HAZARDOUS WASTE CURRICULUM
FOR
AVIATION MAINTENANCE

Prepared by:

Brevard Teaching and Research Laboratories

Florida Community Colleges Consortium
for Pollution Prevention Education

Florida Department of Environmental Protection

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INTRODUCTION

Through their continuing efforts to prevent pollution and protect individuals from hazardous waste mishandling, the Florida Department of Environmental Protection (FDEP) awarded a grant to the Florida Community College Consortium for Pollution Prevention Education to develop a hazardous waste curriculum for the aviation maintenance industry. Coordinated by Brevard Teaching and Research Laboratories (BTR Labs) of Brevard Community College, the project employed the assistance of an advisory committee from several agencies and institutions including the Consortium members, Florida Department of Environmental Protection, Federal Aviation Administration (FAA), COMNAVBASE Jacksonville, Broward Community College and Embry Riddle Aeronautical University.

There are two primary uses for this manual: 1) to supplement the current Florida aviation maintenance curriculum with a hazardous waste/pollution prevention component and 2) to allow for hazardous waste/pollution prevention continuing education opportunities for certified aviation mechanics and affiliated management. The manual is divided into 13 Chapters designed to teach key hazardous waste concepts as they relate to the aviation industry. Chapters 1 through 6 discuss general hazardous waste concepts such as defining hazardous waste, hazardous waste regulatory agencies, identifying hazardous waste and proper hazardous waste handling (from labeling to disposal). Chapters 7 through 13 identify hazardous waste associated with aviation maintenance and provide waste minimization alternatives and proactive pollution prevention practices.

This manual is designed to supplement current FAA mechanic certification and FDEP regulatory compliance requirements. All procedures and programs required by FAA should be strictly adhere to, as should manufacturer's maintenance and procedures manuals. Many of the product/application alternatives and pollution prevention practices discussed in this manual require proper approval prior to on-site implementation.

For further information regarding this manual or to request additional copies contact Brevard Teaching and Research Laboratories, 1470 Treeland Blvd., SE, Palm Bay, Florida 32909, (407)-632-1111 ext. 22087.

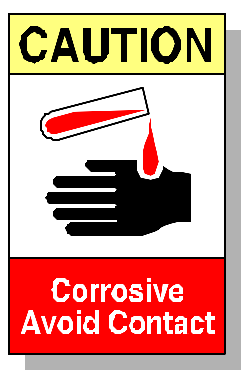
CHAPTER 1
WHY BE CONCERNED ABOUT HAZARDOUS WASTE?

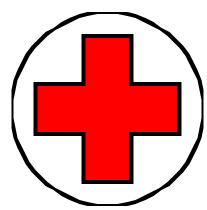
There are four main reasons an aviation maintenance mechanic should be concerned about hazardous waste. These reasons pertain to job safety, health, money and the environment.

1 Aviation maintenance mechanics have several key responsibilities in keeping aircraft in safe flying condition. These responsibilities range from servicing and repairing to overhauling various aircraft components, systems and instrumentation. However, an incomplete understanding of aviation maintenance hazardous waste concepts could not only jeopardize the flying condition of the aircraft but possibly endanger lives.

EXAMPLE:

> The 1996 Valujet crash in the Florida Everglades is an example of hazardous waste handling negligence. The cause of the crash which took the lives of all 110 passengers and crew was five ordinary cardboard boxes containing expired, unexpended, uncapped chemical oxygen generators (Ducan et al., 1996). This tragic crash might have been prevented, if the pertinent individuals handling these generators had recognized them as hazardous waste and labeled, stored, packaged and transported them accordingly.





2 Improper handling of hazardous waste can threaten human health. For example, acids or bases (such as battery acids and metal cleaning solutions) can destroy or cause irreversible damage to normal living tissues, such as mucus membranes, eyes, gastrointestinal tract, respiratory passages and skin. Toxins are another health hazard that poison your system. Toxic solvents, heavy metals, paint thinners and adhesives can accumulate in your body over time. This could affect your nervous system particularly the brain and circulatory system.

EXAMPLE:

A list of some materials and their hazardous health effect(s).

MATERIALS		HEALTH EFFECT(S)
Beryllium	Infrared waves	Causes or promotes cancer
Cadmium	Ultraviolet light	
Chromic acid		
Alkaline dust	Halogens	Inflammation of skin and mucous membranes
Ozone	Phosgene	
Nitrogen	Carbon Dioxide	Displaces oxygen in tissues
Hydrogen	Helium	
Halogenated hydrocarbons		Depressant effect upon the central nervous system
Alcohols		

3 Another important reason to appreciate proper hazardous waste handling is possible financial impacts. Regulatory penalties can range from $100 to $50,000 per violation per day. These penalties occur from improper handling, storage, transportation and/or disposal of hazardous waste. In addition to losing money, improper handling of hazardous waste can result in job loss or worse, imprisonment.

EXAMPLE:

In an actual case from Florida Department of Environmental Protection, an aviation repair facility had potential fines up to $13,000 and $100 per day for each day they fail to timely comply with the hazardous waste violations. The following is a list of their costly violations:

- Failure to notify as a hazardous waste generator.
- Failure to label all hazardous waste containers with accumulation start dates and the words “hazardous waste.”
- Failure to keep all containers holding hazardous waste closed at all times (i.e., except when actually adding or removing waste).
- Failure to perform a hazardous waste determination on spent rags contaminated with listed waste.
- Failure to use the manifest system for off-site removal of hazardous waste.
- Failure to maintain inspection logs for hazardous waste containers.
- Allowed hazardous waste to be taken off-site without utilizing a Land Disposal Certification/Notification.

All of these costly violations could of be prevented if the knowledge and application of simple hazardous waste concepts had been exercised at the facility.

4 Lastly, sound hazardous waste practices not only protect your job safety, health and liability, but the environment. Improperly handled hazardous waste can destroy natural waterways, poison or kill wildlife and contaminate food and drinking water.

Photo Courtesy of Department of Environmental Protection

EXAMPLE:

Used oil from a single automotive oil change can spoil one million gallons of fresh water for an entire year (Pennsylvania Department of Environmental Protection, 1996).

Used oil in surface waters can also threaten wildlife. Oil depletes the oxygen supply for many aquatic organisms such as fish and inhibits the flying ability of water fowl. Furthermore, contaminated water with high concentrations of metals from the oil are absorbed by plants and accumulate in their tissues. In return, by contaminating the food supply, it can ultimately affect human health.

CHAPTER 2
WHAT IS HAZARDOUS WASTE?

DEFINITION OF HAZARDOUS WASTE

Hazardous waste is a discarded substance that because of its quantity, concentration, physical, chemical or infectious characteristics may cause or contribute to a serious illness or pose a substantial or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of (Naval School, 1997). Hazardous waste can take the form of a solid, liquid or compressed gas. In the aircraft industry, waste can originate from the service or repair of aircraft components to temporary storage of outdated products that have not been used or new products purchased in excess.

The term hazardous waste is often used in conjunction with hazardous materials, chemicals and substances. The following addresses the differences between these terms.

❑ HAZARDOUS CHEMICAL: is any chemical which has properties that present either physical or health hazards. Hazardous chemicals from Occupational Safety and Health Administration (OSHA) include both physical and health hazards and are listed in Table 1.

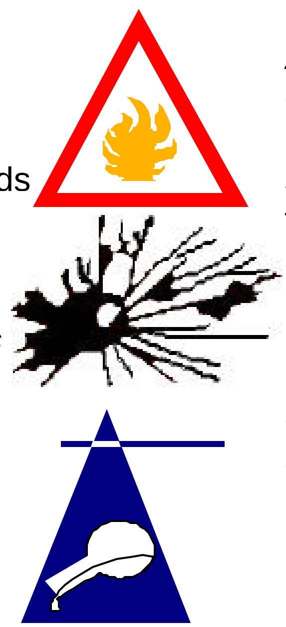
Table 1. A listing of OSHA hazardous chemicals (Naval School, 1997).

PHYSICAL HAZARDS

Fire Hazards
combustible liquids
flammable aerosols
gases, liquids & solids
oxidizers
pyrophoric

Explosion Hazards
compressed gases
explosives

Reactive Hazards
organic peroxides
reactive material



HEALTH HAZARDS

Acute Hazards
corrosive materials
irritants
sensitizers
toxic agents
agents affecting target organs

Chronic Hazards
carcinogens
agents affecting
target organs

❑ HAZARDOUS MATERIAL: is a substance or material which is capable of posing an unreasonable risk to health, safety and property when transported in commerce. Hazardous materials are divided into nine classes by the Department of Transportation (DOT) that include:

explosives	gases
flammable liquid	combustible liquid
flammable solids	oxidizers
organic peroxides	poisonous materials
radioactive materials	corrosives

❑ HAZARDOUS SUBSTANCE: is a listed substance that is deemed as hazardous if spilled in excess.

Using the above terms, hazardous waste could also be considered a hazardous material when transported and a hazardous substance when spilled. Table 2 is a partial list of hazardous waste related to the aviation maintenance.

Table 2. A list of hazardous materials and waste found in aviation maintenance industry (modified from Kroes et al., 1993).

AIRCRAFT SYSTEMS	***AIRCRAFT SERVICING***	***COMPONENT SHOPS***
System Liquids	**Lubricants**	**Inspection**
Gasoline	Dry lubricants	Liquid penetrants
Jet fuels	Spray lubricants	Dye penetrants
Hydraulic fluids	Greases	***Welding***
Brake fluids	Oil	Argon gas
Anti-ice additives	***Solvents & Cleaners***	Hydrogen gas
Gases	Methyl ethyl ketone	Oxygen gas
Freons	Toluene	Acetylene gas
Nitrogen	Engine cleaners	Fluxes and pastes
Oxygen	Carburetor cleaners	***Others***
Halons	***Paints & Primers***	Compressed air
Others	Paint strippers	Glass beads
Alcohols	Primers	Bluing and thinner
Methanol	Doping porducts	Quenching fluids
Batteries	Lacquers	Muriatic acid
Glycol	Enamels	Locking compounds
Baking soda	Epoxies	Oxidizers
Degreasers	***Adhesives***	Mineral spirits
Disinfectants	Fiberglass resins	Cutting fluids
	Gasket& rubber adhesives	Soldering fluxes

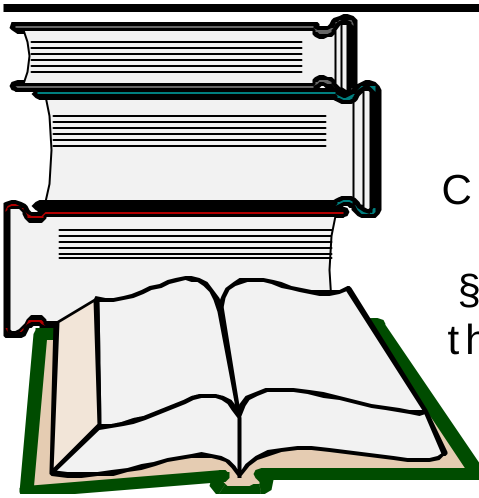
CHAPTER 3
HAZARDOUS WASTE REGULATIONS AND REGULATING AGENCIES

The regulation of hazardous waste is dependent upon the waste identity and operation. Hazardous waste is regulated by several federal, state and local governmental agencies. Modifications in hazardous waste regulations occur periodically in both the state and federal government. The Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA) and the Department of Transportation (DOT) are the three main federal regulatory agencies of hazardous waste while the Department of Environmental Protection is the principal State of Florida regulatory agency.

CODE OF FEDERAL REGULATIONS

The Code of Federal Regulations (CFR) is a series of documents revised yearly and published by federal governmental agencies. All areas of federal regulations, which are divided into 50 titles, are covered in CFR including hazardous waste regulations. Table 3 identifies components addressing hazardous materials, substances and waste regulations from the EPA, OSHA and DOT. Copies of CFR can be obtained from public, college or law libraries or from the U.S. Government Printing Office. CFR will be cited throughout the text for reference.

The 50 titles are broken down into specific segments for easy reference and a single title may be presented in one or more volumes. CFR numbering is composed of titles, chapters, subchapters, parts and subparts. Chapters are identified by Roman numeral with their subchapters identified in capital letters and parts identified as Arabic numbers. Below is an example of cited regulation.



40 CFR §261.7

40 CFR is Title 40 of the Code of Federal Regulations

§ represents the symbol for the part and section number

261 is the part and 7 is the section

Table 3. An overview of the Code of Federal Regulations on hazardous materials, substances and waste (modified from Keegan and Keegan, 1996).

ENVIRONMENTAL PROTECTION AGENCY-40 CFR

- **SUBCHAPTER 1-SOLID WASTE**
  - **PART 260-Hazardous Waste Management System; General**
    - Subpart A- General Information
    - Subpart B- Definitions
    - Subpart C- Rulemaking
  - **PART 261-Identification and Listing of Hazardous Waste**
    - Subpart A- General
    - Subpart B- Criteria for Identifying the Characteristics of Hazardous Waste and for Listing Hazardous Waste
    - Subpart C- Characteristics of Hazardous Waste
    - Subpart D- Lists of Hazardous Waste
      Hazardous Waste Appendices
  - **PART 262-Standards Applicable to Generators of Hazardous Waste**
    - Subpart A- General
    - Subpart B- The Manifest
    - Subpart C- Pre-Transport Regulations
    - Subpart D- Recordkeeping & Reporting
    - Subpart E- Exports of Hazardous Waste
    - Subpart F- Imports of Hazardous Waste
    - Subpart G- Farmers
  - **PART 263-Standards Applicable to Transporters of Hazardous Waste**
    - Subpart A- General
    - Subpart B- Compliance With the Manifest System and Recordkeeping
    - Subpart C- Hazardous Waste Discharges
  - **PART 265-TSD Facility Standards for Generators**
    - Subpart C- Preparedness and Prevention
    - Subpart D- Contingency Plan and Emergency Procedures
    - Subpart I- Use and Management of Containers
    - Subpart AA-Air Emission Standards for Process Vents
    - Subpart BB-Air Emissions Standards for Equipment Leaks
    - Subpart CC-Air Emission Standards for Tanks, Surface Impoundments, and Containers
  - **PART 266- Standards for the Management of Specific Hazardous Waste and Specific Types of Hazardous Waste Management Facilities**
    - Subpart C- Recyclable Materials Used in Disposal
    - Subpart F- Recyclable Materials Utilized for Precious Metal Recovery
    - Subpart G- Spent Lead-Acid Batteries Being Reclaimed
    - Subpart H- Hazardous Waste Burned in Boilers and Industrial Furnaces
  - **PART 268- Land Disposal Restrictions**
    - Subpart A- General
    - Subpart B- Schedule for Land Disposal Prohibition and Establishment of Treatment Standards
    - Subpart C- Prohibitions on Land Disposal
    - Subpart D- Treatment Standards
    - Subpart E- Prohibitions on Storage

Table 3. Continued.

