipments of hazard · be packaged, labelc · accordance with De · tation (DOT) require · 22 hazard classes es · carriers required to 1

Law	Citation	State Authorization	Section	Key Provis
Occupational Safety and Health Act of 1970	PL 91-596 (29 USC 651, et. seq.)	yes	Sec 6. Occupational Safety and Health Standards	<ul style="list-style-type: none"> and emergencies cor materials within 15 · establishes use and c hazardous substance · establishes exposure · chemical manufactu hazards of the chem · Material Safety Data with each chemical
			Sec. 22. National Institute for Occupational Safety and Health	<ul style="list-style-type: none"> · NIOSH established t
			Sec. 8. Inspections, investigations, and recordkeeping	<ul style="list-style-type: none"> · inspection may be c · employers required t health problems
Resource Conservation and Recovery Act of 1976, as amended 1984	PL 94-580 (1976) and PL 98-616 (1984) (42 USC 3251 et. seq.)	yes	Sec. 3001. Identification and Listing of Hazardous Waste	<ul style="list-style-type: none"> · EPA identifies speci defined as producig · waste may be hazarc (ignitable, corrosive
			Sec. 3002 and 3003 Standards Applicable to Generators and Transporters	<ul style="list-style-type: none"> · must register with E · transported waste m · exempts generators p 100 kg/month
			Sec. 3004. Standards Applicable to Hazardous Waste Treatment, Storage, and Disposal Facilities	<ul style="list-style-type: none"> · facilities operating i (Part A) permit · provisions on emerg recordkeeping, moni financial liability
			Sec. 3005. Permits for Hazardous Waste Treatment, Storage, and Disposal Facilities	<ul style="list-style-type: none"> · new and facilities c obtain final (Part B)

Law	Citation	State Authorization	Section	Key Provis
			Sec. 9003. Regulation of Underground Storage Tanks	· notification to State requirements for ow Tanks
Safe Drinking Water Act of 1974, as amended 1986	PL 93-523 (42 USC 300f, et seq.)	yes	Sec 1412. Drinking Water Regulations	· EPA establishes ma goals and standards by 1989 · definition of treatme · contaminant regulat · filtration and disinf
			Sec. 1421. Protection of Underground Sources of Drinking Water	· establishes undergro program · Five classes of wells
			Sec. 1428. Wellhead Protection Program	· States required to in protection program
Superfund Amendments and Reauthorization Act	PL 99-499 (42 USC 11013 and 11028)	no	Title I Response and Liability	· Reauthorizes and an
			Title II Miscellaneous	· Catch all
			Title III Emergency	· Creates a major new and emission
			Planning and Community Right-to-Know	· reporting and requir with local emergenc
Toxic Substances Control Act of 1976	PL 94-469 (15 USC 2601, et seq.)	no	Sec 5. Manufacturing and Processing Notices	· chemical manufactu 90 days prior to ma
			Sec. 6. Regulation of Hazardous Chemical Substances	· authority to prohibit of chemicals where of environment invc
			Sec. 4. Testing of Chemical Substances	· authority to require for health and envir

3.0 RCRA REGULATIONS FOR SMALL QUANTITY GENERATORS

Introduction

This chapter is designed to help businesses determine if they are small quantity generators of hazardous waste. In addition, proper storage, shipment, treatment, and disposal procedures are discussed.

What Is a Small Quantity Generator (SQG)?

In 1976, Congress passed the Resource Conservation and Recovery Act (RCRA), which directed the U.S. Environmental Protection Agency (U.S. EPA) to develop and implement a program to protect human health and the environment from improper hazardous waste management practices.

U.S. EPA first focused on large companies which generate the greatest portion of hazardous waste. Establishments producing less than 1,000 kilograms (2,200 pounds) of hazardous waste in a calendar month, known as small quantity generators (SQGs), were exempted from most of the hazardous waste regulations published by U.S. EPA in May 1980.

In November 1984, the Hazardous and Solid Waste Amendments (HSWA) to RCRA were signed into law. With these amendments, Congress directed the U.S. EPA to establish new requirements that would bring small quantity generators who generate less than 1,000 kilograms (kg) of hazardous waste in a calendar month into the regulatory system. U.S. EPA issued final regulations for these small quantity generators on March 24, 1986. Most of the requirements became effective September 22, 1986.

Types of Businesses Most Likely to Produce Small Quantities of Hazardous Wastes

Types of businesses most likely to produce small quantities of hazardous wastes include

- vehicle maintenance firms,

- metal manufacturers and metal finishers (including electroplating and printed circuit boards),

- construction companies,

- printing companies,

- photographic processors,

- and laundries and dry cleaners.

Other businesses affected by the SQG RCRA regulations include educational and vocational shops, analytical and clinical laboratories, and pesticide applicators. The most common hazardous wastes produced by SQGs are:

<i>Typical types of hazardous waste</i>	<i>Examples</i>
Acids/bases	Various acids, ammonium hydroxide, sodium hydroxide
Ignitable wastes	Acetone, n-butyl alcohol, ethyl ether, methyl alcohol, xylene
Solvents	Perchloroethylene, isopropyl or ethyl alcohol, trichloroethylene
Pesticides	Aldicarb, aldrin, DDT, dieldrin
Spent plating wastes	Cyanide, heavy metals, solvents
Ink sludges	Ink sludges with chromium or lead
Reactives	Hypochlorites, sulfides
Lead acid batteries	Lead dross, spent acid
Dry cleaning residues	Spent filter cartridges, solvent distillation residues

RCRA Regulatory Requirements for Small Quantity Generators.

<i>Requirement</i>	<i>Less than 100 kg/mo</i>	<i>100-1,000 kg/mo</i>
Determine quantity of hazardous waste generated	Required	Required
Obtain EPA I.D. number	-	Required
Observe accumulation time or quantity limits	Required	Required
Observe storage facility criteria	-	Required
Prepare and plan for accidents or emergencies	-	Required
Properly label and package shipments	-	Required
Ship wastes with a manifest	-	Required
Use a licensed transporter	-	Required
Ship to an approved treatment, storage, or disposal facility	Required	Required
Keep records	-	Required

4.0 HAZARDOUS WASTE

What is a Hazardous Waste?

A waste is any solid, liquid, or contained gaseous material that you no longer use, and either recycle, throw away, or store until you have enough to treat or dispose of.

As a result of doing business, a company may generate wastes that can cause serious problems if not handled and disposed of carefully. Such wastes could:

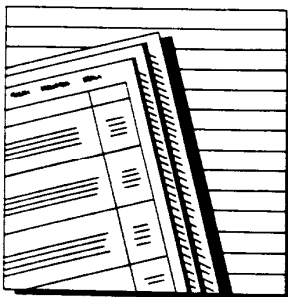
- ▶ cause injury or death; or
- ▶ damage or pollute land, air, or water.

These wastes are considered *hazardous*, and they are currently regulated by federal and state public health and environmental safety laws.

There are two ways a waste may be brought into the hazardous waste regulatory system: *listing*, and identification through *characteristics*.

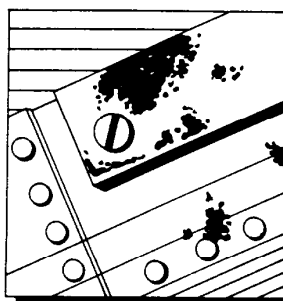
- ▶ **Listed wastes.** Your waste is considered hazardous if it appears on any one of the four lists of hazardous wastes contained in the RCRA regulations. These wastes have been listed because they either exhibit one of the characteristics described below or contain any number of toxic constituents that have been shown to be harmful to health and the environment. The regulations list over 400 hazardous wastes, including wastes

derived from manufacturing processes and discarded commercial chemical products. Many of the listed hazardous wastes that you are likely to generate are included in Appendix B of this handbook.



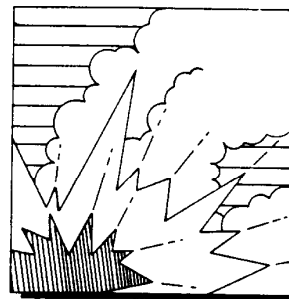
- ▶ **Characteristic wastes.** Even if a waste does not appear on one of the EPA lists, it is considered hazardous if it has one or more of the following characteristics:

It is easily combustible or flammable. This is called an *ignitable* waste. Examples are paint wastes, certain degreasers, or other solvents.



It dissolves metals, other materials, or burns the skin. This is called a *corrosive* waste. Examples are waste rust removers, waste acid or alkaline cleaning fluids, and waste battery acid.

It is unstable or undergoes rapid or violent chemical reaction with water or other materials. This is called a *reactive* waste. Examples are cyanide plating wastes, waste bleaches, and other waste oxidizers.



5.0 MANIFESTS

· **Item 1 - EPA Identification Number** Enter your EPA I.D. number in the space provided (see Figure).

Item 1 also asks for a five-digit manifest document number. You should use a consecutive numbering system in which the first shipment from the facility in 1989, for example, is assigned the manifest document number "89001," the second shipment is assigned the number "89002," etc.

· **Item 2 - Page 1 of _** Indicate the total number of original pages (not carbon copies) you are using. For example, the first page (EPA Form 8700-22) plus the number of Continuation Sheets (EPA Form 8700-22A, see Figure 3-5) if any.

· **Items 3 and 4 - Generator's Name and Mailing Address** Enter the name, mailing address, and telephone number of the generator. The address should be the location that will manage the returned manifest forms.

· **Items 5 through 8 - Transporters' Names and U.S. EPA I.D. Numbers** Enter the name and U.S. EPA I.D. number of the transporter in Items 5 and 6. If the waste will be transferred to a second transporter during shipment, the same information for the second transporter must be provided in Items 7 and 8. If more than two transporters are used, enter each additional transporter's company name and U.S. EPA I.D. number in Items 24-27 on the Continuation Sheets (EPA Form 8700-22A, see Figure 3-5). Each continuation sheet has space to record two additional transporters.

· **Items 9 and 10 - Designated Facility Name and Address** Enter the company name, address, and U.S. EPA I.D. number of the facility designated to receive the waste listed on the manifest. The address must be the site address, which may differ from the facility's mailing address.

· **Item 11 - Department of Transportation (DOT) Description of the Waste, Including the Shipping Name, Hazard Classification, and Identification Number** Enter (1) the proper DOT shipping name of the substance, (2) the DOT hazard class, and (3) the UN or NA identification number for the substance (see Section 3.8.3.).

Note: If additional space is needed for waste descriptions, enter these additional descriptions in Item 28 on EPA Form 8700-22A (see Figure 3-5).

