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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Environmental Training Modules Module 8 - Generation/Treatment/ Minimization of Hazardous Waste

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

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

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ENVIRONMENTAL TRAINING MODULES

MODULE 8

GENERATION/TREATMENT/MINIMIZATION
OF HAZARDOUS WASTE

Prepared by:

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NSRP 0548
(N1-94-02)

TRAINING MODULES OVERVIEW

Executive Summary and User s Guide (NSRP 0540) Gives an overview of the 10 module set of environmental training modules, plus key issues involved in training in general. Instructions are supplied for how the modules can be modified to suit individual shipyards, as well as hardware and software requirements.

Module 1 (NSRP 0541) **Good Environmental Practices**

Content: Craft/trade-specific training on items that workers must deal with on a regular basis – material handling, labeling, waste generation/minimization, requirements awareness.

Recipients: New employees on arrival, and existing workers as a refresher.

Module 2 (NSRP 0542) **Environmental Practices for Specific Craft/Trade Groups**

Content: Specific training on air, hazardous materials, waste minimization, and related environmental considerations, with a focus on the generator personnel and their individual practices and procedures. Emphasis on those personnel likely to encounter a high incidence of problems during their regular duties.

Recipients: Specific craft/trade groups of workers.

Module 3 (NSRP 0543) **Shipyard Incident Response Training**

Content: Detailed presentation of response requirements specified by OSHA. Basic ingredients of a viable program for a shipyard – what is required and how to reach a satisfactory state of readiness. Includes specific duties of all participants, as well as how to ensure coordination and a common focus. This Module will provide the shipyards with an in-house capability for conducting this important training.

Recipients: Environmental Manager, Environmental Staff Personnel, Safety Engineer, Safety Personnel, Fire Department Personnel, Laboratory Staff and Technicians, Emergency Response Coordinator, Medical Personnel.

Module 4 (NSRP 0544) **Shipyard Oil Pollution Prevention and PIC Training**

Content: Provides a detailed overview on the federal regulatory oil pollution prevention and response requirements. Also contains specific training material for those shipyard employees with designated “Person in Charge” responsibilities.

Recipients: Ship and Craft Managers and Leadmen, Environmental and Safety Department Personnel, designated Persons in Charge.

Module 5 (NSRP 0545) **General Environmental Awareness**

Content: Overview of environmental statutes and regulations affecting shipyards, including responsibilities for compliance including both civil and criminal penalties for non-compliance. Includes an overview and explanation of environmental processes - how laws are formulated, the role of environmental groups, consultants, advisers.

Recipients: Senior Management

Module 6 (NSRP 0546) Technical Overview of Environmental Statutes and Regulations

Content: A general but in-depth overview of all environmental statutes and regulations with a focus on shipyard interests, and emphasis on the technical aspects of the requirements.

Recipients: Environmental Managers and staff personnel.

Module 7 (NSRP 0547) Environmental Requirements of Concern to Shipyards

Content: General overview of ALL requirements as they apply to shipyards. Emphasis on technical aspects and actions needed for compliance, rather than on the penalties for non-compliance. Includes overall strategy for developing a strong environmental posture.

Recipients: Senior Management, Supervisors, Generator Personnel; all workers who interface with environmental matters.

Module 8 (NSRP 0548) Generation/Treatment/Minimization of Hazardous Waste

Content: Discussion of regulatory requirements and statutes that apply to shipyard hazardous waste activities. Stresses the high points of the laws, and how to satisfy them. Includes overview of training provided to hazardous waste operators.

Recipients: Middle-level Managers

Module 9 (NSRP 0549) Hazardous Waste Operator Training

Content: Detailed training on practices and procedures performed by hazardous waste operators. Includes reclamation techniques, safe handling practices, labeling/marketing, inventory control, hazard minimization.

Recipients: Hazardous Waste Operators; helpers and assistants

Module 10 (NSRP 0550) Environmental Training for Subcontractor Personnel

Content: Briefing on environmental requirements and considerations applicable to all Subcontractor Personnel entering a shipyard environment.

Recipients: Subcontractor Personnel; visitors to a shipyard; transient personnel such as delivery agents, auditors, and oversight personnel.

Generation/Treatment/Minimization of Hazardous Waste for Shipyard Personnel

Title:

The Hazardous Waste Problem (An Overview)

Objective of this Training Session:

The purpose of this module is to provide employees with an overview of the potential effects of hazardous waste on people and the environment.

Introduction: Generally speaking, hazardous waste is any form or type of waste that has chemical properties which may be adverse to human or environmental health. These hazards are inherent properties derived from the chemical constituents of the waste material. The mere fact that a material or product, for whatever reason, is no longer useful for its intended purpose (i.e., a waste) is immaterial to its hazardous properties. For example, a solvent that is flammable or toxic maintains these hazardous properties regardless if the solvent is fresh from the drum or has been used to degrease engine parts and must now be disposed. The fact that it is now a waste (that exhibits hazardous chemical properties) merely identifies when it becomes subject to certain federal and state statutory and regulatory requirements that control how hazardous waste will be managed and disposed.

The proper management of hazardous waste derived from shipyard operations and processes is vital to the continued operations of the facility. Severe penalties can result from the improper control and disposal of hazardous waste. Additionally, not knowing or understanding the obligations imposed on shipyard personnel for complying with applicable federal and/or state statutes and regulations does not provide a very substantial defense for violations. From a business perspective, the improper management of hazardous waste will often result in greater costs and long term liability than a properly managed program. As a result of these reasons and more, it is incumbent that shipyard managers, ship superintendents, craft and shop managers, foremen and leadmen, and hazardous waste handlers learn and understand the elements of the hazardous waste regulatory structure and shipyard management program.

What Makes Waste Hazardous?

There are many inherent hazards that chemicals in waste material can exhibit. These can include both physical hazards such as fire and explosions, and well as human and environmental health hazards. Some common chemical hazards and scenarios are given below:

Safety and immediate (acute) health effects of hazardous wastes:

- Chemical burns to skin or eyes - example: a worker gets sulfuric acid in her eyes and suffers serious injury.
- Inhalation of harmful fumes or dusts - example: inhalation of degreaser solution (e.g., a chlorinated solvent) makes a worker dizzy and nauseous.
- Fires and explosions - example: an oxidizer (e.g., sodium hypochlorite) contacts a flammable organic (e.g., acetone) and a warehouse erupts into flames.

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Long term (chronic) health effects of hazardous wastes:

- Chronic illness - example: a lead worker eats his lunch every day without washing his hands and develops symptoms of lead poisoning after several years.
- Latent chronic illness (delayed) - example: a worker is exposed to a toxic plating solution, retires from the shipyard and develops liver problems two years later.
- Cancer - example: a worker is exposed repeatedly to a fire retardant hydraulic fluid known to cause cancer and develops skin cancer on his arm.

Environmental effects of hazardous wastes:

- Air pollution - example: solvents evaporate from hazardous waste drums with open bung holes.
- Soil contamination - example: a heavy metal plating solution leaks from a rusty drum which was abandoned by the generator and contaminates the soil.
- Ground water contamination - example: paint solvents leak from an old storage tank, seep deep into the ground, and contaminate ground water.
- Drinking water contamination - example: leachate from an old dump site contaminates a private well on adjacent property.
- Contamination of lakes, rivers and oceans - example: antifoulant paint chips containing heavy metals blow off of a floating dry-dock and into a river.
- Accumulation in plants and animals - example: a careless worker dumps hazardous waste in the storm drain. Fish near the storm drain outfall float up to the surface and are consumed by a hungry seagull.

In addition to safety and health risks that can be inherent chemical properties of hazardous waste, there are societal risks associated with the improper management of hazardous wastes. The general public expects and demands that hazardous materials and waste be managed in compliance with the law, and in such a manner as to reduce or eliminate the potential impact on human health and the environment. Some common societal risks and scenarios are given below:

Legal liabilities pertaining to hazardous materials/waste:

- Fines to the shipyard - example: a generator of hazardous waste generates some waste material. He doesn't realize that the waste is hazardous, and discards the material in a trash box without consulting his shop's hazardous waste coordinator. When the waste arrives at the local solid waste landfill, an observant operator suspects that the waste material might be hazardous. The landfill contacts the state hazardous waste agency, and the shipyard is fined for improper disposal of hazardous waste.

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- Criminal charges against the worker, including personal fines and jail sentences - example: an inspector knowingly falsifies information on a hazardous waste manifest. During transportation of the waste, a serious accident occurs, resulting in release of the hazardous waste. A subsequent investigation of the accident reveals the false entries on the manifest. The inspector faces criminal charges and could serve up to fifteen years of imprisonment.

Business issues:

- Cost avoidance - example: a worker mixes a drum of waste chlorinated solvent into a barge loaded with used oil. Instead of reclaiming or selling the oil, the shipyard must now pay to dispose of thousands of gallons of hazardous waste.
- Damage to public image - example: an article in the local newspaper accuses the shipyard of improper hazardous waste management practices due to several minor incidents which have occurred over the last six months. Even if the accusations are unfounded, the article influences the public's perception of the shipyard.
- Internal audit findings - example: during a recent audit by a third party auditor, several drums were found which had been in a ninety-day storage area for more than ninety days. This finding raised serious questions about the shipyard's system for tracking its hazardous wastes prior to manifesting, and indicated potential long term liability for poorly managed hazardous waste disposed of in previous years.
- Debarment - A small amount of hazardous waste is disposed of in a waste bin by a shipyard subcontractor and is discovered later in the day by a state inspector. The shipyard is given a violation for improper disposal. In an effort to settle the violation, the shipyard later pleads guilty to a misdemeanor charge of illegal disposal of hazardous waste. Two months later, the shipyard is notified by government contracting officers that it has been placed on the list of debarred contractors and is no longer allowed to bid or receive government contracts.

The above examples are given to illustrate how hazardous waste can be hazardous to the health of people, the environment and the shipyard. The key to avoiding such problems is to understand the requirements and implement a comprehensive hazardous waste management program.

Statutory and Regulatory Framework for Managing Hazardous Waste: The Resource Conservation and Recovery Act (and its subsequent amendments) is the primary federal statute controlling the generation, storage, transportation and disposal of hazardous waste. RCRA established many important aspects of hazardous waste management, such as generator “cradle to grave” responsibility and tracking of the hazardous waste from generator to transporter to disposal facility. The requirements of RCRA are implemented through regulations promulgated by the Environmental Protection Agency and other federal agencies, such as the Department of Transportation.