PART 279- Standards for the Management of Used Oil
- Subpart A- Definitions
- Subpart B- Applicability
- Subpart C- Standards for Used Oil Generators
- Subpart D- Standards for Used Oil Collection Centers and Aggregation Points
- Subpart E- Standards for Used Oil Transporter and Transfer Facilities
- Subpart F- Standards for Used Oil Processors and Re-Refiners
- Subpart G- Standards for Used Oil Burners Who Burn Off-Specifications Used Oil for Energy Recovery
- Subpart H- Standards for Used Oil Fuel Marketers
- Subpart I- Standards for Use as a Dust Suppressant and Disposal of Used Oil

PART 302- Designation, Reportable Quantities, and Notification
- Section 302.4- List of Hazardous Substances and Reportable Quantities

PART 303- Citizen Awards for Information On Criminal Violations Under Superfund
- Subpart A- General
- Subpart B- Eligibility to File a Claim for Award and Determination of Eligibility and Amount of Award
- Subpart C- Criteria for Payment of Award

PART 311- Worker Protection

PART 355- Emergency Planning and Notification

PART 370- Hazardous Chemical Reporting: Community Right-To-Know
- Subpart A- General Provisions
- Subpart B- Reporting Requirements
- Subpart C- Public Access and Availability of Information
- Subpart D- Inventory Forms

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION- 29 CFR
- Subpart C- General Safety and Health Provisions
  - Section 1910.20- Access to Employee Exposure and Medical Records
  - Section 1910.38- Employee Emergency Plans and Fire Prevention Plans
  - Section 1910.120- Hazardous Waste Operations and Emergency Response
- Subpart I- Personal Protection Equipment
  - Section 1910.132- General Requirements
  - Section 1910.1030- Bloodborne Pathogens
  - Section 1910.1200- Hazard Communication
  - Section 1910.1450- Occupational Exposure to Hazardous Chemicals in Labs

Table 3. Continued.

DEPARTMENT OF TRANSPORTATION REGULATIONS- 49 CFR

SUBCHATER A- HAZARDOUS MATERIALS TRANSPORTATION, OIL TRANSPORTATION AND PIPELINE SAFETY

- **PART 106- Rulemaking Procedures**
- **PART 107- Hazardous Materials Program Procedures**
- **PART 110- Hazardous Materials Public Sector Training and Planning Grants**

SUBCHAPTER B- OIL TRANSPORTATION

- **PART 130- Oil Spill Prevention and Response Plans**

SUBCHAPTER C- HAZARDOUS MATERIALS REGULATIONS

- **PART 171- General Information, Regulations, and Definitions**
- **PART 172- Hazardous Material Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information and Training Requirements**
  - Subpart A- General Information
  - Subpart B- Table of Hazardous Materials and Special Provisions
  - Subpart C- Shipping Papers
  - Subpart D- Marking
  - Subpart E- Labeling
  - Subpart F- Placarding
  - Subpart G- Emergency Response Information
  - Subpart H- Training
  - Subpart I- Radiation Protection Program
- **PART 173- Shippers- General Requirements for Shipments and Packaging**
  - Subpart A- General Information
  - Subpart B- Preparation of Hazardous Materials for Transportation
  - Subpart C- Definitions, Classification and Packaging for Class 1
  - Subpart D- Definitions, Classification, Packing Group Assignments and Exceptions for Hazardous Materials Other than Class 1 and Class 7
  - Subpart E- Non-Bulk Packaging for Hazardous Materials Other Than Class 1and Class 7
  - Subpart F- Bulk Packaging for Hazardous Materials Other Than Class 1 and Class 7
  - Subpart G- Gases; Preparation and Packaging
  - Subpart I- Radioactive Materials
- **PART 174- Carriage by Rail**
- **PART 175- Carriage by Air**
  - Subpart A- General Information & Regulations
  - Subpart B- Loading, Unloading and Handling
  - Subpart C- Specific Regulations Applicable According to Classification of Materials
- **PART 176- Carriage by Vessel**
- **PART 177- Carriage by Highway**
- **PART 178- Specifications for Packaging**
  - Subpart L- Non-Bulk Performance-Oriented Packaging Standards
  - Subpart M-Testing of Non-bulk Packaging and Packages
  - Subpart N- Intermediate Bulk Container Performance
  - Subpart O-Testing of Intermediate Bulk Containers

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) manages all areas of environmental protection of air, soil, water and natural resources and is assigned Title 40 of the CFR. The following discusses acts passed by the EPA to protect the air and water (The Clean Air Act and The Clean Water Act) and hazardous waste management (Resource Conservation Recovery Act).

The Clean Air Act of 1970 allows the EPA to control hazardous air pollutants (HAP). Hazardous air pollutants could come from emissions of solvent rags hanging up to dry, open solvent containers, or from emissions of benzene and styrene from fueling operations. The act restricts criteria pollutants such as emissions of mobile sources, acid rain and protects the ozone layer by requiring permits for any discharges of pollutants into the air. Operations such as painting, electroplating, degreasing, fuel storage and incinerators that generate HAP might need a permit depending upon the size and location of facility to operate.

The Clean Water Act of 1977 allows the EPA to protect surface waters such as rivers, streams and lakes. This act ensures that surface waters remain suitable for human use and is typically implemented through the EPA to state agencies. It requires permits for point source discharges and limits the type and amount of pollutants that can enter a given waterway. Any untreated discharges are prohibited under the Clean Water Act. In 1987, the act was amended to address nonpoint source (NPS) pollution, which is the source of at least 50% of the water quality problems in the United States today. NPS pollution, often referred to as stormwater runoff or urban runoff, is water pollution that can not be traced to its specific origin or starting point. This amendment to the Clean Water Act instructs states to develop management plans to reduce nonpoint source pollution through Best Management Practices (BMPs).

In 1976, the EPA established the Resource Conservation Recovery Act (RCRA) to regulate hazardous waste. RCRA focuses on recycling and disposal of solid waste, storage tank regulations as well as hazardous waste regulations.

There are three divisions of RCRA:

1. solid waste (subtitle D)

2. hazardous waste (subtitle C)

3. underground storage tank (subtitle I).

Subtitle C of RCRA provides the framework to follow the life cycle of hazardous waste from the cradle (generation) to the grave (disposal). The cradle to grave system places permanent legal and financial responsibility on the hazardous waste generators.

Listed below are the five major components of hazardous waste management (Subtitle C).

1. Classification of hazardous waste (40 CFR Part 261)

2. Cradle to grave manifest system, record keeping and reporting requirements

3. Standards for generators (40CRF Part 262), transporters (40 CFR Part 263), owners of treatment, storage and disposal facilities (40 CFR Parts 264 &265), and recycling facilities (40 CFR Part 266).

4. Enforcement of standards through permitting program and civil penalty policies

5. Authorization of state programs to operate in lieu of the federal program

OCCUPATIONAL SAFETY & HEALTH ADMINISTRATION

The Occupational Safety and Health Administration (OSHA) is assigned to Title 29 of the CFR and is part of the Department of Labor. It regulates the obligations of employers to guarantee a safe and healthy working environment for their employees. OSHA also regulates waste operations at treatment, storage and disposal facilities and the clean-up of any substance or waste which has been spilled in the workplace. In 1983, OSHA established the Hazardous Communication Standards (29 CFR 1910.1200) also called the Employee Right-to-Know Law. These standards require all employees to be informed about known workplace hazards including potential exposures to and dangers of harmful substances and associated health effects.

There are five basic requirements in the Hazardous Communication Standards.

1. An inventory of all hazardous materials used in the workplace must be maintained. The inventory must contain the name of the hazardous material, location and the approximate quantity.

2. All hazardous materials must be properly labeled.

3. Material Safety Data Sheets (MSDS) must be obtained by the manufacturer and stored in the work area for easy employee reference.

4. Employee information and training programs must be provided to all employees exposed to hazardous chemicals. This training includes understanding all of the Right-To-Know laws, proper handling and labeling procedures, known health hazards, exposure limits of hazardous materials and personal protection methods.

5. A written hazardous communication program must be presented at the workplace.

DEPARTMENT OF TRANSPORTATION

In 1865, the transportation of hazardous materials was regulated by the federal government to protect the railroad from poorly identified and packaged explosives and ammunition (U.S. Fish and Wildlife Service, 1996). Today, the Department of Transportation (DOT), assigned Title 49 of the CFR, regulates the cycle of transportation of hazardous materials in commerce by highway, rail, water and air. This cycle of transportation includes preparing, offering, loading, moving and unloading of hazardous materials, including hazardous waste transportation. There are four regulatory branches of DOT that include the Federal Aviation Administration (FAA), Federal Highway Administration (FHA), Federal Railroad Administration (FRA) and the United States Coast Guard.

The FAA manages not only air traffic control but examines the safety of planes and the credentials and competency of pilots and mechanics. The FAA conducts safety and security related research programs and provides safety regulations and inspections. FAA inspectors also observe maintenance work and examine aviation maintenance databases.

The Federal Aviation Regulations (FARs) are rules promoting safety of aviation. Regulations pertaining to airworthiness standards, maintenance, preventive maintenance, rebuilding and alterations are found in Title 14 of the CFR, under FARs Part 1-199. Table 4 is a list of federal aviation regulations pertaining to aviation maintenance. It is the responsibility of all mechanics to be aware of these regulations and changes that may occur to them.

Table 4. Federal Aviation Regulations pertaining to aviation maintenance.

PART	TITLE
1	Definitions and Abbreviations
13	Investigative and Enforcement Procedures
21	Certification Procedures for Products and Parts
33	Airworthiness Standards: Aircraft Engines
35	Airworthiness Standards: Propellers
39	Airworthiness Directives
43	Maintenance, Rebuilding, & Alterations
145	Repair Stations
147	Aviation Maintenance Technician Schools

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

The Florida Department of Environmental Protection (FDEP) is the state agency responsible for protection and conservation of Florida's environment and natural resources. The Division of Waste Management is the branch responsible for protecting the public's health and environment by properly managing pollution, waste and hazardous waste substances. Florida's regulations on hazardous substances are found in Parts I, III, and IV of Chapter 62-730 of the Florida Administrative Code (FAC). The EPA hazardous waste regulations in 40 CFR Parts 260-266, 270, 273 and 124 have been adopted by FDEP. However in some instances, certain state regulations may be more strict than the federal. The FAC 62-730 regulations can be obtained through the FDEP.

The state of Florida also provides assistance to local industry in hazardous waste regulations, pollution prevention and waste minimization practices. The Florida Pollution Prevention Program established in 1991 in the Florida Pollution Prevention Act is a non-regulatory state program that provides technical assistance, information resources, telephone consultation, workshops and on-site waste reduction evaluations.

CHAPTER 4
HAZARDOUS WASTE CHEMICAL PROPERTIES

General knowledge of hazardous waste chemical properties is necessary for proper identification, operation and disposal. There are many chemical properties of hazardous waste from physical states to solubility. This chapter will discuss these properties in detail.

PHYSICAL STATES

Gas, liquid and solid states are physical states of matter. These physical states are defined as the following:

- *Gas* is matter that takes both the shape and volume of the container it fills.
- *Liquid* is matter that has definite volume but takes the shape of its container.
- *Solid* is matter that has definite shape and volume.

A common example of the different physical states is ice, water and vapor. Ice is a solid state of water which can stand alone. As a liquid, water can no longer stand alone and must take the shape of its container. However, as water becomes vapor it can no longer be easily contained and can rapidly enter the atmosphere.

Different physical states can affect the potential danger posed by the material. Materials dangerous in one physical state may be relatively harmless in another. For example, lead in a solid form which is often used as a ballast is relatively nontoxic. However, a liquid form of lead which can be found in gasoline is very toxic. In general, a solid is less harmful than liquid or gases. However, if a solid becomes a powder, it can be more harmful by having similar physical properties of a liquid or gas. Table 5 describes the different hazards of physical states.

It is important to understand the different physical states of a material, especially for emergency situations, where materials could quickly change to different states. Melting point and boiling point are two transitions of physical states. The melting point is the transitional point of a solid changing into a liquid, and the boiling point is the transitional point of a liquid changing into a gas. These transitions could start from heat, chemical reactions or ambient temperatures.

Table 5. The different hazards of physical states (modified from Naval School, 1997).

	GASES	LIQUIDS	SOLIDS
DEGREE OF HAZARD	More hazardous than liquids or solids	More hazardous than solids.	Less hazardous than gases or liquids unless powdered.
FIRE HAZARD	Ignite easily.	Ignite easily when vaporized.	Ignite when ignition temperature reached.
PATHWAY TO BODY	Easily enter body through inhalation.	Absorbed by skin if splashed or spilled. Can only be inhaled when vaporized.	Great difficulty entering body unless in fine particles.
BEHAVIOR IN ENVIRONMENT	Easily dispersed.	Can sink, float or dissolve in water. Can be very hot (boiling) or very cold and thus cause burning or freezing. Can be collected, contained, or absorbed if insoluble or dispersed or diluted if soluble.	Easily collected and contained.

BOILING POINT

The boiling point (BP) is the temperature at which a liquid becomes a gas. It is measured either in degrees Fahrenheit (°F) or Celsius (°C). Listed below are common boiling points of various substances.

• Water	212°F	100°C
• Chlorine	-29°F	-34°C
• Gasoline	102°F	39°C
• Ethyl Alcohol	173°F	78°C

Boiling points can indicate health hazards associated with inhalation. Generally, chemicals with low boiling points (similar to Chlorine) present a greater inhalation hazard under normal atmospheric conditions than chemicals with higher boiling points.

VAPOR PRESSURE

The vapor pressure (VP) is measured in pounds per square inch (PSI) and measures a substance's tendency to emit vapors. It is when the vapor of a substance is in equilibrium with the liquid at a specified temperature. Higher vapor pressures indicate that the substance is very volatile. Vapor pressure and volatility also increase with temperature.
Values of vapor pressure are often given as millimeters of mercury (mm Hg) of a specific temperature. In general, a greater inhalation hazard will occur with chemicals having high vapor pressure (VP>10 mg Hg at room temperature). Below are the units of measure for vapor pressure.

- 1 mm Hg=1 Torr
- 1 ATM (atmosphere)=760 mm Hg
- 14.7 PSI (pounds per square inch)=1 ATM=760 mm Hg

SPECIFIC GRAVITY/DENSITY

Specific gravity (SG) or density of a liquid is expressed as a pure number without units and is compared to that of water (defined as 1.0). The SG is the density of the material normalized to (divided by) the density of water (0.0361 lb/in^3). Materials with specific gravity greater than 1.0 will sink in water and those less than 1.0 will float on top of water. Gasoline will float on top of water because it has an SG of 0.8, while lead and mercury with SG value of 11.3 and 13.6 respectively, will sink.

VAPOR DENSITY

Vapor density is the mass per unit volume of a given vapor or gas relative to air. Some vapors may be poisonous due to their toxic properties, while others may have no toxic properties but may pose a hazard by displacing air and causing an oxygen deficiency. Heavy vapors may also cause a fire or an explosion if the vapors are flammable and are presented with an ignition source. Carbon dioxide, chlorine, hydrogen sulfide and sulfur dioxide are examples of gases that are heavier than air.

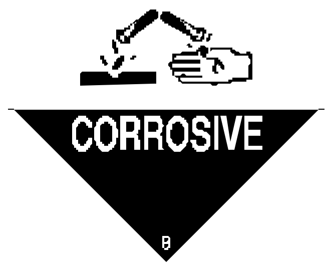
SOLUBILITY

Solubility is the amount of a given substance (the solute) that dissolves in a unit volume of liquid (the solution). It can also be termed as the ability of one substance to dissolve uniformly in another. An example of a soluble substance is alcohol in water and of an insoluble substance is oil in water. Insoluble substances can often be blended together. However, eventually these substances will separate. Solubility ranges from 0-100% and is dependent upon the substances involved and the temperature of the solution. It is important to know the solubility of a substance. Knowledge of the solubility and reactivity of a spilled substance is critical to proper spill containment and clean up. It can also provides important environmental information, for instance, could the spilled material dissolve in water and spread by rain water.

THE pH SCALE

The pH scale measures a substance acidity or basicity by looking at the concentration of free hydrogen ions (H+). A substance (such as pure water) is termed neutral if the pH is 7. If the substance has a pH less than 7, it is considered acidic and if the substance has a pH greater than 7, it is considered to be basic. The measurement of pH is based on a logarithmic scale from 0 to 14. Therefore a substance with a pH of 5 is ten times more acidic than a substance with a pH of 6 and 100 times more acidic than a substance with a pH of 7.