· **Item 12 - Number and Type of Containers** Enter the number of containers for each waste and the appropriate abbreviation for the type of container:

DM	=	Metal drums, barrels, kegs
DF	=	Fiberboard or plastic drums, barrels, kegs
DW	=	Wooden drums, barrels, kegs
TP	=	Portable tanks
TT	=	Cargo tanks (tank trucks)
TC	=	Tank cars
DT	=	Dump trucks
CM	=	Metal boxes, cartons, cases
CF	=	Fiberboard or plastic boxes, cartons, cases
CW	=	Wooden boxes, cartons, cases
CY	=	Cylinders
BA	=	Burlap, cloth, paper, or plastic bags

Items 13 and 14 - Quantity of Waste Being Transported Enter the total quantity and unit of measurement (gallons, pounds, or cubic feet) of waste described on each line. Enter the appropriate abbreviation:

G	=	Gallons (liquids only)
P	=	Pounds
T	=	Tons (2,000 lb)
Y	=	Cubic yards
L	=	Liters (liquids only)
K	=	Kilograms
M	=	Metric tons (1,000 kg)
N	=	Cubic meters

Item I - U.S. EPA Hazardous Waste I.D. Number You must enter the U.S. EPA Hazardous Waste I.D. number for each waste listed under Item 11.

Item 16 - Generator's Certification The authorized representative of the SQG is required to sign the manifest. If a transportation mode other than highway is used, the word "highway" should be lined out and the appropriate mode (rail, water, or air) inserted in the space below. If another mode in addition to the highway mode is used, enter the appropriate additional mode (e.g., rail) in the space below.

Are There Any Exemptions to the Manifesting Requirement?

In some cases, spent materials can be regenerated, recycled, or reclaimed for reuse (e.g., lead acid batteries, solvents). SQGs are not required to prepare a manifest when using the service of a reclaimer provided:

- the waste is being reclaimed under a contract,
- the contract specifies that either the SQG or the reclaimer retain ownership of the material,
- the type of waste and frequency of service are specified,
- the service owns the vehicle used to transport the waste and regenerated material, and
- the SQG keeps a copy of its contract with the reclaiming service for at least 5 years after the contract terminates or expires.

What Should I Do if the Signed Manifest Is Not Returned to Me by the Designated Facility?

If you do not receive a signed copy from the designated waste facility within 35 days, you must determine why by contacting either the transporter or destination facility.

UNIFORM HAZARDOUS WASTE MANIFEST		1. Generator's US EPA ID No.		Manifest Document No.		2. Page 1 of		Information in the shaded areas is not required by Federal law.		
3. Generator's Name and Mailing Address GENERAL METAL PROCESSING CO. 501 MAIN ST. SMALLTOWN, VA 23000						A. State Manifest Document Number				
4. Generator's Phone (804) 555-0509						B. State Generator's ID				
5. Transporter 1 Company Name SAFETY HADLER				6. US EPA ID Number VA101018912345		C. State Transporter's ID				
7. Transporter 2 Company Name						D. Transporter's Phone				
8. US EPA ID Number						E. State Transporter's ID				
9. Designated Facility Name and Site Address DISPOS-ALL, INC 1300 NORTH AVE FRIENDLY TOWN, VA 23000						10. US EPA ID Number				
11. US DOT Description (Including Proper Shipping Name, Hazard Class, and ID Number)						12. Containers		13. Total Quantity	14. Unit Wt./Vol	15. Waste No.
a. HAZARDOUS WASTE, LIQUID OR SOLID, NOS ORM-E, NA9189						0102 DM		0011	0 GAL	
b. WASTE CYANIDE SOLUTION, NOS UN1935						0101 DM		0005	5 GAL	
c. WASTE FLAMMABLE LIQUID, NOS UN1993						0101 DM		0005	5 GAL	
d.										
J. Additional Descriptions for Materials Listed Above						K. Handling Codes for Wastes Listed Above				
15. Special Handling Instructions and Additional Information										
16. GENERATOR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations. Unless I am a small quantity generator who has been exempted by statute or regulation from the duty to make a waste minimization certification under Section 3002(b) of RCRA, I also certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and I have selected the method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment.										
Printed/Typed Name JOSEPHINE K. DOE						Signature Josephine K. Doe			Month Day Year 10 8 13 10 18 16	
17. Transporter 1 Acknowledgement of Receipt of Materials										
Printed/Typed Name						Signature			Month Day Year	
18. Transporter 2 Acknowledgement of Receipt of Materials										
Printed/Typed Name						Signature			Month Day Year	
19. Discrepancy Indication Space										
20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.										
Printed/Typed Name						Signature			Month Day Year	

EPA Form 8700-22 (Rev. 4-85) Previous edition is obsolete.

*Information in the shaded areas is not required by Federal law, but this or other additional information may be required by your state.

6.0 SARA Title III

On October 17, 1986, the Superfund Amendments and Reauthorization Act (SARA) was signed into law. Title III of SARA is also known as the Emergency Planning and Community Right-to-Know Act (EPCRA). As the name implies, EPCRA has two major themes: emergency planning and community right-to-know. This section discusses the various aspects of compliance with Title III of SARA, details major sections of SARA, and discusses what facilities are subject to the various requirements. A list of key deadlines is also provided.

6.1 Background

Many small businesses may be subject to provisions of SARA Title III based on the types and amounts of chemicals present on-site. This Federal legislation, prompted by the Bhopal incident in 1984, requires (1) industry to provide information concerning hazardous substances used, and (2) local governments and communities to plan for hazardous materials emergencies.

Title III establishes requirements for Federal, state, and local governments, and industry for emergency planning and community right-to-know reporting on hazardous chemicals. The program is designed to help protect communities from potential chemical emergencies.

6.2 Emergency Planning and Notification, Community Right-to Know, and Toxic Chemical Release Reporting

Title III has four major parts: emergency planning, emergency notification, community right-to-know, and toxic chemical release reporting.

6.3 Emergency Planning (Sections 301, 302, and 303)

The emergency planning sections are designed to develop government emergency preparedness capabilities through increased coordination and planning on the state and local level.

Section 301 establishes two planning levels within each state - a state emergency response commission (SERC) and local emergency planning districts governed by a local emergency planning committee (LEPC).

Facilities which are subject to emergency planning requirements under Section 302 include those with listed extremely hazardous chemicals on-site in a quantity equal to or greater than the established threshold planning quantity (TPQ). These facilities are to notify the SERC and LEPC that they are subject to the provisions of EPCRA.

Section 303 also requires local emergency planning commissions to submit emergency response plans to the SERC. The plan must include identification of facilities and transportation routes for ex-

tremely hazardous substances, emergency response procedures, community and facility coordinators, emergency notification procedures, release detection, emergency equipment available, evacuation plans, training programs, and methods and schedules for exercising emergency response plans.

6.4 Emergency Notification (Section 304)

Emergency notification is an essential element of EPCRA emergency planning. Facilities that have an unplanned release of any listed extremely hazardous substance or CERCLA Section 103(a) chemical exceeding the reportable quantity must notify the LEPC and SERC immediately.

Written follow-up is also required under this section. Information provided during the emergency notification should be reported, updating it with additional information such as actions taken to respond to and contain the release, known and anticipated health effects, medical advice, etc.

6.5 Community Right-to-Know Reporting (Sections 311 and 312)

The Community Right-to-Know provisions of SARA Title III are intended to increase the public's knowledge and access to information regarding the presence of hazardous chemicals in the community and releases of these chemicals into the environment.

According to Section 311, facilities that must prepare or have available MSDSs under the Occupational Safety and Health Act (OSHA) hazard communication regulations must submit copies of MSDSs or a list of MSDSs to the local emergency planning and state emergency response commissions and the local fire department.

If significant new information about a chemical is discovered, or if new hazardous chemicals become present in quantities above the established threshold levels, appropriate agencies must be notified.

Section 312 requires submission of emergency and hazardous chemical inventory forms by facilities to the LEPC, SERC, and local fire department. These forms provide information on the types, amounts, and locations of hazardous chemicals at a facility.

Inventory forms for Section 312 reporting are divided into Tier I and Tier II forms. Under Tier I, facilities must provide the following information for each applicable OSHA category of health and physical hazard:

- an estimate of the maximum amount of chemicals in each category present at the facility at any time during the preceding calendar year,
- an estimate of the average daily amount of chemicals in each category, and
- the general location of hazardous chemicals in each category.

Upon request of the SERC, LEPC, or local fire department, the facility must provide Tier II information for each covered substance including:

- the chemical name or common name on the MSDS,
- an estimate of the maximum amount of chemical present at any time during the preceding calendar year,
- a brief description of the chemical storage methods,
- the location of the chemical at the facility, and
- an indication of whether the owner elects to withhold information from disclosure to the public.

U.S. EPA published a uniform format for the inventory forms. Since many state emergency response commissions have additional requirements or have incorporated Federal contents into their own forms, Tier I and Tier II forms should be obtained from the state agencies.

6.6 Toxic Chemical Release Reporting (Section 313)

Section 313 of EPCRA requires facilities to submit Toxic Chemical Release Forms (Form R) for specified chemicals. Owners and operators of certain facilities that process, manufacture, or otherwise use a listed toxic chemical in amounts exceeding threshold quantities must report emissions of such chemicals on an annual basis.

This reporting covers releases from normal business operations. It must also include emergency releases as well as information on off-site shipment of wastes containing listed toxic chemicals. The purpose of this requirement is to inform government officials and the public about releases of toxic chemicals from a facility into the environment.

The forms must be submitted to U.S. EPA and designated state officials on or before July 1, 1988, and annually thereafter on July 1, reflecting releases during each preceding calendar year.

Section 313 applies to owners/operators of facilities that meet all three of the following requirements.

- The facility has ten or more full-time employees.
- The facility is included in Standard Industrial Classification codes 20 through 39.
- The facility manufactures, processes, or uses a listed toxic chemical in the course of a calendar year in excess of specified threshold quantities.

The list of toxic chemicals subject to Section 313 reporting consists of acutely toxic chemicals listed on the Maryland-New Jersey lists. There are over 300 chemicals and categories on these lists.

A complete Form R must be submitted for each toxic chemical manufactured, processed, or otherwise used at each covered facility. These forms must be sent to the U.S. EPA and state designated agencies. U.S. EPA must establish and maintain a national toxic chemical inventory based on the data submitted. The public must have access to this information.

7.0 WHY IS WASTE MINIMIZATION IMPORTANT?

The proper management of hazardous materials and waste is one of the biggest issues facing all Americans. Virtually every industrial and manufacturing process involves hazardous materials or produces hazardous waste. From an economic standpoint, the management of hazardous materials may lead to spiraling costs that can drastically affect any organization and its ability to compete in the market place. There is also the issue of protecting public health and the environment.