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The requirements imposed by RCRA and its implementing regulations will be different depending on what role a person or facility is playing in managing hazardous wastes. These include:

- Generator
- Transporter
- Treatment, Storage, Disposal Facility

The shipyard is subject to the requirements of a generator of hazardous waste. As a generator, the shipyard must comply with and perform the following obligations,:

- Determine whether or not a waste is identified or listed as hazardous in 40 CFR Part 261, "Identification and Listing of Hazardous Waste."
- Obtain an EPA identification number and, if needed, a state identification number.
- Properly store the hazardous waste on-site prior to its transportation to a permitted Treatment, Storage and Disposal Facility ("TSDF"). A large-quantity generator may not store hazardous waste on-site longer than 90 days without a permit.
- Comply with the EPA's container management standards if waste is stored on-site in containers.
- Comply with the EPA's tank management standards if waste is stored on-site in tanks.
- Properly prepare and package the waste for shipment. This includes packaging the waste in DOT-approved containers, and labeling and marking them consistent with DOT requirements.
- Properly manifest the waste using a Uniform Hazardous Waste Manifest form. The manifest must designate the facility to which the waste is being shipped, the transporter, and all identification numbers. (An exception report must be submitted whenever a signed manifest is not returned from a destination within 45 days.)
- Prepare a contingency plan to ensure that operation and maintenance of hazardous waste equipment meet expectations, and a testing program to ensure that required safety and alarm systems are working.
- Keep up-to-date records on your wastes, training programs, safety procedures, manifests, and other key activities.
- Submit a biennial report (EPA form 8700-13A) that covers hazardous waste activity for the previous calendar year. The report must include what and how much waste was generated, who transported it, and where it went.

The regulatory requirements summarized above are for "Large Quantity" generators of hazardous waste. A large quantity generator is a facility that generates 1,000 kilograms (2,200 lbs) or more per month. The federal hazardous waste regulations also recognize other smaller categories of hazardous waste generators for which the regulatory requirements are not as comprehensive. These categories include "Small Quantity"

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generators (more 100 but less than 1000 kilograms per month), and “Conditionally Exempt Small Quantity” generators (no more than 100 kilograms per month). Almost all shipyards, except for very small companies, will be large quantity generators of hazardous waste.

Training Requirements for Hazardous Waste Personnel: Federal hazardous waste management regulations require appropriate training for all personnel that work with hazardous waste. This training is required to ensure that hazardous waste personnel know how to properly do their job, respond to emergencies, and protect themselves from chemical hazards. For large quantity generators of hazardous waste, the following training requirements apply:

- Hazardous waste personnel must successfully complete any requisite training program(s) within six months after the date of their employment, and/or assignment to the hazardous waste handling facility (or duties) and/or assignment to a new position at the hazardous waste management facility.
- Hazardous waste personnel must not work in an unsupervised position until they have completed the training requirements.
- Hazardous waste personnel must take part in an annual review of the initial training requirements.

The federal regulations provide for both general and specific subject areas of training that hazardous waste personnel must receive. These subject areas include:

- General - Instruction or on-the-job training that teaches personnel to perform their duties in a way that ensures the facility’s compliance with applicable sections of 40 CFR 265; *Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*.
- Specific - Instruction or on-the-job training that teaches personnel to respond effectively to emergencies involving the management of hazardous waste. These include:

1. Procedures for using, inspecting, repairing, and replacing emergency equipment;
2. key parameters for automatic waste feed cut-off systems;
3. communications or alarm systems;
4. response to fires or explosions;
5. response to ground water contamination incidents; and
6. shutdown of operations.

Finally, the training program must be directed by a person trained in hazardous waste management procedures, and must include instruction which teaches facility hazardous

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waste management procedures (including contingency plan implementation) relevant to the positions in which the personnel are employed.

Proper training is the first step to both ensuring compliance with the hazardous waste regulations, as well as facility and worker safety. Training for the proper management of hazardous waste is no different than training for any other production craft. Once a worker becomes skilled, he or she will be capable of doing their jobs with greater efficiency and safety.

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Title:

Standards Applicable to Generators of Hazardous Waste

Objective of this Training Session:

To provide a understanding of the federal regulatory requirements for generators of hazardous waste.

Introduction: The federal regulatory standards for generators of hazardous waste are codified at 40 CFR 262. This Part of the Code of Federal Regulations contains several Subparts as follows:

- Subpart A - General
- Subpart B - The Manifest
- Subpart C - Pre-Transport Requirements
- Subpart D - Recordkeeping and Reporting
- Subpart E - Exports of Hazardous Waste
- Subpart F - Imports of Hazardous Waste
- Subpart G - Farmers
- Subpart H - Transfrontier shipments of hazardous waste for recovery within the OECD

For most shipyards, only Subparts A, B, C, and D will be applicable in their normal operations. For this reason, the specific details for Subparts E, F, G, and H will not be provided in this training session.

Subpart A - General: This Subpart provides for several general requirements:

- defines the purpose, scope and applicability of the regulations to generators of hazardous waste;
- requires a generator of solid wastes to determine if the waste is a hazardous waste; and,
- requires an EPA Identification Number prior to treatment, storage or disposal of hazardous waste.

Subpart B - The Manifest: This Subpart defines the requirements for the use of the Uniform Hazardous Manifest for the transport of hazardous waste. It includes:

- general requirements for using manifests;
- acquisition of manifests;
- the number of manifest copies required and to whom the copies are supplied; and

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- specific direction on the use of the manifest.

Subpart C - Pre-Transport Requirements: Before transporting hazardous waste, or offering waste for transport, a generator must meet specific pre-transportation requirements. These include:

- packaging the waste in accordance with Department of Transportation regulations on packaging (49 CFR parts 173, 178, and 179);
- labeling the package in accordance with Department of Transportation regulations (49 CFR part 172);
- marking each package in accordance with Department of Transportation regulations (49 CFR part 179), and for each container of 110 gallons or less the following words and information:

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's Name and Address: _____

Manifest Document Number: _____

- placard transport vehicle, or offer the initial transporter the appropriate placards, according to Department of Transportation regulations (49 CFR 172 Subpart F);
- accumulation of hazardous waste on-site for a period of no longer than 90 days, without a permit or without having interim status. Furthermore, on-site waste storage must comply with EPA on-site management standards for containers, tanks, drip pans, containment buildings, and waste container marking and labeling requirements.

Subpart D - Recordkeeping and Reporting: The hazardous waste regulations require that a generator keep specific records regarding hazardous waste activities, and also prepare and file reports regarding these activities. These include the following:

- on-site recordkeeping of manifests, Biennial and Exception Reports, test results, waste analysis and other documentation regarding waste determinations;
- file a Biennial Report of hazardous waste activity by March 1 of each even number year (EPA Form 8700-13A);
- file an Exception Report if the generator does not receive a copy of the manifest with the handwritten signature of the owner or operator of the designated facility within 35 days of the date the waste was accepted by the initial transporter;
- provide any additional report that the EPA may require concerning the quantities and disposition of hazardous wastes.

Summary: The above requirements as contained in 40 CFR 262 Subparts A, B, C, and D establish the basic standards for generators of hazardous waste. The consistent and correct execution of

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these requirements is essential to maintaining compliance with the federal regulations. This information is important not only to hazardous waste personnel, but also to shipyard craft and shop managers, ship superintendents, and others whose activities result in the generation of hazardous waste. When facility personnel have the knowledge and understanding of how the requirements are implemented at the point of generation, greater efficiency of operation can be achieved.

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Title:

Other Regulatory Requirements for Generators of Hazardous Waste

Objective of this Training Session:

To gain an understanding of additional regulatory requirements that a facility may be subject to concerning the management of hazardous waste.

Introduction: 40 CFR 262 - *Standards Applicable to Generators of Hazardous Waste* - contains the specific federal requirements for hazardous waste generators. Additionally, Subpart 262.34 - *Accumulation Time* - provides for other hazardous waste generator requirements if the waste is stored on site for less than 90 days, and is managed in such a way so as to comply with certain specific Subparts of 40 CFR 265 - (*Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*). The specific Subparts of Part 265 that are applicable to all generators that store hazardous waste on-site on for 90 days or less are:

- Subpart C - *Preparedness and Prevention*; and
- Subpart D - *Contingency Plan and Emergency Procedures*.

Additionally, hazardous waste must be stored on-site using containers, tanks, drip pads and/or containment buildings. Depending on which of these is used, one or more of the following subparts will be applicable:

- Subpart I - *Use and Management of Containers*
- Tanks, Subpart J - *Tank Systems*;
- Subpart W - *Drip Pads*; and
- Subpart DD - *Containment Buildings*.

Finally, if waste is stored in containers or tanks, the following sections of Part 265 is applicable:

- Subpart CC - *Air Emission Standards for Tanks, Surface Impoundments, and Tanks*.

Where applicable to shipyard operations, each of the above subparts that contain regulatory requirements for generators of hazardous waste will be detailed in the following training session.

Subpart C - Preparedness and Prevention: This Subpart requires that facilities be maintained and operated to minimize the possibility of an accident or emergency involving hazardous waste. Specific requirements include:

- Equipment for internal communications for emergency notification and instructions, external communication equipment to notify and request assistance from off-site emergency responders, fire suppression and spill control and clean-up equipment, and water to supply water hose systems.

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- All facility communications or alarm systems, fire protection equipment, spill control equipment, and decontamination equipment, where required, must be tested and maintained as necessary to assure its proper operation in time of emergency.
- Whenever hazardous waste is being physically managed (poured, spread, pumped, transferred, etc.), all personnel involved in the operation must have immediate access to an internal alarm or emergency communication device. If even just one employee is on the premises while the facility is operating, that person must have immediate access to a communication device capable of summoning external emergency assistance.
- The facility must maintain aisle space to allow unobstructed movement of personnel, fire protection equipment, spill control equipment and decontamination equipment to any area of the facility operation in an emergency.
- The facility must attempt to make arrangements with local and state emergency response organizations (police, fire and emergency response teams) as appropriate for the type(s) of hazardous waste handled, to familiarize them as to the facility layout and operations. Where state or local authorities decline to enter into such arrangements, the facility must document the refusal in its operating record.

Subpart D - Contingency Plan and Emergency Procedures: This Subpart requires the preparation of a detailed plan that addresses the various possible emergencies that may occur during the on-site management of hazardous wastes, and the procedures that should be implemented when an emergency does occur. Specific requirements include:

- The requirement for each facility to have a contingency plan that is designed to minimize hazards to human health or the environment from fires, explosions or any unplanned sudden or non-sudden release of hazardous wastes to air, soil or surface water. The provisions of the plan must be carried out whenever there is a threat to human or environmental health caused by a fire, explosion or release.
- The requirement for the content of the plan to describe the actions that facility personnel should take in response to fires, explosions or releases of hazardous waste. The plan must also contain a description of arrangements agreed to by local and state emergency response organizations, the identification of the facility emergency coordinators and their office and home phone numbers and an up to date list of all emergency equipment at the facility. Finally, the plan must include an evacuation plan for facility personnel in the event an evacuation is necessary.
- Copies of the contingency plan and all revisions must be kept at the facility and submitted to all local emergency response organizations that may be called upon to provide emergency services.
- The contingency plan must be reviewed and amended based on changes to applicable regulations, facility design, construction or operation, changes in emergency coordinators and/or changes in emergency equipment.