Materials with high (>12) or low (<2) pH readings are corrosives and therefore are considered hazardous. These substances can cause severe damage when in contact with human tissue and will deteriorate metals. Furthermore, strong acids and bases are very reactive and can produce high temperatures, cause explosions or emit toxic gases.



FLAMMABILITY

Flammability is the ease with which a material (gas, liquid or solid) will ignite either spontaneously or from exposure to high temperatures, flames, sparks or other ignition sources.

Flammable gases are compressed gases such as hydrogen, acetylene and propane that will burn. Gases such as oxygen, carbon dioxide and nitrogen will NOT normally burn and are considered nonflammable gases. However, oxygen will support combustion.

Flammable liquids do not burn but give off vapors that ignite. Flammable liquids are classified by DOT and OHSA into flammable and combustible materials. This classification is based upon the liquid flashpoint, which is the minimum temperature that a liquid must reach to produce an ignitable concentration of vapors.

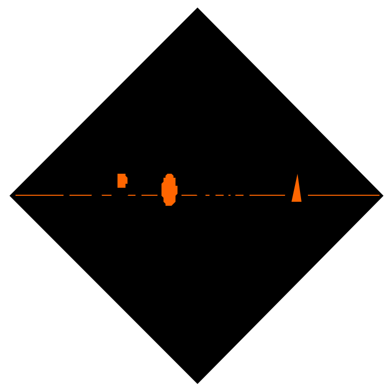
Flammable solids are materials other than an explosive that ignite quickly and burn vigorously. Some flammable solids can be ignited by friction, absorption of moisture or a spontaneous chemical change on exposure to air.

SPONTANEOUS COMBUSTION

Spontaneous combustion occurs when used materials such as oily rags and wastepaper are improperly stored. Improper storage of these materials can prevent heat from transferring into the atmosphere causing it to accumulate in the container. The heat produced by the slow oxidation of these materials can build up in the container and ignite the substances involved.

EXPLOSIVE (FLAMMABLE) LIMITS

Specific air and vapor mixtures will burn upon exposure to an ignition source. The range of these mixtures concentration (percentage by volume) is defined as explosive limits. Lower explosive limits (LEL) exist when the air and vapor mixtures are too lean to burn, while upper explosive limits (UEL) exist when the mixtures are rich to burn. Mixtures that are in between these limits have the highest potential for fire and explosion.



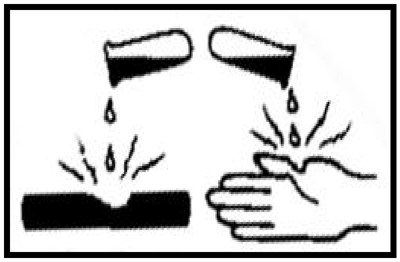
CHAPTER 5
CHARACTERIZATION OF HAZARDOUS WASTE

When does a waste becomes a hazardous waste? First, the material must be a waste that becomes subject to hazardous waste regulations. If the waste meets the criteria of the listed hazardous waste or hazardous waste characteristics it is a hazardous waste. The criteria for listed hazardous waste and hazardous waste characteristics is included in 40 CFR part 261.

HAZARDOUS WASTE CHARACTERISTICS

A hazardous waste is any waste that is ignitable, corrosive, reactive or toxic. The EPA defines these four hazardous waste characteristics and assigns a three digit number preceded by a “D” to each of these characteristics.

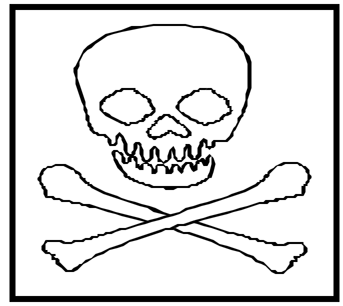
❑ *IGNITABLE* wastes (D001) are easily combustible or flammable. These wastes will have a flashpoint less than 140° F. Examples of ignitable wastes include paints, paint thinner, solvents, gasoline and degreasers.



❑ *CORROSIVE* wastes (D002) erode metals and burn skin. These wastes are liquids that have a pH <2 or a pH >12. Examples of corrosive wastes are rust removers, acids or alkaline fluids, paint strippers and battery acids.

❑ *REACTIVE* wastes (D003) are very unstable and react violently with water or other materials. These wastes will produce toxic gas when exposed to water and corrosive materials and have the capability of exploding in the presence of a flame. Examples of reactive wastes are bleaches, oxidizers (e.g., oxygen generating canisters), cyanides and explosives.

❑ *TOXIC* wastes (D004-D043) have high concentrations of heavy metals (such as chromium and lead) or specific toxic organic compounds. Examples that are often considered toxic wastes are water and sludge from fuel storage tanks and used oil tanks; chlorinated and fluorinated spent solvents; water and sludge from shops floor drains, pipes and oil-waste separators; and paint waste.



LISTED HAZARDOUS WASTE

Approximately 500 chemicals and hazardous wastes are listed by their technical name in 40 CFR Part 261. These listed wastes are generated either as "process wastes" or "discarded wastes". Process wastes are industrial chemicals that are used for their intended purpose and are under the F-List and K-List. Discarded wastes are commercial chemical products that even unused can cause a threat to human health and the environment. The P-List and U-List catalog chemicals that when discarded are hazardous in their pure formulas. The following describes the differences between the F, K, P and U Lists in greater detail.

❑ The *F-LIST* contains hazardous wastes from non-specific sources and is located in 40 CFR 261.31. This list consists of commonly used solvents in cleaning, degreasers and extraction processes. It also includes wastes from electroplating, metal refinishing, pesticide manufacturing, wood preserving, petroleum refining and other processes. Solvents on the F-List are assigned a three digit number preceded by a "F". Halogenated, spent solvents are numbered F001 and F002. Non-halogenated, spent solvents are numbered F003 to F005. Examples of materials on the F-List are benzene, carbon tetrachloride, methyl ethyl ketone, methylene chloride, trichloroethane, toluene and trichloroethylene.

❑ The *K-LIST* contains hazardous wastes from specific source and is located in 40 CFR 261.32. These sources would come from specific industrial processes such as wood preservation and from the production of pigment, chemicals, iron, steel and pesticides. Specific source wastes on the K-List are assigned a three digit number preceded by a "K".

❑ The *P-LIST* contains discarded acutely hazardous commercial chemical products and is located in 40 CFR 261.33(e). Acutely hazardous waste are defined by the EPA to be wastes that are severely dangerous in small amounts that they are regulated the same as other hazardous wastes of larger amounts. This list contains wastes from discarded chemical products, off-specification material, containers and spill residues. The P-List includes chemicals found in herbicides, pesticides and other poisonous products. Acute discarded wastes from commercial chemical products are assigned a three digit number preceded by a "P". For example, the waste characteristic code for a discarded container of arsenic acid is P010. Even when the acid was spilled and cleaned up using an absorbent, the spill debris number will remain the same as the acid.

❑ The *U-LIST* contains toxic commercial chemical products and is located in 40 CFR 261.33(f). This list includes toxic wastes from discarded chemical products, off specification materials and spill residues. Toxic wastes from the U-List are assigned a three digit number preceded by a "U".

CHAPTER 6
HAZARDOUS WASTE HANDLING

Chapters 4 and 5 discussed hazardous waste properties and identification. The next step is to understand how to properly recognize, label, store and dispose of hazardous waste.

IDENTIFYING HAZARDOUS WASTE

There are several mechanisms for identifying hazardous waste in the workplace.

The first step should be to review the Material Safety Data Sheet (MSDS). The MSDS will provide health, safety and emergency response information. These sheets should be available to all employees and be located near the product of concern. The format of MSDS will be discussed in detail in the following section.

If the MSDS is insufficient or not available, hazardous waste information can be obtained from the product label or from the product supplier or manufacturer.

Other sources such as comparing products with the hazardous waste characteristics and listed waste in the federal regulations or referring to a typical hazardous waste table could be used in determining hazardous waste. If a problem still exists in the hazardous waste determination then laboratory testing should be performed.

REFERENCES FOR HAZARDOUS WASTE
MATERIAL SAFETY DATA SHEETS

There are several references used to find additional information about hazardous chemicals and products. Material Safety Data Sheets and other documents are good resources to gather more information about a chemical or product.

Material Safety Data Sheets (MSDS) are a requirement from OSHA to the manufacturers to provide detailed health, safety and emergency response information for products that contain a chemical or physical hazard (Figure 1). The format of MSDS is consistent, but the layout may vary between manufacturers. MSDS are divided into nine sections discussed in detail below.

I. Product Identification

This section provides product information that is used by the manufacturer to identify the following:

- Manufacturer's name, address and telephone number
- Emergency contact
- Chemical name and synonyms

- Trade name and synonyms
- Chemical family and/or formula
- Chemical Abstract Service (CAS) number, if the material is pure.

II. Hazardous Ingredients

This section describes various hazardous ingredients of a product that are more than 1% of the total or 0.1% of the total if the ingredients are carcinogens. It will also provide percentages of hazardous ingredients, exposure limits and information on hazardous mixtures with other solids, liquids or gases.

III. Physical Data

This section describes the physical properties of the product (see chapter 4 for a description of key properties). It could include the following:

- Boiling Point
- Vapor Pressure
- Vapor Density
- Solubility in Water
- Specific Gravity
- Percent Volatile
- Evaporation Rate
- Appearance and Odor

IV. Fire and Explosive Data

This section describe fire and explosion hazards based upon flash point and other data. Appropriate extinguishing agent for a fire, the flash point (the lowest temperature at which a flammable liquid gives off enough vapor to burn), and the explosive limits (LEL/UEL) are included. Information on special fire-fighting procedures and any unusual fire hazards is also provided.

V. Reactivity Data

This section describes how the product will react under specific conditions. It includes information on the stability, incompatibilities, hazardous decomposition and polymerizations of the product.

VI. <u>Health Hazard Information</u>

This section provides information for employees and medical personnel to identify health hazards and overexposure risks. It includes primary means of exposure (such as inhalation or skin irritation), threshold limits and effects of overexposure (such as headache, nausea, narcosis and irritation). This section also provides emergency and first-aid procedures, risks of cancer and any other health hazards.

VII. <u>Spill, Leak and Disposal Procedures</u>

This section describes general containment, evacuation and disposal procedures for accidental spills of the product.

VIII. <u>Special Protection</u>

This section provides special equipment needs for personal protection in the worst case exposure condition of the product. The equipment that might include ventilation, respiratory equipment, special clothing, gloves and eye protection.

MATERIAL SAFETY DATA SHEET May be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1919.1200. Standard must be consulted for specific requirements.	**U.S. Department of Labor** Occupational Safety and Health Administration (Non-Mandatory Form)
IDENTITY	*Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.*
Section I	
Manufacturer's Name	Emergency Telephone Number
Address *(Number, Street, City, and ZIP Code)*	Telephone Number for Information
	Date Prepared
	Signature of Preparer *(optional)*

Section II - Hazardous Ingredients/Identity Information			
Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended

Section III - Physical/Chemical Characteristics			
Boiling Point		Specific Gravity (H2O = 1)	
Vapor Pressure (mm Hg)		Melting Point	
Vapor Density (AIR = 1)		Evaporation Rate (Butyl Acetate = 1)	
Solubility in Water			
Appearance and Odor			

Section IV - Fire and Explosion Hazard Data			
Flash Point (Method Used)	Flammable Limits	LEL	UEL
Extinguishing Media			
Special Fire Fighting Procedures			
Unusual Fire and Explosion Hazards			

Figure 1. Example Material Safety Data Sheet

Section V - Reactivity Data			
Stability	Unstable		Conditions To Avoid
	Stable		
Incompatibility *(Materials to Avoid)*			
Hazardous Decomposition or Byproducts			
Hazardous Polymerization	May Occur		Conditions To Avoid
	Will Not Occur		

Section VI - Health Hazard Data			
Route(s) of Entry:	Inhalation?	Skin?	Ingestion?
Health Hazards (Acute or Chronic)			
Carcinogenicity:	NTP?	IARC Mongraphs?	OSHA Regulated?
Signs and Symptoms of Exposure			
Medical Conditions Generally Aggravated by Exposure			
Emergency and First Aid Procedures			

Section VII - Precautions for Safe Handling and Use
Steps to Be Taken in Case Material is Released or Spilled
Waste Disposal Method
Precautions to Be Taken in Handling and Storing
Other Precautions

Section VIII - Control Measures		
Respiratory Protection *(Specify Type)*		
Ventilation	Local Exhaust	Special
	Mechanical *(General)*	Other
Protective Gloves	Eye Protection	
Other Protective Clothing or Equipment		
Work/Hygienic Practices		

Figure 1. Continued.

OTHER REFERENCES FOR HAZARDOUS WASTE

The Chemical Hazardous Response Information System (CHRIS)--The Hazardous Chemical Data Book was developed for the U.S. Coast Guard for water transportation emergencies. This book provides information about hazardous chemicals with a format similar to the MSDS. There are four volumes of CHRIS available from the U.S. Printing Office or through the local library.

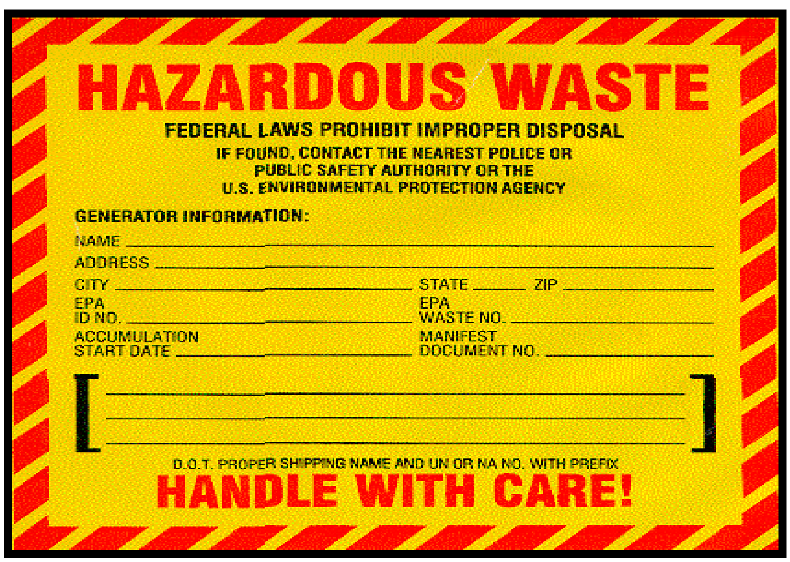
The Fire Protection Guide on Hazardous Materials was designed by the National Fire Protection Association (NFPA) and contains information on hazardous chemical properties. This guide can also be used in fire prevention and other emergencies.

The *NIOSH Pocket Guide to Chemical Hazards* contains information on hazardous chemicals including the chemical names, formulas, synonyms, exposure limits, physical descriptions, chemical and physical properties, incompatibilities, personal protective equipment and health hazards. This guide is set up in a tabular form for quick and easy reference.

LABELING HAZARDOUS WASTE

All hazardous materials and waste should be clearly labeled with the correct information provided by DOT. (Hazardous shipping names, hazardous classes and ID numbers can be found in 49 CFR part 172.101 in the Hazardous Material Table.) Labels should never be removed and should contain the following information:

- Complete chemical name (chemical formula may be added as an option)
- Concentration and units
- Federal waste code numbers
- Beginning date of accumulation
- Indication of hazards
- Business name and address.