Why is hazardous waste minimization so important?

- Waste minimization is very important because business is facing a crisis in the handling, transportation, and disposal of hazardous wastes.
- Nationally, the number of hazardous waste disposal facilities has substantially decreased.
- Regulators are restricting the use of landfills.
- Transportation and disposal costs are rising.
- Substantial long-term liability is associated with handling and disposal of hazardous waste.

Why minimize? Initially, many companies implemented waste reduction options because of new pollution regulations and the rising cost or unavailability of landfills. However, nearly all these companies later realized other, more important benefits, including:

- lower operating costs from the substitution of less expensive raw materials;
- lower energy costs through the use of newer, more efficient equipment;
- improved product quality;
- increased safety from reduced employee exposure to hazardous materials; and
- improved public image--the less waste you produce, the less your business is viewed as a contributor to environmental problems.

8.0 DEFINITIONS OF SOME IMPORTANT TERMS

Before proceeding, you should become familiar with the following definitions.

8.1 Waste minimization means the reduction, to the extent feasible, of hazardous waste that is generated or subsequently treated, stored, or disposed. It includes any source reduction or recycling activity undertaken by a generator that results in either (1) the reduction of total volume or quantity of hazardous waste, or (2) the reduction of toxicity of hazardous waste, or both, so long as the reduction is consistent with the goal of minimizing present and future threats to human health and the environment.

8.2 Source reduction refers to the reduction or elimination of waste generation at the source, usually within a process. Source reduction measures can include some types of treatment processes, but they also include process modifications, feedstock substitutions or improvements in feed-stock purity, various housekeeping and management practices, increases in the efficiency of machinery, and even recycling within a process. Source reduction implies any action that reduces the amount of waste exiting from a process.

8.3 Recycling refers to the use or reuse of a waste as an effective substitute for a commercial product, or as an ingredient or feedstock in an industrial process. It also refers to the reclamation of useful constituent fractions within a waste material--or removal of contaminants from a waste to allow it to be reused. Recycling refers to the use, reuse, or reclamation of a waste, either on- or off-site, after it is generated by a particular process.

8.4 RCRA solid waste has been defined by RCRA as any discarded material not specifically excluded by the Act. A discarded material is any material (solid, liquid, or contained gas) which is abandoned (disposed, burned, or incinerated), recycled, or considered inherently waste-like. Because it is difficult to devise a definition that distinguishes between product-like and waste-like sludges and byproducts, U.S. EPA will evaluate these materials individually when they are recycled to determine if the RCRA rules apply.

8.5 Hazardous waste is defined by RCRA as a solid waste (including liquids and gases) which may:

- cause or significantly contribute to an increase in mortality or in serious illness, or
- pose a substantial hazard to human health or the environment when improperly managed.

The definition of hazardous wastes can be found in Title 40 of the U.S. Code of Federal Regulations (CFR) Section 261.3. By definition, wastes are hazardous if they are (1) listed (specifically named) or (2) if they exhibit any of four hazardous waste characteristics (ignitability, corrosivity, reactivity, or extraction procedure[EP] toxicity). Mixtures of a solid waste and a listed hazardous waste are also considered hazardous.

8.6 Listed hazardous wastes defined as any waste which appears on any one of the following three lists of hazardous wastes contained in RCRA:

- the F lists of hazardous wastes from non-specific sources (e.g., waste water treatment sludges from electroplating operations),
- the K list of hazardous wastes from specific sources (e.g., bottom sediment sludge from the treatment of waste waters from wood preserving),
- the U and P lists of discarded commercial chemical products, including products that do not meet precise manufacturing specifications, their containers, and spill residues.
 - The products on the U list are called toxic wastes (e.g., vinyl chloride).
 - Those on the P list are called acute hazardous wastes (e.g., cyanides).

8.7 Characteristic hazardous wastes a waste which may not appear on one of the U.S. EPA lists, but is considered hazardous if it has one or more of four characteristics:

- Ignitability
- Corrosivity
- Reactivity
- EP (Extraction Procedure) Toxicity

8.8 Acutely hazardous wastes has been defined by the U.S. EPA as waste so dangerous in small amounts that it is regulated the same way as large amounts of other hazardous wastes. Acutely hazardous wastes, for example, may be generated from certain pesticides or dioxin-containing wastes. Those wastes included on the P list of hazardous wastes have been identified as acutely hazardous wastes.

9.0 ADVANTAGES OF WASTE MINIMIZATION

9.1 Overview

The many incentives for waste minimization, although interrelated, fall into three categories:

- Economic--money can be saved, or a profit made.
- Regulatory--fewer compliance requirements with reduced waste.
- Good public image--by showing concern for the environment, the safety and health of workers, and the surrounding community.

Many business owners and operators see a close relationship between the increasing waste management costs for industry and rising health and environmental concern by society. The resulting economic pressures are encouraging industry to be more efficient in the management of its waste, including its toxic and hazardous substances.

Numerous case studies indicate that the sound management of resources results in simultaneous economic and ecological benefits regardless of the size of an organization.

Thousands, even millions, of dollars are being saved, not just in reduced disposal costs, but in reduced expenditures on energy, fuel, water, and raw materials. If less waste is produced, there is less potential for damage to the environment. Consequently, waste reduction is sound economically as well as ecologically. It's simply good business.

9.2 Economic Incentives

Reduced Costs Through Better Management and Efficiency

The less a firm wastes, the more efficient its operation. Your total operating costs can be significantly reduced by minimizing your waste generation. In addition, many companies have experienced improved production capacity and product quality, as well as savings in expenditures for utilities and raw materials. Reduced costs can be accomplished through better management and a more efficient use of raw materials.

Reduced Treatment, Transportation, and Disposal Costs

A successful waste minimization program can help your business reduce the amount of money it spends on treating, transporting, and disposing of hazardous wastes. The combination of new laws and regulations, and the increasing cost of liability insurance, have caused a dramatic increase in the cost of hazardous waste management. With increasing disposal costs, waste minimization is providing an economical alternative to the treatment, transportation, and disposal of hazardous wastes.

Income Derived Through Sale or Reuse of Waste

It is sometimes said that one company's waste is another's resource. This is often true, as the various waste exchanges throughout the country have proven. Profits can be realized when firms sell their wastes as by-products to other firms which can use them as raw materials. Additionally, many wastes can be reused, sometimes as fuels (as in the case of waste solvents), or as recycled raw materials within the process itself.

Reduced Costs for Waste Water Treatment

The cost of meeting waste water treatment standards can be extremely high. Increasingly stringent pretreatment and effluent limitations are forcing many industries to install costly waste water treatment facilities. Both capital and operating expenses for these facilities are escalating rapidly. By judiciously minimizing their waste, many companies can significantly reduce this expense.

Lower Risks for Spills, Accidents, and Emergencies

The use of hazardous materials, and the generation, handling, and management of hazardous waste entails a certain amount of risk. Hazardous substance spills, accidents, and emergencies can cost small businesses thousands of dollars. These risks can be reduced with the proper management of the hazardous materials used, and the minimization of those which are wasted.

Lower Long-Term Liability and Insurance Costs

According to RCRA, a hazardous waste generator is responsible for its waste from "cradle to grave." In other words, once you generate a waste, you are legally responsible for it forever. In addition, Federal and state laws have established the precedent that generators of hazardous waste are at least partially responsible for the cleanup of wastes which have leaked from disposal sites containing their waste. This kind of financial responsibility can potentially cost small quantity hazardous waste generators substantial sums of money.

This responsibility translates into what many insurance experts now call the "liability crisis." The liability insurance premiums for firms producing hazardous waste have increased by hundreds of percent in the last 5 years due largely to the increase in law suits against hazardous waste generators involved in accidental spills and leaking disposal sites.

One possible way to eliminate or reduce this expense is to eliminate or reduce the cause of the liability--the generation of hazardous waste. By minimizing the hazardous waste you generate, you can reduce your long-term liability.

9.3 Regulatory Incentives

New Federal laws and regulations limit waste management alternatives by eliminating or greatly restricting land-based disposal. As a result, generators of hazardous waste will be forced to examine other waste management alternatives, including waste minimization.

In addition to the outright ban of certain disposal options and increasing costs of all waste disposal, the amount of managerial work required to comply with environmental regulations can become extremely expensive to small business. By minimizing the generation of hazardous waste, these compliance requirements can be reduced as well.

9.4 Improved Public Image

While the strongest incentives for reducing waste generation are undoubtedly economic and regulatory, many companies are setting up waste minimization programs out of sensitivity to public concern over toxic chemicals. This type of corporate good citizenship is perceived to have long-term benefits, such as good relations between plants and local communities, as well as between companies and the general public.

In addition to reducing costs and increasing profits, an efficient hazardous waste minimization program can:

- improve safety;
- reduce the amount of wastes for disposal, consequently reducing environmental impacts on the community; and
- reduce the number of hazardous materials used in the workplace.

These three factors add up to one important business too~an improved public image. Hazardous waste is a controversial topic, and most communities are vehemently opposed to the disposal of hazardous wastes in their localities. By reducing the amount of hazardous waste you generate, you can show the public and your potential customers that you are making an effort to curtail the pollution of our land and ground water.

The public always looks favorably upon companies with good safety records. In addition, a safe working environment will tend to attract more new employees than a less-safe job site. Since a waste minimization program can lead to improved on-the-job safety, such an improvement can only help to attract new employees and improve public relations.

Finally, with the inception of the Federal Emergency Planning and Community Right-to-Know Act of 1986 (SARA Title III), there are established requirements regarding emergency planning and "community right-to-know" reporting on hazardous and toxic chemicals. The community right-to-know provisions will help to increase the public's knowledge and access to information on the presence of hazardous chemicals in their communities and releases of these chemicals into the environment.

The general public, in particular, is usually uneasy with the presence of hazardous chemicals in their neighborhoods. A reduction in the use of hazardous chemicals can improve a company's relationship with its community neighbors.

10.0 OVERVIEW OF A POLLUTION PREVENTION ASSESSMENT

This section is designed to present an overview of a pollution prevention assessment.