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- The requirement that there must be at least one employee on-site or on-call at all times, with the responsibility for coordinating emergency response measures.
- The requirement that whenever there is an imminent or actual emergency situation, the emergency coordinator shall activate the facility alarm or communication system, and notify state or local agencies with designated response roles if their help is needed. Additionally, the emergency coordinator must make determinations and assessments regarding the nature of the emergency and its potential impact on and off-site of the facility. During the emergency, the coordinator must take all reasonable measures to ensure fires, explosions and releases do not occur, or recur or spread. Following the emergency, the coordinator must provide for treatment, storage or disposal of recovered waste, and any waste generated as a result of the emergency. Finally, the affected area of the facility must be cleaned up and decontaminated prior to resumption of operations.

Subpart I - Use and Management of Containers: This Subpart requires that facilities which store hazardous waste on-site in containers (such as 55 gallon drums) must use and manage the containers according to the following requirements:

- Containers holding hazardous waste must be maintained in good condition. If the container is not in good condition the waste must be transferred to another container, or managed in some manner that prevents leaks, spills or releases.
- The container, or its liner, must be compatible (non-reactive) with the waste stored in it. Any container holding hazardous waste must not be opened, handled or stored in a manner that may rupture or cause it to leak.
- At least weekly, containers holding hazardous waste must be inspected for leaks and/or deterioration caused by corrosion.
- Reactive or ignitable waste in containers must be located at least 15 meters (50 feet) from the facility property line.
- Incompatible wastes or materials must not be placed in the same container. Containers holding wastes incompatible with other waste stored in nearby containers (or other devices) must be separated from each other by means of a dike, berm, wall, or other device.
- Any facility that stores hazardous waste in containers must comply with the applicable requirements for air emission standards for use of containers to manage hazardous waste.

Subpart J - Tank Systems: The requirements of this subpart apply to facilities that use tank systems to store hazardous waste. The requirements include:

- Existing tank systems without secondary containment must be assessed and certified by a registered engineer, per the requirements of this subpart, to be fit for use.

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- The design and installation of new tank systems or components must be such that the requirements of this subpart are met. Additionally, the tank system must be assessed and certified by a registered professional engineer, per the requirements of Subpart 265.192.
- Secondary containment must be provided for existing tanks within a phased time schedule, and for new tanks prior to being put into service. The secondary containment systems must meet the standards established in Subpart 265.193.
- Hazardous waste must not be placed in a tank system if it could cause the tank, its ancillary equipment or secondary containment system to rupture, leak, corrode or otherwise fail.
- The facility must inspect various elements (as specified in Subpart 265.195) of the tank system on a daily basis. The inspection results must be entered into the operating record of the facility.
- When a tank system is closed, it must be decontaminated of all waste residues, contaminated soils and other residuals, which must be managed as hazardous waste.
- Ignitable or reactive waste must not be placed in a tank system, unless the waste is treated, rendered, or mixed before or immediately after placement, such that the resulting waste material is not ignitable or reactive.
- Incompatible wastes must not be placed in the same tank system.
- Any facility that stores hazardous waste in tank systems must comply with the applicable requirements for air emission standards for use of tank systems to manage hazardous waste.

Subpart CC - Air Emission Standards for Tanks, Surface Impoundments, and Containers: These requirements apply to facilities that store hazardous waste in tanks, surface impoundments or containers, if the waste has a volatile organic content of 500 ppm (0.05%) or greater. Its purpose is to reduce the amount of volatile organic emissions from hazardous waste during on-site storage and handling. Specific requirements for tanks and containers include:

- Tanks - Depending on the design capacity of the tank and physical properties (vapor pressure) of hazardous waste it will store, the facility must control air pollutant emissions in accordance with either “Tank Level 1” or “Tank Level 2” standards as specified in Subpart 265.1085.
- Containers - Depending on the design capacity of the container, the physical properties of the waste (vapor pressure and percent of organics) and if the container is used for treatment of hazardous waste by a waste stabilization process, either “Container Level 1” or “Container Level 2” or “Container Level 3” standards specified in Subpart 265.1087 will apply. Level 1 air pollution controls for containers (which includes 55 gallon drums) can be met by using DOT approved containers, and keeping the lid or closure closed when not actively adding or removing material.

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Title:

Hazardous Waste Safety - Health Hazards

Objective:

To provide a detailed explanation of the potential health hazards that hazardous waste handlers may encounter during the performance of their job. The hazardous waste handlers will be able to protect themselves and other workers from unnecessary risks with an understanding of what these hazards are.

Introduction: The hazards associated with hazardous waste are not unique to “waste,” but are derived from the intrinsic physical and chemical properties of those chemicals that make up the product that has become a waste. For this reason, any discussion of the hazards of hazardous waste are in fact merely reflective of chemical hazards. These hazards may be health hazards such as skin irritation, tissue and/or organ damage, reproductive impairment or disease. Additionally, chemicals can have physical hazards which can effect your health such as flammability and reactivity. This training session provides information on these aspects of chemical hazards that will help you in determining what risks may be present in a hazardous waste. From this determination, proper operational, engineering, and behavioral controls can be applied to reduce any risks to an acceptable level.

Toxic Hazards: Toxicology is the branch of science that studies poisons and their effects. The earliest toxicologists, in their struggle for survival, divided all substances into two categories: foods or poisons. Poisons were those materials that either killed you or made you very sick. Thus, early "toxicology" had no regard for long-term toxicity. Only immediate effects were considered.

Paracelsus (1493-1541), an early physician, was one of the first modern toxicologists who recognized that the quantity of the substance was a critical determinant of toxicity. His understanding of toxicology is defined by: "All substances are poisons, there is none that is not a poison. The right dose differentiates a poison and a remedy."

The first person known to recognize occupational illness was Percival Pott (1775), who observed high rates of scrotal cancer in London's chimney sweeps. The chemical culprit, found much later, was benzo-a-pyrene, belonging to a class called poly-nucleated aromatic hydrocarbons, which is a common product of combustion.

The last 30 to 50 years have exhibited explosive growth in the study of toxicology. Although this field may at first seem narrow, it is actually quite broad. There are many subdivisions, as displayed in the table below:

Type of Toxicology	Focus and Concern
Clinical	Concerned with the effects of chemical (drug) poisoning and the treatment of poisoned people.
Descriptive	Concerned directly with the toxicity-testing of chemicals.

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Environmental	Concerned with the ultimate environmental fate of chemicals and their impact upon the biological ecosystem and human populations.
Forensic	Concerned with applying techniques of analytical chemistry to answer mediological questions about the harmful effects of chemicals.
Industrial	Concerned with the disorders produced in individuals who have been exposed to harmful materials during the course of their employment.
Mechanistic or Biochemical	Concerned with elucidating the biochemical mechanisms by which chemicals exert their toxic effects.
Regulatory	Concerned with assessing descriptive data with regard to the risk involved in the marketing of chemicals, their legal uses, and chemical reporting.

What is Toxic? - It is not always clear what materials are toxic. For example, cyanide salts, commonly found in metal plating shops, are toxic. But, water and oxygen are toxic too. Most would agree that cyanide is very toxic, and the ingestion of small amounts can be fatal. Yet, we regularly ingest water, and we regularly inhale oxygen to survive. How can they be toxic?

A key concept of toxicology is quantity or dose. The quantity of material to which an organism is exposed directly determines its hazard. Water and oxygen in proper amounts are essential to sustain life. Yet, too much oxygen is toxic, resulting in biochemical disturbances and cellular damage. Too much water is also toxic and fatal! Another key to accurate hazard evaluation is the proper comparison between the toxicity of a chemical and the potential risk it poses. Toxicity refers to the ability of a chemical to cause injury once it reaches a susceptible site in, or on, the body. Without considering risk and toxicity, an accurate hazard evaluation is unlikely. It must be understood that it is the toxicity, in conjunction with exposure, that defines the risk to which the hazardous material handler is exposed.

Risk is independent of toxicity, since it refers to the factors that determine the hazards of a material, rather than the intrinsic ability of a chemical to cause harm. The likelihood that a chemical will cause injury, susceptibility of the recipient, length of exposure, concentration and toxicity of the material are all factors which are significant to the hazard of a situation. For example, cyanide salts are highly toxic, although they are not likely to cause widespread exposure problems because they are generally found in solid form and are not airborne and mobile. However, anhydrous ammonia, far less toxic than cyanide salts, may present a greater widespread risk because as a vapor, it is highly mobile.

Exposure may occur through a variety of different media. However, all the exposures may be grouped in terms of the timeframe of exposure, and time delay for the ultimate response.

- **Acute** - single exposure or occurring over a short time period (one day or less).

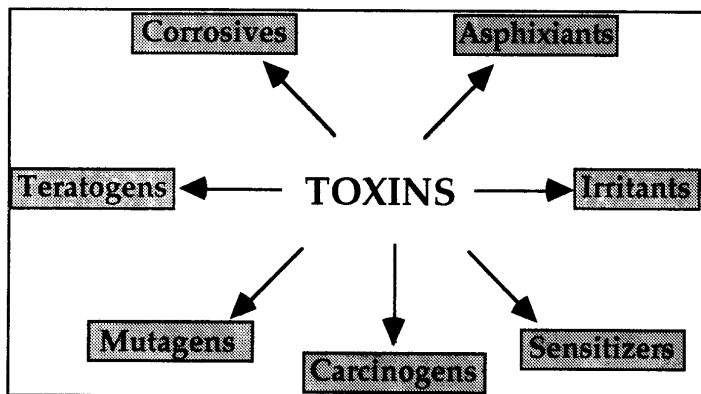
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- **Subchronic** - intermediate exposures between acute and chronic, may be for up to ninety days.
- **Chronic** - multiple or constant exposure to concentrations that do not cause an acute toxic response.

Acute effects occur when one feels symptoms within a short period of time, (within minutes or hours). Examples of acute effects include: headaches, teary eyes, sore throat, dizziness and nausea. In contrast, a chronic effect or illness develops slowly and may last for a long time. Chronic poisoning is usually because of continued exposure to a harmful chemical for months or years. Examples of chronic effects include cancer, sterility, kidney and liver damage.

BE AWARE OF BOTH THE ACUTE AND CHRONIC EFFECTS OF A HAZARDOUS SUBSTANCE.

Hazardous Substance Exposure Health Effects: There are several types of toxic effects that hazardous substances may have on the body when exposure occurs. These are important to understand in an emergency situation. Some, such as acrolein (a common combustion byproduct) are so reactive that simple contact causes cytotoxicity (cellular death). Other toxins, though chemically inert, can fatally displace oxygen. Toxins are divided into several basic types: asphyxiants, corrosives, irritants, sensitizers, carcinogens, mutagens, and teratogens. Remember, however, that materials may fit in more than one category.