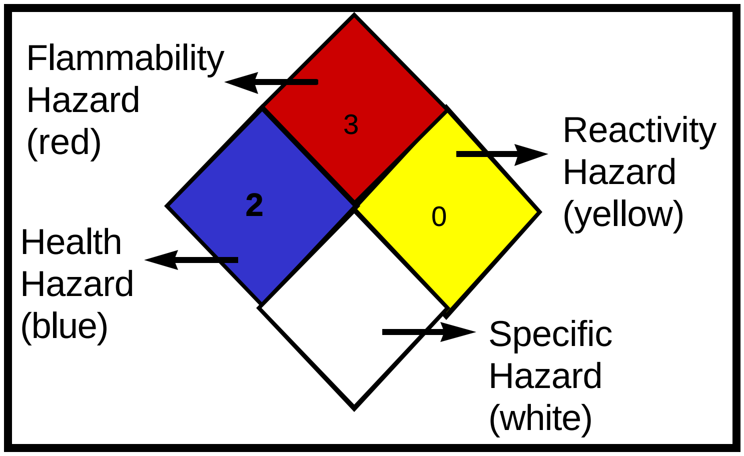


It is important to note that all hazardous waste containers must be labeled regardless of the length of storage.

There are several different labeling systems. One of the most common labeling systems used is from the *National Fire Protection Association* (NFPA).

The NFPA ratings include health hazards, flammability, reactivity and special hazards. These ratings are in a form of four diamonds, which together create one complete diamond. The placement of the diamonds represents the degree of hazard. The following will discuss each diamond in more details.

The health hazard diamond is blue and indicates on a numbering scale from 0-4 the degree of hazard.



Below is the scale:

- 0=Ordinarily Combustible Hazardous in a Fire
- 1=Slightly Hazardous
- 2=Hazardous
- 3=Extreme Danger
- 4=Deadly

The flammability hazard diamond is red and indicates on a numbering scale from 0-4 the flash point of a substance (how susceptible the substance is to burning).

Below is the scale:

- 0=Will Not Burn
- 1=Will Ignite if Preheated
- 2=Will Ignite if Moderately Heated
- 3=Will Ignite at Most Ambient Conditions
- 4=Burns Readily at Ambient Conditions

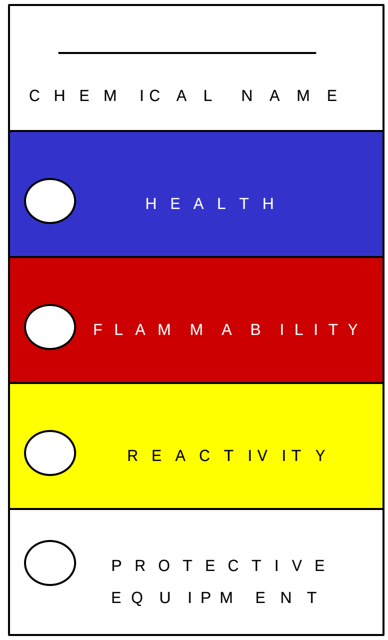
The reactivity hazard diamond is yellow and indicates on a numbering scale from 0-4 the stability of a substance (how the energy released from the substance will react if it is burned, decomposed or mixed).

Below is the scale:

- 0=Stable and Not Reactive with Water
- 1=Unstable if Heated
- 2=Violent Chemical Change
- 3=Shock and Heat May Explode
- 4=May Explode

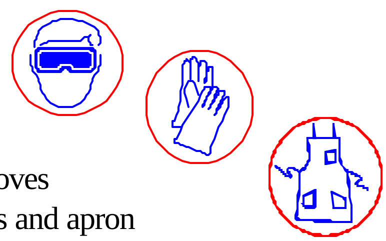
The specific hazard diamond is white and indicates if there is more than one major hazard, such as oxidizers, acids or corrosives. It uses abbreviations to recognize the specific hazard, such as "OX" as oxidizers and "W" as reacts with water.

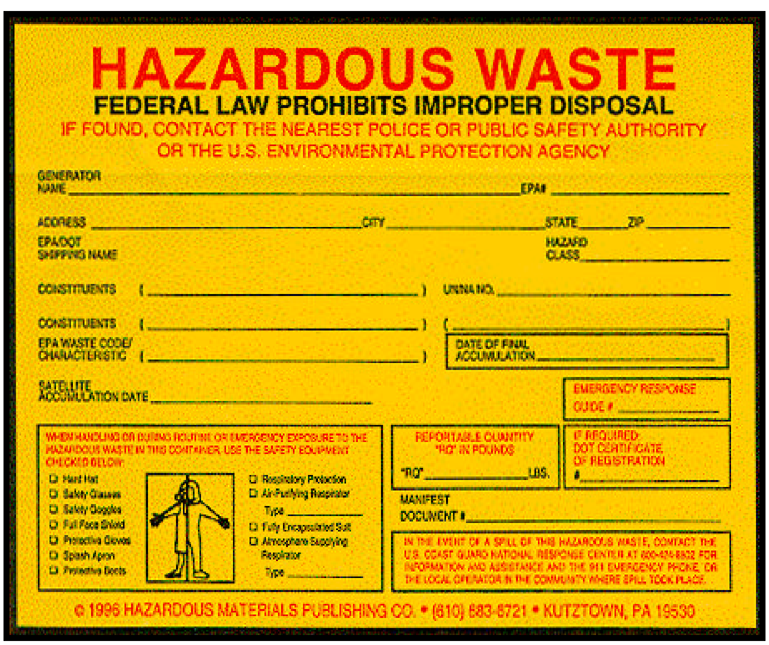
The *Hazardous Material Information System* (HMIS) was developed by paint manufacturers and is a visual display of the nature and degree of potential exposure hazards. It is similar to the NFPA diamonds by having a numeric rating system. However it differs from NFPA by using a color bar system instead of a diamond. HMIS contains four color bars including: Health, Flammability, Reactivity and Personal Protection. A numeric rating system is used for the health, flammability and reactivity bars to display the severity of the hazard (0 for least severe to 4 for most severe).



Personal protection bar does not use a numerical system but is represented by a letter which specifies the different levels of protection. Below is an example of letters representing different levels of safety equipment.

Letter	Equipment
A	safety glasses
B	safety glasses and gloves
C	safety glasses, gloves and apron





HAZARDOUS WASTE
FEDERAL LAW PROHIBITS IMPROPER DISPOSAL
IF FOUND, CONTACT THE NEAREST POLICE OR PUBLIC SAFETY AUTHORITY OR THE U.S. ENVIRONMENTAL PROTECTION AGENCY

GENERATOR NAME ____ EPA# ____
ADDRESS ____ CITY ____ STATE ____ ZIP ____
EPA/DOT SHIPPING NAME ____ HAZARD CLASS ____
CONSTITUENTS (____) UN/NA NO. ____
CONSTITUENTS (____) (____)
EPA WASTE CODE/ CHARACTERISTIC (____)
DATE OF FINAL ACCUMULATION ____
SATELLITE ACCUMULATION DATE ____
EMERGENCY RESPONSE GUIDE # ____

WHEN HANDLING OR DURING ROUTINE OR EMERGENCY EXPOSURE TO THE HAZARDOUS WASTE IN THIS CONTAINER, USE THE SAFETY EQUIPMENT CHECKED BELOW:
- Hard Hat
- Safety Glasses
- Safety Goggles
- Full Face Shield
- Protective Gloves
- Splash Apron
- Protective Boots
- Respiratory Protection
- Air-Purifying Respirator Type ____
- Fully Encapsulated Suit
- Atmosphere Supplying Respirator Type ____

REPORTABLE QUANTITY "RQ" IN POUNDS
"RQ" ____ LBS.

IF REQUIRED: DOT CERTIFICATE OF REGISTRATION # ____

MANIFEST DOCUMENT # ____

IN THE EVENT OF A SPILL OF THIS HAZARDOUS WASTE, CONTACT THE U.S. COAST GUARD NATIONAL RESPONSE CENTER AT 800-424-8802 FOR INFORMATION AND ASSISTANCE AND THE 911 EMERGENCY PHONE, OR THE LOCAL OPERATOR IN THE COMMUNITY WHERE SPILL TOOK PLACE.

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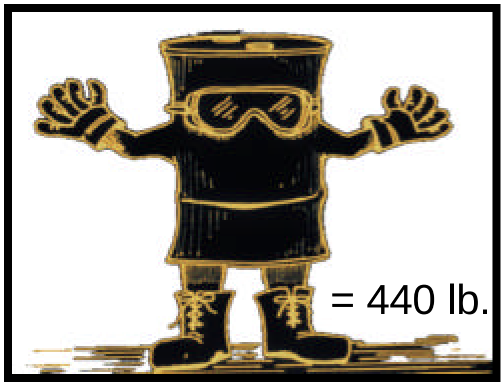
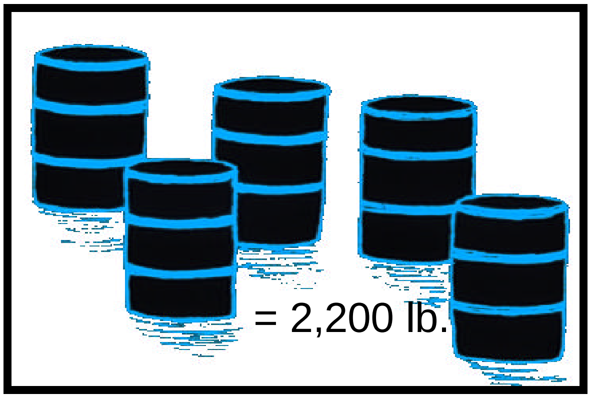
Hazardous Waste Labels have been approved by DOT and the EPA for shipping hazardous waste. These labels display proper shipping name and the EPA waste classification. Labels could also contain information on recommended personal protection equipment or display additional hazardous warnings (such as explosives, blasting agent, poison gas, biomedical, chlorine or oxygen).

HAZARDOUS WASTE STORAGE

The storage of hazardous waste is regulated by EPA and state agencies by the amount of waste generated. There are three categories of hazardous waste generators: Conditionally Exempt Small Quantity Generators (CESQG), Small Quantity Generators (SQG) and Large Quantity Generators (LQG). Generally, one drum is equivalent to approximately 440 pounds of hazardous waste. A CESQG generates no more than 220 lb. (approximately half of a drum) of hazardous waste per month and are exempt from hazardous waste management regulations if they adhere to the fundamental requirements of the EPA. However, hazardous waste management regulations do apply to SCG which generates between 220 to 2,000 lb. (less than five drums) of hazardous waste per month and LQG that produce more than 2,200 pounds of waste (more than 5 drums) per month. Of course, these regulations are stricter for large quantity generators than small quantity or conditionally exempt generators. The regulations that would apply to you would be dependent upon your place of employment and it's generation of hazardous waste.





The following are recommendations for proper storage of hazardous waste.

❑ All hazardous waste must be stored in approved containers with closed lids at all times. Containers must be stored out of the elements (away from rain, high temperatures, lightning or humidity) and separated by a berm, dike, or wall to prevent reactions among waste. Also cooling and ventilation systems must be provided were appropriate.

Photo Courtesy of NADEP Jacksonville

❑ Proper signs such as "No Smoking, Fire Hazard and Hazardous Waste Storage" should be placed at the hazardous waste storage area and all containers should be inspected weekly.

❑ Hazardous waste storage areas should have adequate aisle space and hazardous waste spill response materials (such as absorbents and personal protective equipment).

❑ Hazardous waste should not be disposed of in trash dumpsters or outside.

❑ There should be no mixing of dissimilar waste streams (such as organic solvents and aqueous solutions) into one container. If non-compatible waste are mixed, it could cause dangerous chemical reactions. Furthermore, mixed waste cannot be economically recycled.

❑ Nonhazardous waste should not be mixed with hazardous waste. If mixed, the whole batch becomes hazardous and the cost of disposal increases.

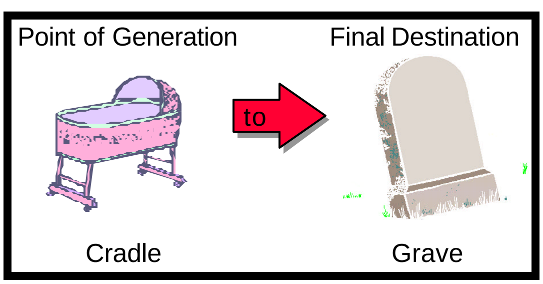
❑ Once a container is used for hazardous waste, it should not be used for another waste. Even empty hazardous waste containers are often considered hazardous waste. Due to the extra expense of legal hazardous waste disposal, the cost of solid waste disposal rises substantially if mixed with hazardous waste.

HAZARDOUS WASTE DISPOSAL

Hazardous waste disposal cannot occur on site without a disposal permit. Procedures for obtaining a permit can be found in 40 CFR Part 270. Depending on the amount of waste generated, a facility may retain waste for a certain time period before disposal.

All hazardous waste must be shipped in acceptable containers for transportation and properly labeled. Requirements pertaining to preparing hazardous waste for shipment can be found in 49 CFR Part 172.

Important requirements of hazardous waste transportation include a licensed transporter with EPA identification numbers (available from FDEP), manifest (shipping papers) and proper placarding, packaging and container specifications. A hazardous waste manifest is a multi-copy shipping paper that accompanies the package and must be signed by the generator, carrier and receiver. The shipper should receive the manifest after the materials have reached their proper destination to a permitted facility and keep the papers on file for three years.



Remember the generator of the hazardous waste is responsible for the waste from the point of generation (cradle) to the final destination (grave). The liability never leaves the generator of the hazardous waste.

WASTE MINIMIZATION

Waste minimization is any process that reduces or eliminates the amount of waste generated. As a result, it lowers treatment and disposal costs, reduces health hazards, reduces liability and protects the environment. Basically, there are two main techniques to accomplish hazardous waste minimization. These techniques are pollution prevention and recycling (Table 6).

Pollution prevention consists of product changes and source reduction. By substituting hazardous products with non-hazardous products and by using only the amount necessary to perform the task would be examples of product changes. Source control would consist of material changes such as material purification and substitution, technology changes and good operating practices. For example, good operating practices would consist of properly managing the hazardous materials inventory, and keeping lids tightly sealed (especially volatile hazardous materials).

Recycling consists of reusing and reclaiming used materials. This not only reduces waste but it also lowers disposal and raw material costs. Recycling programs can work with a variety of waste products. The most common recycled hazardous waste is organic solvent. This waste can be recycled by distillation, and small recovery units. Filtration can also be used to remove oils from metal shavings or for recycling antifreeze.

Table 6. The different practices for waste minimization.

WASTE MINIMIZATION PRACTICES

- POLLUTION PREVENTION
  - PRODUCT CHANGES
    - Non-toxic procurement
    - Product substitution
    - Product conservation
    - Less toxic product composition
  - SOURCE REDUCTION
    - INPUT MATERIAL CHANGES
      - Material purification
      - Material substitution
      - Purified water reuse
    - TECHNOLOGY CHANGE
      - Process changes
      - Equipment, piping or layout changes
      - Additional automation
      - Changes in operation settings
      - More efficient technologies
    - GOOD OPERATING PRACTICES
      - Procedural measures
      - Loss prevention
      - Best management practices
      - Waste stream segregation
      - Material handling improvements
      - Production scheduling
      - Preventative maintenance
- RECYCLING
  - USE & REUSE
    - Return to original process
    - Raw material substitute for another process
  - RECLAMATION
    - Processed for resource recovery
    - Processed as a by-product

CHAPTER 7
HAZARDOUS WASTE ASSOCIATED WITH AVIATION MAINTENANCE

Aircraft mechanics work at a variety of facilities types. Airports can range from large international terminals and regional hubs to small city, county and privately owned/publicly used airports. However, regardless of size and type of airport, each one generates hazardous waste and should have specialized pollution control plans.

Large international and regional airports have staff that monitor all activities generating hazardous waste and waste disposal. Every maintenance and overhaul activity generating waste is carefully screened and evaluated. Waste generating operations are engineered to reduce pollution and protect the environment. Air-carriers and fixed base operators at these facilities have submitted operating procedures that are in compliance with the pollution control plan.