Pollution Prevention Principles and Practices

Reference: U.S. Environmental Protection Agency, **Facility Pollution Prevention Guide, EPA/600/R-92/088, May, 1992.**

10.1 Pollution Prevention Assessment: Getting Underway

1. Client selection
 - a. selection criteria
 - b. constraints
2. Discuss expectations for the assessment.
 - a. Conduct an exhaustive pollution prevention assessment or focus upon selected waste streams?
 - b. Include nonhazardous wastes?
 - c. Include energy conservation?
 - d. Multimedia pollution prevention assessment?
3. Explain anticipated work product.
4. Request some or all of the following information:
 - a. product description
 - b. process description
 - c. process flow chart
 - d. plant layout diagram
 - e. raw materials
 - f. identification of current wastes, process sources
 - g. identification of current waste management practices
 - h. utility bills for the past 12 months of operation
 - i. copies of hazardous waste manifests for the past 12 months
 - j. copies of invoices for waste hauling and disposal fees for the past 12 months
 - k. copies of POTW agreement and MSDSs as needed
 - l. identification of key plant personnel, including in-house waste and production specialists
 - m. safety concerns, safety equipment needs: hard hats, safety shoes, hearing

- protection, safety glasses, safety orientation
- n. directions to plant
- o. identification of major waste concerns and problems

5. Inquire about special concerns. Will a camera be permitted?
6. Schedule initial site visit. Inquire about schedules for operations which need to be seen.
7. Explain assessment team's expectations for site visit.

10.2 Planning for the Site Visit

1. Form assessment team.
2. Set goals for site visit.
3. Develop flexible agenda for site visit.
4. Consult references for background material concerning process.
5. Organize data, identify obvious trends, characteristics, and gaps.
6. Construct descriptive waste table.
7. Anticipate assignment of general task areas.
8. Telephone contact at plant to confirm arrangements, including reservation of conference room.
9. Identify and reserve needed equipment, instruments.
10. Review directions to plant and set departure time.

10.3 On-Site Activities

1. Introduce assessment team members. Distribute business cards.
2. Review purpose of assessment, our expectations for site visit.
3. Show report for previous assessment.
4. Review agenda. Request opportunity to hold wrap-up sessions with company personnel.

5. Request overview of plant operations.
6. Interview plant personnel.
 - a. What are the principal products?
 - b. What are the raw materials?
 - c. In what form do the raw materials arrive?
 - d. Is there packaging waste?
 - e. Do the raw materials require preparation, such as cleaning?
 - f. Does expired raw material constitute a waste stream?
 - g. What is the sequence of production steps?
 - h. What wastes are formed during each step?
 - i. How is each waste currently managed? (storage, treatment, recycling, disposal)
 - j. Are there off-site production steps?
 - k. Are wastes generated during testing operations?
 - l. What happens to off-specification and returned production?
 - m. Are wastes generated during finishing and packaging?
 - n. What waste streams merit special emphasis?
 - o. How can we be of most help to the company?
7. Plant tour
 - a. Time management during tour
 - b. Listening and learning
 - c. Working as a team
 - d. Taking notes
 - e. Getting information for a waste inventory table:
Process/Source, Waste, Current Management Practice, Possible Alternative Practice, Contact Person
 - f. Asking questions
 - g. Identifying personnel for further information
 - h. Note opportunities for improvements in housekeeping
8. Brainstorming for potential pollution prevention opportunities
 - a. Do we understand the process?
 - b. Do we know how the wastes are formed?
 - c. Are there any major gaps in the data?
 - d. Brainstorming for PPOs
 - e. Assigning on-site tasks to fill gaps in data
 - f. Preliminary screening of PPOs
9. Wrap-up session with plant personnel
 - a. Describe potential PPOs, benefits.
 - b. Request feedback from plant personnel. Is technical feasibility a

- problem for any of the potential PPOs?
- c. Explain to plant personnel what happens next.
- d. Thank plant personnel for participation and assistance. Invite plant contact to call if questions arise.
- e. Departure. Retrieve equipment, and return borrowed items.

10.4 Identifying Pollution Prevention Opportunities

1. Pollution Prevention Hierarchy
 - SOURCE REDUCTION**
 - RECYCLING**
 - TREATMENT**
 - DISPOSAL**
2. Avoidance of Cross-Media Transfer
3. Consider energy conservation aspects
4. Raw material management
 - a. prevention of expired lots
 - b. JIT purchasing
 - c. purchasing specifications
 - d. packaging; supplier take-back?
 - e. off-specification lots; supplier take-back?
5. Parts and equipment cleaning
 - a. specifications for cleaning
 - b. reducing soiling at the source
 - c. substitution of less hazardous cleaners
 - d. staged cleaning
 - e. trigger for dumping cleaner
 - f. reducing drag-out and drag-in
 - g. rinsing
 - h. drying
6. Machining
 - a. raw material specifications, packaging
 - b. cutting coolant management
 - c. hydraulic oil
 - d. preventative maintenance
 - e. finishing operations
 - f. recycling scrap
7. Painting

- a. surface preparation
 - b. HVLP paint guns
 - c. powder coatings
 - d. thermal spraying
 - e. low VOC paints
 - f. thinner recycling
 - g. segregation of spent solvents
 - h. equipment clean-up
8. Plating, Chromating, Anodizing
- a. surface preparation
 - b. reagent concentrations
 - c. bath temperature, insulation
 - d. drag-out reduction
 - e. establishing bath-dump triggers
 - f. countercurrent rinsing, air agitation
 - g. bath covers
 - h. automated process lines
 - i. preventing drag-in
 - j. bath filtration
 - k. spent bath reclamation
 - l. over-the-tank spray rinsing
 - m. DI water for make-up
 - n. reclamation of off-specification parts
9. Paints, Coatings, Adhesives, Chemicals
- a. prevention of expired raw materials
 - b. staged cleaning of equipment
 - c. recycling off-specification products
 - d. recycling cooling water
 - e. recovering and reusing supporting solvents
 - f. reformulating feedstocks to reduce solvent content
 - g. light to dark sequencing for pigmented products
 - h. use of less hazardous reagents, e.g. substitute H_2O_2 for dichromate oxidizer
 - i. tank cleaning, line flushing
 - j. recycling clean-up wastes
10. Printing
- a. extend bath life with chemicals, drag-out reduction
 - b. automate printing to generate less waste paper
 - c. electrostatic printing
 - d. conserve silver, recover silver from spent baths and rinses
 - e. inventory control

- f. recycle waste inks
- g. stage-clean printing equipment

10.5 Off-Site Follow-Up Activities

1. Assigning tasks
 - a. process description
 - b. waste generation
 - c. potential PPOs
2. Materials balances: Benefits and Frustrations
3. Screening potential PPOs for feasibility
 - a. technical
 - b. economic
 - c. environmental
4. Preparation of formal PPOs
 - a. obtaining technical information from suppliers of products and services
 - b. searching data bases
 - c. analysis
 - d. preparation of descriptive material
 - e. computations, significant figures
 - f. consistency of units and terms
5. Review of PPOs
6. Tables
7. Figures
8. Generic material
9. Need for follow-up plant visits, contacts with plant personnel
10. Assemble report
11. Internal review of report
12. Internal revision of report
13. Present report draft to client, request comments

14. Revise report
15. Present final report to client
16. Follow-up implementation survey

10.6 Rationale for Pollution Prevention

1. Economic: It will save you money.
2. Image: It will safeguard your reputation, and it may increase sales of your products. For example, Ford is now advertising that it is the first domestic car maker to use non-CFC refrigerants.
3. Avoid making false statements: You have probably certified that you are doing all that you can to prevent pollution.
4. Avoid penalties for violations of environmental laws: Violators are being fined and shut down. Individuals convicted of crimes are being fined and sent to prison. Persons and organizations which make good faith compliance efforts are often immune from civil and/or criminal penalties. Immunity disappears when there is malice, concealment, or a willful violation.

11.0 GENERAL WASTE MINIMIZATION PRACTICES

This section is designed to review some general waste minimization practices for metal parts cleaning, paint application and process equipment cleaning.

11.1 Metal Parts Cleaning

Metal parts cleaning is a common concern of many industries. This section details some general routines of good operation and some specific waste minimization practices for metal parts cleaning.

Waste Description

The specific wastes associated with metal parts cleaning, along with their sources, are listed in table. The waste produced is generally not dependent of the type of method; rather, it depends on the cleaning material used and the type of soil removed.

Good Operating Practices for Waste Minimization

Good operating practices for waste minimization are defined as procedural or institutional policies which result in a reduction of waste, and may include:

- personnel practices,
- procedural measures,
- loss prevention practices, and
- waste stream segregation.

Specific Waste Minimization Practices

Spent abrasives, solvents, acid and alkaline cleaning solutions, and rinse water are the most common wastes from metal parts cleaning. All but the solvent wastes are extremely diluted with water. The most common waste minimization practices which can be applied to these wastes include:

<u>Waste stream</u>	<u>Minimization practice</u>
Abrasives	Use water-based binders Use liquid spray compositions Control the water level in equipment
Solvent cleaners	Implement solvent recycling technologies

	Install on-site recycling equipment Employ solvent loss minimization practices Solvent replacement
Acid and alkaline	Remove sludge frequently or cleaners continuously. Install lids on tanks. Implement better operating practices.
Rinse waters	Operate rack system properly. Operate barrel system properly. Operate rinse tanks properly. Install water sprays on rinse tanks. Install fog nozzles on heated tanks. Use chemical rinsing. Use deionized water for rinsing.

11.2 Paint Application

Paint application is a common concern of many industries. This section discusses some general routines of good operation, and some specific waste minimization practices for paint application.

Waste Description

The specific wastes associated with paint application technologies are listed in the table. The industry is extremely diverse, so the quantity of each waste produced varies greatly from operation to operation.

Good Operating Practices for Waste Minimization

Good operating practices for waste minimization start with procedural or institutional policies which result in a reduction of waste, and may include:

- personnel practices,
- procedural measures,
- loss prevention practices, and
- waste stream segregation.

Good operating practice applies for every waste stream and is one of the first methods which should be implemented in a waste minimization program.

Specific Waste Minimization Practices

Wastes from parts cleaning, paint application, paint stripping, and equipment cleaning are the most common hazardous wastes from painting operations. The most common waste minimization

practices which can be applied to these wastes are:

<u>Waste stream</u>	<u>Minimization practice</u>
Parts cleaning	See section above on parts cleaning
Paint application	Use equipment with low overspray.* Implement better operating practices.
Paint stripping	Implement proper painting techniques. Implement proper cleaning techniques. Use mechanical paint stripping system. Use non-phenolic/non-acid stripper. Implement better operating practices.
Equipment cleaning wastes	Use equipment with low over-spray. Implement better operating practices.

*The following table lists the efficiency of several systems in avoiding overspray.

<u>System</u>	<u>Efficiency(%)</u>
Conventional air-atomized spray	30-60
Conventional pressure-atomized spray	65-70
Electrostatic air-atomized spray	65-85
Electrostatic centrifugal-atomized spray	85-95
Roller/flow coating machines	90-98
Electrocoating systems	90-99

11.3 Process Equipment Cleaning

Process equipment cleaning is a common concern of many industries. This section details some general routines of good operation and some specific waste minimization practices for process equipment cleaning.