Asphyxiants: Asphyxiants are gases that deprive the body tissue of oxygen. There are two types: simple and chemical. A **simple asphyxiant** displaces the oxygen in the breathing air. These are very important to identify in confined spaces, and especially in emergency situations. Examples are carbon dioxide, ethane, helium, hydrogen, methane, argon, and nitrogen. Another type of asphyxiant is a **chemical asphyxiant**. Chemical asphyxiants are gases that actually prevent oxygen use by the cells even though enough oxygen is delivered. Examples are carbon monoxide, hydrogen cyanide, and hydrogen sulfide. At high levels, all asphyxiates can cause a person to collapse, become unconsciousness, and even die.

Simple asphyxiants are hazardous due to the hypoxia caused by oxygen depletion. Environments with oxygen levels less than 19.5% are considered hazardous and are illegal to enter without respiratory protection. A concentration of 7% (70,000 parts per million - ppm) of a simple

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asphyxiant is sufficient to cause hazardous oxygen depletion as displayed in the table below. A rule of thumb is that a given contaminant will deplete the oxygen concentration by one-fifth of the original contaminant concentration. A 10% (100,000 ppm) concentration of contaminant will deplete the oxygen by approximately 2%, which is very dangerous without supplied air.

Approximate Oxygen Levels Based on Contaminant Concentrations

Contaminant Gas (ppm)	Gas (% in air)	Oxygen Reading
10,000	1.0	20.7
20,000	2.0	20.5
30,000	3.0	20.3
40,000	4.0	20.1
50,000	5.0	19.9
60,000	6.0	19.7
70,000	7.0	19.5

Chemical asphyxiants act biochemically on the respiratory system. The toxicity of these compounds is not directly related to oxygen depletion. Consequently, much smaller concentrations of chemical asphyxiants are hazardous, as compared to simple asphyxiates.

There are several sub-groups of chemical asphyxiants based on where and how they affect the respiratory system.

- **Blood asphyxiants** combine with red blood cells and render them incapable of carrying oxygen to the cells in the body. Carbon monoxide, the most common blood asphyxiant, has a 200 times greater affinity for oxyhemoglobin than does oxygen.
- **Tissue asphyxiants** are carried by the red blood cells and deposited in other cells of the body. They render the cell incapable of accepting further oxygen from the red blood cells. Hydrogen cyanide, a common material found in metal plating shops, and a common combustion by-product, functions by interfering with the cells' ability to convert food sugars to a form more readily usable by the cell biochemical process. This eliminates the demand for oxygen, causing suffocation and cell death.
- **Respiratory paralyzer asphyxiants** short circuit the respiratory central nervous system. Hydrogen sulfide (H_2S) attacks the olfactory nerve and paralyzes the nerve that controls the breathing process. Other examples of respiratory paralyzers are carbon disulfide (CS_2), acetylene, ethylene and ethanol.

Irritants: Irritants are toxins that cause temporary (but sometimes severe) inflammation of the eyes, skin or respiratory tract. Some examples of irritants are ammonia (NH_3), hydrogen fluoride (HF), chlorine (Cl_2), and hydrogen chloride (HCl). Irritants can also be corrosive materials which attack the mucous membrane surfaces of the body. These are more than "irritating." They are

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deadly at moderate concentrations. Irritants are divided into two types: respiratory and skin irritants.

Respiratory Irritants	May cause injury to the nose, mouth, throat and lungs. Examples of respiratory irritants that affect both the upper and lower lung are chlorine and ozone. Respiratory tract irritation can be minor, such as a tightening of the chest or bronchitis. But it may also be very serious, as in pulmonary edema, which can cause death.
Skin Irritants	May cause contact dermatitis, redness, itching and drying of the skin. Examples are organic solvents and detergents. Very corrosive agents, such as chromium and nickel, can cause skin ulcers and destroy tissue.

The water-solubility of irritants will affect where they impact the body. Highly water soluble irritants, such as the halogen acid gases, (HF, HCl and Cl₂, HI, SO₂ and NH₃), will readily dissolve in the first moisture they meet; at the eyes, nose and throat. Moderately water soluble irritants are in the upper respiratory tract and lungs. Halogen gases, ozone, phosphorus trichloride and phosphorus pentachloride are examples of moderately water soluble irritants. Slightly water soluble irritants do not readily dissolve in water, and bypass the moist areas (mucous membranes) that the first two groups attack. These materials exert their damage deeper in the lungs by destroying the alveoli, sometimes with delayed effects of up to 12 hours. For example, nitrogen oxides can produce fatal effects, principally pulmonary edema, from 4 to 48 hours after exposure.

Allergenic Sensitizers: After repeated exposures to certain chemicals, some individuals experience an allergic or immune reaction. Allergic sensitizers generally affect the skin and respiratory tract. The symptoms are often the same as those caused by irritants. Symptoms include dermatitis or bronchitis. As with irritants, the response may be very serious, and may even cause death. Examples include: isocyanates, phenol resins, and epoxy resins.

Systemic Toxins (Internal Poisons): Systemic toxins are chemicals that can cause damage to vital organs in the human body. They can damage blood cells, the nervous system, the liver, the kidneys and reproductive cells. The following table provides a description of each type:

Blood System (Hemolytic) Toxins	These toxins damage blood cells or interfere with blood cell formation. Examples include benzene, methylene chloride, arsine, phosphorus, and naphthalene.
Nervous System (Neuro) Toxins	These toxins damage the nervous system. Typical symptoms include dullness, muscle tremor, restlessness, convulsions, loss of memory, epilepsy, and loss of muscle coordination. Examples include mercury, insecticides, hexachlorophene, and lead.
Liver (Hepato) Toxins	These toxins cause liver damage, including jaundice and liver enlargement. Examples include alcohols and carbon tetrachloride.

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Kidney (Nephro) Toxins	These toxins damage the kidneys, causing swelling and increased serum proteins in the urine. Examples include halogenated hydrocarbons and heavy metals.
Reproductive Cell (Gameto) Toxins	These toxins damage the reproductive cells (egg and sperm) or interfere with their formation. Examples include lead, cadmium, cellosolves, and vinyl chloride.

Carcinogens: Cancer is the uncontrolled growth of malignant (harmful) cells at any site in the body. Carcinogens are chemicals that are known to cause cancer in humans or animals. Over 200 substances are known human carcinogens. Many other substances are under study as suspected carcinogens. Carcinogens differ somewhat from other toxins for two important reasons: 1) very small amounts of material can cause a carcinogenic effect; and 2) the effects of exposure may not appear for years. Theoretically, one molecule can cause cancer (called the one-molecule one-hit theory), although cancer is much more likely after substantial, repeated exposures. In general, it is believed that the development and problems caused by cancer may be delayed for 20 to 30 years after exposure. Whenever a known or suspected carcinogen is involved, the hazardous waste handler must use the highest levels of appropriate protection. Some examples of carcinogens are coal, tar, asbestos, vinyl chloride, ethylene dibromide, toluene and benzene.

Teratogens: "Terata" in Greek means "monster." Teratogens are agents that are known for their ability to cause malformations in an unborn child. Classic forms of fetal malformations are phocomelia (reduced limbs) or amelia (absent limbs). Chemicals are classified as teratogens and reproductive toxins if they affect the ability to conceive, bear, or nurture offspring, and/or influence the function or viability of sperm cells. Teratogens are toxins that cause physical defects in a developing embryo or fetus. Some substances known to be teratogenic in humans are anesthetic gases, organic mercury compounds, and ionizing radiation.

Mutagens: Mutagens are toxins that cause a change (mutation) in human genetic material (DNA and RNA). Mutation of the reproductive cells may cause birth defects in future children. These genetic changes can have numerous effects including the failure of important biochemical processes. Some known human mutagenic toxins are: ethylene oxide, ionizing radiation, hydrogen peroxide, hydrazine, EDB (ethylene dibromide) and benzene. Mutation of other cells in the body may cause cancer or defects in developing embryos or fetuses.

Corrosive Hazards: Corrosives are also defined as those materials causing irreversible damage to living tissue upon skin contact, as determined in laboratory studies. Corrosive materials are capable of destroying metals as well as organic materials (such as skin tissue). Some corrosive materials may also be strong oxidizers such as nitric and perchloric acids. Examples of high pH corrosive materials are sodium hydroxide and potassium hydroxide. Inorganic chlorides such as phosphorus pentachloride, stannic tetrachloride, and thionyl chloride are also corrosives because they yield hydrochloric acid upon hydrolysis.

Biological Hazards: Wastes from hospitals, medical offices, and research laboratories may contain infectious substances that can cause infection or disease in humans. These substances are

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called etiologic agents or regulated medical waste, and may be contained in water and dispersed by the wind. These substances may be in the form of body parts, sharps (needles), bandages and vials containing human blood. Other biologic hazards may be contained in poisonous plants, insects, animals and indigenous pathogens. Hazardous waste site workers must be aware of these types of substances and be capable of identifying them.

Radioactive Hazards: Radiation hazards, although very dangerous, are the least likely to be encountered. There is a much higher probability of exposure to chemical and physical hazards at a hazardous material site or during an emergency response operation at the shipyard. Surprisingly enough, radiation hazards are easily detected, measured and controlled. There are two types of radiation: non-ionizing and ionizing. Non-ionizing radiation is present in daily life from microwave ovens, and radio and television waves.

Reactivity: Reactive materials may cause fires, explosions and may liberate toxic gases during their reaction that are hazardous to human health and the environment. Reactives are dangerous for the hazardous waste handler because they can be unpredictable. In general, reactive substances exhibit one or more of the following characteristics:

- Normally unstable and readily change violently without detonating;
- Reacts violently with water;
- Forms potentially explosive mixtures with water;
- When mixed with water, generates toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment;
- Cyanide or sulfide bearing waste that, when exposed to pH conditions between 2 and 12.5, can generate toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment;
- Capable of detonation or explosive reaction if it is subjected to a strong initiating source or if heated under confinement; and
- Readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure.

These characteristics generally define highly reactive materials such as explosives, water reactive materials (i.e., sodium, strong acids), or sulfide and cyanide bearing compounds.

Some compounds by themselves are not reactive when mixed with other materials having similar properties, and do not produce dangerous reactions. However, the same compounds, when mixed with materials that are not compatible, will cause an adverse reaction. For example, two mineral acids such as sulfuric and hydrochloric, when mixed, do not adversely react. However, mixing one of the same compounds with methyl ethyl ketone will cause the generation of heat and fire.

When examining possible mixtures of compounds, it is necessary to evaluate the compatibility of the compounds. An incompatible mixture of compounds could produce one or more of the following: heat, polymerization, fire, explosions and gas (toxic and/or flammable). For example,

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spilling an oxidizing material onto clothing, or mixing it with a material such as sawdust, will cause heat and fire.

Some compounds are reactive with water. Calcium carbide, a granular type of material, is a flammable solid and dangerous with a wet substance. If a container is left open on a humid day, moisture from the air will be absorbed and initiate a fire. This reaction will also generate flammable acetylene gas.