Photo Courtesy of Jerry Clifford

Smaller airports and agri-business strips do not have the luxury of full-time pollution control staff. The job may be done by an airport administrator, fixed base operator or an A&P mechanic. The pollution prevention plan at these facilities may be as simple as a pollution prevention runoff plan.

Regardless of the size, each facility requires aircraft mechanics to be knowledgeable of the handling, storing and disposal procedures of hazardous materials and waste. The majority of hazardous waste are generated by the cleaning, corrosion control, fluid lines and ground handling (such as fueling and deicing) procedures. These operations with other maintenance procedures will be discussed in the following chapters. Each chapter will describe the different hazardous materials and waste associated with each procedure and provide pollution prevention and waste minimization practices.

NOTE: It takes approval by the manufacturers and the FAA to implement many of these waste minimization practices. Therefore, always obtain proper engineering approval to implement new practices and follow the manufacturer’s instructions and/or the acceptable methods, techniques and practices.

CHAPTER 8
AIRCRAFT CLEANING

Aircraft cleaning is a major contributor of hazardous waste generated at aviation maintenance facilities. To reduce the amount of hazardous waste generated at these facilities, new concepts, materials and processes need to be explored. Different cleaning methods and cleaners should be substituted into current cleaning processes. These methods could range from manually wiping or squeegeeing a part to substituting a mechanical cleaning method for a solvent or chemical cleaner. Cleaning methods could also include material substitutions such as using aqueous and terpene cleaners in place of chemical or chlorinated solvents. It is important to note that all cleaning processes should first use the least hazardous cleaning agents and methods to minimize waste.

This chapter will review the different cleaning processes, identify the hazards associated with each process (Table 7) and provide general waste minimization options and pollution prevention practices for aircraft cleaning operations.

HYDROCARBON CLEANING

The use of hydrocarbon cleaners such as mineral spirits, naphtha and kerosene are replacing the more hazardous hydrocarbons such as xylene and methyl ethyl ketone (MEK). These cleaners have new formulas that improve solvency, lower vapor pressure and increase flashpoint. Hydrocarbon cleaners dissolve oils, greases, waxes, fluxes and inks. They do not react with metals, but may affect some types of plastics.

Hydrocarbon cleaners do possess some hazards such as flammability and mildly neurotoxic vapors. Many hydrocarbons are Volatile Organic Compounds (VOCs) which are major contributors to the development and destruction of atmospheric ozone or “smog” and are regulated under the Clean Air Act (Florida Pollution Prevention Program, 1995a & b). Nevertheless, hydrocarbon solvents can have some recyclable capabilities. Used hydrocarbon solvent solutions can be reused in a pre-wash step to remove heavy soil deposits after filtering the insoluble particles.

The disposal of hydrocarbon solutions, if it is not contaminated with heavy metals or halogens (chlorinated solvents), can also be simple. Since hydrocarbons have a high BTU value, used solutions can be sent out with waste oil for incineration. However, if the solution is contaminated, it must be considered as hazardous waste and incineration is no longer an option.

Table 7. Some hazardous materials and waste associated with aviation maintenance cleaning procedures.

HAZARDOUS MATERIALS		HAZARDOUS WASTE
SOAPS & DETERGENTS		Spent Solvent
ACIDIC/ALKALINE CLEANERS		Still Bottom Waste
Chromic Acid	Ethyl Alcohol	Paint Residue
Citric Acid	Isopropyl Alcohol	Heavy Metals
Nitric Acid		Contaminated Blasting Media
Phosphoric Acid		Contaminated Rags, Brushes
HYDROCARBON CLEANERS		Petroleum Distillate Waste
Naphtha		Caustic Wastes
Kerosene		Waste Water
Mineral Spirits		
Xylene		
Methyl Ethyl Ketone		
CHLORINATED SOLVENTS		
Trichloroethane		
Trichloroethylene		
Trichlorotrifluoroethane		
ABRASIVE BLASTING		
Silica Sand		
Plastic Pellets		
Aluminum Oxide		
Nut Shells		
Glass Beads		

Another type of hydrocarbon cleaner is terpene. Terpene cleaners are plant derived hydrocarbon with D-limonene from orange peels as the common ingredient. These cleaners have a very high solvency and clean greases, oils, fluxes and adhesives very well. However, because of their low volatility, an extra rinse and/or dry step is needed for the cleaning process. These cleaners are also non-reactive with metals and most plastics. These cleaners are unique because they are biodegradable and can be economically separated from soils and oils, unlike other hydrocarbon cleaners. However, caution needs to be taken with the disposal of terpenes because of their high biological and chemical oxygen demands.

AQUEOUS CLEANING

Aqueous cleaning can be either acidic/alkaline cleaners, soaps or detergents. These cleaners can be used instead of the organic compounds for most general aircraft cleaning. Aqueous cleaners can remove oil, grease and dirt from propellers and windows to the interior of the aircraft. They work well on a variety of substrates including ferrous metals, copper, chrome and plastic.

These cleaners are also fairly safe to use. They do not have a flashpoint and are considered to be environmentally safe. These cleaners do not contain volatile organic compounds (VOCs), or contribute to ozone depletion and can be recycled indefinitely.

Aqueous cleaners are cost-effective and produce satisfactory, nonhazardous results with a properly maintained oil/water separator and pH adjustments. They are also easy to use in place of vapor degreasers for part washers.

EXAMPLE:

> NADEP JAX, a Navy aviation maintenance facility in Jacksonville, Florida, replaced approximately 80% of their vapor degreasers which used 1,1,1-trichloroethane with aqueous cleaning parts washers. This replacement not only reduces hazardous environmental emissions, but yielded savings for NADEP in reduced raw materials and disposal costs (Florida Pollution Prevention Program, 1992).

Still, there are some disadvantages to these cleaners. Aqueous cleaners have low solubility and low evaporation rates. They also can conduct electricity and cause corrosion and stain metals.

ABRASIVE BLASTING

Another cleaning alternative is selected abrasive blasting. Blasting uses a forced media such as silica sand, steel grit, aluminum oxide, nut shells, glass or plastic beads to mechanically displace soils (Wolfe et al., 1991). It can remove oxides and scales resulting from extreme heat exposure. A disadvantage of blasting is that it can cause pitting and erosion of the material surfaces.

An abrasive blasting booth for cleaning parts. *Photo Courtesy of NADEP Jacksonville*

TURBINE ENGINE COMPRESSOR FIELD CLEANING

Contaminants on compressor blades reduce their aerodynamic efficiency leading to an overall reduction of engine performance. Two methods are commonly used to remove these deposits: a fluid wash and an abrasive blast. Both systems must be used according to manufacturer's instructions. Waste expelled from the engine cleaning process may be hazardous (with heavy metals and other materials) and should be contained. The operation should be done on a concrete diked area so the cleaning material can be recovered and properly disposed of. A suitable blast fence must be positioned behind the engine to direct the jet blast and waste into the recovery area.

DEGREASING

Vapor degreasing is an extremely efficient cleaning process, using chlorinated solvents. In this process, the solvents are heated to a temperature that emit vapors. The vapors condense on the part surfaces, penetrate and disintegrate the contaminating soil. The cleaning process is complete when the part and solvent are at the same temperature, which in return suspends the condensing process.

The chlorinated solvents used in this process include trichloroethylene (TCE) trichloroethane (TCA), and trichlorotrifluoroethane (CFC-113). All of these solvents are listed on the EPA's undesirable cleaning solvents list and are heavily regulated. TCE is an excellent cleaner with low toxicity levels and a high flashpoint. However, TCE is not environmentally safe and is a VOC and Hazardous Air Pollutant (Florida Pollution Prevention Program, 1995a&b). It has also been recognized to cause long term health effects such as liver and kidney diseases and increased carcinogenic risk. TCA, which can substitute for TCE, is less toxic and a less effective cleaning solvent. It is also identified along with CFC-113 as a class 1 ozone depleter.

Today, a variety of alkaline/detergents, emulsion cleaners and hydrocarbon substitutes can replace chlorinated solvents and CFC-113 vapor degreasing. Alkaline solutions and detergents can be used for general degreasing while hydrocarbons and solvent emulsions can be used for heavier soils such as oils, tars and greases. Even terpene (orange oil) and water emulsions can substitute for CFC-113 cleaning.

WASTE MINIMIZATION & POLLUTION PREVENTION

To properly clean an aircraft and to minimize waste, consult the manufacturer's instructions and plan the work ahead of time. Washing an aircraft should be accomplished in a designated area that is sloped, covered and bermed to facilitate wastewater collection and to prevent stormwater runoff. Wastewater can not be allowed to spill onto unprotected areas where it could contaminate the ground water. Optimally, the wash area should have a sump that can collect the cleaner and wastewater prior to being filtered and reused. The washing area should also have a permitted connection to a water treatment facility or a suitable retention pond. Other alternatives for aircraft cleaning are utilizing offsite commercial washing and steam cleaning facilities or a high pressure wash system, such as a hydroblast that uses a lower volume of water compared to conventional washing.

The use of mild soaps, detergents and aqueous base solvents is best for general aircraft cleaning. Engine exhaust deposits and other stubborn stains can be cleaned with petroleum based or mild caustic solvents. When cleaning, always use the minimum amount of material to do the job and avoid over spraying, showering and splashing solvents. Also, to enhance recycling capabilities, use the minimal number of solvents per cleaning. Keep spent solvents separate and avoid mixing solvents with contaminants such as waste and other solids.

To minimize waste from parts cleaning and degreasing processes, always sustain the quality of the solvent by properly maintaining equipment. Prevent unnecessary evaporation losses by controlling the ventilation in the cleaning area and by turning off the solvent flow and covering the tank when it is not in use. When the vapor degreasing is finished, wait for condensation to stop before slowly removing the parts. Parts should be arranged on the racks for optimal drainage and located with drip boards or dip guards that return solvents back into the storage tanks.

Recycle solvents when feasible by reusing high-grade spent solvents for lower-grade uses. This can be accomplished by allowing solids such as paint, to settle and by decanting the liquid solvent for reuse. All unused solvent containers should be properly labeled, covered and stored in a containment area in case of an accidental release. Keep all used rags in properly marked, closed containers to prevent emissions from spent solvents. Reuse contaminated rags by having them cleaned by an industrial laundry service; do not dispose of them in a landfill.

CHAPTER 9
CORROSION CONTROL AND AIRCRAFT PAINTING

The definition of corrosion is to eat into or wear away by oxidation or by the action of chemicals. This happens to aircraft metals when protective coatings break down. Aircraft mechanics interrupt the corrosion process by routinely replacing the protective coatings. Paint protects the aircraft from oxidation, salt water, engine exhaust and acid rain by sealing to the aluminum surfaces with chromium compounds (Wolfe et al., 1991).

However, the painting process is a large contributor to hazardous waste and hazardous air emissions. In the past, most companies disposed of their hazardous paint waste in landfills and deep well injection (Evanoff, 1990). Today, with stricter regulations requiring proper disposal, some operators estimate 50% of their cost of waste disposal comes from painting processes.

This chapter will review the hazardous materials used and the waste generated by typical painting processes (Table 8). Current waste minimization and pollution prevention practices associated with aircraft painting will also be discussed.

CHEMICAL STRIPPING

The process of stripping and painting an aircraft starts with preparing the aircraft for stripping by covering all plexiglass and other areas with tape and aluminum. A stripping compound is applied to the surface of the aircraft for a period of time. A typical stripper would contain methylene chloride, phenol and sodium chromate. These chemicals are hazardous air pollutants (HAPs) and are highly caustic, toxic and carcinogenic. The paint and spent stripper are removed from the aircraft by a rinse cycle, usually with a high pressure hose. Approximately 1,000 gallons of water and 200 gallons of stripper are washed off of a large aircraft (Rocker et al., undated).

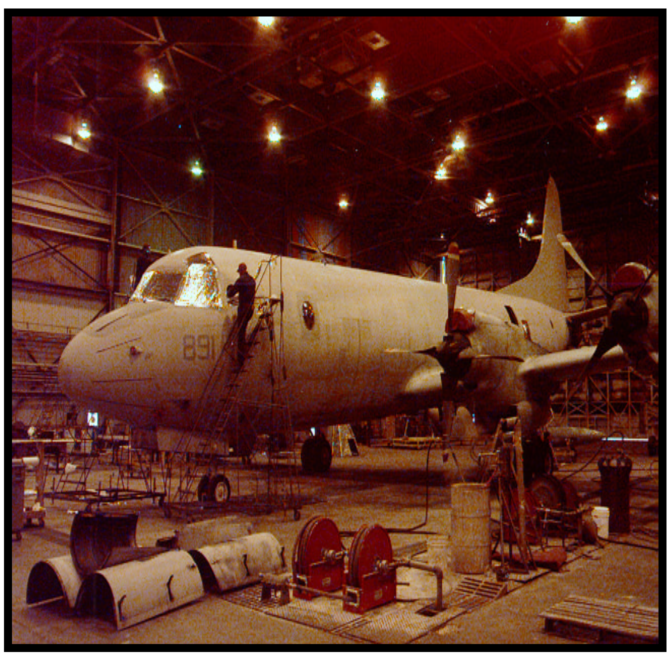


Photo Courtesy of NADEP Jacksonville

Table 8. Common hazardous materials and waste associated with aviation maintenance corrosion control and painting procedures.

HAZARDOUS MATERIALS	***Paint***
	Enamels
Strippers	Lacquers
Methylene Chloride	Polyurethane
Phenol	Heavy Metals (from pigment)
Sodium Chromate	***Solvents***
Benzyl Alcohol	Toluene
Plastic Beads	Petroleum Products
Corrosion Control	Methyl Ethyl Ketone
Phosphoric Acid	Isopropyl Alcohol
Fluoride	
Alodine	**HAZARDOUS WASTE**
Chromium	
Primer	Dry Strippers
Zinc Chromate	Paint Dust
Epoxies	Paint Sprayed Tape, Rags
Gray Enamel	& Towels
	Wash Water
	Spent Solvents

Ninety percent of the wet stripping process can be accomplished with a dry stripper (containing approximately 80% methylene chloride and 10% formic acid). Dry stripping eliminates the majority of chromium and phenol from the stripping process (Rocker et al., undated). Using a dry stripper prevents chemicals and paint waste from entering the wastewater stream. In this process the paint and stripper from the aircraft's surface are removed by a vacuum or broom and placed in a drum for disposal. Using a dry stripper can also save approximately 1,000 gallons of water per aircraft in the painting process (Rocker et al., undated).

In 1985, Northwest airlines was the first commercial airline to implement particle blasting for paint removal (Bauer and Ruddy, undated). Particle blasting with compressed air is the least polluting approach to remove paint and is similar to sandblasting. It may use plastic beads in a low pressure hose to wear away the paint. This process produces an etched surface for paint adhesion and the beads can be recycled and reused. However the dust from the paint is still toxic and operators need to ensure that overblasting does not cause damage to the surface or get dust into the aircraft's instruments.

Benzyl alcohol solution either in an acidic (using formic acid) or basic (using ammonia/amine compound) form can be used as another alternative for chemical stripping (Bauer and Ruddy, undated). This solution usually takes longer than chemical stripping, but the air emissions from this process are not consequently hazardous. However, benzyl alcohol and formic acid are VOCs and emissions still need to be regulated.

CORROSION CONTROL

Corrosion control is accomplished by etching the surface of the aircraft and applying a corrosion inhibitor. The surface of the aircraft is etched with a solution containing phosphoric acid and fluoride. This solution is usually applied with a spray gun or wand with an equal volume of water and the surface is also scrubbed down with abrasive pads. This process cleans and roughens the surface to allow greater paint adhesion.