Waste Description

Wastes generated during the periodic cleaning of internal surfaces of process equipment differ widely in composition and quantity depending upon:

- type of deposit being cleaned,
- type of cleaning fluid,
- type of cleaning method,
- size of equipment being cleaned, and
- cleaning frequency.

Specific Waste Minimization Practices

There are two distinct approaches which can be taken to effect a waste minimization program in process equipment cleaning. These are:

- reducing the frequency of the cleanups, and
- reducing the quantity and/or toxicity of wastes.

Here are the most common waste minimization practices.

<u>Approach</u>	<u>Minimizationpractice</u>
Reduce cleaning frequency	Use proper plant and equipment design. Record cleaning costs as a separate item. Convert batch to continuous process. Maximize dedication of equipment. Avoid unnecessary cleaning. Inhibit fouling deposit formation.
Reduce quantity and/or toxicity of cleanup wastes	Minimize residues. Minimize the amount of cleaning of solution. Carefully choose the cleaning medium and plan cleaning solution reuse.

12.0 WASTE-SPECIFIC MINIMIZATION PRACTICES

This section describes minimization practices for six specific wastes:

- solvents,
- halogenated organic (non-solvent) wastes,
- metal wastes,
- corrosive wastes,
- oils, and
- sludges.

12.1 Solvents

Source of Solvent Wastes

Solvent wastes are generated primarily by industrial operations that include:

- painting and coating shops that use solvents to clean equipment;
 - metal-working and machine plating shops that use solvents during degreasing;
- and
- surface cleaning processes in the electrical, electronics, and printing industries.

Solvent Recycling Technologies

The main solvent recycling and minimization techniques are:

- **Distillation.** Separation techniques that rely on the boiling point differences between the components of a liquid waste.
- **Solids removal.** Elimination of suspended particles to reduce fouling.
- **Emulsion or dispersion breaking** Separation of solvent or oil droplets in water, or of water droplets in oil.
- **Dissolved and emulsified organics recovery.** Organics separation techniques that concentrate the organics so they can be recovered.

Each of these operations may be performed singly or in sequence. The recyclable product may

be the solvent or the isolated contaminants, or both.

On-Site Recycling Equipment

Due to recent developments, small solvent recycling units are now commercially available for businesses generating low volumes of waste solvents. These simple heating and condensing systems remove impurities from the solvent waste streams, returning the solvent or the solvent blend to the process which generated it.

Some companies have been able to scale down their equipment considerably since the equipment was first marketed.

- There are numerous manufacturers of solvent recovery equipment in a variety of sizes. The smallest of these units reclaims solvents having a boiling point of 160°C or less. The waste solvent is reclaimed in 15-gallon batches, although clean solvent can be drawn off during operation. Recovery levels range from 80 to 95 percent, depending on the amount and type of contamination.

Solvent Loss Minimization Practices

Solvents are used most frequently in:

- the soak tank, and
- the vapor degreaser.

The vapor degreaser, because it produces considerable air pollution, has been studied in much greater detail with respect to pollution control. However, the primary methods for reducing waste are the same for both the degreaser and the soak tank. The two most important goals are to minimize solvent vapor loss and maintain solvent quality. The following methods were considered the most successful in achieving these objectives

Install lids/silhouettes on tanksAll tanks should be covered when not in use. Covers that can be used during the cleaning process (known as "silhouette entries") are available and allow for even greater reduction in vapor loss. All covers should be designed to slide horizontally over the top of the tank, since this disturbs the vapor zone less than hinged covers.

Increase the freeboard space on tanksAn increased freeboard has been proven to decrease emissions. Early degreasers had a freeboard equal to one-half the tank width. When the U.S. EPA in the mid-1970s recommended a 75 percent freeboard, emissions were decreased up to 46 percent. Increasing the freeboard to 100 percent can provide an additional 39 percent reduction when air turbulence is present.

Install freeboard chillers in addition to cooling jacketsA second set of refrigerated coils is installed above the condenser coils. These coils chill the air above the vapor zone and create a

second barrier to vapor loss. Reductions in solvent use of up to 60 percent have been realized. However, water contamination of the solvent can occur due to frost buildup on the coils, so special water collection equipment is also necessary.

Implement better operating practices Several housekeeping measures can significantly affect the amount of solvent waste produced.

- Separators should be cleaned and checked frequently to avoid cross contamination of solvents or water which can lead to acid formation. Also, parts should not enter the degreaser while wet.
- Promptly remove sludge collected at the bottom of the tank. This increases cleaning efficiency because contaminants do not absorb solvent and dissolve into the solution. As solvents are used, their ability to neutralize acids lessens. While the common practice is to add new solvent to the aged solvent, a more efficient method is to analyze the solvent and add specific components. The expense of analysis will be offset by the savings in solvent for tanks of approximately 500 gallons or more.
- Other waste reduction techniques, based on better operating practices, include:
 - standardizing the solvent used to allow for easier recycling,
 - consolidating cold cleaning operations into a centralized vapor degreasing operation,
 - locating cold cleaning tanks away from heat sources,
 - controlling the amount of heat supplied to vapor degreasers,
 - avoiding spraying parts above the vapor zone or cooling jacket, and
 - avoiding solvent vapor drag-out.

12.2 Halogenated Organic (Non-Solvent) Wastes

Source of Halogenated Organic Wastes

Non-solvent wastes are generated primarily by:

- the pesticide and fertilizer industry, which generates chlorinated pesticide dust and rinse waters;
- miscellaneous repair services, which generate PCB-contaminated fluids (during the

maintenance and repair of electrical transformers) and contaminated specialty organic cleaning fluids; and

- the lumber and wood products industry, which generates chlorinated organic wastes from the manufacture of wood preservatives and from application of pentachlorophenol to lumber products.

Halogenated organic wastes include both liquid and solid waste streams.

Non-Solvent Recycling Technologies

These are the main non-solvent recycling and minimization practices:

- **Use of waste as fuel.** Halogenated organic wastes are used as fuel in cement kilns. Energy in the form of heat is recovered, as well as acid gas, which reacts with free alkali in the cement to produce a low-alkali cement.
- **Baghouse filters.** Pesticides and pesticide intermediates are usually recycled on site. Baghouse filters are used to collect dust and particulates generated by product drying or blending.

Recycling opportunities are generally more restricted for this class of materials because:

- some of these wastes, especially those containing polyhalogenated aromatics, may be contaminated with dioxins; and
- markets for some of the recycled products, such as carbon tetrachloride, have been declining sharply in recent years.

Halogenated Organic Waste Minimization Practices

Solid waste is generated from the collection of dust in baghouses during material handling, grinding, blending, and standardizing operations. These waste minimization techniques are available:

Use wet instead of dry grinding. Then spray dry the output to reduce the amount of dust emitted.

Increase the use of dust suppression techniques. Atomized water sprays, enclosed weigh-transfer hoppers, or better care during manual handling will all decrease dust emission.

Recycle baghouse fines. Baghouse emptying should be scheduled to encourage recycling.

Better operating practices. As always, closer attention to handling, storing, and spill prevention will increase plant efficiency.

12.3 Metal Wastes

Source of Metal Wastes

Metal wastes are generated primarily by these industrial applications:

- Electroplating, photofinishing, and printing commonly produce process and rinse waters contaminated with silver, nickel, zinc, tin, copper, chromium, lead, or cadmium.
- Equipment cleaning in the steel and metallurgy industries generates aqueous solutions containing toxic metals and oxides.
- Manufacture of leaded paint and gasoline generates sludges containing metals.

Metal Recovery From Waste Rinse Waters

These technologies are available to recover metals from waste rinse water before treatment:

Evaporation. Waste rinse water is evaporated by heating, leaving behind a concentrated solution. The solution is concentrated until its metals content is equal to that of the plating bath. This solution is then reused. This method has been used frequently for chromium recovery from rinse water.

Evaporation should be combined with multiple countercurrent rinse tanks or spray/fog rinsing. Rinse water should be deionized or softened prior to use in order to prevent calcium and magnesium salt buildup.

Reverse osmosis. At high pressure, dilute waste is applied to a membrane. This allows the water to pass through, but retains the metals and other solutes. Thus, on one side of the membrane, a concentrated metal solution is produced which can be returned to the plating bath. On the other side of the membrane, water is collected and can be reused as rinse water. Reverse osmosis uses less energy than evaporation, but the characteristics of the membranes available limit the type of waste streams that can be treated. Only very dilute streams can be treated, and the solution must be pre-filtered to extend membrane life.

Ion exchange. This involves passing a solution over an ion exchange resin which exchanges one of its own ions for a metal ion in solution. Once a resin has reached its capacity, it must be regenerated. This is accomplished using an acid or base depending on the resin. Another step may be necessary to remove the metal from the acid or base so the metal can be used.

Electrolytic metal recovery Metal ions in solution are plated electrochemically onto a cathode surface within the solution. When the cathode becomes fully coated with the metal, it is removed

from the solution and placed into a plating bath as an anode, replenishing the bath with the metal. One advantage of this method is that it recovers only the plating metal, not the impurities, from the waste rinse water. This method is most efficient with solutions of metal ions in concentrations greater than 100 mg/l (milligrams per liter), and has been used to recover copper, tin, gold, silver, cadmium, and other metals.

Electrodialysis. An electric current and selective membranes are employed to separate the positive and negative ions from a solution into two streams. While electrodialysis is used mainly to concentrate dilute solutions of salts or metal ions, it has been used to remove nickel, copper, cyanide, chromium, iron, and zinc from waste rinse water.

Metal Waste Recovery Technologies

These are the main metal waste recovery technologies:

Agglomeration. This is a process which gathers small particles into larger particles, where the small particles can still be identified. Because of their metallic contents, mill scale, sludges, and dusts from various industries are agglomerated to be used in blast or induction furnaces. Agglomeration avoids particulate carryover from furnaces.

Particulate and vapor recovery from gases Metals are usually recovered as fine particles. Cadmium dust generated from cadmium batteries or pigment plants can be recycled. More volatile metals (such as mercury or lead) must be recovered from the vapor phase.

Metal concentration process There are several methods for concentrating metals from a bulk solid or liquid into a sludge or solution. Unit operations for concentrating metals include hydro-metallurgical processing, solvent extraction, ion exchange, and others. These processes have been developed either to recycle the metals or to treat the bulk stream to render it non-hazardous.

· Nickel-plating solutions are reacted with soda ash to precipitate nickel carbonate, which then is collected and reacted with sulfuric acid to generate an impure nickel sulfate solution. Adding small quantities of sodium sulfide will precipitate iron salts as iron sulfide. The solution is next separated from iron sulfide by filtration and evaporated to recover pure nickel sulfate. Spent nickel catalysts, after being dissolved with mineral acid, can be treated the same way.