Toxicity and Routes of Exposure: The dose makes the poison. This is the basic tenet of toxicology. Since the dose is the amount of substance to which an organism is exposed, a restatement could be **the exposure makes the poison**. Exposure is dependent upon the degree to which a substance, in absorbable form, comes in contact with surfaces of an organism capable of absorbing it.

The concept of exposure routes is very important for the shipyard hazardous waste handler because of their need to recognize a hazardous situation where exposure can be extremely dangerous or even fatal. There are three main routes by which toxins can enter the body: absorption, inhalation and ingestion.

Exposure Route	Absorption Site
1. Inhalation	Lungs by inhalation (breathing in) and absorption through the lung walls into the body
2. Dermal	Skin by direct contact and absorption through the skin into the body (also eyes)
3. Oral	Digestive tract by ingesting (swallowing) substances into the body's digestive tract or gastrointestinal (GI) tract

Note: The route of exposure can result in different rates of absorption and different toxic effects. Exposures can be controlled by using proper personal protective equipment (PPE).

Inhalation Exposure (The Lung Exposure Route)

Inhalation exposure is the most common way that hazardous substances enter the body, especially in an emergency response situation. The lungs are the largest exposed surface area of the body and facilitate the transfer of gases into and out of the body. If your alveoli (the tiny sacs at the bottom of the lungs) were flattened out, they would cover an area the size of a tennis court. This huge surface area is only a single cell thick, which allows a chemical to travel into the bloodstream quickly. The large surface area can result in rapid absorption into the bloodstream.

The most significant factor in the rate of absorption for inhalation is respiration. The rate of absorption can increase substantially if the rate or depth of respiration increases. This has important implications for hazardous waste handlers who are likely to be performing heavy physical work in contaminated environments, and therefore, are breathing faster and deeper.

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Since the lungs serve as an absorption point, they can also be the route of entry into the body for many substances that effect target organs, or systems other than the lungs themselves. An important example of a systemic toxin absorbed through the lungs is carbon monoxide.

The mucous cells within the lining of the nose trap inhaled dirt and other foreign particles, pushing them toward the throat where they are swallowed. Most inhaled foreign particles are delivered to the digestive system in this way. Although the digestive system is less delicate than the lungs, and more capable of disposing of hazardous materials, it still may be severely effected by substances that enter the body through inhalation.

Similarly, potentially hazardous particulate compounds may be deposited in different areas of the lungs depending on the particle size, with the smallest particles penetrating the furthest. Once deposited, particulates in the lungs can have acute or chronic toxic effects.

Factors that may influence the absorption of inhaled toxicants are:

- Specific gravity of the particle
- Particle charge
- Hygroscopicity
- Respiratory frequency
- Respiratory depth
- Local temperature and humidity
- Nature of the aerosol (fineness of dispersion)

Toxic Effects of Inhalation

The responses of the respiratory system to toxic agents may be divided into the following general categories:

- **Irritation of the respiratory tract** results in constriction of airways and may lead to infection and fluid build-up in the lungs. Examples of chemicals that cause irritation are hydrogen chloride and ammonia.
- **Sensitization** can lead to short-term constriction of the airways through an allergic response and may also develop into long-term or chronic pulmonary disease. Examples of sensitizers include isocyanates and sulfur dioxide.
- **Production of fibrosis (scar-like tissue)** may block the air passages, thereby causing decreased lung capacity. Examples of toxins that can cause fibrosis include silica, asbestos and beryllium.
- **Development of lung cancer, and resulting necrosis (cell death).** Examples of toxins causing this result include coke oven emissions, asbestos and arsenic. The lungs are also the entry site for asphyxiants and other toxins.

Dermal Exposure (The Skin Exposure Route):

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The skin is a specialized organ that provides a barrier between the environment and internal organs. The skin is not highly permeable and provides good protection against most compounds. Although a small amount of toxicants can enter through the hair follicles and sweat glands, the majority of chemicals must pass through the densely packed skin cells before entering into the blood stream. Hazardous waste handlers should never assume that the skin provides adequate protection in a situation involving hazardous waste. If the skin is damaged, its protective barrier can break down immediately.

It is important to remember that many forms of chemicals, including solids, liquids, gases and vapors, can affect and penetrate the skin. The amount of toxin absorbed depends on skin condition factors, chemical quantity, concentration, total time contact is maintained, and the surface area and location of skin exposed to the hazardous substance.

Factor	Description
Skin Condition	Skin condition factors can increase susceptibility to further damage from toxins, as well as increase absorption into the body. This includes skin that has been previously damaged by trauma, heat, cold, humidity, or chemical exposure.
Quantity of Dosage	Absorption of materials through the skin is time dependent, which means the longer the contact, the more that will be absorbed. Usually, the longer the duration of exposure, the more severe the toxic response. Chlordane, malathion, and DDT are examples of chemicals that can cause cancer if the cumulative exposure is sufficient.
Local Factors	Local factors such as temperature and blood flow at the entry site will also influence the rate of absorption. High temperature conditions, such as found in chemical protective clothing, can actually increase the skin absorption rates of some chemicals.
Exposure Site	The site of skin in contact with the toxin is important since permeability differs according to body region. Areas rich in hair follicles, such as the scalp, forehead, jaw area and underarm, allow much greater absorption than do other parts of the body. The skin of the scrotum allows almost total absorption of some chemicals.
Enhanced Absorption	Absorption can be enhanced if the substance and skin are covered, for example by a bandage or clothing. Moisture due to sweat will also increase absorption.

Other factors that may influence the absorption of substances through the skin are:

- Contact between clothing and skin
- Humidity of the skin
- Increased temperature of the skin
- Damage to the skin (cuts, abrasions)

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- Use of solvents that facilitate penetration
- Altering pH of the skin
- Increasing toxicant concentration
- Decreasing toxicant particle size

Two Toxic Exposure Examples:

- 1) The same amount of mustard you would put on a hot dog, if placed on the skin (dermal exposure), would be a local irritant.
- 2) Cutting an onion results in eye irritation, yet no irritation to the hands.

Toxic Effects of Skin Absorption

Contact with a chemical substance by the skin may cause two major effects: 1) The Local Effects and 2) The Systemic Effects:

1) The Local Effects:	
Irritation	Many chemicals cause an immediate reddening, rash, or other irritation to the skin upon contact.
Tissue damage	Chemicals such as corrosives, including acids or bases, eat into the skin and cause damage to the tissue beneath it.
Allergic effects	Some chemicals, such as nickel, chromium, formaldehyde, turpentine, and isocyanates cause the skin to become hypersensitive after repeated exposures. This is called sensitization dermatitis.
2) The Systemic (internal) Effects:	Systemic effects from absorption through the skin. Many solvents are absorbed through the skin, circulated through the bloodstream, and then cause damage within the body.

Oral Exposure (The Digestive Tract Exposure Route)

The oral route is the third way a chemical can enter the body. The main point of entry of this type of exposure is through the mouth. The chemical then passes to the gastrointestinal (GI) tract, which can be thought of as a “tube” going through the body. Chemicals that are eaten, intentionally or accidentally, may be absorbed into the body through this “tube”. Ingestion is the most common route of entry in cases of suicide and childhood poisoning, but less likely in work and environmental exposures. However, ingestion can occur when substances or contaminated hands, or clothing, come in direct contact with the mouth. In addition, some toxins may be consumed by eating meals or smoking in an environment where food and cigarettes can become contaminated. Metals such as lead, cadmium and arsenic are absorbed following their ingestion.

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The cells that line your upper respiratory tract (bronchia, throat) have small hair-like projections called cilia. These cilia move back and forth to carry mucous from the lungs to the throat, where they may be swallowed or spit out. Dusts that were filtered out in your upper respiratory tract can be trapped in the mucus and moved to your mouth where you can swallow them. In workplaces where dust levels are very high, ingestion (swallowing) has been a primary route of exposure. For example, lead exposure in radiator shops has caused several cases of stomach cancer.

Absorption rates for the different regions of the GI tract will vary due to differences in pH and surface areas. Therefore, the region of greatest absorption will be different for different compounds. In the workplace, many people may eat or drink harmful chemicals without knowing it. Toxic (poisonous) materials are absorbed from the digestive tract into the blood stream.

Personal hygiene is essential for the hazardous waste handler. At a minimum this requires:

- Wash thoroughly before eating, drinking or smoking
- Eat, drink and smoke in clean areas only

Toxic Effects of Ingestion: When a toxin is ingested, it affects the entire gastrointestinal system, which includes the mouth, pharynx, esophagus, stomach, small intestine and large intestine, as well as several other organs within the gastrointestinal system. These organs are collectively responsible for the absorption, digestion and storage of nutrients for human life. Like all organs, the gastrointestinal system may also be effected by toxins that enter the body through the skin or lungs. Some of these toxins may cause liver toxicity resulting in inflammation or other diseases such as:

- **Cirrhosis:** Cirrhosis is a progressive disease of the liver, which may occur with chronic exposure to carbon tetrachloride, but the most common cause is chronic alcohol consumption.
- **Malignant tumors:** Vinyl chloride monomer (used in making the polymer of vinyl chloride) can cause malignant tumors of the liver. Other suspected liver carcinogens are DDT, dieldrin and trichloroethylene.

Dose/Response Relationship

The dose/response relationship is the basis for measuring of toxicity. This relationship rests upon three assumptions:

1. The response is a function of the concentration at a site.
2. The concentration at a site is a function of the dose.
3. The response and dose are causally related.

These assumptions are simply stating that for the dose/response to be valid, increasing the dose should increase the concentration at the site of toxicity. All toxicology studies are based on the dose-response relationship. This is an attempt to relate the amount of a substance (the dose) given to a test animal to the effect shown by the animal (the response). The following table displays the dose/response relationship:

Example of the Dose/Response Concept:

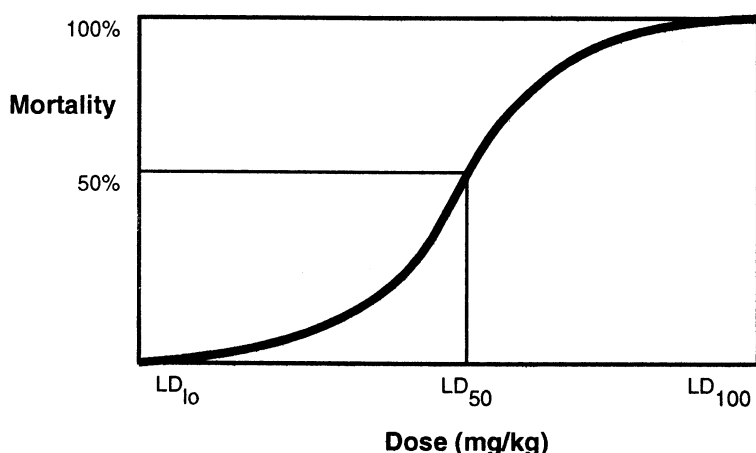
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Dose = Concentration	Time	Response
1 quart of 12% ethanol (alcoholic beverage)	15 mins.	brain effects ("drunk")
1 quart of 12% ethanol	daily	chronic organ damage
1 quart of 12% ethanol	annually	no observed effect

Note: The same dose given over a short period of time may have a substantial effect, while the same dose over a long period of time may have no effect at all.