After etching, the aircraft is rinsed with hot water to remove all impurities and a corrosion inhibitor (Alodine) is applied which leaves a protective chemical coating on the surface. The application of the inhibitor for an entire aircraft uses approximately one pound of Alodine mixed with 30 gallons of water and is accomplished with a spray gun or wand. Alodine is hazardous due to the large amount of chromate (a known carcinogen)in it. Again, the aircraft is rinsed with approximately 200 gallons of cold water (for a large aircraft) and allowed to dry.

PRIMER

After the aircraft is sanded and wiped down, the surface is primed. Zinc chromate, epoxies and gray enamel undercoat are examples of some commonly used primers. To acquire proper consistency of the primer, all are thinned with solvents such as toluene or petroleum products (naphtha or mineral spirits). All paint thinners should be stored in approved flammable liquid storage cabinets and kept away from any source of ignition.

PAINT

Generally, commercial aircraft are painted every four years. The surface is painted with a base coat two or three times then trim and color is added to the surface. There are three components to paint: the pigment, binder and solvent. The pigment provides the color, durability and adhesion of the paint. The binder keeps the pigment in a liquid form, while the solvent dissolves both the pigment and binder and allows them to be easily applied. There are three types of paint finishes: lacquers, enamels and polyurethane. Unlike enamels that dries slowly and provides a glossy coat, lacquers dry quickly but do not produce a glossy coat unless polished. The most widely used paint is polyurethane because it produces both a glossy coat and good corrosion control with no polishing.

PAINT WASTE

Waste are generated from solvent evaporation, mixing excessive amounts of materials, overspraying, and solid paint sludge. These waste are considered hazardous because they contain listed hazardous solvents and heavy metals from pigments. Waste paint and solvents such as MEK or isopropyl alcohol from cleaning booths and spray equipment must also be disposed of as hazardous waste because of heavy metal contamination. Even paint-sprayed masking tape, rags and paper towels need to be disposed of as hazardous waste. If a rag contains an excessive amount of a listed solvent it is restricted from landfill disposal and must require treatment or recovery of all solvents or thermal destruction.

The wastewater from the painting process can contain chemicals and solvents that must be treated by filtering and proper disposal. For example, KC Aviation in Dallas, Texas has an on-site wastewater treatment facility for their paint shop (Irsfeld, 1989) and is an example of a filtering and treatment process. The treatment facility consists of a sump pump system and holding tanks that automatically release chemicals to treat the water. This system can separate phenols, chrome, lead, zinc, cyanide and select out gases. It can also control acidity and filter out sludge into barrels. With this system, KC Aviation can produce discharge water that meets local pollution standards. Regardless of the treatment type or disposal processes that occur on site, untreated wastewater should never go into the stormwater or other drainage system.

WASTE MINIMIZATION & POLLUTION PREVENTION

To properly strip and paint an aircraft and minimize waste always keep equipment clean and leak free. Store paints and strippers in tightly sealed containers and mix the correct amount of paint needed for each project. Reduce the types of hazardous waste generated by using multipurpose solvents, water based primers and low volatility paints. The amount of paints can also be reduced by using less material. For example, two commercial airlines, American Airlines and USAir reduced paint waste by limiting the amount external painting (Bauer and Ruddy, undated). They use a higher grade of aluminum that can be uniformly polished in appearance to avoid painting the entire aircraft. However, this practice is not widespread because of concerns of corrosion on unprotected aluminum.

During stripping or painting, parts should be clean, dry and rust free. Always follow temperature guidelines with temperature sensitive stripping material and use High Volume Low Pressure (HVLP) type equipment to reduce over spray. Spent solvents can be recovered and disposed of in a drum by using a plastic sheeting underneath the aircraft.

The wash water can be minimized by several different methods. The wastewater stream can be reduced by using squeeges rather than high pressure hoses for rinse cycles. It can also be reduced by not running water over the stripping and paint areas and by reusing the alkaline wash water in another rinse step. Reusing wash water has been noted to reduce water consumption by 50% (Rocker et al., undated).

After the painting is completed, use spray equipment cleaning cabinets to reduce the amounts of solvents used for cleanup and try to use leftover paint for other purposes to avoid disposal. An identified waste storage area should be maintained and properly vented to prevent accumulation of flammable vapors.

CHAPTER 10
WELDING

Many engines and structural aircraft parts are welded during manufacturing, repair or modification. Welding is a process that joins metal parts by fusion. There are three types of fusion welding: oxyacetylene (gas welding), electric-arc and inert-gas welding. Oxyacetylene and inert-gas welding are the most commonly used welding processes in aviation. All types of welding except solder, braze, gas-weld and arc-weld steel are recommended to be covered at the beginner level. However, advanced training and certification are required for mechanics who want to pursue advanced welding techniques.

This chapter will review the general welding process for all types of welding and identify the hazardous materials and waste (Table 9). Waste minimization and pollution prevention practices will be recommended. However, all manufacturer manuals and engineering information must be followed to ensure the integrity of the material joined.

Table 9. Some hazardous materials and waste associated with aviation maintenance welding procedures.

HAZARDOUS MATERIALS	HEALTH HAZARDS
Oxygen	***Toxic Fumes***
Acetylene	Iron Oxide
MAPP®	Nickel
Metals	Chromium
Painted Metals	Flouride
	Silica
	Toxic Gases
	Carbon Monoxide
	Nitrogen Dioxide
	Ozone
	Radiation
	Ultraviolet Light
	Infrared Radiation

OXYACETYLENE AND INERT-GAS WELDING

Oxyacetylene welding produces heat by burning a mixture of oxygen and acetylene. Acetylene, a very flammable gas is stable under low pressure and normal temperatures. However, it can self-explode if it is compressed to a pressure greater than 15 pounds per square inch (psi). A safer substitute for oxyacetylene that does not become unstable at any operating pressure is a mixture of methylacetylene and propadiene sold as MAPP®. Pure oxygen is also highly combustible with oil and grease. Therefore, it is important to ensure pure oxygen does not come in contact with MAPP® or an explosion could occur.

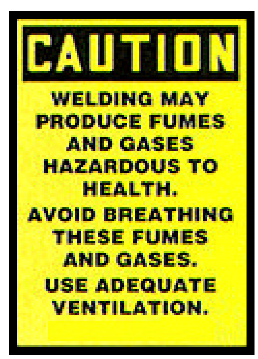
Inert-gas welding is similar to electric-arc welding process except it uses an inert gas such as helium and argon to shield the arc and molten metal to prevent oxidation and burning. There are many types of inert-gas welding such as gas tungsten-arc welding (GTAW), metal inert-gas (MIG) and tungsten inert-gas (TIG) welding.

Welding rods or filler rods are used for all of these processes. They are used to supply additional metal to form a joint. These rods usually consist of one metal, although some rods (composite rods) may contain more than one metal.

Welding produces a variety of hazards from hazardous fumes, toxic gases to ultraviolet (UV) and infrared (IR) radiation. Fumes are formed from the vaporization of molten metal. The type of fumes depends upon the composition of metals that are being welded (Table 10). Even welding rods can produce hazardous fluoride and silica fumes. Toxic gases such as carbon monoxide, nitrogen dioxide, and ozone are also produced by welding. MIG and TIG produce the greatest amount of ozone gases especially when aluminum is welded. The presence of chlorinated hydrocarbons such as solvents on metals can produce a highly toxic irritant gas, phosgene.

Table 10. The types of fumes different metals produce from welding.

METALS	FUMES
iron steel	iron oxide
stainless steel	nickel chromium
plated galvanized painted metals	cadmium zinc oxide lead



Adverse health effects can be caused by overexposure of welding fumes and gases. Some health risks include chronic or acute systemic poisoning, metal fume fever and respiratory irritations. Other hazardous health risks involve risks of burns from flame, arc, molten metal and metal splatter to radiation from ultraviolet, infrared and intense visible light.

All welding should be performed in a designated, controlled shop environment with fire protection, ventilation, and proper IR and UV protection. Sufficient ventilation is required in the work areas to remove toxic fumes. Eye protection with the correct shade of lens against UV and IR rays is recommended by welding equipment manufacturers and OSHA. Protective clothing must also be worn to protect the skin from UV and IR burn and respirators must be in compliance with OSHA guidelines (Part 1910.251 and 1910.254). Health posters, safety regulations, MSDS and EPA, DOT and OSHA placard must be properly displayed.

WASTE MINIMIZATION & POLLUTION PREVENTION

Carefully plan the work to minimize welding time. Keep welding areas clean and shielded with suitable barriers against IR and UV rays. Remove all paint and solvents from metals before welding. Reduce the amount of fumes, by using welding rods that produce a low fume and by using the least amount of heat and toxic welding materials when a choice is allowed by the manufactures manuals. Cautiously adjust acetylene torches during ignition to minimize carbon black formation. Keep weld finishing (grinding) to a minimum and clean welding flux.

CHAPTER 11
HYDRAULIC FLUIDS

Hydraulic fluids act as a lubricating medium that reduces friction and heat between moving parts. Generally, there are two types of hydraulic fluids used in aviation maintenance: mineral-base fluids and phosphate ester-base fluids. All of these fluid lines are marked with colored identification bands indicating the content to the mechanic. Leaks of hydraulic fluids are an important environmental concern. It has been observed that approximately 85% of all hydraulic fluids eventually leak out of their systems and into the environment through slow leaks, line breaks or failure of fittings and seals (Foszcz, 1996).

This chapter will review the different hydraulic fluids that are used in aircrafts and the hazardous materials and waste associated with these fluids (Table 11). Waste minimization and pollution prevention practices pertaining to working with hydraulic fluids will also be discussed.

Table 11. Some hazardous materials and waste associated with aviation maintenance hydraulic fluid procedures.

HAZARDOUS MATERIALS	HAZARDOUS WASTES
Mineral Based Fluids	Spent Solvent
Phosphate Ester-Based Fluids	Contaminated Rags
Skydrol®	Absorbing Spill Material
Stoddard Solvent	
Naphtha	
Varsol	
Trichloroethylene	

MINERAL BASED FLUIDS

Mineral based fluids (Mil-H-5606) are a mixture of petroleum oil and are used in light aircraft and some of the older heavy airplanes. They are used in many systems, especially systems with low fire hazards such as wheel brakes, flaps and landing gear. They should not be mixed with other used petroleum products.

To clean a hydraulic system from contamination, the system is flushed with cleaner. The cleaner varies depending upon the type of hydraulic fluid used. Mineral based systems may be flushed with Stoddard solvent, naptha, or varsol to clean contamination. These flushing-cleaning materials must be handled as hazardous waste because of heavy metal contamination.

PHOSPHATE ESTER-BASED FLUIDS

Phosphate ester-based fluids (Mil-H-8446) are a hydraulic oil that are fire resistant and can be used in most transport aircraft. However they should not be mixed with other fluids and needs to be saved for recycling in separate and properly labeled containers. A modification of a phosphate ester-based fluid is a synthetic hydraulic fluid called Skydrol®. This modified fluid is also a hazardous material and must not be mixed with other waste. However, Skydrol® can be burned in cement kilns for disposal.

Phosphate ester-based fluids are flushed with trichloroethylene and must be saved as hazardous waste. The contaminated cleaning rags associated with these hydraulic fluids and flushing are also considered hazardous waste.

WASTE MINIMIZATION & POLLUTION PREVENTION

The mechanic should plan how to service hydraulic systems safely and with the smallest loss of fluid. Personal safety equipment, suitable containers, drip pans and other necessary equipment should be in place before servicing is started. No fluid line should be opened until it has been properly identified and its function and content have been reviewed in the maintenance manual. Open lines on concrete paved areas when possible and use drip pans to catch fluids when aircraft is in a hanger. Remove pressure from the system before opening lines and cap all lines as they are removed. Keep waste materials in marked, dated and suitable containers in the hazardous waste storage area and do not mix waste. Clean up all spills promptly by using absorbing materials. Do not hose spills off into the stormwater or other drainage system.

CHAPTER 12
AIRCRAFT FUELS AND OILS

Aircraft mechanics must ensure that fuel systems and holding tanks can safely hold and deliver fuel, prevent unwanted pressure buildups and be free of contamination. The systems operated at most airports are fixed position underground delivery systems, mobile trucks and/or tank systems. All of these systems utilize aviation gasoline or jet fuels.

This chapter will review the material used in aircraft fuels and oils and discuss the hazards associated with these materials (Table 12). Waste minimization and pollution prevention practices relating to aircraft fueling will also be discussed.

Table 13. Some hazardous material and waste associated with aviation maintenance fueling procedures.

HAZARDOUS MATERIALS	HAZARDOUS WASTES
Aviation Gasoline	Absorbing Spill Material
Lead Tetraethyl	Contaminated Rags
Jet Fuel (Turbine Fuel)	Water/Fuel Mixture
JET A (JP5)	
JET B (JP4)	
Oil	

AVIATION GASOLINE

Aviation 100 octane low lead is the choice of reciprocating engines operators and is the only aviation gasoline in production using lead as a performance enhancer. Many light reciprocating engines have been modified under a STC to operate using automobile pump gas. Both are flammable and the 100 LL contains lead tetraethyl.

JET FUELS

Jet fuels are classified as flammable or combustible liquids that can contain trace amounts of lead. They are incompatible with other flammable materials such as oxidizers and acids. They can be toxic if inhaled or swallowed and can cause eye or skin irritations. Benzene, a major component of jet fuel, is also a known carcinogen.

Safety standards require that all fuel must be removed from the aircraft prior to any maintenance procedures. This fuel is usually stored in drums and can not be reused in an aircraft under FAA regulation. However, often due to a shortage of drums, the fuel is mixed with waste oil tanks, which increases disposal costs. If the fuel and waste oil are kept separate from the beginning, disposal costs can be reduced and the recyclable capabilities of the fuel are enhanced.

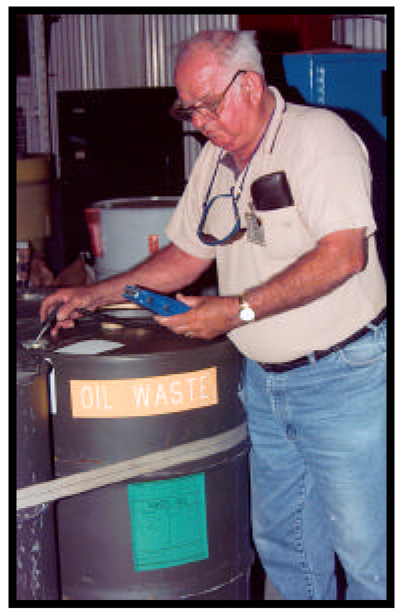
The FAA also regulates the quality and composition of jet fuel for commercial and private aircraft (Wolf et al., 1991). The critical parameter in the quality of fuel is the water content. Water from ambient air often gets into the fuel storage tanks and condenses. This water must be removed daily from each tank. During this process some fuel is removed with the water and is considered a liquid waste.

A solid waste occurs when spilled jet fuel is mixed with clay absorbents for clean up. Disposing used absorbents and spilled jet fuel in hazardous waste landfills holds the generator permanently liable for the waste and it takes up valuable space in the landfill (Wolf et al., 1991). An alternative disposal method for jet fuel would be to utilize the high BTU value of the fuel and burn it in hazardous waste incinerators or in cement kilns as supplemental fuel (Wolf et al., 1991).

USED OIL

Used oil is defined by the EPA as "any oil that has been refined from crude oil or any synthetic oil that has been used and as a result of such use is contaminated by physical or chemical impurities." These impurities would include dirt, metals, water and chemicals.