Metals reduction techniques Recover metal from rinse water before treatment. Waste must be concentrated before application of a reduction technique.

· In electrolytic recovery, metal ions migrate to the cathode where they are reduced to their elemental form and are plated out.

· A recently developed process involves addition of sodium borohydride to neutral or alkaline solutions of metals and the precipitation of metals in their elemental form by reduction. After filtration, the metals can be sold directly to scrap metal dealers.

12.4 Corrosive Wastes

Corrosive wastes are generated by industries that use acidic or alkaline solutions in production or finishing processes.

Source of Corrosive Wastes

Some of the primary industries that generate corrosive wastes include:

- metal-finishing industries, which produce corrosive wastes during electroplating, etching and cleaning operations, among others (spent alkaline cleaning solutions and pickling solutions are the most frequently generated wastes);
- electrical and electronics industry, which generates spent metal-bearing acid solutions from the cleaning of scale from metals during the production of semiconductors, and from etching of metal circuit boards; and
- textile mill industry, which generates spent sodium hydroxide from mercerizing.

Corrosive Waste Recycling Technologies

Corrosive wastes that are recycled include spent acids and alkalis from chemical manufacture and petroleum refining processes and also the acid from spent pickle liquor. The following technologies are commonly used to recycle corrosive wastes.

Thermal decomposition. This process is used in the recovery of sulfuric acid from spent acid sludges to recover ferric chloride from acidic titanium dioxide waste. Thermal decomposition is also used to recover hydrochloric acid from spent pickling liquor or halogenated organic residues.

Evaporation. Liquid waste is partially evaporated by heating, leaving a concentrated solution. Both atmospheric and vacuum evaporators are used to concentrate corrosive wastes. Evaporation is applicable only to concentrated acids or bases with low amounts of volatile organics.

· Spent acid containing 70 percent sulfuric acid is generated from the production of nitrobenzene by reacting benzene with nitric acid in the presence of sulfuric acid. After removal of organic impurities by stripping, the spent acid is concentrated by evaporation for reuse in the nitration process.

Crystallization. Corrosives are removed from a solution by cooling. The resulting crystals are then separated from the solution by a variety of methods.

Ion exchange. Ion-exchange resins can remove heavy metals and cyanides from acid and base solutions. The purified solutions can then be reused in the manufacturing process.

· A recent ion-exchange process purifies acid solutions by ion exchange without producing a waste regenerant stream. The process uses a resin that selectively removes acids and rejects metallic contaminants. Metallic salts pass through the resin bed and are collected. The bed is flushed with water to displace the acid for reuse.

12.5 Oils

Source of Oil Wastes

Oil wastes are generated primarily by:

- oil and grease removal in vehicle maintenance,
- cleanup operations in industries such as the paper industry, and
- equipment repair operations.

Off-Site Collection Centers

There are many used oil collection sites in most states. Although these centers were generally established for the purpose of receiving used oil from households, some may be willing to accept used oil from businesses.

Oil Recycling Technologies

These are the main oil recycling and minimization practices:

Separation. An oil/water separator uses a series of vertical and horizontal corrugated plates to force oil to the surface of the unit where it is skimmed off. Oil droplets coalesce and rise to the underside of the plates. Eventually the oil passes through weep holes to the upper surface where it is collected by a skimmer. A computer simulation program allows precise calibration of the plates to maximize recovery from a specific waste stream.

Centrifugation. A centrifuge system decants the oil and removes dirt and metal clippings from the slurry. Centrifuging oil slurries and sludges allows for the sale of the water-free oil to power stations or other industrial plants or for reuse by the same plant.

Continuous flow electrochemical waste treatment processes. These are custom designed for each application, so they can be scaled down for use by small businesses. Biological oxygen demand (BOD) and suspended solids are reduced. The process, combining electrostatic and electrolytic principles with chemical pH adjustments, reduces sludge production considerably.

Solvent extraction. Dimethylformamide (DMF) solvent extracts PCBs from waste oils. By

washing with water in the second stage, solvent is separated and a PCB concentrate is left.

Dechlorination. Sodium compounds are used to dechlorinate PCBs. A nonhalogenated organic compound and a sodium salt are generated.

Each of these technologies has been used with good results.

Oil Loss Minimization Practices

Good operating practices, which can be implemented with little cost, can have a large effect on the amount of oil waste produced. These housekeeping practices can minimize oil waste:

Prevent spills. Using properly designed storage tanks and documenting the dollar value of any spillage which does occur can lessen the probability of a spill.

Install collection/drip pans Placing pans under machinery and lubricating operations will allow for the recovery of oils instead of their disposal with absorbents or rags.

Launder oil-soaked rags During laundering, oil can become biodegradable.

Use rags and absorbents to their limit Absorbents and rags are often thrown out before their useful life is over. Use them to capacity to reduce the volume of contaminated absorbents.

12.6 Sludges

Source of Sludges

Sludges are generated primarily by industrial applications such as:

- electroplating and other metal manufacturing operations,
- crude oil cleaning in the petroleum refining industry, and
- paint stripping activities.

Sludge Minimization Practices in Storage Tank Cleaning

Sludge buildup can greatly reduce the efficiency of an operation. These waste minimization practices are available for reducing the generation of sludge:

Reduce lead in gasoline. The toxicity of tank sludges will be lower.

Install storage tank agitatorsThis will prevent the deposit of settling solids and hence reduce the need for cleaning.

Use corrosion resistant materialThe use of a liner or construction materials which are more resistant to corrosion will reduce sludge production.

Prevent the oxidation of crude oilThis prohibits the formation of gums and resins. Oxidation can be minimized by providing a nitrogen blanket over the surface or by using floating roofs.

Dry sludge to reduce disposal volumeA reduction in volume will result in a savings due to reduced disposal costs.

Sludge Minimization Practices in Utility Production

Sludge that settles in a cooling tower basin is removed whenever the cooling tower is out of operation. Here are some suggestions to reduce sludge volume:

Install air coolers.This reduces the contamination of cooling water with process fluid, as well as the volume of cooling water in circulation.

Prevent leaks in the heat exchanger tubeCross contamination from the process side of heat transfer equipment is one of the sources of sludge-creating materials. The use of seal welded tube joints, or double tube sheets, will minimize process fluid leakage into the cooling water, and vice versa.

Properly treat cooling tower waterOperators should refrain from over treatment to avoid excess buildup due to chemical addition.

13.0 INDUSTRY-SPECIFIC WASTE MINIMIZATION PRACTICES

This section provides detailed information and examples of waste minimization practices which can be applied to the following specific industrial categories:

- Vehicle Maintenance
- Fabricated Metal Manufacturing and Metal Finishing
- Electroplating
- Printed Circuit Board Manufacturing
- Printing
- Photography
- Analytical and Clinical Laboratories
- Pesticides

13.1 Vehicle Maintenance

Industry Description

The vehicle maintenance industry includes a broad range of businesses. Typically included in this industry are businesses that repair or maintain:

- cars,
- vans,
- trucks,
- heavy equipment, and/or
- farm equipment.

These businesses are generally involved in these maintenance or repair activities:

- removing oil or grease;
- removing rust, dirt, or paint;
- repairing or rebuilding engines;
- refinishing or restoring vehicles;
- painting vehicle bodies; and/or
- replacing lead acid batteries.

Sources of Waste

Almost every aspect of vehicle maintenance operations involves some form of hazardous waste. Some of the most common include:

- rust removers - contain concentrated aqueous solutions;
- carburetor cleaners - contain flammable or combustible liquids;
- used rags - contain flammable or combustible solvents;
- paints - contain flammable or combustible thinners or reducers; and
- auto and truck batteries - contain strong acids or alkalies and lead.

Typical processes which generate hazardous wastes and their associated wastes include:

<u>Process/operation</u>	<u>Waste generated</u>
Oil/grease removal	Ignitable waste, spent solvents, combustible solids, waste acid/alkaline solutions
Engine parts/ equipment cleaning	Ignitable waste, spent solvents, combustible solids, waste acid/alkaline solutions
Rust removal	Waste acids, waste alkalies
Paint preparation	Spent solvents, ignitable wastes, ignitable paint waste, paint wastes with heavy metals
Painting	Ignitable paint wastes, spent solvents, paint wastes with heavy metals, ignitable wastes
Spray booth, spray guns, brush cleaning	Ignitable paint wastes, heavy metal paint wastes, spent solvents
Paint removal	Ignitable paint wastes, heavy metal paint wastes, spent solvents
Used lead acid	Used lead acid batteries, strong acid/alkaline solutions

Specific Waste Minimization Practices

The four main waste streams from the vehicle maintenance industry include:

- work cleaning wastes,
- solvents,
- paint wastes, and
- oils.

All of the waste minimization practices which can be used by the vehicle maintenance industry are similar to those which can be used in many other industries and include:

<u>Common waste stream</u>	<u>Primary process waste description</u>	<u>Minimization practice</u>
Work cleaning wastes	Spent alkaline cleaning solution, spent acid cleaning solution	See Section on Metal Parts Cleaning, <i>General</i>
Paint wastes	Ignitable paint wastes, paint wastes with heavy metals	See Section on Paint Application, <i>General</i>
Solvents	Spent solvents from oil/grease removal, paint preparation, and paint removal	See Section on Solvents, <i>Waste-Specific</i>
Oils	Waste oils from oil changes	See Section on Oils, <i>Waste-Specific</i>

13.2 Fabricated Metal Manufacturing and Finishing

Industry Process Description

Fabricated metal manufacturers and metal finishers utilize numerous and varied industrial processes during the production of fabricated metal products. Because of the large amount of waste minimization information applicable to these processes, as well as the fact that metal finishing operations are often performed independently from the manufacturing process itself, this section will be divided into industry-specific subsections--distinguishing metal manufacturing from metal finishing activities.

Fabricated Metal Manufacturing

Fabricated metal manufacturers include those producing electrical and non-electrical machinery, furniture, transportation equipment, and other metal equipment and supplies for industrial, commercial, and household use.

The processes used to manufacture metal products include, but are not limited to:

- cutting
- machining
- grinding
- die sinking
- painting/enameling
- welding
- buffing/polishing
- cleaning/degreasing

Metal Finishing

The metal finishing industry consists of those firms involved in the physical or chemical modification of metal surfaces to impart particular characteristics to the material, e.g., reducing surface reactivity; increasing corrosion resistance, strength, or conductance; or producing desired textures or colors.

The many different processes utilized by the industry are dictated by the specifications of the product manufacturers and include:

- heat treating
- electroless plating
- electroplating
- chemical conversion coating
- anodizing
- etching
- galvanizing
- chemical milling/hardening

Surface treatment processes are generally batch operations which include three basic steps: surface preparation/cleaning, surface treatment, and rinsing or postfinishing operations.