Typical Dose-Response Curve

The mean response of a group at a particular dose is called the dose-response relationship. A way of representing the response of a population to different doses is with the sigmoid dose response curve. This curve compares the percentage of mortality among test subjects across a range of doses.



A basic piece of information available from the curve is the toxicity of the material. The curve shows that the effect of increasing the dose results in increased mortality of test subjects. Some individuals died at relatively low concentrations, while the hardest succumbed only at the highest dosage. The most toxic materials have the steepest curves, meaning that the difference in dosage between when the first death is observed, and where the entire population expired, is small.

Toxic Chemical Responses

The range of observable undesired effects resulting from exposure to a hazardous substance is broad. Some compounds may have numerous toxic responses. The identification of compounds by the type of response they cause can be quite useful. For example, compounds that cause delayed toxic effects may require more caution because they may give limited signs of exposure. Some chemical classifications are presented on the following page:

Immediate And Delayed Responses	
Immediate	Single administration, rapid onset (ethanol, nerve gases, aspirin)

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Delayed	Occur after a lapse of time (carcinogens - latency period 20 - 30 years)
Reversible and Irreversible	
Reversible	Re-establishment of normal function or regeneration of injured tissue (anti-cholinesterase, most liver toxicity because of the liver's ability to regenerate)
Irreversible	Permanent functional or tissue injury (teratogens, most CNS toxicity since differentiated cells cannot divide and be generated)
Acute and Chronic Responses	
Acute	Response following a single or short term exposure (acid, mace)
Chronic	Response following repeated small dose carcinogens (DDT, lead)
Local and Systemic Injuries	
Local	Injury at the site of first contact (caustic substances, inhalation of irritants)
Systemic	- Injury following absorption and distribution - Most systemic effects have one or two target organs - Most frequent target: CNS, Next: circulatory system - Least frequent: muscle and bone (lead - accumulated in bone - toxic in soft tissue DDT - concentrated in adipose tissue - no toxic effect there)
Synergistic and Antagonistic Effects	
Additive	The effect of two toxicants is equal to the sum of their individual effects (2 anticholinesterase, - malathion and carbaryl)
Synergistic	The combined toxicity is greater than the sum of the individual effects (carbon tetrachloride and ethanol; asbestos and smoking)
Antagonistic	Combined toxicity is less than the sum of the individual effects (atropine and nerve gas)

Toxins and their Effects

When a set of test animals is exposed to a given dose of a toxin, some may show minimal effect while others are more affected by the same dose. Any measure of the toxicity of a material must account for the mean, or average response of a population, rather than the particular response of an individual. Individual variabilities includes sex, age, individual susceptibility, nutrition, and health, which are explained in the table below:

Sex:	Males and females exhibit different responses. For example, females typically have higher body fat, and thus may be more susceptible to fat soluble substances. Males, on the other hand, may experience reproductive harm if the toxin targets rapidly growing cells. Females are susceptible to teratogenic and mutagenic
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	threats if pregnant, with the first trimester being the most vulnerable.
Age:	Metabolism of foreign compounds is an important detoxifying (and toxifying) process. For example, biochemical processes in the liver include the conjugation of glutathione (a protein) with the toxic compound to render it inactive and non-toxic. Older individuals tend to have lower glutathione levels and are less able to deactivate toxins. The greater the age of the individual, the more vulnerable they are to toxins. Respiratory and cardiac disease are more common in older individuals.
Individual Susceptibilities	Allergies or other physical impairments can increase one's sensitivity to particular chemicals. For example, occasionally someone may report reactions to household chemicals that otherwise wouldn't affect the general population. Obviously, the same may be true with industrial chemicals.
Nutrition & Health:	Physically fit persons are less susceptible to chemical exposures. The natural mechanisms that the body has for dealing with chemical exposures are at their peak when one is in good health. On the contrary, illness or poor health can mask symptoms from a chemical exposure. For example, a persistent cough may be attributed to a cold or flu, instead of a chlorine gas exposure.

Measurement of Exposure

The terms and definitions for measuring toxicity are an essential part of a hazardous waste responders vocabulary. This data represents the relative hazards of toxicants, allowing handler to make assessments about the threat of an incident. Generally, the lower the numbers, the more toxic the material.

When people think of a dose, they usually think of one vitamin a day, or two aspirins every four hours. This type of dosage would result in different exposures depending upon the size of the recipient. The use of laboratory animals in toxicity tests would result in even greater size disparities.

To provide a uniform measure of exposure, the dosage is usually expressed as a ratio of the weight of the chemical to the weight of the animal. In this way, it is possible to extrapolate the test animal dosage to humans.

Measures of Exposure (Dose)

Dose	Abbreviation	Metric Equivalent	Abbreviation
parts per million	ppm	milligrams per kilogram	mg/kg
parts per billion	ppb	micrograms per kilogram	ug/kg

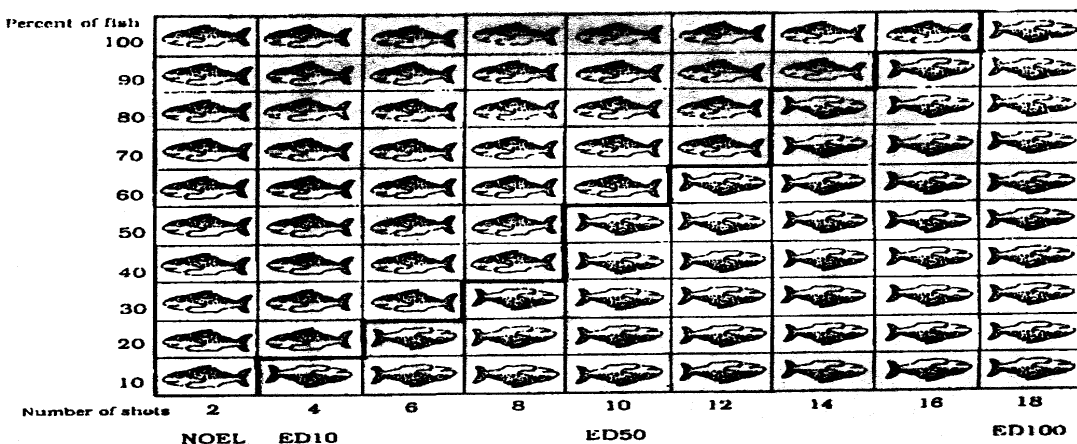
Lethal Dosage (LD-50) and Lethal Concentration (LC-50)

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The simplest toxicology study relates the percentage of test animals that die (mortality response) from the dose given. The dose is usually expressed in mg/kg (for ingestion or inoculation), in mg/M² (for skin exposure), or in mg/M³ (for inhalation). The response is expressed in percent (%) of animals that have died. The dose of a chemical that kills 50% of the test animals is the LD-50.

LC-50 is usually expressed in parts per million in air. It is the concentration that kills half the population in a given observation period. It is independent of body weight. The LC-50 measurement is used to determine the toxicity of vapors, fumes and dusts in air. The test procedure is very similar to LD-50 tests. The lethal dosage and concentration measures acute toxicity, and is commonly used to measure relative toxicity. The important thing to remember is that a low LD-50 value indicates a more toxic chemical, (i.e., 1 mg/M³) while a high LD-50 (i.e., 10,000 mg/M³) indicates a less toxic chemical.

An example of the dose/response relationship is illustrated by dumping shots of 100-proof whiskey into a ten-gallon tank containing ten goldfish. How many shots (dosage) will cause the fish to swim upside down? After one or two shots, none of the fish die, but after about four shots, one of the fish dies. As more shots of whiskey are added, more fish begin to die. After ten shots, five of the ten or 50% of the goldfish are swimming upside down. If the effect being observed is death, then the lethal dosage (LD-50) would be the measure of the lethal dose for 50% of the population.



High LD values describe chemicals that are less toxic. The following table displays some of the LD-50 values for several substances. Notice that Dioxin (TCDD) and Botulinus toxins are extremely deadly.

Approximate Acute LD-50's of a Selected Variety of Chemical Agents

AGENT	LD-50 (mg/kg)
Ethyl alcohol	10,000
Sodium chloride	4,000
Ferrous sulfate	1,500

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Morphine sulfate	900
Phenobarbital sodium	150
DDT	100
Picrotoxin	5
Strychnine sulfate	2
Nicotine	1
d-Tubocurarine	0.5
Hemicholinium-3	0.2
Tetrodotoxin	0.10
Dioxin (TCDD)	0.001
Botulinus toxin	0.00001

Probable Oral Lethal Dose for Humans: Hazardous substances can be ranked by their potential human toxicity. The table below describes the five different levels that are generally used to rate level of toxicity. It relates the lethal dosage for an average adult and the respective lethal ingested quantity:

Toxicity Rating or Class	Lethal Dose Concentration For Average Adult	Lethal Quantity For Average Adult
1. Practically non-toxic	> 15,000 mg/kg	More than 1 quart
2. Slightly toxic	5,000 -15,000 mg/kg	Between pint and quart
3. Moderately toxic	500 - 5,000 mg/kg	Between ounce and pint
4. Very toxic	50-500 mg/kg	Between teaspoon and ounce
5. Extremely toxic	5-50 mg/kg	Between 7 drops and teaspoon
6. Supertoxic	< 5 mg/kg	A taste (less than 7 drops)

OSHA establishes enforceable safety standards or criteria for chemicals that are designed to protect public health. The basis for the standard is usually a toxic response occurring at a much lower dose than where mortality occurs. Therefore, tests are devised to determine the dose which produces no observable adverse effects when small doses are administered over a period of time. Many standards and criteria have been established. However, they are all based on determining the dose level where toxic responses will not occur, and then dividing this dose by a safety factor to compensate for uncertainty.

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No Observed Effect Level (NOEL): The highest concentration or dosage where no effect is observed.

Threshold Limit Value - Time Weighted Average (TLV-TWA): This is the upper limit of a toxic material to which an average person, in average health, may be exposed on a day-to-day basis (40 hour work week, 8 hour work periods), with no adverse effects. TLVs are typically expressed in milligrams per cubic meter (mg/m³) for gases or vapors, and micrograms per cubic meter (ug/m³) for fumes and mists.

These are time weighted averages, and are not intended as a definitive line between safe and dangerous concentrations, but rather allow excursions above the TLV only when the average exposure does not exceed the TLV-TWA.