Used oil has unlimited recyclable capabilities. Approximately 380 million gallons of used oil is recycled each year (U.S. Environmental Protection Agency, 1996). There are several processes to recycle oil. Oil can be reconditioned, refined, processed and burned for energy recovery or collected and transported just to name a few. However, to recycle used oil it should never be mixed with other substances such as gasoline or paint solvents. If mixed, used oil may be considered a hazardous waste if it is found to contain excessive amounts of metals such as lead, arsenic, cadmium or chromium (Pennsylvania Department of Environmental Protection, 1996).



Testing the chemical composition of oil waste.
Photo Courtesy of NADEP Jacksonville

To prevent the mixing of used oil with other materials, always label all storage containers and tanks as "used oil" or "oil waste." Keep storage containers leak free and separated from other chemicals and materials.

Used oil filters should also be properly opened, inspected, drained and crushed before disposal. If filters are drained for at least 12 hours, they are not considered hazardous waste. Draining and crushing filters not only reduces storage and transport costs but protects the environment from oil contamination.

WASTE MINIMIZATION & POLLUTION PREVENTION

Fueling zones should be on concrete paved areas where spills can be contained and fire equipment is available. All fuel hoses should be empty before removing them from filler openings. Always be aware of the amount of fuel the tank will hold as it is filling. Do not over fill the tank. Remember, as temperature changes in the fuel tanks it can cause the fuel to expand and overflow from the vents. All used fuels and engine oil should be stored in marked and dated containers to be recycled.

Both fuel and oil storage tanks should have a lockable fill cap to prevent the dumping of undesirable materials into the tanks. Oil tanks which are usually serviced when the aircraft is fueled should also not be overfilled. The tank or sump is designed with room for expansion as the oil temperature rises. However, when tanks are overfilled, it can cause oil to spill from the tank or engine breathers. Also, all parts tagged for repair or disposal as scrap, should be drained of oil.

Aviation gas and turbine fuel will contaminate the ground water. Minimize spills of aircraft gasoline, turbine fuel and engine oil by using absorbent materials and by not spraying down the spills with water. Large fuel spills must be reported to HazMat teams or the fire department when they are detected.

Fuel and water mixtures can also be minimized by several methods. The first method uses a filtration system that separates the fuel and water components. This separation can often allow the water to go in the city drainage system and allow the fuel to be used in ground support equipment. Another method recertifies the fuel according to FAA guidelines for aircraft use. However, this method is not widely used due to potential liability.

CHAPTER 13
SAFETY AND SUPPORT SYSTEMS

Cabin cooling systems, oxygen systems, compressed gas, ice/rain control systems and batteries are contributors to the overall production of hazardous waste in the aviation maintenance industry. This chapter will review the hazards (Table 13) and waste minimization and pollution prevention practices associated with these systems.

Table 13. Some hazardous materials and waste associated with aviation maintenance safety and support systems procedures.

HAZARDOUS MATERIALS	HAZARDOUS WASTES
Cabin Cooling Systems	***Cabin Cooling Systems***
Refrigeration Gas (freon)	Phosgene Gas
Refrigeration Oil	Spent Refrigerant Gas & Oil
Oxygen Systems	***Oxygen Systems***
Compressed Oxygen	Spent Oxygen Generators
Oxygen Generators	
Ice and Rain Control Systems	***Ice & Rain Control Systems***
Ethylene glycol	Spent Deicer Fluid
Propylene glycol	
Batteries	***Batteries***
Lead-acid Batteries	Spent Batteries
Nickel-cadmium Batteries	
Electrolyte Fluid	

CABIN COOLING SYSTEMS

There are two types of cabin cooling systems: vapor-cycle machine and air-cycle machine. The vapor-cycle machine is a closed system that uses the evaporation and condensation of a refrigerant (usually freon) to reduce the temperature inside the cabin. Air-cycle machine uses the compression and expansion of air, not a refrigerant, to reduce the temperature of the cabin. Light aircraft use ram air for ventilation and vapor-cycle machine for cooling. Heavy aircraft use air-cycle machine for heating, cooling and pressurization. The majority of hazardous waste produced from the systems is from the vapor-cycle machine.
High concentrations of refrigerant gas can cause oxygen starvation and produce a poisonous gas (phosgene gas) when exposed to an open flame. Refrigerant, in liquid form and under pressure, will

expand and cause a rapid temperature drop. If exposed, frost bite and/or severe eye damage can occur. Therefore, proper clothing and eye protection should be used when handling refrigerants.

It is illegal to vent refrigerant into the atmosphere. If the refrigerant is vented into the atmosphere it will eventually reach and destroy ozone. Freon (a common refrigerant) must be recovered using EPA approved recovery equipment and be either reused or collected and processed as hazardous waste. Even refrigeration oil which is usually contaminated with heavy metals when removed from a system needs to be treated as a hazardous waste.

Minimize loss of refrigerant to the atmosphere during servicing by checking the machine thoroughly for leaks before charging the system and by using the correct charging equipment. All refrigerants must be stored in properly labeled and approved color coded tanks so materials are not mixed. If materials are mixed or contaminated, they must be tagged as such and handled as hazardous waste for disposal.

OXYGEN SYSTEMS

5

Pressurized oxygen bottle systems are used for breathing in non-pressurized aircraft and in flight crew emergencies. Chemical oxygen generators are used for emergency oxygen breathing for passengers aboard cabin pressurized aircraft. Chemical oxygen generators are oxidizers that upon activation a chemical reaction involving sodium chlorate ($NaClO_3$) and iron (Fe) will produce extreme heat and oxygen. When the generators are installed in the aircraft they are housed in protective thermal canisters.

Oxygen generators that are beyond their 12 year shelf life, need to be replaced. However, unused, out-of-date generators still contain extremely hazardous chemicals that can combine and produce a reaction. Therefore, all expired generators taken out of an aircraft must be spent, capped and handled as hazardous waste. They must be transported on cargo only aircraft accompanied with shipping papers and properly labeled as an oxidizer.

COMPRESSED GASES

Compressed gases are used in a variety of maintenance procedures, some that have already been discussed. The following table is a list of compressed gases used in aviation maintenance.

Table 14. Compressed gases commonly used in aviation maintenance.

GASES	PROCEDURES
Acetylene Argon Helium Hydrogen Oxygen	Welding
Oxygen	Breathing
Nitrogen	Tire & Strut Inflation Fire Extinguishing Propellant
Refrigerant 1301 Carbon Dioxide	Fire Extinguishing Agent
Butane Propane	Fuel for motor vehicles, torches, burners and heaters
Refrigerant 12	Refrigerant

There are two types of hazards associated with the use, storage and handling of compressed gases: the chemical hazard associated with the cylinder and the physical hazards represented by the cylinder maintained under high pressure. Table 15 list the chemical hazards associated with the gases.

To decrease the risk of exposure, never leave the valve open when the cylinder is not in use. Cylinders may contain pressures up to 6,000 psi with a direct relationship to temperature (National Safety Council, 1988). Safety mechanisms of the cylinder may not work properly if the cylinder is heated to raise the pressure of the gas.

All cylinders must be properly labeled with any associated chemical hazards and kept away from all sparks, flames and electrical circuits. Flammable gases should be stored separately from other gases, and oxygen gases should be stored separately from flammable gases. Empty cylinders should be labeled “EMPTY” and stored separately from operational cylinders. All storage areas should be properly ventilated with noncombustible material flooring. Cylinders stored outside must be protected from the elements with noncombustible materials. Never store cylinders by walkways such as stairs or public hallways.

Table 15. Common chemical and physical hazards associated with compressed gases (modified from Magnussen, 1996).

COMPRESSED GASES	CHEMICAL HAZARDS	PHYSICAL HAZARDS
Oxygen	Supports and accelerates combustion of flammable materials.	Cause severe frostbite to skin or eyes.
Nitrogen Argon Helium Carbon Dioxide	Cause rapid asphyxiation and death if released in a confined area.	May cause severe frostbite to eyes or skin.
Hydrogen	Flammable Gas. A mixture of hydrogen and oxygen will explode in a confined area with a spark.	May cause severe frostbite to eyes or skin. Leaks can not be detected by sight, sound, smell or taste.
Acetylene	Explosive. Under certain conditions, forms explosive compounds with copper, silver and mercury. Reacts violently with fluorine and other halogens.	Thermodynamically unstable and sensitive to shock and pressure.

ICE AND RAIN CONTROL SYSTEMS

Ice and snow accumulation on aircraft in flight are removed or prevented from forming in several ways. Heat bleed from turbine engines or exhaust heat from reciprocating engines can be directed to wings, control surfaces and windows. Light aircraft, if equipped, use pneumatic and electric heated strips to remove ice formation.

Aircraft de-icing should be performed in designated areas as close to departure time as possible. Deicing area drains should be kept open to direct the residue into traps that can separate and recover the fluid. Deicer fluid is usually sprayed on the surface of the aircraft which in return melts the snow or ice. Pollution occurs when fluid falls on the ground along with semi-frozen material. The deicer fluid consists of ethylene glycol that is hazardous and difficult to recycle. A less toxic substitute is propylene glycol. However, used propylene glycol is still hazardous due to high levels of metals and acids. National Aeronautics and Space Administration (NASA) is developing a new non-glycol anti-icing fluid that might someday be a substitute product (Edwards, 1995). Meanwhile, current alternatives to deicing fluid are using infrared lamps or leaving the aircraft in hangers until takeoff.

BATTERIES

There are two general types of batteries used in aircrafts. *Lead acid batteries* are the most commonly used batteries for light general aircraft and *nickel cadmium batteries* are used in aircrafts with turbine engines. Both types of batteries must be considered as hazardous waste if they are not recycled. Even cracked and leaking batteries must be stored and transported as hazardous waste.

Photo Courtesy of Department of Environmental Protection

Potential hazards associated with batteries are corrosion, toxic chemicals and explosive gases (National Safety Council, 1988). When installing or removing batteries, check for spilled electrolyte fluid. Electrolyte fluid is corrosive and produces burns. If the fluid contacts your skin or eyes, flush the area with water immediately. Safety glasses should be worn for protection when working with batteries.

Lead acid batteries produce oxygen and hydrogen gas while charging. To prevent build up of explosive gases from lead acid batteries, ensure that vent tubes and lines are in good working condition with no obstructions. Do not cool a battery with a fire extinguisher because the discharging agent could produce a static discharge and cause the hydrogen/oxygen mixture to explode. In addition, nickel-cadmium and lead acid batteries should not be serviced or stored in the same area or with the same tools. These batteries can contaminate each other.

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APPENDIX A
ACRONYMS

ASTM - American Society of Testing and Materials

ATM - Atmosphere

BP - Boiling Point

BMP - Best Management Practices

BTU - British Thermal Unit

CAS - Chemical Abstract Service

CESQG- Conditionally Exempt Small Quantity Generator

CFC - Chlorofluorocarbon (Ozone Depleting Material)

CFR - Code of Federal Regulations

CHRIS - The Chemical Hazardous Response Information System

DOT - Department of Transportation

EPA - Environmental Protection Agency

FAA - Federal Aviation Administration

FAC - Florida Administration Code

FAR - Federal Aviation Regulation

FDEP - The Florida Department of Environmental Protection

FHA - Federal Highway Administration

FPPA - Florida Pollution Prevention Act
FRA - Federal Railroad Administration

GTAW - Gas Tungsten-Arc Welding

HAP-Hazardous Air Pollutant

HAZMAT-Hazardous Material(s)

HAZWOPER-Hazardous Waste Operations and Emergency Response

HCS - Hazard Communication Standard

HMIS - Hazardous Material Information System

HVLP - High Volume Low Pressure

IR - Infrared

LEL - Lower Explosive Limit

LQG-Large Quantity Generator

MIG - Metal Inert-Gas

mm Hg - Millimeters of Mercury

MSDS - Material Safety Data Sheets

NADEP - Navy Aviation Depot

NEPA - National Environmental Policy Act

NFPA - National Fire Protection Association

NIOSH - National Institute of Occupational Safety & Health

NPS - Nonpoint Source

OSHA - Occupational Safety and Health Administration

PEL - Permissible Exposure Limit

ppm - parts per million

PSI - Pounds Per Square Inch

RCRA - Resource Conservation Recovery Act

SG - Specific Gravity

SQG- Small Quantity Generator

TCA - Trichloroethane

TCE - Trichlorethylene

TIG - Tungsten Inert-Gas

UEL - Upper Explosive Limit

UV - Ultraviolet

VOC - Volatile Organic Compounds

VP - Vapor Pressure

APPENDIX B
GLOSSARY

Abrasive Blasting: A cleaning process using forced abrasive substances such as silica sand, steel grit, nut shells or glass beads to physically remove soils from an aircraft surface.

Acutely Hazardous Waste: A waste that can be considered to present a substantial hazard whether improperly managed or not. Such wastes are lethal to humans in low doses.

Air Cycle Machine: A type of cabin cooling system that uses the compression and expansion of air to reduce the temperature inside the cabin.

Air Worthy: A condition in which the aircraft or component meets the requirements of its type design and is capable of safe operation.

Aqueous Cleaning: A cleaning process that uses either acidic/alkaline cleaners, soaps or detergents for removing oil, grease and dirt from propellers, windows and general parts of the aircraft.

Arc Weld: A fusion welding process that uses an electric arc in joining two metals together.

Berm: An embankment or ridge of either natural or man-made materials used to prevent movement of liquids, sludges, solids or other materials.

Best Management Practices (BMPs): Systems, activities and structures that human beings can construct or practice to prevent nonpoint source pollution

Binder: A component of paint that keeps the pigment in liquid form.

Biodegradable: The ability of a substance to be broken down physically and/or chemically by biological organisms.

Boiling Point: The temperature at which the liquid phase changes into the vapor phase at a given atmospheric pressure.

BTU: A basic unit of heat in the English system of units that raises 1 pound of pure water 1^{o} Fahrenheit. This unit of heat is designated as a British Thermal Unit.

Carcinogen: A substance that causes cancer in living tissue from either acute or chronic exposure.

Chemical Stripping: A process of applying a chemical compound to an aircraft surface for removing paint.

Cold Cleaning: A degreasing process that uses aqueous based mixtures, light hydrocarbons and mineral spirits as degreasing solvents. Parts are either immersed in tanks filled with these solvents or sprayed with the solvent and drained on a rack.

Container: Any device that is open or closed, portable, in which a material can be stored, handled, treated, transported, recycled or disposed of.

Corrosion: A chemical deterioration of a metal when exposed to chemicals. Rusting is an example of corrosion.

Corrosive: A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact or which may cause fire when in contact with other materials.

Degreasing: A cleaning process that removes grease, oils and tar from aircraft parts by the use of either chlorinated solvents or light hydrocarbons and mineral spirits.

Density: The amount of weight or mass in a unit volume. It is measured in pounds per cubic foot or slugs per cubic foot or grams per cubic centimeter.

Dike: An embankment or ridge of either natural or man made materials used to prevent movement of liquids, sludges, solids or other materials.

Discarded Waste: Commercial chemical products that even unused can cause a threat to human health and the environment.

Disposal: The discharge, deposit, injection, dumping, spilling, leaking or placing of any hazardous waste into or on any land or water so that such hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground water.

Dry Stripper: A chemical stripper that does not need water to strip paint from the aircraft and never enters the waste water stream.

Electrolyte: A liquid or gas chemical that conducts an electrical current by movement of charged atoms called ions such as in a battery.

F-List: A list of hazardous wastes consisting of commonly used cleaning solvents, degreasers, wastes from electroplating, metal refinishing, wood preserving and petroleum refining from non-specific sources.

Filtering: The removal of impurities from a liquid or gas by passing it through a porous material.

Flammability: The tendency of a material (gas, liquid or solid) to ignite either spontaneously or ignite from exposure to high temperatures, flames, sparks, or other ignition sources.

Flash Point: The minimum temperature at which a substance gives off flammable vapors that would ignite in contact with a spark or flame.