Sources of Waste

Wastes generated by both the fabricated metal manufacturing and metal finishing industries fall into eight major categories:

- spent solvents/solvent still bottoms,
- paint wastes with heavy metals,
- strong acid and alkaline wastes,
- other ignitable and reactive wastes,
- plating and stripping solutions,
- waste oils,
- heavy metal waste water sludges, and
- metal dusts, grindings, and cuttings.

Specific information relating wastes to sources (processes) is shown in the tables.

Fabricated metal manufacturing wastes.

<u>Process origin</u>	<u>Waste stream</u>	<u>Control methodology</u>
Metal cutting/ machining	Waste oils	<ul style="list-style-type: none">· Standardize oil types used on machining equipment.· Improve equipment scheduling/establish dedicated lines.

- Reuse or recycle cutting, cooling, and lubricating oils.
- Substitute lime or borax soap for lubricating oils.
- Centrifuge oil/scrap metal mixtures

Process origin

Waste stream

Control methodology

Heavy metal wastes, dust, and sludge

Segregate scrap metal.

Spent solvents

· *See Cleaning/Degreasing category below.*

Grinding/buffing/ polishing

Spent abrasives

- Use water-based or greaseless binders.
- Use an automatic liquid spray system for application of abrasive onto wheel.
- Ensure sufficient water use during cleaning.

Cleaning/ degreasing

Spent alkaline/ acid parts cleaners

Use deionized water to prepare solutions.

- Remove sludge frequently/continuously
- Install lids on tanks.
- Use water sprays/fog nozzles.
- Implement better operating practices.

Spent solvent cleaners

- Install lids/silhouettes on tanks.
- Increase freeboard space on tanks.
- Install freeboard chillers on tanks.

<u>Process origin</u>	<u>Waste stream</u>	<u>Control methodology</u>
Painting/ Enameling	Spent alkaline/ acid parts cleaners	<ul style="list-style-type: none"> · Remove sludge from solvent tanks frequently. · Extend solvent life by pre-cleaning parts by wiping, using air blowers, or pre-dipping in cold mineral spirits dip. · Reclaim/recover solvent on or off-site. · Substitute less hazardous solvent degreasers (e.g.,
	Waste paint	<p>petroleum solvents instead of chlorinated solvents) or alkali washes where possible.</p> <ul style="list-style-type: none"> · Slow speed of parts removal from vapor zone. · Rotate parts to allow condensed solvent drop-off. · See Section on Solvents, <i>Waste Specific</i>
	Spent solvents/ strippers	<ul style="list-style-type: none"> · See above. · Use equipment with low overspray. · Implement better operating practices. · Substitute water based, high solids, or powder coatings for solvent-based ones. · Substitute bead for solvent strippers. · Implement better operating practices.
	Solvent vapors	<ul style="list-style-type: none"> · Use solvent recovery or

incineration to reduce VOC emissions from cure ovens.

Metal finishing wastes.

Process origin

Heat-treating

Waste stream

Spent cyanide or barium salt solution from salt bath pot cleaning. Quenching oils and bath residues
Spent solvent degreasers.

Control methodology

- Replace cyanide or barium salt with alternate methods
- Use more dilute process solutions.
- Recycle oil quench baths by filtration.

Process origin

Electroplating/
anodizing/

Waste stream

Alkali wash wastes. quenching wastewater treatment sludges.

Control methodology

- Replace solvents with alkali washes.
- Extend useful life of alkali wash by removing oil.

Metal finishing (electroless plating, chemical etching, chemical milling)

Cleaning solutions. Spent plating solutions/sludges. Waste rinse waters. Treatment wastes.

- Increase plating solution life.
- Use cyanide-free solution.
- Utilize zinc plating solutions.
- Minimize drag-out.
- Use Cr(III) instead of Cr(VI)

Spent bath solutions

- Extend bath life.
- Recover metal/acid from spent baths.
- Spray/brush items instead of immerse.
- Use thinner foil for printed circuit boards.
- Use alternative treatment techniques.
- Use less toxic process solutions.
- Use more dilute process solutions
- Use better operating practices.

Waste rinse water

- Reduce dragout of solution from

	<ul style="list-style-type: none"> tank. · Employ effective rinsing methods. · Use immiscible rinses. · Use no-rinse coatings. · Reuse and recycle spent rinse water. · Replace hexavalent chromium with trivalent. · Use still rinsing technique. · Reclaim metal from rinse water wastes. · Change rinse composition. · Minimize process water use. · Use better operating practices.
Filter wastes	<ul style="list-style-type: none"> · Reclaim metal from solid waste. · Effectively dewater solids.
Spills and leaks	<ul style="list-style-type: none"> · Use better operating practices.
Stripping wastes	<ul style="list-style-type: none"> · Use non-chrome etchants. · Reduce generation of offspec coating.

13.3 Electroplating

Industry Process Description

Electroplating is a process in which metal is coated with one or more other metals by electrodeposition. Electrodeposition is achieved by passing an electric current through a solution containing dissolved metal ions and the metal object to be plated. This results in the deposition of the dissolved metal ions onto the surface of the object.

An electroplating process generally calls for moving the object to be coated (workpiece) through a series of baths arranged in a carefully designed sequence. Typically, the sequence consists of cleaning, rinsing, and a number of alternating electroplating and rinsing steps. The workpiece can be carried on racks or in barrels.

Sources of Waste

From a waste minimization standpoint, the ten primary electroplating process wastes can be grouped to reflect only four different process origins:

- work cleaning wastes,
- spent plating solutions/sludges,
- waste rinse water, and
- treatment wastes.

Some or all of the ten waste types may be combined into a single stream before treatment and disposal. A description of the ten primary process wastes organized according to these four common process origins is provided later in a table in this section.

Contaminated rinse water accounts for a majority of waste produced. Rinse water is used to remove the drag-out from a workpiece. Drag-out refers to the excess cleaning or plating solution that adheres to the workpiece surface and is carried out of the bath along with the workpiece. If the drag-out from one bath is carried into the next bath it is referred to as "drag-in," and is considered a contaminant in the later bath.

Spent cleaning and plating solutions are another waste source. Cleaning solutions may be acidic or basic, and may contain organics, and heavy metals. Some cleaning solutions may also contain cyanide. Spent plating solutions contain high concentrations of metals. These solutions are not regularly discarded but may require purging if impurities build up.

The waste water produced in the electroplating process may contain a variety of heavy metals and cyanide. The metals are removed by adding lime or other precipitation agents. The result is a dilute metal hydroxide sludge, which is thickened and then disposed of in a landfill.

Electroplating industry waste streams and minimization practices.

<u>Common waste stream</u>	<u>Primary process waste description</u>	<u>Minimization practice</u>
Work cleaning wastes	Spent alkaline cleaning solution; spent acid cleaning solution; degreaser sludges from solvent cleaning; solvent recycle still bottoms.	See section on Metal Parts Cleaning, <i>General Waste</i>
Spent plating solutions and sludges	Spent plating solutions; filter sludges from electroplating.	<ul style="list-style-type: none"> · Increase plating solution life. · Use non-cyanide plating solutions. · Replace cadmium plating with zinc. · Replace hexavalent chromium with trivalent. · Return spent plating solution to manufacturer.

Waste rinse water

Waste rinse water

- Increase solution temperature
- Use less concentrated plating solution.
- Withdraw workpiece slowly from solution.
- Add wetting agents to plating solution.
- Position workpiece properly on rack.
- Recover drag-out of plating solutions.
- Install multiple rinse tanks.
- Install fog nozzles and sprays.
- Reuse rinse water elsewhere in plant.
- Install still rinsing tanks.
- Install automatic flow controls.
- Use mechanical/air agitation of bath.

Treatment wastes

Wastewater treatment sludge; vent scrubber wastes; ion-exchange resin reagents from process water demineralization.

- Use efficient precipitating agents.
- Use trivalent instead of hexavalent chromium.
- Install sludge dewatering systems.
- Implement better operating practices.
- Install metal recovery systems.

13.4 Printed Circuit Board Manufacturing

Industry Process Description

Printed circuit board manufacturing involves imprinting metal circuitry onto a board composed of nonconductive material (e.g., glass, epoxy, or plastic) through a series of operations characteristic of the particular production method used. The three principal production methods used in their manufacture are:

- conventional subtractive process,
- fully additive process, and
- semi-additive process.

The subtractive production method is currently the most predominant of the three types. It typically begins with a copper-clad laminate board which is subjected to the following operations.

- **Board preparation:**curing, sanding, drilling, deburring.
- **Electroless copper plating:**scrubbing/cleaning, surface activation etching, electroless

plating catalyst application.

- **Printing and masking:** Panel plating: electroplating, etching, resist application. - Pattern plating: resist application, printing/developing.
- **Electroplating:** cleaning/rinsing, tin/lead plating, light etch/ acid dip, stripping/rinsing, copper electroplating.
- **Etching**

The final stages of the subtractive process involve cleaning and application of selective metallic coatings for solderability and/or corrosion protection.

The additive method differs in that an unclad board is used initially. The only areas of the board to be plated are those containing the circuitry itself; all other areas are coated with plating resist, thus eliminating the need to etch unwanted copper.

Sources of Waste

The waste streams resulting from the five major operations mentioned in the preceding section are listed in table.

Airborne particulates generated during board preparations are normally collected and separated using bag-house and cyclone separators. The collected dusts are then removed for disposal at landfills as solid wastes.

Acid vapors are collected and are neutralized prior to sewer discharge or disposal, while organic vapors are collected and condensed, drummed and land disposed, combusted, or reclaimed.

The majority of the liquid waste streams are subject to in-house treatment prior to sewer discharge. Typical treatment systems may consist of pH adjustment and metal precipitation, followed by sludge removal and dewatering.

Spent organic solvents are most often reclaimed, either in-house or at an off-site facility.

Printed circuit board waste streams and minimization practices.

<u>Process origin</u>	<u>Waste stream</u>	<u>Control methodology</u>
Cleaning/surface preparation	Airborne particulates; acid fumes/organic vapors; spent acid/alkaline solution; spent halogenated solvents; waste rinse water.	· See Section on Metal Parts Cleaning, <i>General Waste Section</i>

Catalyst application/ electroless plating	Spent electroless copper bath; spent catalyst solution; spent acid solution; waste rinse water.	<ul style="list-style-type: none"> · Use combined sensitization/activation. · Use lower concentration plating bath. · Use differential electroless plating. · Use weak/biodegradable chelating agents. · Use in-line metal recovery techniques. · Use computerized/automated control.
Pattern printing/masking	Acid fumes/ organic vapors; vinyl polymers; spent resist removal solution; spent acid solution; waste rinse water.	<ul style="list-style-type: none"> · Use aqueous processable resists · Use screen print instead of photolith. · Use Asher dry resist removal method.
Electroplating	Spent plating bath; waste rinse water.	<ul style="list-style-type: none"> · See Section on Electroplating, <i>Industry Specific</i> · Use pattern instead of panel plating.
Etching	Spent etchant; waste rinse water.	<ul style="list-style-type: none"> · Use dry plasma etching techniques. · Use additive in place of subtractive method. · Use less-toxic etchants. · Use in-line metal recovery techniques. · Use thinner copper foil for cladding.