Threshold Limit Value - Ceiling (TLV-C): This is the maximum limit of a toxic material to which an average person in average health may be exposed on a day-to-day basis (40 hour work week, 8 hour work periods) with no adverse effects. This value is used in conjunction with TLV-TWA and represents the maximum limit of excursions above the TLV-TWA. TLV-C is considered allowable, provided the average exposure throughout the work week does not exceed the TLV-TWA.

Permissible Exposure Limit (PEL): This is the maximum permitted 8-hour time weighted average concentration of an airborne contaminant. The PEL is determined by OSHA and is equivalent in definition to the TLV-TWA which is set by the American Conference of Governmental Industrial Hygienists (ACGIH). The PEL is a legal limit, whereas the TLV is a recommended standard. Often they are the same values.

Short Term Exposure Limit (STEL): This is the maximum permitted exposure for no more than 15 minutes.

Immediately Dangerous to Life and Health (IDLH):

This is the concentration of airborne contaminants, normally expressed in parts per million (ppm) or milligrams per cubic meter, which represents the maximum level from which one could escape within 30 minutes, without any escape impairing symptoms, or irreversible health effects. This level is established by both the National Institute of Occupational Safety and Health (NIOSH) and the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH definition differs from NIOSH in that irreversible health effects are not considered. Therefore, carcinogenic compounds are not included in ACGIH IDLH listings.

Maximum Allowable Concentration (MAC): Absolute maximum exposure (ppm) at a given time.

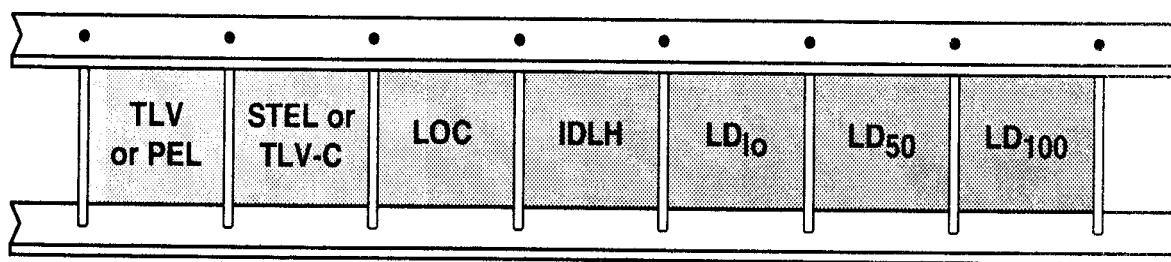
Level of Concern (LOC): This value is used to determine the geographic area of risk in the event of a chemical release. LOC is generally defined as IDLH/10. Typically, evacuation or protection measures may be necessary in LOC conditions.

Limit	Exposure Duration	Legally	Comments
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		Mandated?	
TLV	8 hours per day up to 40 hours per week	No	Set by ACGIH
PEL	8 hours per day up to 40 hours per week	Yes	Set by OSHA
STEL	15 minutes	Yes	Set by OSHA
IDLH	30 minutes for escape only	No	Determined by NIOSH
LOC	None	No	Evacuation Guideline

One way to visualize the relative ranking of the various toxicity terms for a material is the hazard ladder. Each toxicology value is arranged in order of increasing concentration and severity. TLVs for example, are the lowest numbers and they represent levels which cause relatively minor effects. Conversely, LD-100 values are comparatively large and fatal.



Emergency Response Planning Guide (ERPG)

Hazardous concentrations have been developed for emergency response situations where response individuals may be exposed for short periods of time. These ceiling limit values are developed and recommended by the American Industrial Hygiene Association (AIHA). The ERPG limits are not intended for repeated or extended exposures. The three levels are defined as follows:

ERPG-1: Maximum airborne concentration to which nearly all individuals could be exposed for up to one hour, without experiencing or developing health effects more severe than sensory perception, or mild irritation.

ERPG-2: Maximum airborne concentration below which, it is believed, nearly all individuals could be exposed for up to one hour, without experiencing or developing irreversible, adverse or other serious health effects or symptoms which could impair an individual's ability to take protective action.

ERPG-3: Maximum airborne concentration below which, it is believed, nearly all individuals could be exposed for up to one hour without experiencing or developing life threatening health effects.

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The MSDS: “A Valuable Tool For Determining a Substance Toxicity”

The Material Safety Data Sheet (MSDS) is the primary source of technical information concerning safe handling procedures and health affects of a chemical. According to OSHA Hazard Communication Standard (HCS) regulations, an MSDS must be readily available near the work station for every hazardous chemical used. Employees must know how to obtain an MSDS, and must be trained on how to interpret them. Since the central role of the MSDS is to provide hazardous material safety information, it is important that the hazardous waste handler understands how to read them effectively.

This training session provides a section by section review of the MSDS and the kind of information that must be provided by companies furnishing MSDSs. Although, the format of many MSDSs may be somewhat different, each MSDS must contain all these elements. The following table provides an outline of a typical MSDS and the subjects contained in each section:

MSDS SECTION	OUTLINED INFORMATION
SECTION I MANUFACTURER / PRODUCT IDENTIFICATION	Product name Address of manufacturer’s importer or other party responsible for preparing the MSDS Emergency and non-emergency telephone numbers The date prepared or last changed
SECTION II HAZARDOUS INGREDIENTS/ IDENTITY INFORMATION	Hazardous chemical names Chemical identity CAS #, and concentration (%) OSHA PEL limits in air ACGIH TLV limits in air
SECTION III PHYSICAL/CHEMICAL PROPERTIES	Vapor density Melting point or range Specific gravity Boiling point or range Solubility in water Appearance and odor Warning properties
SECTION IV FIRE AND EXPLOSION HAZARD DATA	Flash point Auto-ignition temperature Lower explosive limit (LEL) Upper explosive limit (UEL) Special fire fighting procedures Fire extinguishing materials Unusual fire and explosion hazards
SECTION V HEALTH HAZARD INFORMATION	Symptoms of overexposure for each route of exposure How to recognize exposure Acute and chronic effects of exposure First Aid Emergency Procedures for exposure Suspected carcinogens (yes or no) Medical conditions aggravated by exposure

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SECTION VI REACTIVITY DATA	Product stability Conditions to avoid Materials to avoid Hazardous decomposition Hazardous polymerization
SECTION VII SPILL LEAK & DISPOSAL INFORMATION	Spill response procedures Proper disposal of spilled wastes
SECTION VIII PRECAUTIONS FOR SAFE HANDLING AND USE	Ventilation and engineering controls Respiratory protection Eye protection Clothing and equipment Hand protection (gloves) Good work practices, handling, and storage requirements Decontamination of equipment
SECTION XI LABELING	DOT shipping name Precautionary statements NFPA hazard rating

The following describes the MSDS sections, outlines information presented, identifies key terms, and provides for a better MSDS understanding.

SECTION I - MANUFACTURER'S IDENTIFICATION

The first section of the MSDS contains the name and address of the chemical manufacturer, importer or party responsible for preparing the MSDS. Both emergency and non-emergency telephone numbers are provided for obtaining additional information on the hazardous product. The date that the MSDS was prepared or last changed should also be included in this section.

The most important information contained in this section is the emergency information phone numbers. This gives the caller access to an individual that should be educated about the product and associated health risks, clean-up procedures, and personal decontamination. The person at the emergency phone should be able to clarify the information provided on the MSDS over the phone.

SECTION II - HAZARDOUS INGREDIENTS/IDENTITY INFORMATION

Any chemical substance that has been found to present a physical or health risk must be identified on the MSDS by its specific chemical name and its common name. Chemical mixtures that have been tested as a whole, and have been determined to be hazardous, must be listed by the chemical and common names of the components that contribute to the hazard(s), as well as the common name(s) of the mixture. Mixture ingredients which have been identified as carcinogens or potential carcinogens by the National Toxicology Program (NTP), the International Agency for Research on Cancer (IARC) or OSHA, and comprise 0.1 percent, or greater, of the total mixture composition, must also be listed and identified by both the chemical and common names. The

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table below provides a description of the key terms that will be encountered in this section of the MSDS.

Key Terms	Description
ACGIH	American Conference of Governmental Industrial Hygienists is a private organization of occupational safety and health professionals. ACGIH limits are usually lower (more stringent) than OSHA limits, but are not legally enforceable.
OSHA	Occupational Safety and Health Administration is the federal agency which sets safety and health standards and regulates working conditions in most of the nation's workplaces.
CAS#	The Chemical Abstracts Service Registry Number is a number given to each chemical that identifies it as a specific chemical compound.
PEL	Permissible Exposure Limit is the amount of any chemical to which a worker can legally be exposed. It can be an average exposure over time, or a one-time maximum exposure limit. This limit is established by OSHA.
TLV	Threshold Limit Value is an exposure limit recommended by ACGIH. There are three types of ACGIH TLVs : TLV-TWA -The allowable Time-Weighted Average concentration for an eight hour work day. TLV-STEL -The Short-Term Exposure Limit, or maximum average concentration, for a continuous 15 minute exposure period. TLV-C -The Ceiling Limit, or maximum concentration, that should not be exceeded even for a split second.
Ppm	Parts per million, or parts of the chemical per million parts of air.
mg/m³	Milligrams per cubic meter. This is the weight of the chemical (usually a dust or vapor) in a particular volume of air.

SECTION III - PHYSICAL/CHEMICAL CHARACTERISTICS

This section of the MSDS requires the inclusion of several important physical/chemical characteristics of the hazardous substance. Among these are the boiling point, melting point, specific gravity, vapor pressure, evaporation rate, vapor density and solubility. The physical appearance and odor of the compound are also required information. This is very important for both hazard recognition and emergency response analysis. The table below provides a description of the key terms encountered in this section of the MSDS.

Key Terms	Description
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Boiling Point	The boiling point of a chemical or chemical mixture is the temperature at which the vapor pressure of a liquid equals the atmospheric pressure. Therefore, it is the temperature at which the substance rapidly changes from a liquid to a gas. The lower the boiling point, the more quickly it will evaporate and emit potentially harmful vapors into the air.
Melting Point	The melting point is the temperature at which a solid will be in equilibrium with the liquid phase at atmospheric pressure. At this temperature, a solid will begin to flow like a liquid.
Evaporation Rate	The time required to evaporate a certain volume of a liquid chemical compared to the time required to evaporate the same volume of a reference liquid (usually ethyl ether). In general, the higher the evaporation rate, the lower the boiling point, and the greater potential for release of hazardous vapors.
Solubility	The solubility of a substance in water should be reported as the percentage of product (by weight) that can be dissolved in distilled water at a specified temperature.
Specific Gravity	Specific gravity is the ratio of the density of a liquid, or solid, to the density of an equal volume of water at a specified temperature. A substance with a specific gravity <1.0 will float on water, while substances with specific gravity >1.0 will sink in water.
mmHg	Millimeters (mm) of the metal mercury (Hg) is a unit of measurement for pressure. For example, when used to define vapor pressure, it shows how likely a liquid is to vaporize. At sea level, the earth's atmosphere exerts 760 mm Hg of pressure.
Vapor Density	Vapor density is expressed as the density of chemical vapor relative to that of air, which is assigned a vapor density of 1.0. Knowledge of the vapor density of a chemical product will allow the waste handler to determine whether the vapor will rise or sink in the ambient air. A chemical with a vapor density less than 1.0 will rise in air, while a chemical with a vapor density greater than 1.0 will tend to sink in air and "flow" along the ground, collecting in puddles.
Vapor Pressure	Vapor pressure refers to the pressure (expressed in mmHg) exerted by a chemical vapor in equilibrium with its liquid or solid phase at any given temperature. Information on vapor pressure can provide the waste handler with an indication of how easily a chemical can become airborne. The higher the vapor pressure, the more likely it is that significant quantities of a chemical will be airborne, if it escapes. High vapor pressure is greater than 10 mmHg. Low vapor pressure is less than 1 mm Hg.
Appearance and Odor	The appearance and odor of a chemical product is identified by using the appropriate descriptive terminology. For example: viscous, colorless liquid with an aromatic odor.