Gas: The form of matter which takes the shape of its enclosed container and expands to fill the entire container.

Gas Weld: A weld produced by heat from burning a mixture of oxygen and acetylene.

Generator: Any person whose act or process produces hazardous waste.

Hazardous Air Pollutant (HAP): A pollutant that may cause or contribute to and increase in mortality or in serious illness and to which no ambient quality standard is applicable. Beryllium is an example of a hazardous air pollutant.

Hazardous Chemical: A chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. Any chemical that is a physical hazard or health hazard.

Hazardous Material: A substance or material which is capable of posing an unreasonable risk to health, safety, property when transported in commerce.

Hazardous Substance: A substance deemed as hazardous if spilled in excess.

Hazardous Waste: A discarded substance that because of its quantity, concentration, physical, chemical or infectious characteristics may cause or contribute to serious illness or pose a substantial or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of.

Hydraulic Fluids: An incompressible fluid, usually some form of oil, used to transmit force from one location to another such as in the operation of brakes, landing gears and many of the flight controls.

Hydrocarbons: A large group of organic compounds composed largely of carbon and hydrogen; many are derived from petroleum.

Hydrocarbon Cleaning: A cleaning process that uses hydrocarbon cleaners that can dissolve oils, greases, waxes, fluxes and inks but do not react to metals. Stoddard solvents, naphtha, kerosene are used as these types of cleaners.

Ignitable: Capable of being set afire, or of bursting into flame spontaneously or by interaction with another substance or material.

Incinerator: Any enclosed device using controlled flame combustion that neither meets the criteria for classification as a boiler nor is listed as an industrial furnace. Such a device is used to thermally degrade waste materials.

K-List: A list of hazardous wastes from specific sources that would include industrial processes such as wood preservation and production of pigment, chemicals, steel and pesticides.

Liquid: An intermediate phase of matter between solid and gas that has a definite volume and takes the shape of its container.

MAPP â - Mixture of methylacetylene and propadiene used as a substitute for oxyacetylene in welding procedures.

Material Safety Data Sheets: Sheets containing printed chemical safety information provided by chemical manufacturers.

Melting Point: The temperature at which the solid phase of matter changes into the its liquid phase.

MEK - Methyl Ethyl Ketone, a hydrocarbon compound that is used in cleaning and painting processes.

NFPA Hazard Diamond: A diamond shape label from the National Fire Protection Association that has ratings of health hazards, flammability, reactivity and special hazards. These ratings are given separately on four diamonds which together form one complete diamond.

Nonpoint Source Pollution: Pollution that cannot be traced to a specific origin or starting point, but seems to flow from many different sources, such as stormwater runoff.

Oxidizer: A substance such as chlorate, permanganate, inorganic peroxide, or a nitrate that yields oxygen readily to stimulate the combustion of organic matter.

P-List: A list containing discarded acutely hazardous commercial chemical products. These wastes are dangerous in very small amounts.

Paint Solvent: That paint component which dissolves both the pigment and binder to allow them to be used.

Particle Blasting: A stripping process that uses plastic beads in a low pressure hose with compressed air for paint removal. This process produces an etched surface for paint adhesion.

pH: A logarithmic measurement on a scale of 0 to 14 that measures the acidity or basicity of a substance.

Phosphate Ester-Based Fluids: A fire resistant hydraulic oil that is used on most transport aircraft. It is also a hydrocarbon compound containing phosphate.

Pigment: A paint component that provides the color, durability and adhesion of the paint.

Pollutant: Any contaminant of air, water, land or other natural resources that will cause such to be harmful, detrimental or injurious to public health, safety or welfare, or to domestic, commercial, municipal, industrial, agricultural, recreational or other legitimate beneficial uses.

Pollution Prevention: Preventive practices that protects the air, water, land and other natural resources from harmful contamination.

Pollution Prevention Runoff Plan: A plan designed to reduce the amount of pollution caused by storm water runoff.

Process Wastes: Industrial chemicals that are used for their intended purposes and are under the F-List and K-List.

Reactive: Having properties of explosivity or of chemical activity which can be a hazard to human health or the environment.

Reclamation: A recycling waste minimization technique that is a restoring process of recovering used materials.

Reuse: A recycling waste minimization technique that consists of returning a used material for the same process or substituting a raw material for another process.

Sludge: Any solid, semi-solid, or liquid waste generated from a municipal, commercial, or industrial wastewater treatment plant.

Solid: A phase of matter characterized by having a definite shape and volume.

Solubility: The capability of a substance to be dissolved. It is also the amount of a given substance that can be dissolved in a unit volume of solvent.

Specific Gravity: The density of a substance relative to the density of water. It is the density of a substance divided by the density of water. Specific gravity has no units and thus it is expressed as a pure number.

Spent Materials: Any material that has been used, and as a result of contamination, can no longer serve the purpose for which it was produced without first processing it.

Spontaneous Combustion: Combustion that results from heat built up in materials improperly stored in a container. Heat is caused by slow oxidation of the material until it is hot enough to ignite.

Still Bottom Waste: Residue or by-product of a distillation process such as solvent recycling or the sludge on the bottom of cleaning tanks.

Storage: The containment of hazardous wastes, either on a temporary basis or for an indefinite period in such a manner as not to constitute disposal or use of such hazardous waste.

Stormwater Runoff: Rain water that runs over land during and immediately after a storm event.

Sump: Any pit or reservoir that serves as a tank and those troughs/trenches connected to it that serve to collect hazardous waste for transport to hazardous waste storage, treatment or disposal facilities.

Tank: A stationary device, designed to contain an accumulation of hazardous waste, which is constructed primarily of non-earthen materials such as wood, concrete, steel to provide structural support.

Terpene Cleaner: A plant derived hydrocarbon cleaner with D-limonene from orange peals as the common ingredient. These cleaners have very high solvency making them extremely effective in cleaning greases, oils, fluxes and adhesives.

Toxic Waste: A waste that poses a substantial or potential hazard to human health or the environment when improperly managed.

Transporter: A person engaged in the off-site transportation of hazardous waste by air, rail, highway or water.

U-List: A list of toxic commercial chemical products including toxic wastes from discarded chemical products, off specification materials and spill residues.

Vapor Cycle Machine: A cabin closed cooling system that uses the evaporation and condensation of a refrigerant (usually freon) to reduce the temperature inside the cabin.

Vapor Degreasing: A cleaning process in which chlorinated vapors condense on part surfaces, penetrate and disintegrate the contaminating soil.

Vapor Density: The weight of a vapor or gas compared to the weight of an equal volume of air.

Vapor Pressure: The pressure exerted by a vapor above its liquid surface in a closed container and is measured in terms of pounds per square inch or in millimeters of mercury (mmHg).

Volatile: The degree to which a liquid tends to evaporate.

Waste Generator: Any person, by site, whose act or process produces hazardous wastes.

Waste Minimization: Any process that reduces or eliminates the amount of hazardous waste generated.

APPENDIX C
CLASSIFICATION & INCOMPATIBILITIES
OF HAZARDOUS MATERIALS

A classification and incompatibilities of hazardous materials commonly used in aviation maintenance process such as cleaning (C), painting (P), welding (W), fueling (F), hydraulics (H), and safety and support equipment (S). (* symbolizes a carcinogen)

MATERIALS	PROCESS	CLASSIFICATION	INCOMPATIBLE MATERIALS
Acetone	P	Flammable	Corrosives, Oxidizers, Batteries
Acetylene	W	Flammable	Heat Source
Argon	W	Compressed Gas	Heat Source
Aviation gasoline	F	Toxic, Flammable	Corrosives, Oxidizers
Beryllium	W	Toxic*/Combustible	Acids/Bases, Oxidizers, Hydrocarbons
Cadmium	W	Toxic*	Corrosives, Oxidizers
Carbon black	W	Toxic/Combustible	Oxidizers
Chromic acid	C	Toxic*/Corrosive	Flammable/Combustible, Bases, Oxidizers
Citric acid	C	Corrosive	Corrosives, Oxidizers, Heavy Metals
Detergents	C	Corrosive	Acid Containing Compounds
Epoxy ester resins	P	Toxic	Acids/Bases, Oxidizers
Ethyl alcohol	C	Flammable	Oxidizers
Ethylene glycol	F	Combustible	Oxidizers
Flux	W	Flammable	Oxidizers, Acids
Freon	S	Noncombustible	Reacts With Water
Helium	W	Compressed Gas	Heat Source
Hydraulic fluid	H	Combustible	Corrosives, Oxidizers
Infrared waves	W	Toxic*	N/A

MATERIALS	PROCESS	CLASSIFICATION	INCOMPATIBLE MATERIALS
Isopropyl alcohol	C/S	Flammable	Oxidizers, Acids
Lead	S	Toxic	Corrosives, Oxidizers
Lead tetraethyl	F	Combustible/Reactive	Oxidizers
MEK	C/P/H	Flammable/Combustible	Corrosives, Oxidizers, Batteries, Heat Source
Methylene chloride	C	Toxic	Corrosives, Oxidizers, Batteries
Naphtha	C/P/H	Combustible	Corrosives, Oxidizers, Batteries
Nitric acid	C	Corrosive	Corrosives, Oxidizers, Heavy Metals
Oxygen	W	Oxidizers	Heat Source
Paint	P	Toxic	Corrosives, Oxidizers
Perchloroethylene	P	Oxidizers	Corrosives, Oxidizers, Batteries
Potassium hydroxide	S	Corrosive	Flammable/Combustible, Bases, Oxidizers
Stoddard solvent	C/P/H	Combustible	Corrosives, Oxidizers, Batteries
Sulfuric acid	S	Corrosive	Solvents, Heavy Metals, Oxidizers
Toluene	P	Flammable	Oxidizers
Trichlorethylene	C	Toxic/Combustible	Bases
Trichloroethane	C	Combustible	Oxidizers, Caustics
Ultraviolet rays	W	Toxic*	N/A
Xylene	C/P	Flammable	Corrosives, Oxidizers, Batteries
Zinc	W	Combustible	Oxidizers

APPENDIX D
AGENCY CONTACT INFORMATION

U.S. Environmental Protection Agency
http://www.epa/gov/

Region IV (AL, FL, GA, KT, MI, NC, SC, TN)	404-347-3016
Hazardous Waste Management Division	
Air, Pesticides, and Toxic Management Division	404-562-9077
Waste Management Division	404-562-8651
RCRA Hotline	800-424-9346
Small Business Hotline Compliance with any EPA regulation	800-368-5888

U.S. Department of Transportation
http://www.dot.gov/

Transportation of Hazardous Materials	202-366-4488
Federal Aviation Administration	
Small Business	202-267-8881
Publications	202-267-3484
Flight Standards	202-267-8237
Research an Special Programs Administration	
Hazardous Material Training	202-366-4900
Consumer Hotlines	
Aviation Safety Hotline	800-255-1111
Hazardous Material Safety	800-467-4922
Hazardous Material Spills	800-424-8802

Occupational Safety & Health Administration
http://www.osha.gov/

Information and Consumer Affairs	202-219-8151
Health Standards Programs	202-219-7075
Safety Standards Programs	202-219-8061
Technical Support	202-219-7031

Florida Department of Environmental Protection
http://www.dep.state.fl.us/

Bureau of Solid & Hazardous Waste	904-448-0300
Hazardous Waste Compliance Assistance Program	800-741-4337
Pollution Prevention Program	904-488-0300

APPENDIX E
SUPPLEMENTAL REFERENCES

AIRFRAME & POWERPLANT MANUALS

AUTHOR: Crane, Dale
TITLE: *Aviation Maintenance Technician Series*
PUBLISHER: Renton, Washington: Aviation Supplies & Academics, Inc., 1993.
WEB PAGE: N/A

AUTHOR: Federal Aviation Administration
TITLE: *Airframe & Powerplant Mechanics General Handbook*
PUBLISHER: Washington, D.C.: U.S. Department of Transportation, 1978.
WEB PAGE: N/A

AUTHOR: Federal Aviation Administration
TITLE: *Acceptable Methods, Techniques, and Practices-Aircraft Inspection and Repair*
PUBLISHER: Washington, D.C.: U.S. Government Printing Office, AC 43.13-1A, 1972.
WEB PAGE: N/A

AUTHOR: Kroes, Michael; Watkins, William; Delp, Frank
TITLE: *Aircraft Maintenance & Repair*
PUBLISHER: Westerville, Ohio, Glencoe/McGraw-Hill, 1996.
WEB PAGE: N/A

AUTHOR: National Safety Council
TITLE: *Aviation Ground Operation Safety Handbook*
PUBLISHER: Washington, D.C.: Library of Congress, 4th ed., 1988.
WEB PAGE: N/A

AUTHOR: Augestein, David
TITLE: *Fact Sheet 6-11: Used Oil Management, Used Oil Absorbants, Accepting Used Oil From the Public, Antifreeze Disposal and Recycling, Mobile and Stationary Air conditioning and Refrigeration, Parts Cleaning Solvents*
PUBLISHER: Findlay, Ohio, Environmental Development Corporation, GreenLink, Doc. No. 1201, Aug. 15, 1996.
WEB PAGE: http://www.ccar-greenlink.org/documents/cat1200/doc1201.html#7

AUTHOR: Augestein, David
TITLE: *Fact Sheet 12-15: Used Oil Filters, Scrap Tire Disposal and Recycling, Asbestos and Dust Controls During Brake and Clutch Repair and Inspection and In Building Materials, Spent Battery Disposal and Recycling*
PUBLISHER: Findlay, Ohio, Environmental Development Corporation, GreenLink, Aug. 15, 1996.
WEB PAGE: http://www.ccar-greenlink.org/documents/cat1300/doc1301.html

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AUTHOR: Bauer, Jerry; Ruddy, Edward
TITLE: *Aircraft Depainting: Alternatives for Environmental Compliance*
PUBLISHER: Kansas City, Missouri, Burns & McDonnell Engineering Co., undated.
WEB PAGE: N/A

AUTHOR: California Department of Health Services
TITLE: *Hazardous Waste Generated by Metal Refinishing Facilities Fact Sheet*
PUBLISHER: "EnivroSense", April 1990.
WEB PAGE: http://es.inel.gov/techinfo/facts/california/metal-fs.html

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AUTHOR: California Department of Toxic Substances Control
TITLE: *Aqueous Alternative to Solvent Cleaning*
PUBLISHER: Sacramento, California, Department of Toxic Substances Control, Doc. No. 607, 1994.
WEB PAGE: N/A

AUTHOR: Florida Pollution Prevention Program
TITLE: *Fact Sheet #9: Industrial Cleaning-Hydrocarbon Based Cleaners. They're back!*
PUBLISHER: Tallahassee, Florida, Department of Environmental Protection, Oct. 1995.
WEB PAGE: http://www.dep.state.fl.us/waste/programs/p2/31.htm

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AUTHOR: Florida Pollution Prevention Program
TITLE: *Fact Sheet #8: New Cleaning Solvents*
PUBLISHER: Tallahassee, Florida, Department of Environmental Protection, Oct. 1995.
WEB PAGE: http://www.dep.state.fl.us/waste/programs/p2/30.htm

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AUTHOR: Florida Pollution Prevention Program
TITLE: *Fact Sheet #6: Terpene Cleaners*
PUBLISHER: Tallahassee, Florida, Department of Environmental Protection, Oct. 1995.
WEB PAGE: http://www.dep.state.fl.us/waste/programs/p2/28.htm

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AUTHOR: Florida Pollution Prevention Program
TITLE: *Fact Sheet #3: Using Aqueous Cleaners*
PUBLISHER: Tallahassee, Florida, Department of Environmental Protection, Oct. 1995.
WEB PAGE: http://www.dep.state.fl.us/waste/programs/p2/25.htm

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