13.5 Printing

Industry Process Description

There are several commonly employed printing processes currently used by the graphic arts industry, including lithography, gravure, flexography, letterpress, and screen printing. Of these, lithography, gravure, and flexography are the most widely utilized.

While the operational details may vary between these various printing processes, the basic steps

involved are the same. These steps include:

- Image processing,
- plate or cylinder making,
- printing,
- drying, and
- finishing.

Sources of Waste

Lithography and flexography generally produce the following three main types of waste:

- trash,
- process waste waters and,
- equipment cleaning wastes.

While gravure printing generates similar waste streams, the waste waters produced are actually more akin to metal processing operations, and the sections of this manual dealing with metal parts cleaning, electroplating, and metal finishing operations (Sections Metal Parts Cleaning, *General Waste*, Electroplating, *Industry Specific*, and Fabricated Metal Manufacturing and Metal Finishing, *Industry Specific*, respectively) should be consulted for further information regarding this waste type.

Trash is by far the largest waste stream produced by the printing industry. Scrap paper generated is either recycled, incinerated, or sent for disposal. Scrap photographic material is often sold for metal recovery. Empty containers are typically discarded, but may be recycled in some cases.

Waste waters may be subject to pretreatment for metal recovery or neutralization prior to sewer discharge, or drummed for off-site disposal if necessary.

Equipment cleaning waste handling depends on the types of inks and solvents used. Cleaning rags are either incinerated or sent for laundering or disposal. Any waste water-based inks are generally discarded with other trash. Solvent-based inks and spent cleaning solvents may be recycled, incinerated, or sent to a hazardous waste treatment or disposal facility.

Printing wastes.

Waste Process stream	origin	Composition	Control methodology
Trash	Image processing	Empty containers, used film packages, out-dated	<ul style="list-style-type: none">· Recycle empty containers.· Recycle spoiled photographic film.

		material.	
	Plate making	Damaged plates, developed film, dated materials.	<ul style="list-style-type: none"> · Use electronic imaging, laser plate making.
	Printing	Test production, bad printings, empty ink containers, used blankets.	<ul style="list-style-type: none"> · Install web break detectors. · Monitor press performance. · User better operating practices.
	Finishing	Damaged products, scrap.	
Wastewater	Image processing	Photographic chemicals, silver.	<ul style="list-style-type: none"> · Use silver-free films. · User water-developed litho plates.
	Plate making	Acids, alkali, solvents, plate coatings, (may contain dyes, photopolymers, binders, resins, pigment, organic acids), developers (may contain isopropanol, gum arabic, Iacquers, caustics) and rinse water.	<ul style="list-style-type: none"> · Electronic imaging/laser print making. · Recover silver and recycle chemicals. · Use counter-current washing sequence. · Use squeegees. · Use better operating practices. · Remove heavy metals from wastewater.
	Printing	Spent fountain solutions (may contain chromium)	
Equipment cleaning	Printing	Lubricating oils, waste ink, clean-up solvent (halogenated and non-halogenated), rags	<ul style="list-style-type: none"> · Recycle waste ink and solvent · Use automatic cleaning equipment. · Recover heating value from waste. · Use automatic ink leveler.

- Use less toxic solvents.
- Use better operating practices.

13.6 Photography

Sources of Waste

The primary wastes associated with the photography industry include the spent fix solutions from the film development process. Commercially available recycling equipment exists that makes it possible to reuse spent developer, bleach, bleach-fix, and fix-processing solutions. Equipment is also available to recover the silver present in the wash water after the fix bath.

The most common waste minimization practices which can be applied to the three main waste streams in the photography industry are:

<u>Waste stream</u>	<u>Minimization practice</u>
Process bath wastes	Metallic replacement Chemical precipitation Install metal recovery system
Color developer wastes	Metal recovery techniques Countercurrent washing Use of squeegees Reduction of water consumption
Bleach, fix, bleach-fix wastes	Use of non-complexed bleaches, ozone oxidation, electrolysis, persulfate salts, and/or liquid bromine.

13.7 Analytical and Clinical Laboratories

Industry Process Description

Analytical and clinical laboratories can operate any number of the following departments, each generating quantities of hazardous waste:

- pathology
- radiology
- nursing units
- equipment repair
- Laundry
- histology
- autopsy
- dialysis
- maintenance
- pharmacy

- embalming
- clinical/research
- sterile processing
- laboratories

Sources of Waste

From a waste minimization standpoint, the primary types of analytical and clinical laboratory wastes can be grouped as:

- formaldehyde,
- photographic wastes,
- mercury,
- pesticides, insecticides,
- strong acids or alkalies,
- oxidizers,
- ignitable paint wastes,
- paint wastes with heavy metals,
- spent solvents,
- halogenated solvents,
- poisons, and
- unused chemical reagents.

Some or all of the wastes within a single group may be combined before treatment and disposal. However, waste of different types should be segregated. A description of the major laboratory wastes organized according to these eleven common areas is provided later in this section in the table.

Spent solvents account for a large portion of the wastes produced. Solvents are used in cleaning laboratory glassware, extractions, and other laboratory procedures. Solvents may also be used for cleaning tools, paint spray guns and brushes, and in photographic developing. Most laboratory sections generate some kind of waste solvent. These wastes can include alcohols and halogenated solvents (e.g., carbon tetrachloride).

Strong acids and alkalies are another waste source. Acid and alkaline solutions are often used as chemical reagents in clinical and research laboratories, or as cleaning agents by maintenance departments.

Photographic wastes include the heavy metal solutions used in photographic developing. These are usually generated by radiology departments.

Waste formaldehyde is generated by those laboratory departments conducting autopsies or involved in embalming.

Paint wastes are common in the maintenance areas of larger laboratories. Paint wastes can contain a variety of heavy metals such as lead or ignitable solvents. Care should be taken to segregate

these wastes as much as possible to facilitate efficient waste management.

Waste mercury is generated by accidental thermometer breakage, and in the equipment repair sections dealing with sphygmomanometers.

Waste pesticides and insecticides are often produced when exterminators attempt to provide a pest-free laboratory.

Waste oxidizers are occasionally produced from the use of oxidizers such as silver nitrate. Such chemicals were common laboratory reagents in the past.

Poisons such as phenol and mercuric chloride are often generated by clinical and research labs.

Analytical and clinical laboratory waste streams and minimization practices.

<u>Common waste streams</u>	<u>Primary process waste description</u>	<u>Minimization practice</u>
Photographic wastes	Spent processing solutions containing heavy metals.	· See Section on Photography, <i>Industry Specific Section</i>
Spent solvents	Spent solvents from glass cleaning; oil, grease, and paint removal.	· See Section on Solvents, <i>Waste Specific Section</i>
Formaldehyde	Waste formaldehyde from embalming, autopsies.	· Purchase only necessary quantities. · Store efficiently.
Mercury	Waste mercury from broken thermometers; waste from instrument repair.	· Good Operating Practices · Take care in handling thermometers. · Purchase only necessary quantities.
<u>Common waste streams</u>	<u>Primary process waste description</u>	<u>Minimization practice</u>
Strong acid/alkaline paint, varnish	Rustremovers; lacquer, removers; laboratory reagents.	· See Section on Corrosive wastes Waste, <i>Waste Specific Section</i> · See Section on Analytical and Clinical Laboratories, <i>Industry Specific</i>

Pesticides and insecticides	Waste pesticides and insecticides from maintenance and grounds crews.	· See Section on Pesticides, <i>Industry Specific Section</i>
Paint wastes	Paint wastes containing flammable solvents or heavy metals.	· See Section on Paint Application, <i>General Waste Section</i>
Oxidizers	Waste oxidizing laboratory reagents such as silver nitrate.	· See Section on Analytical and Clinical Laboratories, <i>Industry Specific</i>
Halogenated organics	Spent halogenated hydrocarbons such as carbon tetrachloride.	· See Section on Halogenated Organic Waste, <i>Industry Specific Section</i>
Used chemicals	Waste laboratory reagents.	· Implement good operating practices · Purchase only necessary quantities. · Make chemical substitutions. · Store efficiently.
Poisons	Waste such as phenol and mercuric chloride.	· Purchase only necessary quantities. · Make chemical substitutions.

13.8 Pesticides

Industry Process Description

Pesticide formulators prepare pesticide products from pesticide concentrates, solvents, carriers, and other additives. Pesticide applicators apply the pesticide to the treatment site.

Pesticides are most commonly formulated into wettable powders, dusts, emulsions, granules, and aerosols. Although the processes involved in producing these various formulations are different, there are general operations common to all of them. These common operations include:

- mixing,
- dissolving,

- blending, and
- packaging.

Pesticide applicators purchase the pesticide products, usually dilute them with water or another diluting agent, and apply the pesticide to the treatment site using special application equipment.

Sources of Waste

Waste containing pesticides and other hazardous materials are produced as part of the pesticide formulation and application processes. The waste is principally a result of cleaning equipment between batches, cleanup of spills, and the production of off-specification product. Other pesticide wastes include the empty pesticide containers (e.g., packages or drums) and dust collected in air pollution equipment. These wastes are further described in the table.

Waste categories of pesticide formulations, and applicators and minimization practices.

Waste category	Source	Minimization practice
Rinse water or absorbent	Equipment cleaning, spills area washdown.	<ul style="list-style-type: none"> · Storage and reuse of rinse water or absorbent. · Use of high pressure spray nozzles. · Use of dry absorbents for spill cleanup. · Floor sweeping to collect spills for product reformulation
Off-specification products	Poor process control.	<ul style="list-style-type: none"> · Strict process control or automation. · Reformulation of off-specification batches.
Packages and drums	Pesticide residue in drums. Empty packages or drums.	<ul style="list-style-type: none"> · Rinse drums using minimum amount of water and reuse or recondition them. · Use refillable or returnable bulk tote drums bins.
Dust collected in air pollution equipment	Dust generated during handling, grinding, and other formulation operations.	<ul style="list-style-type: none"> · Recycle dust into process where it was generated.

14.0 REFERENCES

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