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SECTION IV - FIRE AND EXPLOSION HAZARD DATA

The MSDS should detail any unusual fire or explosion hazards that are inherent to the hazardous substance or dangers that may be initiated by a change in environmental conditions. The information that is required for chemicals is the flash-point, flammable limits, lower exposure limit (LEL), upper exposure limit (UEL), recommended extinguishing media, special fire fighting procedures, and unusual fire and explosion hazards. Some chemicals, for example, known as pyrophorics, can ignite spontaneously when they come in contact with air. No flame or spark is needed, which must be identified on this section of the MSDS. The table below provides a description of the key terms that will be encountered in this section of the MSDS.

Key Terms	Description
Combustible	Able to catch fire and burn. Moderate fire risk chemicals with a flash-point between 0°F. and 200°F. are considered combustible.
Flash-Point	The lowest temperature at which a liquid gives off enough flammable vapor to ignite (start to burn) if it comes in contact with a spark, flame or other ignition source. If the flash-point is less than 100°F, a cigarette or static electricity could start a fire. A chemical whose flash-point is less than the temperature of the area where it is used or stored, poses a problem.
Ignition Temperature	Ignition temperature is the minimum temperature required to initiate self-sustained combustion of a material. This temperature may be the same as the flash point but is usually slightly higher.
Auto-ignition Temperature	The auto-ignition temperature is the lowest temperature in which a material will spontaneously ignite and burn. In this situation, heat is the only source of ignition. For most materials, the auto-ignition temperature tends to be high (several hundred degrees Celsius). However, some material, such as white phosphorus, will ignite at temperatures close to room temperature.
Flammability Limits	Flammability limits are the lowest and highest concentrations (%) of vapors in air that will produce a flash fire when an ignition source is provided. Its unit of measurement is percent by volume in air. At a concentration too low to ignite, the mixture is too "lean" to burn. At a concentration too high to burn, the mixture is too "rich" to burn.
Flammable and Explosive	Flammable or explosive limits refer to the range of vapor concentrations in the air (percent by volume) that will burn or explode upon contact with an ignition source. The Lower Explosive Limit (LEL) is the lowest vapor concentration in the air which will explode if heated. The Upper Explosive Limit (UEL) is the highest vapor concentration in the air which will explode if heat is added. The explosive range between the LEL and UEL indicates the degree of hazard. The greater the range, the greater the hazard. The LEL is

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	an important factor to be considered when calculating the volume of air needed to ventilate an enclosed space to prevent fires and explosions.
Oxidizer	A chemical which gives off oxygen. Oxygen feeds fires, and can cause materials that are normally hard to burn to burn more easily and at higher temperatures. Oxidizers should never be stored near flammable or combustible materials.
Extinguishing Media and Procedures	Extinguishing media specific to the particular chemical compound must be identified on the MSDS. Common extinguishing agents include water, foam, halon, carbon dioxide, dry chemicals, and powders. Any special procedures that may be useful to firefighters and other emergency response personnel (i.e., Do Not Use Water) should be reported.

SECTION V - HEALTH HAZARD DATA

This section of the MSDS introduces a variety of information to help the hazardous waste handler understand the effects of exposure. All chemicals can be handled safely, and the human body can, and does, withstand low level exposures to toxic compounds. This section will provide an interpretation of "low level" exposures for the chemical compound. Key terms that are required in this section of the MSDS are listed in the following table:

Key Terms	Description
Routes of Exposure	Routes of chemical exposure include inhalation, ingestion, and absorption. It is important to identify any and all of the potential routes of entry for chemical exposure.
Exposure Signs	Exposure signs describe how an overexposed individual is most commonly affected by the chemical. This should include any obvious physical indications as well as any subjective complaints that can be reasonably attributed to the exposure, such as headaches, burns, rashes, difficulty breathing, and dizziness.
Acute and Chronic Health Hazard	Acute and chronic health hazard data should include any health hazards for which there is statistically significant evidence, based on at least one positive study conducted in accordance with scientific principles.
Acute Exposure and Effects	Acute effects occur immediately or in a short interval after exposure. They are typically sudden and severe (illness, irritation, and/or death) and are characterized by rapid absorption of the material. Acute effects are usually due to acute short-term exposures.
Chronic Exposure and Effects	A chronic effect is one that develops slowly over a period of time, or which recurs frequently. Chronic exposure means a relatively low level of exposure which occurs over a relatively long period of time.

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Aggravated Medical Conditions	Medical conditions that may be aggravated or worsened by exposure to a chemical must be identified on the MSDS. Such conditions may include high blood pressure, asthma and other chronic respiratory conditions, diabetes, allergies, skin disorders, and liver and kidney problems.
Emergency and First Aid Procedures	Emergency and first aid procedures must be specified on the MSDS for the purpose of providing information on the immediate steps to be taken in the event of a medical emergency, until a qualified medical professional can examine the victim.
Carcinogen	A chemical or physical agent capable of causing cancer.
LD-50	The dose of a chemical that will kill 50% of the test animals receiving it. The chemical may be given by mouth (oral), applied to the skin (dermal), or injected (parenteral). A given chemical will generally show different LD-50 values depending on the route of administration and the species of the test animal. This measures acute toxicity.

SECTION VI - REACTIVITY DATA

Reactivity data includes information on chemical stability, incompatibility, decomposition, conditions to avoid and hazardous polymerization. The MSDS should indicate whether the chemical is stable or unstable under reasonable conditions of storage, use, or misuse. It also should indicate whether or not the chemical will react readily with air or change its chemical structure when exposed to various combinations of temperature, pressure and light conditions. MSDSs should identify those conditions to be avoided when handling unstable chemicals. The table below provides a description of the terms used in the reactivity data section of the MSDS.

Key Terms	Description
Stability	A material's ability to remain unchanged. The substance is considered stable if it remains in the same form under reasonable conditions of storage or use. Conditions which may cause dangerous changes are stated on the MSDS. High temperatures or shock from dropping can cause violent reactions.
Reactivity	The ability of a substance to undergo a chemical change by reacting with other substances or by decomposing. Either change can create a potentially hazardous chemical.
Incompatible Materials	Incompatible materials are chemicals or materials that can initiate a potentially dangerous reaction when brought into contact with an otherwise stable substance. The MSDS should identify any such incompatible materials and their attendant hazards.
Hazardous Decomposit-	Hazardous decomposition is the breakdown of a chemical substance into simpler chemical products. If the decomposition products are hazardous, the

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ion	MSDS should explain the conditions that may cause decomposition and name the by-products.
Hazardous Polymerization	Hazardous polymerization is a chemical reaction where molecular units of a chemical bond together under certain conditions to form a long chain called a polymer. Hazardous polymerization may occur when a reaction takes place at a rate that releases enough energy in the form of heat to cause a fire or explosion. Some chemicals can expand and burst their containers during a polymerization reaction. To help prevent hazardous polymerization, information about time periods for which the chemical inhibitor will remain effective must be noted on the MSDS.

SECTION VII - SPILL, LEAK, AND DISPOSAL INFORMATION

Proper precautions for the safe handling and use of a chemical product must be indicated on the MSDS. This includes the steps to be taken in case the material is released or spilled, appropriate waste disposal methods, precautions to be taken in handling and storing the material, and any other safety precautions.

Response procedures for the clean-up of leaks, spills and other accidental chemical releases may include:

- Remove sources of ignition
- Avoid breathing of gases and vapors
- Provide additional ventilation
- Avoid contact with liquids and solids
- Isolate contaminated areas
- Evacuate unauthorized personnel
- Dike materials for spills
- Knock down vapors with water spray
- Apply absorbent material
- Sweep and decontaminate all areas

Appropriate waste disposal methods should also be specified on the MSDS for wastes that are created during spill clean-up and/or production operations. All waste should be disposed of in accordance with Federal, state, and local regulations. The MSDS will never provide specific information about proper disposal because of the potential for a variety of waste stream contaminations and the variations in local and state requirements. All hazardous waste in the shipyard should be segregated and processed in the central accumulation area for proper disposal.

SECTION VIII - CONTROL MEASURES AND SPECIAL PRECAUTIONS

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This section of the MSDS requires information on the recommended control measures for reducing worker exposure to the hazardous substance. Some of the control measures may be described are:

Key Terms	Description
Ventilation and Engineering Controls	Engineering controls are the workers first line of defense against chemical exposures in the workplace. Ventilation systems, special enclosures, and other mechanical protection systems are all examples of engineering controls. Ventilation systems may be of the local exhaust type, which captures and removes contaminants at the source, or the general dilution type, which reduces contaminant levels by circulating fresh air through the work environment. The MSDS can indicate whether these or any other types of specially designed ventilation systems are of use in the workplace.
Personal Protective Equipment (PPE)	Personal protective equipment (PPE) usually includes gloves, safety glasses or goggles, face shields, aprons, boots, and respiratory equipment. Specific information should be given on the exact type of respiratory protection to be worn for every possible level of exposure. Protective gloves and eyeglasses are available in a variety of materials. The MSDS should specify a certain type of eye protection or glove material to be used with any given chemical. Any other special protective clothing or equipment that is known to the manufacturer should be noted on the MSDS.
Other Hygiene Information	Any relevant hygienic and/or work practices which can be employed to protect employee health and safety should also be reported.

SECTION XI - LABELING

This section generally provides precautionary statements that also appear on the chemical container label. This is very useful as it brings a primary source of information, the label, together with the technical information on the MSDS. It also provides other information for emergency responders in the event of a spill, release, or contamination. Some other information is as follows:

- DOT shipping name
- United Nations Shipping Number
- Precautionary statements (Statement of Hazards) (Signal Word)
- NFPA Hazard Ratings
- HMIS Hazard Ratings

Additional copies of this report can be obtained from the
National Shipbuilding Research and Documentation Center:

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